SOIL POPULATION STUDIES.

A QUANTITATIVE ECOLOGICAL STUDY OF SOIL MICROARTHROPODA (MAINLY COLLEMBOLA AND ACARI), WITH SPECIAL REFERENCE TO THE EFFECTS ON THE POPULATION OF THE PERSISTENT SYNTHETIC INSECTICIDES DICHLORODIPHENYLTRICHLOROETHANE (D.D.T.) AND HEXACHLOROCYCLOHEXANE (B.H.C.).

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CONTENTS.

B./

GENERAL INTRODUCTION.

It has long been realized that the soil is no mere mass of dead material in which nutrients are passed to plants by purely chemical and physical processes. Rather, it is known to be a _milieu_ of intense biological activity where complex chemical reactions and physical processes are intimately associated with a vast community of organisms, - a tumultuous array of life, ranging, in the words of Fenton (1947), from bacteria to badgers.

The majority of the invertebrate metazoan inhabitants of soil belong to the category which Fenton has called the mesofauna:- an arbitary middle size group of animals, ranging from species "just visible with a hand lens" to forms several centimetres in length. The mesofauna is made up of representatives from a number of widely different groups, amongst the more important, both by virtue of their numbers and biological interest, being the _Arthropoda_. These are usually dominated by _Collembola_ and _Acari_, ranging in length from about 100μ to approximately 1 cm., and which, with allied forms of similar dimension, are collectively referred to as micro-arthropoda. Less numerous are the larger species of _Chilopoda_ and _Diplopoda_, and certain _Insecta_, although these forms are generally more familiar, many being well known as pests of crops.

The following contribution to soil ecology is concerned mainly with the micro-arthropoda of old grassland in a Glasgow park. In its/

its ultimate form, the investigation was designed to study the following:-

(1) Population of the uncultivated soil.

(2) Effects of cultural operations.

(3) Responses of the population to applications of the persistent synthetic insecticides- D.D.T. and B.H.C., applied separately and together.

The reasons for the inclusion of these insecticidal treatments were several. In the first place, it was considered that such treatments might be used as an experimental technique to investigate the inter-relationships of the animals in the environment under examination. Thus, by disrupting what has been called the "quasi-equilibrium" of the population (Lotka 1925), it was thought that some information might be obtained about the nature of the factors responsible for maintaining this alleged state of fluctuating balance. Furthermore, undesirable changes in the composition of animal communities have become increasingly common phenomena following the increasing use of these persistent chlorinated hydrocarbons, and the micro-arthropodan fauna of the soil appeared to present a convenient natural population in which these changes could be investigated quantitatively. Finally, it seemed that additional data on the efficiency and duration of these substances as destructive agents in soil would be of some value in relation to specific problems of pest control.

In its original conception the investigation did not include observations/

observations on the effects of cultivation. After preliminary trials, however, it became apparent that insecticides applied in the form of surface dressings would not penetrate the soil in sufficient quantities to induce a statistically significant response in the underlying population, and so it was concluded that the only practical way of ensuring an adequate response was to incorporate the insecticides with the soil by cultivation.[1] It therefore became necessary to make a separate assessment of the effects of the cultivation required for the incorporation of the chemicals; and, finally, with a view of throwing further light on the influence of surface vegetation on the hypogeal fauna, the experiment was extended to include a study of the effect of fallowing.

The major part of this investigation was carried out by means of a single large field trial, in which replicated plots were subjected to the required treatments. Thus, the observations on the fauna of the constituent plots were planned in relation to the experiment as a whole, and were therefore to a certain degree interdependent. However, as the work progressed, various difficulties were encountered, so that some other modifications of the original programme became necessary and the investigation also/

1. During the course of the present investigation, and on other occasions, the writer, using emulsion and suspension formulations at various rates, failed to obtain an appreciable soil penetration with surface applications of insecticides on grassland. In recent trials, Dr. Grainger of Auchincruive, found that when solutions of radioactive Iodine were applied to the surface of <u>bare</u> soil, the element could not be subsequently detected below a depth of $\frac{1}{3}$". (Unpublished)

also acquired an increasing complexity, revealing aspects of unforseen interest. Hence, in order to facilitate a clear presentation of the results, it has been found desirable to divide the present paper into two main parts:- Part I, dealing with the population of the uncultivated soil and Part II, with the effects of cultivation and insecticide treatment. Each part includes a review of relevant literature and a discussion of results.

PART I

THE POPULATION OF THE UNCULTIVATED SOIL

I. INTRODUCTION

The importance of the soil fauna in relation to the processes of organic decay, leading to the formation of plant nutrients, can hardly be refuted after a consideration of the more elementary principles of ecology. Yet, the soil Arthropoda which constitute a substantial proportion of this community, have been comparatively little studied; for, apart from species of great economic significance as pests, detailed ecological investigations of these animals are few and of relatively recent origin. Nevertheless, the aspects embraced by this field of study are so varied, that it is not paradoxical to state that the relevant literature is extensive. This is particularly so when investigations of forest soils and litter are taken into account; for, not only are many species common to organic and mineral habitats, the point of transition from litter to soil is often difficult to determine.

Fenton (1947) and Murphy (1953) have reviewed the literature on soil fauna with reference to the problems of forestry, and a more general account is given by Kühnelt (1950). These papers contain extensive bibliographies and the following review of literature is therefore confined to a consideration of the more important investigations, and to those of outstanding significance in relation to the present study.

II. REVIEW OF PREVIOUS WORK

A. Extraction Methods

The progress of soil Arthropod ecology has been closely associated with the development of methods for separating the animals from their environment; for, with the introduction of more efficient techniques, greater populations were encountered, and previously unknown fields of investigation were revealed. This problem of extraction is by no means completely solved, since all the methods used hitherto have a number of serious disadvantages. Before any conclusions can be drawn from comparisons of the results of different workers, the separation techniques used must be taken into account. The methods of extraction hitherto introduced can be resolved into three main categories:-

(1) Direct Sorting.

(2) Automatic Heat-Desiccation Funnels.

(3) Flotation.

1. Direct Sorting.

This method was used by the earlier workers, notably McAttee (1907), Cameron (1913, 1917), and Morris (1920,1922a), and merely consists of breaking down the soil aggregates by hand and picking out the enclosed animals. Ford (1935) also utilized this mode of separation, but broke the soil down with stout needles under water. Some degree of improvement was introduced by

Morris/

Morris (1922b), in as much as a preliminary separation was obtained by washing the soil through a series of sieves of decreasing mesh size; the fractions so obtained being subsequently examined in detail. This latter technique was used by Morris in his later work (1927), and also by Thompson (1924), and by Edwards (1929).

Although having the advantage of simplicity, such methods are totally inadequate for anything but large species. Apart from considerations of accuracy, the labour involved is prohibitive when large numbers of samples have to be examined to fulfil the demands of statistical treatment.

2. Automatic Heat-Desiccation Funnels.

The original desiccation apparatus was devised by Berlese (1905a), and consists of a funnel equipped with a hot water jacket, the soil or litter being supported on a sieve over the wide mouth. The material is slowly dried out by the heat from the water jacket, and, to escape heat and desiccation, the animals move down and eventually drop through the sieve and funnel into a collecting tube below. In a modification of this apparatus, Tullgren (1918) dispensed with the water jacket and suspended an electric bulb over the funnel as a source of heat, and here the light is alleged to act as an additional stimulus to downward movement, most of the animals being negatively photo-tropic. Ford (1937) mounted several Tullgren funnels together in batteries, and in this way dealt with several small herbage samples, and Haarløv (1947) introduced/

introduced further modifications, designed mainly to eliminate condensation on the sides of the funnels, which, he maintained, trapped the smaller animals.

This principle has also been used in the "high gradient" apparatus devised by Macfadyen (1953). Here samples are taken in the field with stainless steel tubes, the upper ends of which are covered by a metal gauze, and the tubes containing the samples are then inverted and placed in steep-sided funnels, heat being derived from a resistance wire suspended above. The sample is undisturbed and hence the original interstices of the habitat are less likely to be obstructed; and, as the upper layers of soil (which normally contain the greatest part of the population), are placed downwards in the apparatus, the animals therein do not have to move great distances to escape.

Extraction techniques utilizing these principles have been largely used for investigations of surface herbage, litter, and for soils with a high organic matter content; examples being the studies of Trägårdh (1929), Ford (1935, 1937, 1938), Forsslund (1944), Strenzke (1949 and 1952), and Macfadyen (1952), although such methods have also been utilized for mineral soil studies, (e.g. Frenzel 1936, and Weis Fogh 1948), and for soils which could be considered to be intermediate in character, (e.g. Strenzke, and Riha 1951).

The funnel methods have the obvious merit of being automatic and, by using a series of small units, can be adapted to deal with a large number of separate samples for statistical studies. Furthermore, the animals are collected in good condition, - a point of great importance/

importance when dealing with groups of considerable taxonomic difficulty. However, a serious objection is that the technique is dependent upon the responses of species usually of great physiological diversity, to the stimuli of heat and desiccation. Thus, highly susceptible species and instars may succumb before making their escape, and others, less susceptible, may fail to respond adequately. Hence in quantitative studies, a bias may occur towards forms reacting favourably to the stimuli. This difficulty is accentuated when the "heavier" mineral soils are the subject of investigation, for such soils contain a high proportion of small particles belonging to the clay fraction, and when dried out, tend to set in a hard mass. Jacot (1936) pointed out that in these soils many animals might be trapped, and this was also the experience of the writer during the course of the present investigation, when funnel methods were utilized to obtain living material for experimental purposes.

The studies of Trägårdh (1933), Haarløv (1947) and Macfadyen (1953), in which measurements were made of the physical changes in samples undergoing desiccation, were largely directed towards eliminating these difficulties, but much research is still required before the efficiency of these methods can be accurately assessed for all groups in a range of soil types.

3. <u>Flotation</u>

In 1936, Ladell published an account of an apparatus designed to extract soil animals by a process of flotation. This technique consists of stirring the soil sample in a cylinder containing, as

a/

a non-toxic medium, a solution of magnesium sulphate of specific gravity 1.11; and, at the same time, a stream of air is bubbled through the suspension from below. The stirring and bubbling breaks down the soil particles, and, after settling, the liberated animals float on the surface of the solution, together with any organic debris present in the sample. Thereafter, by a process of decantation, the animals and debris are collected on a filter paper or sieve; further separation being achieved by examining the "float" under a binocular microscope.

In its original form, Ladell's apparatus was used by Baweja (1939), by Glasgow (1939), and by Jones (1939).

To facilitate their research on "wireworms", Salt and Hollick (1944), designed an extraction apparatus, which, while dependent upon the principles laid down by Ladell, contained the following new features:-

(a) The incorporation of a preliminary washing and sieving process, by means of which the soil is reduced to a fine state before flotation, stones and coarse plant material are isolated, and a proportion of the unwanted finer soil particles jettisoned.

(b) The introduction of the benzol-water method for the partial excerption of the float. This technique consists of shaking the float vigorously with a mixture of benzol and water in a flask, and, since the Arthropod cuticle is wetted by the benzol, and the plant material is not, the animals accumulate above the vegetable material on the benzol-water interface.

In/

In order to drive down as much of the plant debris as possible, the pressure in the flask is then reduced by means of a filter pump. In this way, the air is drawn out of the plant debris, and after restoring atmospheric pressure, a proportion of this material sinks. The upper section of the liquid mixture is then transferred to a wide vessel, and the interface is examined under a binocular microscope mounted on a movable arm.

Designed for the extraction of Elaterid larvae, the smallest component sieve of the original apparatus had a square mesh of 0.2 mm. However, Salt et al (1948) used this, and a modified type with a 0.1 mm. sieve, for a more general study of a Cambridge pasture, and encountered therein a total Arthropod population far heavier than had previously been recorded for any soil. This type of apparatus was used by Strickland (1945) and by Salt (1952); a modified form being also used in the present investigation.

Not being dependent upon the reaction of the animals to a given stimulus, flotation methods tend to give a more complete and impartial extraction, but, these methods are tedious and time-consuming. Thus Salt (1952) recorded that the average time required to remove and roughly classify the Arthropoda from a single sample of mineral soil (151 cu.ins.) was 3.3 man-days. In soils containing a high organic matter content this labour becomes prohibitive, as all the organic material is carried over during flotation, and only a small proportion is disposed of by the benzol-water process. For this reason, funnel methods are to be preferred for such soils.

B./

B. General Surveys of Soil Micro-arthropoda.

It is difficult to state precisely who was responsible for the initiation of ecological studies of soil Arthropoda. Many soil dwelling species were described by the early taxonomists, but ecological field studies do not appear to have been carried out until the beginning of the present century when Diem (1903) published records of invertebrates taken in various alpine and sub-alpine plant associations. Linnaniemi (1907, 1912) dealt with soil dwelling Collembola in the course of a general study of that group in Finland. A well known early quantitative study is that of McAttee (1907), who calculated an invertebrate population of 13.6 million individuals per acre, for the surface soil of an American meadow.

A series of British contributions was initiated by the late Dr. A.E. Cameron (1913, 1917) who, in four surveys of soils in Lancashire and Cheshire, dealt principally with the larger species (mainly Diptera amd Coleoptera), although some records of Collembola are included. Similar surveys were made by Buckle (1921, 1923), who concluded that the majority of soil insects occurred irrespective of soil type and were not confined to any particular plant association. Morris (1920), studied the hypogeal fauna of a Cheshire pasture where he found that the heaviest populations occurred in the upper layers of soil; and later, (1922a, 1927), he examined the invertebrates of arable land at Rothamsted, showing that, whilst applications of dung induced an increase in both numbers of species and individuals, the addition of artificial manures had no apparent effect/

effect.

At Aberystwyth, the soil fauna of a number of fields, mainly pastoral, was studied by Thompson (1924) and Edwards (1929); whilst Ford (1935) investigated the subterranean population of a meadow near Oxford. Although differing in many details, the communities of these areas were shown to have a number of common features; notably the concentration of the fauna in the upper soil, the dominance of the Arthropodan community by Collembola and the occurrence of a seasonal fluctuation, due mainly to the latter group, in which the population rose to a maximum during autumn or early winter.

Using Ladell's apparatus at Rothamsted, Baweja (1939) studied the recolonization of partially sterilized soil, therewith demonstrating a rapid return of animals, accompanied by a subsequent increase in the population to a level nearly twice that of the unsterilized soil. Jones (1939) also used this technique for a short survey of garden soil at Aberystwyth. Salt and his colleagues (1948) examined the Arthropod population of a Cambridge pasture; and, in November, 1946, recorded a population equivalent to 1068.8 million individuals per acre for the upper 12" of this soil, Acari being the most numerous single order. The most recent accounts of British work are those of Macfadyen (1952), and Murphy (1953). The former worker examined the micro-arthropod community of the Cothill fen, Oxfordshire, and here again Acari were found to be dominant. He concluded that whilst the quality of the surface vegetation could determine the density of the population, it had little effect upon its/

its species composition. Murphy included a number of original observations on the fauna of heathland habitats, in an interesting review.

In continental Europe, and especially in Scandinavia, investigators have paid particular attention to the fauna of litter, and to the populations of organic soils in forests and heaths. This tradition can be traced to the classic work of Muller (1879, 1884) on the nature and formation of forest humus, (Mull and Mor), in which the importance of earthworm activity was emphasized. Amongst the more comprehensive Scandinavian surveys of such habitats are those of Trägårdh (1929), Bornebusch (1930), and Forsslund (1944); whilst in Holland, the fauna of a beechwood floor was examined by Van der Drift (1951). A number of these investigators have also included biomass calculations, whereby the weight or volume of the animals in the habitat was estimated, noteworthy in this respect being the studies of Bornebusch and Van der Drift, although it should also be noted that similar estimates were made by Macfadyen in his Cothill study.

Although less numerous, accounts of populations from continental soils predominantly mineral in character, include a number of important contributions. Frenzel (1936) surveyed six meadows selected to represent upland and lowland habitats in Silesia, and found that the population in these areas had much in common with those previously reported from British habitats, notable similarities being the numerical importance of Acari and Collembola, the occurrence of marked seasonal fluctuations in the populations of the latter group, and the/

the uneven vertical distribution of the fauna. He also noted that whilst many genera and species were restricted in their distribution, others occurred in all the habitats studied, and these ecologically plastic forms were designated "Leitformen des Wiesenbodens". In Denmark, Weis Fogh (1948) examined the population of the light soil of grassland on a raised beach. Establishing 7 sampling stations along a 12 metre line, he described the edaphic factors which obtained in each station, and was able to distinguish 2 distinct microarthropod communities; the difference in composition being apparently correlated with moisture conditions. More recently, (1953), Weis Fogh collaborated with Haarløv to devise an ingenious method of studying the soil animals <u>in situ</u>. This technique consists of deep freezing a soil core immediately after sampling, and, by thawing sub-samples in formalin vapour, the animals are killed and fixed in their vital position. The sub-samples are then submerged in agar, and, after setting, are sectioned. By means of this technique these workers obtained a series of remarkable photographs, including a clear demonstration of species - aggregation in the soil micro-caverns, and an illustration of the debris burrowing activities of a Phthiracarid mite.

To conclude this résumé, it is appropriate to mention the more important surveys undertaken in regions further afield. In Greenland, a number of habitats have been examined by Haarløv (1942), and by Hammer (née Jørgensen 1934, 1944). The latter worker also studied the Oribatid mites in Arctic Canada (1952). Tropical soils have also received/

received some attention, notably in Panama, by Williams (1941); in Trinidad, by Strickland (1945, 1947), and in East Africa, by Salt (1952). Finally, amongst American papers, the best known are those of Jacot (e.g. 1936, 1940), dealing mainly with forest soils, but nevertheless, of great general interest.

C. The Biology of Collembola and Acari

With the exception of some early investigations based on direct sorting methods, the general surveys mentioned above have all emphasised the numerical importance of Collembola and Acari as constituents of the Arthropod community in organic and mineral soils.

The population encountered at Glasgow was no exception in this respect, and detailed study was therefore confined to these two groups. It is desirable therefore to consider the present state of biological knowledge of these animals, and although detailed ecological investigations are few, much relevant information can be gleaned from a scattered literature. In the following synopsis, this information is collated under three headings:- (1) Nature and Length of Life Cycles. (2) Food Habits, and (3) Environmental Relationships. Owing to their great diversity, the major Acarine groups are dealt with separately.

1. Collembola

(a) Nature and Length of Life Cycle

The only detailed observations on an Arthropleon (to which sub-order/

sub-order the majority of soil dwelling species belong), appear to be those of Ripper (1930) on Hypogastrura armata (Nic.), - a common mushroom pest. The eggs, laid in batches of up to 30, hatched in about 3 weeks at 17°C, and the nymphs attained maturity in 5 - 7 weeks. Moulting occurred at approximately weekly intervals throughout life, which lasted from 5 - 10 months. Bruschek (unpublished, quoted by Kühnelt, 1950) noted that the complete life cycle of Onychiurus armatus Tull. occupied 45 days at "room" temperature.

(b) Food Habits.

Detailed specific observations are few, but judging from the generalizations in the literature it would appear that the diet of soil dwelling species is not restricted, but includes plant residues, fungi, algae, and animal remains; while predation is not unknown. A selection of observations from the literature is presented in Table I.

(c) Environmental Relations.

Ecological studies have shown that the most important single physical factor governing the distribution of these insects is relative humidity. Although dealing with surface dwelling species, the laboratory studies of Davies (1928) are worthy of note, for he recorded that, at 25°C, saturated conditions were necessary for the survival of all the species examined, and evidence of a similar nature was obtained by MacLagan (1932) for Sminthurus viridis(L). In a field study of 4 subterranean species at Slough,

Glasgow/

TABLE 1.

THE FOOD HABITS OF COLLEMBOLA

Species	Food	Authority
"Many species"	Fungal mycelia and spores	Macnamara (1924).
Isotoma sepulcralis Fol.	Corpses (Human)	do.
Friesea sublimis Macn.	Cannibal	do.
Isotoma macnamarai Fol.	*Achorutes socialis* Uzel	do.
Hypogastrura armata Nic.	Fungi (Mushroom)	Ripper (1930).
Litter dwelling species.	Plant residues, (Hornbeam leaf figured).	Schaller (1949b).
Soil dwelling species.	Soil mixed with organic matter found in gut.	Gisin (1947).
do	Plant residues, fungal mycelia and spores, pollen algae, other *Collembola*, insect remains.	Handschin (1929). Kühnelt (1950)
Onychiurus armatus Tull.	Preference for fungal diet.	Kühnelt (1950).

Glasgow (1939) found that while other factors might also be influential, the horizontal and seasonal distribution of the animals appeared to be largely determined by moisture conditions, and the general importance of this factor is also apparent in the results of the field surveys and laboratory preferenda experiments of Agrell (1941) and Schaller (1949a,1951).

The work of Gisin (1943) requires more detailed consideration, for it provides the foundation of an ecological system, the principles of which have already been extended to other soil dwelling groups. He pointed out that certain structural features of Collembola were closely and consistently related to their choice of habitat, and adapting a terminology originally used by Krausse (1928), he drew up the following morpho-ecological classification:-

1. Atmobiotic forms

Pigmented species, with 8 + 8 large ocelli, antennae very long and furca well developed. Habitat:- Surface herbage (Macrophytes).

2. Hemiedaphic forms

Pigmented species, eyes less well developed and antennae shorter.

(a) Hydrophilous forms

Mucro with broad lamellae.

Habitat - Surface of water.

(b) Mesophilous forms

Tibio-tarsal hairs pointed or clubbed.

Habitat - surface of soil and in litter

(c)/

(c) Xerophilous forms

Mainly with clubbed hairs.

Habitat - under bark, in lichens, and in moss in dry situations.

3. Euedaphic forms

White species, eyes reduced or absent, short antennae, furca reduced or absent.

Habitat - The deeper soil layers.

For each of the major categories noted above, Gisin described a number of distinct communities, which he encountered in the Basle area, and these communities were referred to as synusiae, - a term originally used by plant ecologists - , each one being named according to the dominant species. He defined a synusia as follows:- A synusia is a distinct community (union) of organisms, the character of which is determined by the smallest section of the environment, the latter being referred to as the habitat. In erecting these synusiae, Gisin was not so much governed by the nature of the habitat, as by the characters of the communities themselves, and, as Weis Fogh (1948) has pointed out, the synusiae were thus erected on a purely physiognomical basis. Nevertheless, he was able to demonstrate certain broad relationships between the various synusiae and edaphic conditions and plant associations. Not only can it be said that this synthesis has rationalized the ecology of these insects, its potential value in relation to other groups appears to be considerable. This discipline was followed by Strenzke (1949) in his description of the Collembolan communities/

communities of soil (mainly wet) in the Plön area, and the same worker extended its application to Oribatei (1952).

2. Acari (Cryptostigmata), Oribatei.

(a) Nature and Duration of Life Cycle.

These are usually the most abundant soil mites, and according to Michael (1884, 1888), and Willman (1931), their life histories have the following sequence:- egg, larva (6 legged), protonymph, deutonymph, tritonymph, adult. Cleat (1952) observed that in Scheloribates laevigatus Koch, each post-embryonic stage had a developmental phase and a mobile growing phase. The duration of the life cycle appears to be comparatively long, for Michael (1884) reported that many species took a year or more to attain maturity, and Cleat, who reared 125 individuals of S. laevigatus, noted that the shortest duration of pre-adult life in this species was 45 days, and the longest 115 days; the animals being kept in a saturated atmosphere at 25°C.

(b) Food Habits.

In general their diet appears to be rather similar to that of Collembola. A selection of observations is presented in Table 2.

(c)/

Table 2.

THE FOOD HABITS OF ORIBATEI

Species	Food	Authority
Oribatei, species unspecified	Vegetable material, including mosses lichens, fungi, decaying wood and litter.	Michael (1884).
do	Algae, fungi, and protozoa	Sig Thor (1931).
Ptyctima, species unspecified	Roots, fungi, nymphs burrow conifer litter.	Jacot (1936,1939).
5 species investigated	Fungi and decaying wood.	Forsslund (1938).
17 species investigated	Broadleaf litter, and fungi.	Noordam et al (1943)
Oribatei, species unspecified	Moss, filterpaper, and probably animal remains.	Rayski (1945).
12 species investigated	Fungi, litter, decayed wood, and animal remains.	Riha (1951).
Scheloribates laevigatus Koch	Moss and chicken faeces	Cleat (1952).
Phthiracaridae spp.	Conifer litter	Murphy (1953).
do	Beech litter	Evans(unpublished).

(c) Environmental Relations

The Oribatid populations of a brown earth and a rendzina soil in the Vienna woods were investigated by Riha (1951), the field observations being supported by laboratory studies. She observed that the mites favoured humid conditions, although their resistance to desiccation varied according to the species. It was also noted that the population of the immature stages of many species in soil was remarkably low, and it was suggested that, in the species concerned, pre-adult life was spent in other habitats - a supposition supported by records of immature stages from dead wood, below bark, and from litter. It was further submitted that two of the seasonal minima in the soil adult population might be connected with their propagation rhythm and occasioned by a migration of adults to the juvenile habitats for copulation and egg laying.

In a study of the Plön area, Strenzke (1952) described 6 major Oribatid Synusiae together with their variants, and concluded that the vast majority of these mites were mesophilous hemiedaphons; very few species being truly subterranean i.e. euedaphons. In a section on Ecological Valency, he uses a rather complex terminology to to describe the tolerance or plasticity of the species encountered in relation to five edaphic factors, viz. moisture, organic matter content, litter cover, pH and salt content. For each of these he established a high (poly), medium (meso), and a low (oligo) category, and, according to their plasticity, the species were then classified as/

as follows:- Stenoplastic species. Forms with a restricted range; the limiting values of their optimum requirements lying close together.

Euryplastic species. Less restricted; the limiting values of their optimum requirements being wide, but sufficiently close to facilitate classification.

Eu-euryplastic species. Infrequent forms, the limiting values of their requirements being so wide that their preferenda for any particular range could not be determined.

Thus, *Minunthozètes semirufus* Koch, is described as being *polyeuryhygre* - *mesoeuryione*, which translated, implies that this species favours a high moisture content, and medium pH, but, being euryplastic, is not confined to such soils. While Strenzke's paper undoubtedly constitutes a major contribution, the use of these complex terms might be considered undesirable, and, although the data were obtained by arbitary scoring methods, a more precise assessment of ecological valency might have been achieved by using a system of indices.

3. Acari, (Cryptostigmata), Acaridae

(a) Nature and Duration of Life Cycle.

The old, and since replaced, family name *Tyroglyphidae*, is often used collectively for the free living members of this cohort, and, according to Michael (1901, 1903), and Hughes (1948), these mites have three post-embryonic immature instars, viz. a hexapod larva/

larva, and 2 nymphal stages. Sometimes, and only in some species, an additional instar may be inserted between the proto, and deutonymph stages; this is the so called hypopus, and may be inert, or active according to the species. The inert phase appears to be a resistant stage, whilst the active hypopus is provided with adhesive suckers, and so functions as a migratorial phase, assisting in the dispersal of the species. Their life histories are of comparatively short duration, and, as an example, Baker and Wharton (1952) quote Garman, who observed that the life cycle of *Rhizoglyphus echinopus* (F. and R.) was completed in 9-13 days at 70° - 80°F, and in 17-27 days at 60° - 65°F.

(b) Food Habits.

The observations reproduced in Table 3 have been selected as being relevant to the present study.

Table 3.

THE FOOD HABITS OF ACARIDIAE

Species	Food	Authority
Rhizoglyphus echinopus. (F. and R.)	Products of the bacterial decomposition of cellulose	Franz (1943).
Coelognathus castellanii (Hirst.)	Stored food material with a high fat and protein content, e.g. linseed dried egg, fish meal, cheese etc. and also cereals.	Hughes (1948).
Acarus siro L.	Farinaceous substances, and other dried vegetable products.	Hughes (1948).
Glycyphagus destructor (Schrank.)	Commonly found in association with *A. siro.*	Hughes (1948).

(c) Environmental Relationships.

Apart from R. echinopus - the familiar bulb mite, the Acarids are not usually associated with soil, but are more familiar as pests of stored products. However, Weis Fogh (1948) found these species in his samples, and they were found in litter by Van der Drift (1951); while Evans (private communication) has also encountered them in collections of soil Acari.

Their moisture requirements vary; in particular, Nesbitt (1945) observed that members of the sub-family Acarinae Nesbitt, preferred to live in substances with a low moisture content (20 - 30%), and were commonly found in farinaceous and other dried vegetable products, whilst members of the sub-family Rhizoglyphinae, Zachvatin, could only exist under very humid conditions, many seeming to live in a film of water.

4. Acari, Mesostigmata

(a) Nature and Duration of Life Cycles.

Two Mesostigmatic cohorts, viz. Gamasina, and Uropodina, were encountered in the Glasgow soil, and according to Vitzthum (1941) the hexapod larval stage of these mites is followed by two nymphal instars. In some Gamasina the deutonymph functions as a migratory stage, and uses its legs to cling to the bodies of other animals; these are the nympha coleoptrata so called because of their frequency on beetles. Migratory nymphs (nympha pedunculata) may also be encountered in the Uropodina, but here attachment is effected by means of a pedicel formed by the hardened secretion of anal glands. Michael/

Michael (1881) observed that development of Parasitus coleoptratum(L) and Pergamasus crassipes(L) (Gamasina, Parasitidae), from newly laid eggs to the adult stage, occupied about 21 and 24 days respectively, while the observations of Cummings (1898) on Pseudouropoda obscura (Koch) suggest that the life cycle of this species is of similar duration.

(b) Food Habits.

In the case of Gamasina, the observations reproduced in Table 4 deal mainly with the larger species, and virtually no information appears to be available on the smaller species. Most of the known predacious Mesostigmata are comparatively large, active, and heavily chitinized, and are located amongst the Gamasina, and particularly in the family Parasitidae. The Uropodina include the more sedentary forms, and these appear to be mainly saprophagous or mycetophagous.

(c) Environmental Relations.

So very little is known of the ecology of the soil dwelling Mesostigmata, that little relevant information can be added to that already given above. The larger Gamasina have been observed to occur mostly in the upper soil layers (Weis Fogh, 1948) whilst Willman's observations on the Rhodacaridae (1935, 1936) suggest that some of these delicate forms prefer the deeper soil. Weis Fogh observed that very little seasonal fluctuation occurred in the Mesostigmatic population of his ecological study.

Table 4.

THE FOOD HABITS OF MESOSTIGMATA

Species	Food	Authority
GAMASINA		
Pergamasus crassipes(L) and Parasitus coleoptratum(L)	"Cheese mites"	Michael (1881).
Many species (details given)	Myrmecophilous	Berlese (1903b).
Larger Gamasina species.	Predacious; feeding on Nematoda, Enchytraeidae, and small Arthropoda.	Weis Fogh (1948).
"Many species"	Predacious, but also facultative carrion feeders consuming bodies of larger insects and small vertebrates.	Kühnelt (1950).
Macrocheles species.	Partly coprophagous, and necrophagous.	Kühnelt (1950).
UROPODINA		
Many species (details given)	Myrmecophilous	Berlese (1903b).
Pseudouropoda obscura (Koch)	Bacteria and fungi growing on decayed potato tuber.	Cummings (1898).
Fuscuropoda marginata (Koch)	Fungi.	Kühnelt (1950).
Some species	Coprophagous	Kühnelt (1950).
Prodinychus sp.	Predacious, preying on slow moving Collembola. (Onychiurus species included).	Schindler (unpublished, quoted by Kühnelt, 1950).

5. Acari, Prostigmata and Heterostigmata.

Mites belonging to these two groups - usually collectively known as the *Trombidiformes* - were only taken in small numbers from the Glasgow soil, and of these *Pygmephorus* Kramer species (*Pyemotidae*), and *Cheyletus eruditus*, Schrank, (*Cheyletidae*), were the most abundant.

The *Pyemotidae* have reduced suctorial mouthparts, and this family includes parasitic forms with complex life cycles. Banks (1915) stated that *Pygmephorus* species had migratory instars; specimens being found on a mole, a fly, and on a thrips, while according to Vitzthum (1941) members of this genus are predacious.

According to Hughes (1948), *Cheyletus eruditus* is a common predator of Acarid mites in stored products, and she also noted that the females were parthenogenetic; males being rare. Baker and Wharton (1952) quote Ewing (1915) who investigated the life cycle of a *Cheyletus* species, and found that a larva and two nymphal instars were produced; the development from newly laid eggs to the adult stage occupying about 22 days at laboratory temperature.

III. DESCRIPTION OF THE AREA EXAMINED

The fauna described below was extracted from the soil of the four uncultivated plots in the randomised block experiment described in detail in Part II. of this paper. These plots represent the original condition of the area before the experiment was laid down, and their position is shown in Fig.1, while in the following account they are referred to as Plots 1 - 4 according to the number of the block in which they were located.

The area studied was an old grass field, - about $\frac{3}{4}$ acre in extent, at Bellahouston Park, Glasgow; this part was not used by the public, and had been uncultivated for a period of 12 years. Previous to this it formed part of a nursery in which various ornamental plants were raised. The experiment was laid down in the Southern part of this field, and on this side the boundary consisted of an iron fence beyond which, at a distance of about 5 yards, was a line of lime trees. These may have influenced the faunistic composition of Plot I, as Block I was laid down parallel to this line of trees at a distance of about 9 yards.

The soil was a heavy loam derived from a considerable depth of glacial till overlying a region shown on a geological map as consisting of carboniferous limestone. A botanical analysis of the 4 plots is given in Table 5, and the results of a chemical analysis are included in Table F. (Appendix II).

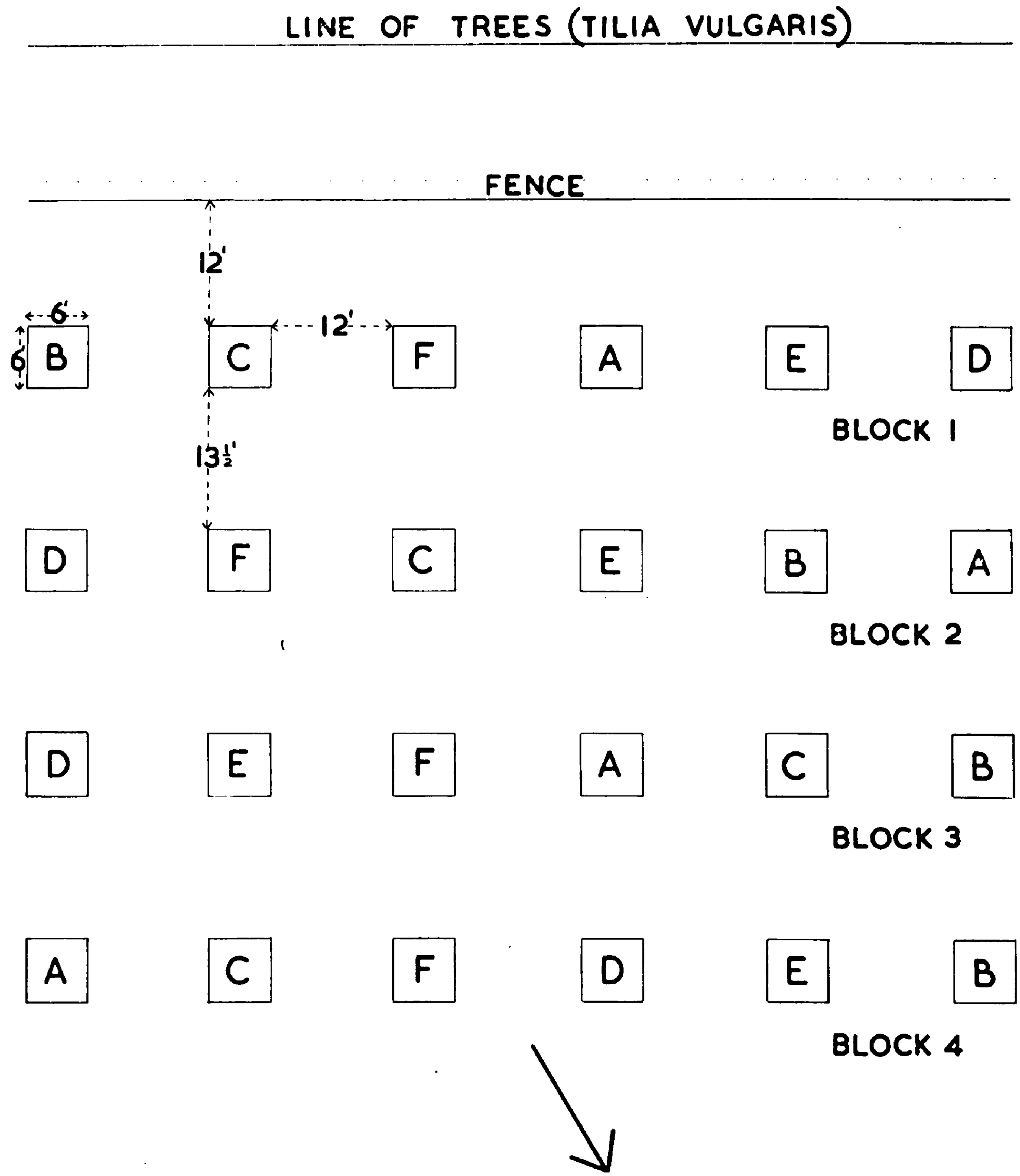

FIG. I. PLAN OF THE EXPERIMENT.

A. UNDUG. B. FALLOW. C. CONTROL. D. D.D.T. E. B.H.C. F. D.D.T.+B.H.C.

Table 5.

THE BOTANICAL COMPOSITION OF THE UNCULTIVATED PLOTS

Percentage composition derived from an estimate of the area occupied by the species in two 2 foot square quadrats taken at random in each plot. October 1951.

Plot 1.

Poa pratensis	55
Agrostis vulgaris	35
'Miscellaneous herbs	10

'Bellis perennis,xxx Trifoliumxx repens, Cerastium vulgatum, Ranunculus repens.

Plot 2.

Festuca rubra	55
Agrostis vulgaris	10
Holcus mollis	5
Anthoxanthum odoratum	5
'Miscellaneous herbs	25

'Trifolium repens,xxx Bellis perennis,xx Plantago lanceolata,xx Hypochoeris radicata, Ranunculus repens, Sagina procumbens.

Plot 3.

Agrostis vulgaris	60
Holcus mollis	20
Festuca rubra	10
Poa pratensis	5
Anthoxanthum odoratum -	trace
'Miscellaneous herbs	5

'Trifolium repens,xxx Ranunculus repens,xx Bellis perennis, Cerastium vulgatum, Sagina procumbens.

Plot 4.

Agrostis vulgaris	80
Anthoxanthum odoratum	15
Holcus mollis	5
'Miscellaneous herbs -	trace

'Ranunculus repens.

x Indicates relative abundance.

In addition small amounts of moss was present in all plots, and this was most abundant in Plot 1, where the macrophytic vegetation was thinner.

IV. METHODS OF STUDY

A. Sampling

1. Size of Sample.

The choice of sample size must depend upon the size of the animals studied; for a sample must be (a) sufficiently large to preclude the occurrence of a large number of zero counts, and (b) small enough to enable the assessment of an adequate number of individual samples. During extensive work on Elaterid larvae, Salt and Hollick (1944, 1946), and others, found that a sample consisting of a cylinder of soil 4" in diameter, taken to various depths, was adequate for a study of these forms. It was the writer's original intention to use samples of this size for the present work, so that observations upon the larger Arthropoda could be included. After some preliminary work, however, it soon became apparent that if a sample of this size was to be used, the scope of the investigation would have to be greatly curtailed owing to the time required for extraction and subsequent sorting. Consequently, a smaller sample was used, and most of the work was carried out with samples consisting of cylinders of soil 2" in diameter which, with the exception of the samples of June, 1951, were taken to a depth of 6". These samples (18.85 cu.ins.,308.93 ccs) contained sufficient numbers of the smaller species but were inadequate for the larger forms.

2. Numbers of Samples.

To determine the ideal number of samples required to assess the population/

population of a given area it would be necessary to conduct a preliminary experiment in order to compare the standard errors of the means of an increasing number of samples. In this way, by taking into account increasing accuracy and increasing labour, the requisite number of samples could be determined (vide Glasgow 1939).

In the present instance there seemed little point in such an experiment, as owing to the time taken for subsequent treatment only two samples per plot could be dealt with. Originally it was estimated that two samples per plot, each sub-divided to represent the vertical strata 0 - 3", and 3 - 9", could be dealt with adequately on each occasion. In this way four separate extractions per plot were involved, and ninety-six separate extractions on each occasion for the experiment as a whole. After processing this number of samples during the summer of 1951, it became abundantly clear that this was too many to facilitate a careful assessment of each sample; consequently, although two samples were taken from each plot, on subsequent occasions they were taken to one level only viz. 0 - 6".

3. Sampling procedure.

The sampling implement consisted of a steel tube with an internal diameter of 2". A handle was fitted in the upper part of this tube, and its lower end was sharpened, and the sample was ejected by pressure from a brass disc attached to a rod operated from the handle.

Each sample was taken at random, but before taking the sample the/

the surface herbage was cut away. The implement was then plunged into the soil to the required depth and the sample ejected into a metal container. The depth of the sample was judged by the depth of the cavity left after its removal, and not by the length of the core; this was considered to be more satisfactory, as the implement had a compressing effect, so that the length of the core was invariably less than the depth of the hole. Samples so obtained were stored in a refrigerator at 5°C until they were put through the extraction process.

All the plots were sampled on the following dates:-
(1) 9th June, 1951 (Sampled at two levels). (2) 16th October, 1951. (3) 14th December, 1951. (4) 20th February, 1952. (5) 18th April, 1952. (6) 17th October, 1952.

B. Extraction

The Arthropoda were extracted by means of a modified form of the apparatus described by Salt and Hollick (1944), and in greater detail by Salt (1952), and the main components of the apparatus used are illustrated in Fig. 2.

The soil samples were first torn apart under water in a shallow basin, and the resulting soil-water mixture was poured on to a 3 mm. mesh sieve fitted with a splash guard A. The mass was then washed with jets of water through the sieve into container B. The stones and coarse plant material retained in sieve A. were repeatedly washed with jets of water, and before this material was discarded, it was carefully examined for large species. Meanwhile, the overflow from B was passed over the lip on to sieve C which had/

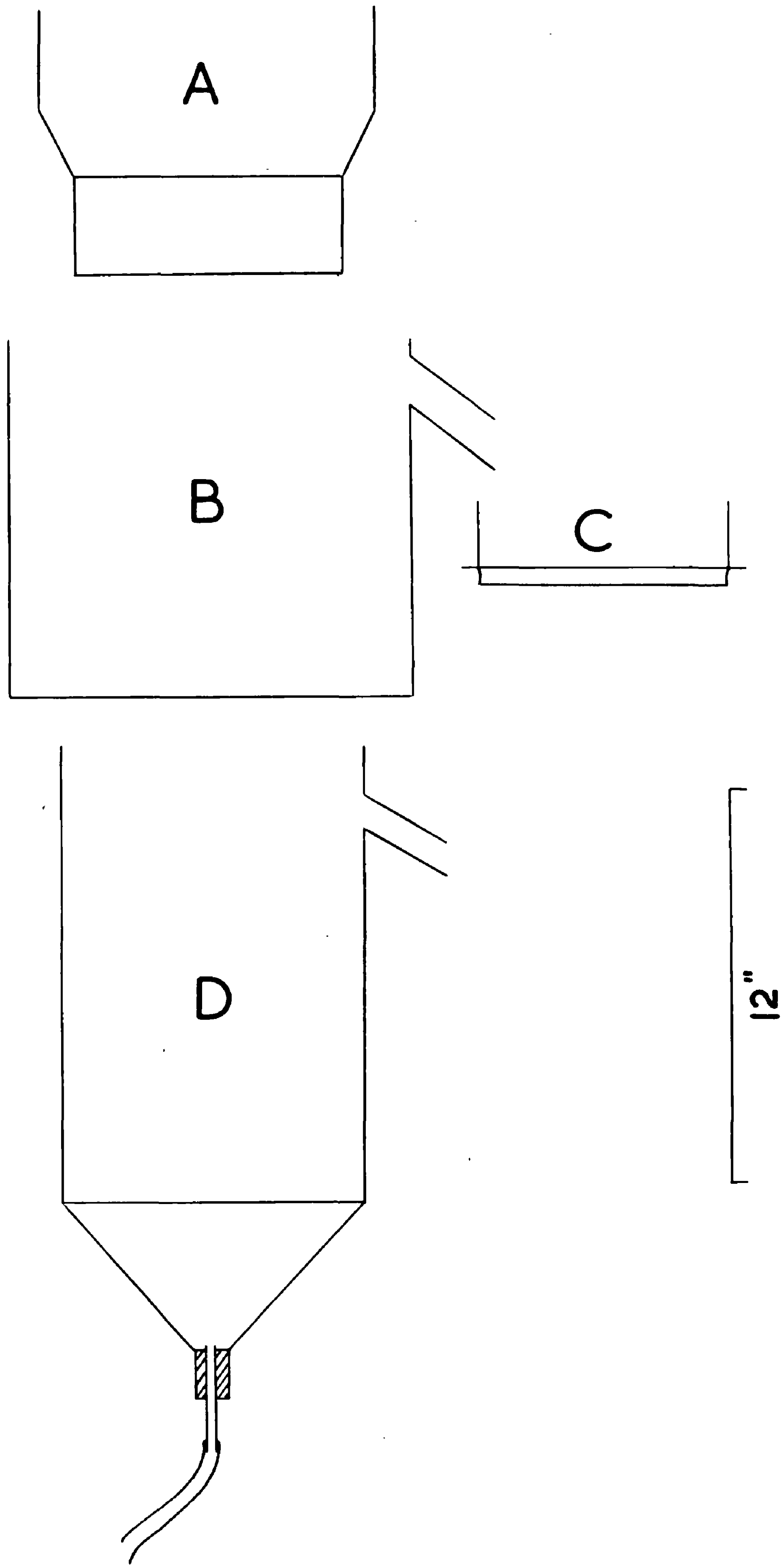

FIG. 2. EXTRACTION APPARATUS

had a regular square mesh of 0.152 mm., (100 mesh sieve, British Standard Specification), and, after this initial washing process, the whole of the contents of B were poured on to C; the soil adhering to the sides and base of the container being washed over with jets of water. The material in sieve C was then allowed to drain, after which its contents were washed with a solution of magnesium sulphate into flotation vessel D, the upper end of which had a lip, and its lower opening a rubber stopper carrying a brass tube. The opening of this tube into the vessel was covered by a piece of bolting silk.

The soil in vessel D was then flooded with magnesium sulphate solution of specific gravity 1.2, and a stream of air, derived from an electric blower, was passed in through the brass tube, and bubbled through the solution. To bring the whole mixture into contact with the air, it was continuously stirred, and, in this way, the soil particles were kept in suspension and the adhering organic matter freed. After five minutes the stirring and bubbling was stopped, and more solution was added to bring the level of the liquid up to the lip. The suspension was then allowed to settle, and, by slowly siphoning more solution into the vessel, the floating material was made to pass over the lip on to sieve C. The mixture was stirred again to ensure that no further material was trapped by the soil, and the decantation was repeated. The contents of vessel D were then run off through the base into a bin, and, after settling, the solution was salvaged for later samples.

The 'float' so obtained was washed gently with water and transferred/

transferred to a flask containing about 50 ml. of benzol and a small quantity of water. Complete transference was obtained by using a wash bottle. The flask was violently shaken for about 2 minutes, after which the contents were washed into a Buchner flask and the pressure therein reduced for about 5 minutes by means of a filter pump. The next stage of the process was accomplished by means of a large glass funnel, the stem of which was extended by a short rubber tube fitted with a pinch cock. The stem and lower part of the cone were first filled with water, and the material from the Buchner flask was poured in; the level of the liquid being brought up to within about an inch of the rim by adding water. The material in the funnel was allowed to settle, and a proportion of the debris dropped into the stem from where it was run off. The level of the liquid was again made up and the process repeated until all the heavier material had been separated. The debris thus taken from the funnel was examined with a hand lens before being finally discarded, while the remaining contents of the funnel were returned to sieve C. The benzol was washed off with alcohol, and the material washed with a jet of 70% alcohol into a beaker and subsequently stored in a specimen tube. On each occasion, all the samples were first processed to this stage; the preserved material, consisting of a mixture of Arthropoda and varying amounts of organic debris, being sorted at a later date.

The process described above, whilst similar to the method devised by Salt and Hollick, nevertheless differed in certain details. In/

In the original apparatus the components were so arranged that the transference of the material from container B to the flotation vessel D, was accomplished by tilting the former, and the flotation vessel was equipped with a 0.2 mm. sieve at the junction of its conical and cylindrical portions; the small Arthropoda being collected by filtering the material passing through this sieve with bolting silk.

Initial trials were made with an arrangement of sieves similar to that of the original apparatus, but for a number of reasons this was found to be impracticable. In the first place, the physical characters of the soil studied were such that persistent choking of the bolting silk filter occurred; this made the process extremely slow, and an adequate number of samples could not have been dealt with had this filter been retained. Furthermore, a soil laboratory with a floor drain was not available, and the amount of flooding which could be tolerated was limited. Hence the initial washing process into B, and the collection of soil on the 100 mesh sieve were carried out in a sink; allowing the surplus water to pass into the drain. The sieve and its contained soil was then carried over to the flotation vessel, and, to avoid choking the 100 mesh sieve, this transference was done in two or more stages. Finally, the funnel separation method was devised so that the material could be preserved; thus the processing of a series of samples did not have to be interrupted by periods of microscopic examination and counting.

The main difference, and probably the only one influencing the thoroughness of the extraction, was the substitution of the 0.152 mm. sieve/

sieve for the bolting silk filter of the original apparatus. The modified apparatus therefore could not be expected to give as high a rate of extraction as the original, because a proportion of the very small species could pass through the sieve. Nevertheless, the extraction rate was considered adequate for a comparative study of this kind; and it will be seen from the data that the populations discovered were greater than those reported by many other workers.

C. Sorting and Identification

The sorting and identification of species in the preserved mixture of Arthropoda and organic debris was accomplished in several stages. Firstly, small portions of the mixture were placed in a 2" diameter Petri dish, the bottom of which was marked into segments, and a systematic search of each segment was made under a binocular microscope, using first a black background, and then a white; the animals being removed with a fine pipette. At the same time a preliminary classification into sub-orders was made, and a complete removal was considered to have been accomplished when the examination of a complete circuit of the dish yielded no further specimens. This process was repeated until the entire sample had been scrutinized.

At this stage another difficulty became apparent. A number of empty "shells" of Oribatid mites were encountered, and these specimens clearly represented animals which had been dead for a considerable period, for the soft parts were absent; and, in the case/

case of some of the larger specimens, soil particles were found within the exo-skeleton. It was decided not to include obviously long dead animals in the counts.

The dominant species, and others of outstanding interest, were then identified. Some of the larger species could be named without much difficulty, and these were picked out first. The next group to be dealt with were those which could be named in temporary microscopic preparations, notably the Tullberginae and the smaller Oribatei. Finally, the more difficult species and specimens were mounted in polyvinyl alcohol after pre-treatment (if necessary) with lactic acid.

D. Laboratory Observations

Periodically, living material was extracted by desiccation methods, the animals being subsequently kept on moist filter paper in Petri dishes, and examined with a view of obtaining information on their feeding habits. Although the importance of data of this kind is not minimized, this work was not a primary consideration of the present study. Hence although some interesting information was obtained, this aspect was not pursued in great detail, for the difficulties of culturing the animals are such that studies of this kind require the undivided attention of the investigator.

V. QUALITATIVE RESULTS

A. A Systematic List of Groups and Species Encountered

INSECTA

PROTURA sp.

COLLEMBOLA
- Neelidae sp.
- Sminthuridae spp.
- Hypogastruridae
  - Hypogastrurinae
    - Hypogastrura cf denticulata Bagnall, 1941, sensu Gisin, 1949.
  - Neanurinae
    - Brachystomella parvula (Schaffer, 1896)
    - Friesea mirablis (Tullberg, 1871)
  - Onychiurinae
    - Onychiurus uliginatus Gisin, 1952
    - Onychiurus spinularius Gisin,1952
  - Tullberginae
    - Tullbergia krausbaueri (Boerner, 1901)
    - Tullbergia quadrispina (Boerner, 1901)
    - Tullbergia crassicuspis Gisin, 1944
- Isotomidae
  - Isotominae
    - Isotoma viridis Bourlet, 1839
  - Anurophorinae
    - Isotomodes productus (Axelson, 1906)
  - Proisotominae
    - Folsomia candida Willem, 1902
    - Folsomia c.f. garretti Bagnall, 1939
    - Folsomia quadrioculata (Tullberg, 1871)
- Mydoniidae
  - Mydoniinae
    - Lepidocyrtus cyaneus (Tullberg, 1871)
- Collembola spp. undet.

PSOCOPTERA sp.

THYSANOPTERA
- Thripidae
  - Aptinothrips rufus (Gmelin, 1789)
- Thripidae spp. undet.
- Phaleothripidae sp.

HEMIPTERA
- Aphididae spp.
- Hemiptera spp. undet.

COLEOPTERA/

COLEOPTERA

Carabidae

Clivina fossor (Linnaeus, 1758)

Staphylinidae

Homalota sp.

Tachyporinae sp.

Staphylinidae spp. undet.

Lathriidae

Corticaria fulva Comolli, 1837

Chrysomelidae

Longitarsus sp.

Curculionidae

Sitona sp.

DIPTERA

ORTHORRHAPHA

Tipulidae sp.
Petauristidae spp.
Tendipedidae spp.
Fungivoridae spp.

CYCLORRHAPHA spp.

PROGONEATA

PAUROPODA sp.
DIPLOPODA sp.
SYMPHYLA sp.

OPISTHOGONEATA

CHILOPODA sp.

ARACHNIDA

ARANEIDA spp.
TARDIGRADA sp.
ACARI.

CRYPTOSTIGMATA

ORIBATEI

Eulohmanniidae

Eulohmannia ribagai Berlese, 1910

Hypochthoniidae

Hypochthonius rufulus (Michael, 1884)

Notaspidae /

Notaspidae
Ceratozetes gracilis (Michael, 1884)
Achipteria coleoptrata (Linnaeus, 1758)
Euzetes globulus (Nicolet, 1855)
Punctoribates punctum (Koch, 1840)
Punctoribates (Minunthozetes) semirufus (Koch, 1840)
Eremaeidae
Oppia clavipectinata (Michael, 1885)
Oribella lanceolata (Michael, 1885)
Oribella paolii Oudemans 1913
Carabodidae
Scutovertex sculptus Michael, 1879
Phthiracaridae
Phthiracarus anonymum Grandjean, 1934.
Oribatei spp. undet.

ACARIDIAE
Acaridae
Acarus siro Linnaeus, 1758.
Coelognathus castellanii (Hirst, 1912)
Rhizoglyphus echinopus (Fumouze and Robin, 1868)
Glycyphagidae
Glycyphagus destructor (Schrank, 1781)

MESOSTIGMATA
GAMASINA
Rhodacaridae
Rhodacarus roseus Oudemans, 1902
Rhodacarellus epyginialis sp.n.
Veigaidae
Veigaia nemorensis (Koch, 1839)
Parasitidae
Pergamasus runciger Berlese, 1904
Pergamasus misellus Berlese, 1904
Macrochelidae
Macrocheles sp.
Pachylaelaptidae
Pachylaelaps sp.
Ascaidae
Digamasellus reticulatus sp.n.
Laelaptidae
Arctoseius cetratus (Sellnick, 1940)
Arctoseiopsis minutus (Halbert, 1915)
Alliphis halleri (Canestrini, 1881)
Cosmolaelaps claviger (Berlese, 1883)
Lasioseius penicilliger (Berlese, 1917)
Platyseius sp.n. Evans, (unpublished)
Hypoaspis aculeifer (Canestrini, 1884)
Eviphis ostrinus (Koch, 1936)
Gamasina spp. undet.

UROPODINA/

UROPODINA
    Dinychidae
        Dinychus tetraphyllus Berlese 1903
    Trachyuropodidae
        Olodiscus minima (Kramer, 1882)
      Uropodina spp. undet.

HETEROSTIGMATA
    Pyemotidae
        Pygmephorus sp.

PROSTIGMATA
    Cheyletidae
        Cheyletus eruditus (Schrank, 1781)
Acari spp. undet.

B. Notes on Some of the Collembola and Acari Encountered

1. Collembola

(a) Euedaphic Species

Tullbergia krausbaueri (Boerner)

This species, which was the dominant Collembolan, has an extensive geographical distribution, having been recorded from New Zealand (Womersley, 1936) and Greenland (Hammer, 1944). In Europe, Gisin (1943) reported it to be common in meadow and woodland soils in the Basle area, under both basic and acidic conditions. It was one of Frenzel's Leitformen, and it has also been widely recorded from British soils, the reports including those from Slough (Glasgow, 1939), Cambridge (Salt, et.al.1948), Cothill (Macfadyen,1952) and from Snowdonia (Davies,1934). The writer has also found this species to be widely distributed in both upland and lowland soils in the West of Scotland.

T. krausbaueri was found difficult to keep alive in the laboratory, for the animals were extremely susceptible to desiccation, and when kept on moist filter paper in petri dishes, small falls in temperature resulted in a condensation leading to the formation of small droplets of water on the bodies of the animals. When this occurred, the animals became moribund within a short time. They appeared to feed on filter paper, and, when individuals with colourless gut contents were placed on black filter paper, within about two days it was noted that their gut contents were distinctly black. When confined with fragments of mushroom, they appeared to feed, but it was not possible/

possible to be certain of this. They were attracted by pieces of decaying potato tuber, and seemed to feed actively on this material. When the tuber fragments were stained with Neutral Red, the stain was taken up by the animals, and, within about 24 hours, they were deep red in colour, the stain having penetrated the whole body. Similar results were obtained with boiled potato, but with mushroom, and slices of fresh potato tuber, although some dye was taken up, the animals were not so intensely stained. It should be pointed out, however, that the evidence thus obtained is by no means conclusive, for the stain, being water soluble, could have been taken up from the moisture on the surface of the suspected food.

Tullbergia quadrispina (Boerner)

Gisin (1943) noted that this species, although common in woodland and meadow soil in Europe, was rigidly bound to a very narrow range of humidity conditions. Glasgow (1939), however, found this to be the only species he studied which showed no correlation with soil moisture, although the very narrowness of its humidity requirements may well have been responsible for the absence of a significant relationship with the moisture gradients used in this study; in fact, he points out that one cannot affirm that its populations are indifferent to moisture, but one can say that its moisture relationships are different to those of Onychiurus armatus. Gisin described a T. quadrispina synusia which he found to occur in fresh grassland ('Frischmatten') in the Basle district; and, in connection with this it is interesting to note that the writer found T. quadrispina to be the dominant Collembolan in the soil (light loam) of a newly sown lawn

at/

at Kilcreggan, Dunbartonshire. In the Glasgow soil it occurred only in small numbers; but it appears to be widely distributed in Britain; records include those from Rothamsted (Morris, 1922a), Aberystwyth (Thompson, 1924) and Oxford (Ford, 1935).

Tullbergia crassicuspis Gisin

The only published record of this form appears to be that of Gisin (1943) who recorded it from the Basle area; the species being subsequently described from this material (Gisin, 1944). It is interesting to note that Gisin found it to be common in a dry pasture, and also in a meadow in clay soil at an altitude of 1000 m. in the Basle district, for it has been previously noted that the Glasgow soil was of a somewhat heavy nature. Although not numerous in the uncultivated plots, it occurred in considerable numbers in some of the cultivated plots of the same experiment (vide Part II. of this paper),but a fairly extensive search (by flotation) of other soils in the West of Scotland failed to reveal any further specimens. It seems worthy of record, however, that this species was found particularly difficult to extract by desiccation methods, and this circumstance might well be partly responsible for its apparent restricted occurrence in Britain. Synthesizing from the points noted above it seems possible that this species replaces *T.quadrispina* in heavier soils, and its apparent preference for drier conditions would indicate that it should occur in newly sown grassland on heavy soil.

Onychiurus uliginatus Gisin

This species is one of the products of the recent sub-division of/

of Onychiurus armatus of authors, by Gisin (1952). He noted its occurrence in damp soil in a number of situations (Alder woods, swamps, and caves) in Switzerland.

Onychiurus spinularius Gisin

Gisin (1952) collected this species from damp soil in woodland in the Geneva district.

Onychiurus species were kept in the laboratory, and their food habits were observed to be similar to those noted for T.krausbaueri. They became intensely stained when confined with dyed decaying potato tuber, and dyed boiled potato, but only lightly stained when kept with dyed mushroom and dyed slices of fresh tubers. In one culture it was estimated that 20 adults, or near adults, consumed about 2 gms. of moist decaying tuber in 4 weeks. Eggs were found in this culture; these were laid singly, or in groups of up to four, and hatched in 24-28 days at 17-19°C. The resultant nymphs did not survive to become adults.

Folsomia candida. Willem

Synonyms - F. distincta, Bagnall (1939, and F. Kingii Bagnall (1939).

Once considered to be synonymous with F. fimeteria (L) the validity of this species was re-established by Stach (1947). Bagnall (1939) records for it a wide British distribution including the West of Scotland from whence the type material of F. Kingii originated. Gisin (1943) reported it to be common in lowland meadow soil in the Basle area, (as F. distincta), and Stach reported a wide Polish distribution.

Folsomia/

Folsomia c.f. garetti. Bagnall

Owing to the inadequacy of the original description, Dr. Gisin has advised the use of an "open" nomenclature for this species. Bagnall (1939) reported it from littoral habitats in East Scotland and N.E. England.

Isotomodes productus Axelson

Handschin (1929) notes this species as being cosmopolitan (N. Africa, Europe, Australia) and Gisin (1943) confirmed its previously noted preference for drier soils; in the Basle area it was prominent in the Tullbergia affinis synusia of dry meadows. The only British record appears to be that of Womersley (1930) who reported its having been found in Stafford and Somerset.

(b) Hemiedaphic species

Brachystomella parvula (Schaeffer)

Gisin (1943) noted this species as being the dominant mesophilous hemiedaphon in meadow and moorland in the Basle area, and mentioned that it was rare or absent in "thin" grassland. In Britain, Davies (1934) recorded it from Snowdonia, and Bagnall (1939) noted its occurrence in Wicken Fen, and also recorded it from Ben Vorlich and from the shores of Loch Long, Scotland.

Hypogastrura c.f. denticulata Bagnall, sensu. Gisin (1949).

According to Bagnall (1939) this species has a wide British distribution (Scotland, Ireland and a number of English counties are listed) and Gisin (1949) reported it to be common in manure and compost in Switzerland. Enormous numbers were found to occur in a compost heap at Kilcreggan, Dunbartonshire.

Friesea/

Friesea mirablis (Tullberg)

Gisin (1943) agreed with Agrell's (1941) observation that this species preferred acidic conditions. British records include those from Cambridge (Salt et. al. 1948) and Cothill (Macfadyen, 1952).

Folsomia quadrioculata (Tullberg)

In the Basle area this was noted to be common in litter and in the surface soil of meadows and woodland, in both upland and lowland environments, and under basic and acidic conditions (Gisin, 1943). This species has been extensively recorded in Britain (Morris, 1922a, Ford, 1935, Macfadyen, 1952, and many others).

2. Acari (Cryptostigmata) Oribatei

Eulohmannia ribagai Berlese

This species was not taken in the uncultivated soil, and only three individuals were collected from the cultivated plots. However its occurrence is of some interest as the monospecific family Eulohmanniidae has not been previously recorded for Britain. Subsequently this species was discovered in considerable numbers in the soil of an Agrostis-Fescue pasture at Lephinmore, Argyll. It was more abundant in soil below 1½" in depth than in the surface layers. Berlese (1910) obtained the type material from Moss. The specimens collected showed the reticulations which Hammer (1952) noted for Canadian specimens.

Hypochthonius rufulus (Michael)

Michael (1884) reported this species from moss but mentioned no locality, and Hull (1916) reported a wide British distribution. Strenzke (1952) described this species as being euryplastic with a preference/

preference for soils with a medium moisture and high organic matter content, and a low pH.

Ceratozetes gracilis Michael

Michael (1884) never found the adults of this species, but bred it from two nymphs taken from moss in Epping Forest and Lynton. Hull (1916) however noted it as occurring "everywhere in England, Scotland, and Ireland". Strenzke reported a wide holarctic distribution, and noted that although it was euryplastic in relation to pH, with a preference for acidic soils, it was stenoplastic with regard to moisture conditions, being almost restricted to soils of medium moisture content. Rayski (1945) showed that this species could act as an intermediate host for Moniezia expansa (Rudolphi) and it occurred in all the pastures he studied (E. Scotland).

Achipteria coleoptrata (L)

This species has an extensive holarctic distribution (Strenzke, Hammer 1944, 1952) and Strenzke considered it to be euryplastic with a preference for medium moisture conditions but apparently indifferent to pH. In Britain it was found by Macfadyen (1952) at Cothill, and Rayski (1945) noted its being abundant in pastures in E. Scotland; and, by experimental infection, found it capable of carrying the cysticercoids of M. expansa.

Euzetes globulus (Nicolet)

This species has been named in accordance with the taxonomic observations of Van der Hammen (1952). Synonyms include the following:- E. seminulum (Müller), sensu Willman (1931), and Strenzke (1952) and E. aterrimus (Koch), sensu Rayski (1945).

Michael/

Michael (1884) considered that this species fed on fungi and lichens, and Hull (1916) noted its abundance in Britain. In Strenzke's study it was practically confined to 16 samples from woodland habitats, and it appeared to be indifferent to pH.

Punctoribates punctum (Koch)

This was another of Frenzel's 'Leitformen' and it has been widely reported from Europe. Strenzke considered it to be euryplastic, with a preference for medium moisture conditions, and noted its indifference to pH. There appears to be no published record of the occurrence of this species (or any of its known synonyms) in Britain, and it is not included in Turk's catologue (1953), but in view of its extensive European distribution, and its abundance in Glasgow, its apparent absence from the British list may well be due to some untraced synonomy.

This species was kept in petri dish cultures in the laboratory, and although it did not breed, it was found that the animals could be kept alive on a moist filter substrate for periods of up to 12 weeks. They appeared to feed on decaying potato tuber and on fungal and bacterial colonies growing on a variety of moist plant debris.

Minunthozetes semirufus (Koch)

Strenzke reported an extensive European distribution for this species, and noted its euryplasticity with a preference for wet soils of a medium pH. It was the dominant Oribatid in the uncultivated plots, and it appears to be common and widely distributed in Britain (Hull, 1916; Macfadyen 1952). Michael (1884) noted that the nymphs of this species burrowed into the stems of grasses. This species was also/

also kept in the laboratory and its food habits appeared to be similar to those of P. punctum, but the animals were particularly attracted by the decomposing body of a nematode worm.

Oppia clavipectinata (Michael)

Although extensively reported in Europe, Strenzke only found this species in 8 of his samples. Michael (1888) collected these animals from a thatched roof in Warwickshire.

Oribella lanceolata (Michael)

Strenzke reported a general holarctic distribution for this species, and described it as being euryplastic with a preference for soils of a medium moisture content. It was indifferent to pH. Michael (1888) found it in moss and reported a wide British distribution.

Oribella paolii (Oudemans)

Yet another of Frenzel's Leitformen, and Strenzke noted that its preferenda were similar to those of O. lanceolata, with which it commonly occurred. It is not listed in Turk's catalogue (1953) but Macfadyen (1952) found it at Cothill.

Scutovertex sculptus Michael

This species does not appear to have been widely reported from Europe, and Strenzke only secured a single specimen. Van der Hammen (1952) noted its presence in Oudeman's collection, and most of this material had been taken from decaying leaves in Holland. In Britain, both Michael (1884) and Hull (1916) considered it to be common, and they reported its occurrence in moss.

Phthiracarus anonymum Grandjean

This species was only collected in very small numbers and although/

although not included in Turk's British Catalogue, it is known to have been collected from litter in Yorkshire by Murphy (private communication).

3. Acari (Cryptostigmata) Acaridiae

Rhizoglyphus echinopus F. and R.

Michael (1903) recorded a world wide distribution for this species, and he considered it to be a primary cause of damage to bulbs, although recent authorities do not subscribe to this view (Franz, 1943, Hodson, 1948). Its distribution in Britain is not easy to assess as few soil ecologists have determined their Acarine species; Morris (1922a) found it at Rothamsted and Hodson (1948) remarked that it was invariably found upon narcissus bulbs.

In the present study it was easily cultured on decaying carrots; hypopi were produced in large numbers and in a soil culture these were observed adhering to gamasid mites, Diplopoda and also to other instars of their own species. It was further noted that the adult specimens cultured on carrots were much larger than those occurring in the field.

Acarus siro Linnaeus

This species is commonly associated with stored flour and other dried vegetable products, and Michael (1903) reported a world wide distribution. Weis Fogh (1948) found it in his collections of soil Arthropoda, but he considered it to have wandered into his Berlese apparatus from packets of oatmeal in his laboratory.

Coelognathus castellanii (Hirst)

This is also known as a pest of stored products and is one of the/

the species said to induce the dermatitis known as 'grocers itch'. No published records have been found of the occurrence of this species in soil, but Dr. Evans of the British Museum has informed the writer that he had also found this species in soil Arthropod collections.

Glycyphagus destructor (Schrank)

Usually associated with A. siro, (Hughes, 1948), this does not appear to have been previously recorded from soil. However, the related G. domesticus (de Geer) a species thought to feed on fungi, and bacteria, (Hughes, 1948), was found in beech litter by Van der Drift (1951). Weis Fogh (1948) also encountered the latter species, although he considered it to have originated in the laboratory.

The occurrence of Acarid mites other than R. echinopus was at first viewed with some suspicion, for it was thought that they might have originated in the laboratory. After consideration however this is thought to have been unlikely. In the first place the samples were stored in a refrigerator, and the region of the laboratory near the extraction apparatus was periodically washed with jets of water; and heavy mite populations could hardly have existed under such conditions. Secondly, they occurred fairly consistently throughout the period of study. Finally, a series of samples from an upland pasture in Argyll were also found to contain large numbers of these mites, only in this case the dominant species was Tyrolichus casei (Ouds) - a species which did not occur in the collections from the Glasgow soil. Furthermore, these hill-land samples were processed within a few days/

days of those from Glasgow.

On reflection, there is no reason to suppose that these animals should not occur in soil or litter; for it is apparent that their main sources of food are plant residues, or organisms and materials associated with its decomposition. Again, the range of humidity conditions in soil is such that the moisture requirements of even the most exacting species can be met and, finally, it might even be argued that these mites originated in this or some other similar environment before the advent of bulk food storage.

4. Acari, Mesostigmata

Rhodacarus roseus Oudemans

This species, which was particularly prominent in the Glasgow soil, has not been widely reported. It occurred in Weis Fogh's plain (1948) and the only records of its occurrence in Britain are those of Halbert (1915, 1920) and Hull (1918). The former worker reported it from decaying leaves and from littoral habitats in Ireland, while the latter collected it from moss in N.E. England.

This species was also found in arable soil at Auchincruive, Ayrshire, and in the soil of an Agrostis-Fescue pasture at Lephinmore, Argyll. In both these localities, it was prominent in soil below 3" in depth.

Rhodacarellus epyginialis n.sp.

This was the dominant Mesostigmatic mite in the collection. The genus has not been previously recorded from Britain, although there are a number of continental records. Willman (1935) found Rhodacarellus subterraneus in soil at a depth of 10 - 20 cm. near Leipzig, and Frenzel (1936) found R. silesiacus to be amongst the few species prominent/

prominent in the lower soil.

In view of their numerical importance attempts were made to elucidate the food habits of the Rhodacaridae but they were not eminently successful. They were found particularly difficult to collect by desiccation methods, and, of the few which were obtained in this way, the majority were very inactive, and many died before they could be observed. From time to time a few individuals were watched in petri dishes, and, although their structure would indicate a predatory mode of life, they showed no interest in small Collembola, Nematoda, and Acarid mites confined with them, and they paid no attention to batches of the eggs of Hypogastrura denticulata. Similarly their activities on fungi and decaying plant material were such that no positive evidence could be obtained.

Veigaia nemorensis (Koch)

This species appears to be extremely common in continental Europe and Britain. It was one of Frenzel's Leitformen, and there are several British records, including that of Hull (1918) who reported it to be common amongst grasses and moss in many English counties and in Ireland.

In the laboratory it was observed to be actively predacious, feeding mainly on Collembola.

Pergamasus runciger Berlese.

This species also appears to be common. The original material was collected in Norway, and Halbert (1915) reported its being common in Ireland. The mite reported as P. rumiger Berlese by Morris (1922a) and Thompson (1924) is presumably this species.

Pergamasus/

Pergamasus misellus Berlese

Berlese (1903a) found the type material of this species in a field near Padua, and no further record has been found.

Both Pergamasus species were observed in the laboratory. They were extremely active and preyed mainly on Collembola, although Acarid mites and Nematode worms were also consumed. They pierced the body of the prey and sucked out the contents, and on one occasion a P. runciger was seen to have an Oribatid mite (M. semirufus) impaled upon its mouth parts.

Digamasellus reticulatus n.sp.

Although its species have been widely reported from continental soils, (vide Leitner 1949), the only previous British record of this genus is that of Evans (1954) who reported the occurrence of D. halophilus Will. in a Welsh salt marsh. D. reticulatus was subsequently found in the Agrostis-Fescue pasture at Lephinmore. Here it was common in soil at a depth of 1½-3" but it also occurred below the 3" point.

Laboratory observations showed this small species to be predacious, preying mainly on Tullbergia krausbaueri, although it also attacked and consumed Arctoseiopis minutus and it was observed sucking out the contents of the eggs of Hypogastrura denticulata. On one occasion it was seen to attack and kill a R. epyginialis.

Arctoseius cetratus Sellnick

Weis Fogh's A. bispinatus appears to be synonymous with this species and he found it common in the upper layers of soil. The only other British record for this species is that of Evans (1954) who reported/

reported it from a salt marsh in Wales. Laboratory observations did not produce any conclusive evidence on the nature of its food habits. It did not appear to be predacious.

Arctoseiopsis minutus (Halbert)

The type material was collected from Sphagnum at Clare Island (Halbert, 1915) and this also occurred in the Welsh salt marsh (Evans, 1954). This species was observed periodically in the laboratory, but, like the preceding species, no conclusive evidence on its food habits was obtained.

Lasioseius penicilliger Berlese

The type material was taken from agricultural soil in Italy (Berlese, 1917) and it has not been previously recorded from Britain. Frenzel included the genus in his list of Leitformen.

Platyseius n. sp.

Material of this species is in the possession of Dr. Owen Evans who will include its description in a paper on the Laelaptidae.

Hypoaspis aculeifer (Canestrini)

Halbert (1923) found this species numerous in dead wood near Dublin and the genus is included amongst Frenzel's Leitformen. In the laboratory it fed on Collembola.

Eviphis ostrinus (Koch)

Halbert (1915) reported this from moss and decaying fir cones in Achill Island, and he noted it as being common in Europe. It was also found by the writer in birch litter (Dunbartonshire), and on several occasions it was found in association with R. echinopus on narcissus bulbs. In the laboratory it was attracted by decaying potato tuber, and did not appear to be predacious.

VI. QUANTITATIVE RESULTS.

Forty-eight 2" samples were taken from the uncultivated area. Of these, the eight taken in June 1951 were 9" deep and sub-divided to represent two strata viz. 0 - 3", and 3 - 9", while the later samples were undivided and taken to a depth of 6". Thus, the June samples being different in size have to be considered separately and they provide some data on vertical distribution. The remaining forty, taken on five occasions during the period October 1951 - October 1952, are comparable and provide data on horizontal and seasonal distribution.

A. Census of Arthropoda

The detailed results of the examination of the samples are presented in Census Tables I - VI (Appendix III).

1. The Density of the population

It was not the object of the investigation to establish the absolute density of the population, but the densities recorded are of some interest in relation to the results of other workers. Over the five occasions on which the 2" samples were taken to a depth of 6", the highest population occurred in October 1952 when an average of 170 Arthropoda per sample were recorded. The lowest population occurred in April 1952 when only 67 individuals per sample were encountered, whilst the mean population over the five occasions represented by these samples was 118 individuals per sample. In June, 1951, the mean population per sample was 96, of which 69 and 27 occurred in the 0 - 3" and 6 - 9" strata, respectively/

respectively.

In Britain it has become almost customary to express populations in terms of millions per acre. There is little to commend this except that it provides a common unit for comparison. The 2" samples are each approximately equivalent to one two-millionth of an acre in area, so that the populations become:- October 1952 - 340 millions per acre; April 1952 - 134 millions per acre; mean population of 6" deep samples - 236 millions per acre; June 1951, upper layer - 138 millions per acre; and June 1951 lower layer - 54 millions per acre.

2. The Quantitative Composition of the Community

The percentage composition of the population in the upper 6" of soil is noted in Tables 6 - 10. These tables summarize the information given in the Census Tables and represent the average composition of the community over the five sampling occasions and over the four plots. The June samples have not been included in this assessment, for, being deeper, these samples are not strictly comparable. The nature of the horizontal and seasonal distribution encountered is noted in succeeding sections. It will be seen that in Oribatei and Mesostigmata species counts refer to adults only; the immature forms being dealt with collectively. This was due to the taxonomic difficulty encountered in these two groups; and, although in some species immature forms could have been paired with the adults, had this been done, a bias towards "easy" species would have occurred.

TABLE 6/

TABLE 6

THE AVERAGE COMPOSITION OF THE ARTHROPOD POPULATION IN THE UPPER 6" OF SOIL

Group	Proportion of Arthropod Population Represented (per cent)
Insecta	41.9
Acari	57.7
Other Arthropoda	0.4

Group	Proportion of Insect Population Represented (per cent)
Protura	0.5
Collembola	93.9
Thysanoptera	0.3
Hemiptera	0.2
Coleoptera	0.6
Diptera	4.5

Group	Proportion of Acarine Population Represented (per cent)
Oribatei	57.1
Acaridiae	15.7
Mesostigmata	26.0
Heterostigmata	0.9
Prostigmata	0.2

TABLE 7

THE AVERAGE COMPOSITION OF THE COLLEMBOLAN POPULATION IN THE UPPER 6" OF SOIL

Species	Proportion of Collembolan population Represented (per cent)
Euedaphic forms:-	
Onychiurus uliginatus	12.8
Onychiurus spinularius	4.8
Onychiurus sp.undet.	1.8
Tullbergia krausbaueri	25.4
Tullbergia crassicuspis	3.1
Tullbergia quadrispina	2.1
Folsomia candida	13.7
Folsomia garretti	0.6
Isotomodes productus	13.5
Hemiedaphic forms:-	
Brachystomella parvula	5.6
Hypogastrura denticulata	5.4
Friesea mirablis	7.1
Folsomia quadrioculata	1.8
Other and undet. Collembola	2.1

TABLE 8

THE AVERAGE COMPOSITION OF THE ORIBATID POPULATION IN THE UPPER 6" OF SOIL

Species	Proportion of Oribatid Population Represented (per cent)
Ceratozetes gracilis	1.7
Achipteria coleoptrata	4.2
Euzetes globulus	1.0
Punctoribates punctum	24.0
Minunthozetes semirufus	42.6
Oppia clavipectinata	5.6
Oribella lanceolata	4.7
Oribella paolii	5.7
Scutovertex sculptus	1.3
Other and undet. Oribatei	0.4
Immature Oribatei	8.7

TABLE 9

THE AVERAGE COMPOSITION OF THE ACARID POPULATION IN THE UPPER 6" OF SOIL

Species	Proportion of Acarid Population Represented (per cent)
Acarus siro	14.7
Coelognathus castellanii	9.3
Rhizoglyphus echinopus	42.3
Glycyphagus destructor	33.6

TABLE 10

THE AVERAGE COMPOSITION OF THE MESOSTIGMATIC POPULATION IN THE UPPER 6" OF SOIL

Species	Proportion of Mesostigmatic Population Represented (per cent)
Rhodacarus roseus	22.3
Rhodacarellus epyginialis	26.6
Veigaia nemorensis	3.7
Pergamasus runciger	10.2
Pergamasus misellus	3.1
Digamasellus reticulatus	3.2
Arctoseius cetratus	1.0
Arctoseiopsis minutus	1.3
Cosmolaelaps claviger	0.4
Lasioseius penicilliger	0.8
Platyseius n.sp.	1.0
Hypoaspis aculeifer	0.7
Eviphis ostrinus	2.1
Olodiscus minima	4.2
Other and undet. Mesostigmata	2.5
Immature Mesostigmata	16.6

B. The Data of June 1951 and Vertical Distribution

The information on vertical distribution whilst limited to one occasion and to two rather broad strata is nevertheless of some value for the data have been treated statistically. The populations of the two strata have been compared on a volume basis, thus, as the population of the lower stratum (3 - 9") represented double the volume of soil occupied by the upper population (0 - 3"), the population figures for the lower soil were halved. In this way both the upper and lower sample populations represented the number of animals per 154.4 cc.s. of soil. In the statistical analyses, degrees of freedom were apportioned as follows:-

Plots	3
Depth	1
Interaction plots x depth	3
Total	7

The plot totals for this analysis were obtained by summing the square roots[1] of the sample populations (after correction for volume) and the values of 'F' for the comparison of the two strata were obtained by using the interaction plots x depth mean square as the denominator. The/

[1]In explanation of the use of square roots in this and in subsequent analyses, it should be noted that the analysis of variance technique is only valid for the comparison of means (or totals), drawn from binominal distributions. Biological data of the kind dealt with in the present study tend to be distributed in a manner approaching the asymmetrical 'Poisson' fashion. Such data can be made to approach the binominal type by using appropriate transformations. In extreme cases Log_{10} transformations could be used, here the less drastic square root transformation has been considered adequate.

The results of analyses of this type are summarised in Table II. It will be noted that the fauna was not uniformly distributed in the profile, and that, with some exceptions, the population of the upper stratum was much more dense than that of the lower. In a number of cases this difference in density was significant.[1] In no case was the population of the lower stratum significantly more dense than that of the upper stratum, although in the case of Rhodacarellus epyginialis the "observed" density of the lower stratum was greater.

C. Horizontal Distribution

During the year October 1951 - 52, 40 comparable samples were taken from the uncultivated plots, and the data resulting from an examination of this material were subjected to analysis in which the 39 degrees of freedom available for the total sum of squares were apportioned as follows:-

Plots	3
Seasons	4
Interaction plots x seasons	12
Samples	20

In this analysis the total variation between samples (i.e. within plots) is measured by the samples mean square. The comparable figure for the total between plot variation has to be obtained by pooling the plot mean squares(each with 3 degrees of freedom) for/

[1] In this investigation the probability level of 0.05 has been taken as the minimum standard of significance. This implies that the chances of the results being fortuitous are at the most 1 in 20. Distributions of 'F' and 't' are given by Fisher and Yates (1938).

TABLE 11

THE VERTICAL DISTRIBUTION OF ARTHROPODA, JUNE 1951.

Numbers of animals per unit volume of soil (154.4 ccs.) and their relative densities in 2 strata, together with values of 'F' obtained in analyses of square root transformed data.

Group or Species	Upper Stratum 0 - 3"	Lower Stratum 3 - 9"	Relative Density in Lower Stratum. Upper Stratum Density=100.0	'F'[1]
Total Collembola	18.2	7.1	39.0	14.05*
Total Tullberginae	5.7	2.5	43.9	45.83**
Tullbergia krausbaueri	4.9	1.2	24.5	15.52*
Tullbergia crassicuspis	0.9	1.1	122.2	<1
Total Onychiurus spp.	2.2	2.7	122.7	<1
Total Hemiedaphic Collembola	4.1	0.2	4.9	37.10**
Total Acari	48.1	6.1	12.7	10.68*
Total Oribatei	36.1	2.6	7.2	20.34*
Minunthozetes semirufus	12.9	1.2	9.3	13.91*
Punctoribates punctum	15.4	0.6	3.9	23.16*
Total Immature Oribatei	2.1	0	-	-
Rhizoglyphus echinopus	2.9	0.3	10.3	1.82
Total Mesostigmata	8.6	3.2	37.2	3.95
Total Rhodacaridae	2.4	2.4	100.0	<1
Rhodacarellus epyginialis	1.4	2.2	157.1	1.41
Total Immature Mesostigmata	2.9	0.2	6.9	22.00*

[1] Degrees of freedom :- n_1 - 1, n_2 - 3. Significance levels indicated thus:- p - 0.05*, p - 0.01**.

for all five occasions, so that the total between plots mean square has 15 degrees of freedom. In the analysis this item can be derived from the sum of squares obtained by summing the plots sum of squares (3 D.F.) and the interaction sum of squares (12 D.F). Thus the samples mean square (20 D.F.) and the plots plus interaction mean square (15 D.F.) provide, respectively, a comparable measure of the variation encountered within plots and the variation found to occur between plots. In addition by using the interaction plots x seasons mean square as the denominator, values of 'F' can be obtained for assessing the significance of plot differences. In this case however it should be noted that the replication consists of repetitive observations on the same plots so that the values 'F' are largely a measure of the consistency of the differences over a period of time.

An analysis of this type was carried out on the square roots of the sample populations of a number of groups and their constituent species. The results of these analyses in so far as they concern horizontal distribution are presented in Table 12. Here the total plot populations are accompanied by the appropriate transformed totals, obtained by summing the square roots of the individual sample populations, and, in the last two columns of this table the mean squares facilitating the comparison of within plot with between plot variation are recorded. The plot differences were first treated by using the variance ratio ('F') test, and, in cases where significant 'F' values were obtained, standard errors of the transformed totals are given. The minimum significant difference between/

HORIZONTAL DISTRIBUTION OF ARTHROPODA IN THE UNCULTIVATED SOIL

a. Plot Totals, Original Data (O.D.) and Square Root Transformed Data (T.D.). Values of 'F' and Standard Errors.

b. Comparison of Within with Between Plot Variation as shown by the Samples Mean Square and Plots+Interaction Mean Square.

Group or Species		Plot 1	Plot 2	Plot 3	Plot 4	'F' [1]	S.E. [2]	Samples M. Square (20 D.F.)	Plots+Int M. Square (15 D.F.)
Total	O.D.	471	368	694	321				
Collembola	T.D.	66.650	57.847	79.640	54.382	4.08*	5.578	2.445	5.025
Total	O.D.	131	152	186	98				
Tullberginae	T.D.	33.433	35.702	36.944	29.575	<1	–	1.642	4.678
Tullbergia	O.D.	126	111	164	70				
krausbaueri	T.D.	32.747	30.182	30.631	24.996	<1	–	1.660	3.429
Tullbergia	O.D.	5	5	22	25				
crassicuspis	T.D.	3.732	4.414	9.498	11.850	1.86	–	0.956	0.977
Total	O.D.	221	29	77	32				
Onychiurus spp.	T.D.	45.106	14.678	20.052	14.066	7.02**	5.537	1.042	6.756
Folsomia	O.D.	21	29	192	13				
candida	T.D.	10.382	13.346	38.869	7.242	14.59***	3.793	1.750	5.349
Isotomodes	O.D.	12	48	141	50				
productus	T.D.	6.928	19.689	35.296	18.063	10.19**	3.656	0.804	3.794
Total	O.D.	83	104	90	116				
Hemiedaphic Collembola	T.D.	25.185	30.187	29.117	30.804	<1	–	1.258	1.024
Total	O.D.	203	868	994	652				
Acari	T.D.	42.714	89.267	96.499	73.852	10.56**	7.262	7.328	15.606
Total	O.D.	57	589	642	264				
Oribatei	T.D.	20.023	72.527	75.125	48.373	16.26***	6.364	5.571	16.411
Punctoribates	O.D.	19	102	204	47				
punctum	T.D.	7.020	29.599	40.012	19.614	11.31***	4.189	1.904	5.372
Minunthozetes	O.D.	24	269	212	157				
semirufus	T.D.	11.352	47.241	43.782	35.167	12.49***	4.576	3.507	6.907
Total	O.D.	3	35	83	40				
Oribella spp.	T.D.	2.414	15.274	25.864	16.870	17.46***	2.312	1.155	2.294
Total	O.D.	3	91	32	9				
Immature Oribatei	T.D.	2.414	27.913	14.623	7.828	16.12***	2.742	0.691	3.026
Total	O.D.	57	97	60	214				
Acaridiae	T.D.	19.435	27.965	19.790	20.933	<1	–	5.591	4.223
Rhizoglyphus	O.D.	51	83	46	1				
echinopus	T.D.	17.635	25.500	14.804	1.000	4.97*	4.579	1.409	3.764
Total	O.D.	6	14	14	213				
Other Acaridiae [3]	T.D.	4.828	7.277	7.863	19.933	<1	–	4.651	5.655
Total	O.D.	87	174	283	163				
Mesostigmata	T.D.	27.914	39.826	51.570	39.390	5.47*	4.132	0.921	3.231
Total	O.D.	33	67	149	97				
Rhodacaridae	T.D.	14.674	24.415	37.147	28.141	4.08*	4.602	0.742	3.425
Rhodacarellus	O.D.	20	34	60	74				
epygynialis	T.D.	9.706	15.655	23.899	23.287	3.46	–	0.986	1.969
Total	O.D.	23	26	30	15				
Pergamasus spp.	T.D.	10.646	14.474	14.992	10.560	<1	–	0.521	1.171
Total	O.D.	15	30	46	26				
Immature Mesostigmata	T.D.	10.610	15.519	19.294	14.524	1.65	–	0.543	0.864

1 Degrees of freedom:- $n_1 = 3$, $n_2 = 12$. Significance levels indicated thus:- p 0.05 *, p 0.01 **, p 0.001 ***

2 12 D.F. Values of $\sqrt{2}t$:- p 0.05, 3.081; p 0.01, 4.320; p 0.001, 6.106

3. Totals of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

between the transformed totals is given by the product $\sqrt{2}$ t S.E. (P = 0.05).

Although a considerable amount of within plot variation was encountered, in most cases the variation between plots greatly exceeded that occurring between samples, and amongst the groups and species analysed there were only two exceptions to this viz. Total Acaridiae, and Total Hemiedaphic Collembola. The magnitude of this interplot variation is emphasized when the results of the 'F' tests are considered, for in many cases significant values were obtained.

The more outstanding differences were apparent when Plots 1 and 3 were compared with each other and with the other two plots. Thus the total Collembolan population of Plot 3 was significantly higher than that of Plots 2 and 4. This was due mainly to the high populations of Folsomia candida and Isotomodes productus in Plot 3; for, in this plot the populations of these two species were significantly higher than in any of the other 3 plots. In Plot 1, on the other hand, the population of Onychiurus species was significantly higher than in any of the other three, and this plot was further characterized by a low Acarine population, and particularly so in relation to Oribatei. Thus, in this plot the populations of the following were significantly lower than in any of the other plots:- Total Acari, Total Oribatei, Minunthozetes semirufus and Total Oribella species. The populations of Punctoribates punctum and immature Oribatei were also low in this plot/

plot, but they differed significantly only from those in Plots 2 and 3. With regard to the *Mesostigmata*, although these mites were generally less abundant in Plot 1, significant comparisons were less frequent.

D. Seasonal and Annual Fluctuation

The four series of samples taken at two monthly intervals from October 1951 to April 1952 provide some information on the seasonal fluctuations of the population. For the purposes of the work described in Part II of this paper it was necessary to arrange the sampling so that the community could be observed at a time of probable high population, and for this reason no samples were taken between April and October 1952. Thus the seasonal variation study is not complete, but the samples of October,1952 provide material for an annual comparison with October, 1951.

The method of analysis described in the preceding section provides a means of assessing the significance of seasonal and annual differences. Here however the 'F' test cannot be used, for purely seasonal differences are incorporated with the annual comparions October 1951 - October 1952. Thus, if the annual differences were small, the values of 'F' might well be insignificant despite the occurrence of seasonal differences of some magnitude. For this reason the significance of seasonal and annual differences have been tested by using the standard errors derived from the interaction mean square. The results are presented in Table 13.

The observed seasonal variation was considerable but the standard errors were so large that in many cases these differences were not significant/

TABLE 13

THE SEASONAL FLUCTUATION OF ARTHROPODA IN THE UNCULTIVATED SOIL

Seasonal Totals of Original Data (O.D.) and Totals of Square Root Transformed Data (T.D.) with Standard Errors.

Group or Species		Oct.51	Dec.51	Feb.52	Apr.52	Oct.52	S.E.[1]
Total	O.D.	407	449	340	150	508	
Collembola	T.D.	54.820	58.700	50.223	33.734	61.042	4.989
Total	O.D.	147	79	92	48	201	
Tullberginae	T.D.	33.071	23.795	23.976	17.037	37.775	6.684
Tullbergia	O.D.	132	64	69	35	171	
krausbaueri	T.D.	31.407	20.734	20.166	13.164	33.085	5.668
Tullbergia	O.D.	6	15	15	12	9	
crassicuspis	T.D.	4.146	7.417	7.882	4.317	5.732	2.581
Total	O.D.	83	94	58	30	94	
Onychiurus spp.	T.D.	21.925	22.945	17.715	9.210	22.107	4.953
Folsomia	O.D.	69	98	40	23	25	
candida	T.D.	18.737	21.405	11.538	6.742	11.417	3.393
Isotomodes	O.D.	42	61	65	12	71	
productus	T.D.	13.741	20.815	21.300	6.700	17.420	3.270
Tot. Hemiedaphic	O.D.	63	106	82	34	108	
Collembola	T.D.	21.616	28.795	23.985	12.968	27.929	2.994
Total	O.D.	567	373	588	362	827	
Acari	T.D.	65.781	51.633	60.390	50.076	74.452	6.495
Total	O.D.	331	178	405	274	364	
Oribatei	T.D.	47.451	31.279	46.669	40.941	49.708	5.692
Punctoribates	O.D.	122	21	120	64	45	
punctum	T.D.	27.827	10.145	22.522	19.119	16.632	3.747
Minunthozetes	O.D.	100	85	161	131	185	
semirufus	T.D.	25.745	20.012	28.172	28.225	35.388	4.093
Total	O.D.	37	15	27	21	61	
Oribella spp.	T.D.	15.178	6.708	9.587	9.921	19.028	2.068
Total Immature	O.D.	42	28	31	12	22	
Oribatei	T.D.	15.429	10.529	11.018	5.560	10.242	2.453
Total	O.D.	60	54	38	9	267	
Acaridiae	T.D.	19.126	17.385	10.513	6.414	34.685	6.246
Rhizoglyphus	O.D.	40	42	37	8	54	
echinopus	T.D.	12.257	13.540	9.513	6.000	17.629	4.096
Total 'Other'[2]	O.D.	20	12	1	1	213	
Acaridiae	T.D.	11.478	7.277	1.000	1.000	19.146	6.884
Total	O.D.	159	137	142	76	193	
Mesostigmata	T.D.	35.105	32.368	31.721	24.093	35.413	3.695
Total	O.D.	87	68	69	37	85	
Rhodacaridae	T.D.	26.003	19.933	22.090	15.336	21.015	4.118
Rhodacarellus	O.D.	34	38	60	31	25	
epyginialis	T.D.	14.534	14.332	20.126	14.092	9.463	3.250
Total	O.D.	13	26	23	11	21	
Pergamasus spp.	T.D.	8.464	12.378	10.888	7.828	11.114	3.250
Tot. Immature	O.D.	30	13	21	14	39	
Mesostigmata	T.D.	14.291	9.388	12.028	9.024	15.216	2.473

1. 12 degrees of freedom. Values of $\sqrt{2}\,t$:- $p\,0.05$, 3.081; $p\,0.01$, 4.320; $p\,0.001$, 6.106.

2. Totals of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

significant.

On the whole the fluctuation was most marked in relation to Collembola, and here the trend was towards low April and high October and December populations. Thus, in the analysis of Total Collembola the April population was significantly lower than that of any other occasion. The April population of Tullbergia krausbaueri was significantly lower than both October populations, but no significant comparison was evident in the analysis of T. crassicuspis. In the population of Onychiurus species, although the observed fluctuation was great, in no comparison were there any significant differences. With regard to the other euedaphic Collembola analysed, the results can be summarized by noting that the April population was significantly lower than the December population and also significantly lower than one of the October populations, while only in the case of Isotomodes productus was there a significant difference between the populations of February and April. In the case of hemiedaphic Collembola the April population was significantly lower than those of the other occasions, with the exception of that which obtained in October, 1951.

The seasonal fluctuation of Oribatei was less marked, and in the case of the adults analysed, the lowest populations were seen to occur in December, and the highest populations of these mites occurred in February and October. In the case of Punctoribates punctum the December population was significantly lower than both those of October, 1951 and February, 1952.

In/

In the Acaridiae and Mesostigmata the seasonal fluctuation could not be regarded as significant,[1] and, finally, with regard to annual differences, although the total Collembolan and total Acarine populations of October 1952 were seen to be considerably higher than those of the previous year, in no case was the annual comparison significant.

[1] The writer is advised by Mr. W.J. Lessells of the necessity for caution in the use of the 't' test. This test is used for assessing the significance of differences between two 'treatments' of particular interest, and it is not a valid procedure to use the test in an attempt to grade all differences into those which are real and those which are not. Thus, in a series of 5 totals, there are 10 possible comparisons, so that the chances are even that 1 comparison will yield a value of 't' significant at the 5% level, and by deliberately taking the highest and the lowest, a selection towards the chance effect is automatically made. In Rhodacarellus epyginialis, a significant value of 't' is evident in the extreme comparison April-October 1952, but there is no reason to regard these months as being of 'particular interest'. In Collembola and Oribatei, significance was not confined to single comparisons and the selection of months of 'particular interest' was supported by the trends in related species, and by the evidence of previous studies.

VII. DISCUSSION

A. The Density and Composition of the Population

In the present study, the average Arthropodan population of the upper 6" of soil, as shown by the analysis of 40 samples, was 117.7 individuals per 2" core; of these 46.3 were Collembola, and 67.9 were Acari. In order that the results may be compared with those of other workers it is necessary to express them in relation to some common unit. Macfadyen (1952) has discussed the relative merits of square and cubic standards, but no matter which standard is adopted, the uneven vertical distribution of the animals sets a severe limit upon the value of comparisons between investigations based on samples of different depths. Most workers have expressed their populations per unit area, and, at the same time have noted the depth to which their samples were taken. A number of British investigators have used a scale of millions per acre, whilst many Continental workers have adopted a square metre as their unit. Both these areas however,and particularly the former, are so large that it is difficult to visualize the actual densities of the population. Accordingly, in Table 14, the populations recorded at Glasgow, and those recorded in a number of the more recent studies of uncultivated land, have been recalculated in relation to a unit of 1 sq. centimetre. With one exception, the earlier investigations based on direct sorting methods have not been included in this table; for the population estimates obtained were so low that there seemed little purpose in using them even for an/

Table 14.

COMPARISON OF SOIL POPULATION RECORDED IN VARIOUS INVESTIGATIONS

Worker	Habitat	Population per cm^2		Sample	Extraction	Remarks
		Acari	Collembola	Depth	Method	
Ford 1935	Meadow, Oxford, Soil (Ridges).	0.18	5.93	23 cm.	Direct Sorting	Mean of 16 samples Oct. - May, 1931-32
do	Meadow, Oxford. Surface of soil and Vegetation.	0.05	0.04	-	Berlese	do
Salt et al 1948	Pasture, Cambridge.	11.98	4.31	15 cm.	Flotation	Mean of 20 samples Nov. 1943 Extraction apparatus with 0.1 mm. sieve for some of samples
Weis Fogh 1948	'Plain' (Pasture, raised Beach) Denmark.	2.01	0.92	5 cm.	Berlese	Mean of 56 samples from * 6 stations, July 1942 - Nov. 1943.
Macfadyen 1952	*Molinia* areas, Fen, Cothill.	13.21	2.50	5 cm.	Modified Tullgren	Mean 120 samples. Sept. 1949 Aug. 1950. Only most abundant species included
do	*Deschampsia* areas, Fen, Cothill.	8.0	2.40	5 cm.	do	do
do	*Juncus* areas, Fen, Cothill.	2.07	0.72	5 cm.	do	do
Present Study	Old Grassland, Glasgow.	3.35	2.28	15 cm.	Flotation	Mean 40 samples. Oct., Dec., 1951. Feb., April, Oct. 1952.

* Calculated from Weis Fogh's Tables 9 - 14. One of his samples has not been included as it was not entirely quantitative.

an approximate comparison. As an example, it can be noted that the total Invertebrate population (inclusive of Nematoda etc.) of an Aberystwyth pasture reported by Thompson (1924) was only about one-twelfth of the Arthropodan population reported in the present study.

The exception is the study of an Oxfordshire meadow described by Ford (1935). Ford recorded a remarkably high population of Collembola for this habitat; and, despite his use of direct sorting methods, his November population of these insects in the upper 9" of soil was approximately 7.1 per cm^2. This figure exceeds even that obtained by Salt et al.(1948); these workers having recorded a population of 6.1 Collembola per cm^2 in the upper 12" of soil of a Cambridge pasture. This difference is remarkable in view of the fact that Salt et al used the flotation technique, and a number of their samples were extracted with an apparatus in which the ultimate sieve was one of bolting silk with a square mesh of 0.1 mm.

When compared with the population of the upper 6" of soil recorded by Salt et al, the mean population of the Glasgow soil appears to be low. It should, however, be noted that the Cambridge populations were based on samples taken in November; and, in the case of Collembola, if the highest seasonal population of the Glasgow soil (noted in October, 1952, and equivalent to 3.1 Collembola per cm^2) is used for comparison, the difference is less marked, and is probably mainly due to the use of a finer sieve in the Cambridge study.

In the case of Acari, however, the discrepancy is much greater. It/

It has already been noted that in the present study the number of immature Oribatei and Mesostigmata was surprisingly low, and this may have been due in part (but probably not entirely) to the loss of the small immature instars through the 0.15 mm. sieve. Even Salt et al remarked that some of the Oribatei encountered were so minute that the larvae probably passed through their 0.1 mm. sieve. Another factor which has to be considered is the collection by the flotation method of the remains of dead mites. Salt et al did not determine their Acari in detail, and do not mention this contingency, so that it is not possible to determine whether their population was inclusive of such forms. Had these remains been included in the assessment of the Glasgow population, the numbers of adult Oribatei would have been very much greater.

It will be seen that the remaining investigations in Table 14 are ones in which the Berlese extraction apparatus, or some modification thereof was used. Comparisons of the Glasgow populations with those recorded in these studies can only be approximate; for, not only are there differences in depth and time of sampling, it is difficult to decide whether the observed differences were due to environmental factors or merely to the use of different extraction methods. Nevertheless, it seems profitable to make a few comparisons. Although definite conclusions cannot always be attained, the results indicate the necessity for further research, particularly in relation to the relative efficiency of extraction methods in relation to soils of different types.

In/

In Macfadyen's fenland study, the Collembola and Acari were found to be less numerous in the Juncus areas than in the other plant associations he examined, but the populations of Collembola in his Molinia and Deschampsia areas did not differ widely from that of the present investigation. It is also of interest to note that Collembolan populations of a somewhat similar magnitude were recorded for a brown earth soil near Vienna (Schaller 1949a), for damp soils in the Plön area (Strenzke 1949), and for natural heathland in Yorkshire (Murphy 1953). It should, however, be indicated that the populations recorded by these workers were based on samples of different depths, but this does not greatly affect the approximate similarity noted, for they also observed that the bulk of their populations usually occurred in the upper strata of their samples.

In the case of Acari, it would be misleading to make comparisons without reference to the composition of the populations. Accordingly the populations of the major Acarine groups recorded by Macfadyen and Weis Fogh, together with those obtained at Glasgow, are given in Table 15.

The most notable feature here is the high population of Oribatei in Macfadyen's Molinia and Deschampsia areas. Here the difference is probably mainly due to environmental factors, the Oribatid mites being more abundant in the organic fen soil, and this conclusion can be supported by noting that investigations of the fauna of organic debris on forest floors (Van der Drift 1951, Evans 1951, and many others) have shown that Oribatei are usually the most numerous Arthropodan inhabitants of certain litter layers.

The/

Table 15

A COMPARISON OF ACARINE POPULATIONS

No. of mites per cm^2

(Details of samples and environment as in Table 14)

INVESTIGATION:- GROUP.	Macfadyen Molinia areas	Macfadyen Deschampsia areas	Macfadyen Juncus areas	Weis Fogh 'Plain'	Present Study
Oribatei	12.07	7.12	1.61	1.12	1.91
Acaridiae	0.05	0.08	0.04	0.10	0.52
Mesostigmata	0.74	0.66	0.31	0.20	0.87
'Trombidiformes'	0.35	0.14	0.11	0.58	0.03

The reason for the low population of the "Trombidiformes" (i.e. Prostigmata and Heterostigmata) in the Glasgow soil is difficult to assess. Environmental differences may be partly responsible. These mites are known to be prominent in purely organic habitats, but, on the other hand, it is suspected that the flotation method of extraction gives an unduly low estimate of the population of these animals. This has been noted by Evans (1951) who observed that a large proportion of these predominantly delicate animals were destroyed during the washing process. In this connection it is noteworthy that "Trombidiformes" were the only group recorded in greater numbers in Weis Fogh's study of the Danish mineral soil.

With the exception of his assessment of the "Trombidiformes", Weis Fogh's investigation is characterized by extremely low populations. Macfadyen (1952) has pointed out that while this may have been due to the habitat studied, he also thought it possible that the Berlese apparatus used by Weis Fogh had given a poor extraction. This latter consideration might certainly have been a contributory factor, especially in relation to Weis Fogh's low Collembolan population, and it is tempting to use this factor to explain his low Mesostigmatic population. It must be noted however that the samples taken in this investigation were only 5 cm. deep, and it is important to recall that the high Mesostigmatic population of the present study was due mainly to the Rhodacaridae, a group which is at least equally abundant in the lower strata. Thus, although these mites have been noted by the writer as being difficult/

difficult to extract with a Berlese apparatus, Weis Fogh was working with a much lighter soil; and, had he taken deeper samples, his populations of *Rhodacarus roseus*, might have been much greater.

A circumstance which requires further consideration is the low population of immature *Cribatei* and *Mesostigmata* in the Glasgow soil. Whilst this may have been due in part to a loss of immature forms during the extraction process, this explanation is not entirely adequate, for a similar loss was not apparent in *Collembola* and *Acaridiae*. Although detailed counts were not made, it was quite obvious that in the collections of the latter two groups, the immature individuals were far more abundant than the adults. A similar deficiency of immature *Cribatei* was noted by Riha (1951). In a phenological study of 10 species in a rendzina and a brown earth soil in Vienna, she noted that the immature forms only constituted 9% and 2% of the total populations in each habitat, respectively. Further observation suggested that most of the immature forms of the species concerned lived in other habitats, and they were found in decaying tree trunks, under bark, and in litter. Apart from *H. rufulus*, the species studied by Riha were not the same as those found in Glasgow. Nevertheless, most of the species occurring in this soil have also been collected from other habitats, e.g. from moss, litter and from lichens and moss on trees (Michael 1884,1888, and Van der Hammen 1952) and it is of particular interest that Michael found that the nymphs of *H. semirufus* burrowed into the stems of grasses. Thus, it/

it is not unreasonable to suppose that the deficiency of immature *Oribatei* in the Glasgow soil might also have been due in part to a similar change of habitat.

The deficiency of immature *Mesostigmata* - whilst not so marked - is sufficient to indicate the possibility of a similar phenomenon.

B. *The Vertical Distribution of the Fauna.*

In the earlier investigations, it was noted that, in uncultivated land, the bulk of the fauna was located in the surface layers of the soil. This uneven vertical distribution has been found to obtain in a number of different uncultivated habitats.

In the present study, comparisons were confined to the densities of the populations in two strata, viz. 0.3" and 3-9", during June 1951, and most of the results merely provide a statistical confirmation of phenomena previously observed by other workers. On the whole, the greatest differences occurred in the populations of *Oribatei*, and in the case of *P. punctum*, the density of the population of the upper soil was 25 times greater than that of the lower layers. These observations are in accordance with those of Macfadyen (1952) and Strenzke (1952) and the latter worker regarded the majority of *Oribatei* as hemiedaphic forms.

With the exception of the hemiedaphic forms, the observed differences between the Collembolan densities of the two layers were much less marked than in the *Oribatei*, and, in the case of *Onychiurus* species, a greater density was observed in the lower layer/

layer, but the difference was not significant. With the exception of those for T. krausbaueri, the results for Collembola agree with the findings of other workers. The marked and highly significant difference between the densities of those species noted by Gisin (1943) as being hemiedaphic provides further support for this morpho-ecological classification. With regard to Onychiurus species, Glasgow (1939) obtained some evidence to suggest that O. ambulans moved to the deeper soil in response to adverse climatic conditions, and Strenzke (1949) noted O. armatus as a deep living species. In the case of T. krausbaueri, the density of which was significantly greater in the upper layer, the Glasgow results are not in complete accordance with those of other workers. This species has been noted as a denizen of the lower soil (e.g. Frenzel 1936, Schaller 1949a, Strenzke 1949), and in Macfadyen's study, (1952), it was more abundant in the 5-10 cm. than in the 0-5 cm. layer. It is not possible to account precisely for this apparently conflicting result. The data obtained at Glasgow merely deny a preference for the lower soil, and such factors as soil texture may have been operative. Moreover, the comparatively broad strata examined may have obscured the true vertical distribution of this species.

In the analyses of the Mesostigmatic populations, no difference was observed in the densities of the populations of Rhodacaridae in the two layers. In respect of R. epyginialis the density in the lower soil was observed to be greater, although the difference was far short of the significant standard.

Frenzel/

Frenzel (1936), and Willman (1936), observed that the members of the genus Rhodacarellus were amongst the few inhabitants of the deeper soil, and thus R. epyginialis is no exception.

On the basis of his observations in a Cheshire pasture, Morris (1920) considered that the main factors determining the vertical distribution of the animals were the location of their food material, and conditions of aeration and of moisture. In purely mineral soils it seems probable that the factor of greatest general importance is the location of the food supply of the animals. Thus, in all uncultivated mineral soils, the organic matter content is much greater in the surface layers of the soil, although the precise nature of its diminution with depth varies according to the soil type (see Russell, 1950. Chapter 30). It is also known that the density of fungi and micro-organisms is greater in this stratum (Russell, 1950. Chapter 12). It is hardly surprising therefore to find in this upper zone, an abundance of saprophagous and mycetophagous species, together with populations of their predators. In arable land, where vertical distribution of the organic material is more even, the surface concentration of the fauna is either not apparent or much less marked (e.g. Morris 1922a, and Jones 1939). In this connection, an interesting observation was made by Murphy (1953), who noted that in cultivated heathland a high population of Acari occurred 8" below the surface in the region of the organic matter forming the original surface. Further evidence of the importance of this factor was also obtained during the course of the present study. Thus, when tubes containing decaying plant material were/

were buried to a depth of 6" in pots of soil, it was subsequently noted that _Collembola_ were attracted to the tubes, although it was somewhat surprising to find that the majority of the individuals in the tubes belonged to hemiedaphic species. Similarly, in a bin used for the reception of surplus soil and organic matter in the laboratory, in addition to forms living near the surface, prominent aggregations of _Arthropoda_ were found to occur around clumps of plant debris at depths of 18-24".

The second determinative factor suggested by Morris, viz. aeration, although likely to be of some significance in mineral soils, is probably most influential in certain organic soils. The restricted vertical distribution observed by Macfadyen (1952) in the Cothill fen soil was probably due mainly to this factor, for, although organic material is abundant throughout the profile of such soils, waterlogging usually results in anaerobic conditions in the lower strata (Russell,1950. Chapter 22). A recent observation of Weis Fogh (1948) is also of interest for he noted that the size of the spaces between the soil aggregates (aptly called 'microcaverns') became smaller in the deeper layers, and, although this factor probably exerts a direct influence on vertical distribution, especially that of larger species, it may also determine the degree of aeration in the lower layers.

An outstanding feature of the analyses of vertical differences was the magnitude of the random variation encountered. As a result, the great differences observed between the densities of/

of the populations of the two layers, and particularly those noted to occur in Oribatid populations, were only significant at the 5% level of probability. The only exceptions to this were Total *Tullberginae* and Total Hemiedaphic *Collembola*, where the 1% probability level was attained. The data presented in other investigations is such that there is no reason to suppose that this variation is peculiar to the Glasgow environment, and it would therefore appear to be undesirable to draw far reaching conclusions on the basis of small observed mean differences in the populations of various strata. Consequently, although much of the supporting evidence is convincing, such phenomena as periodic vertical migrations require to be investigated in much greater detail before their occurrence can be truly established.

C. *Horiztonal Distribution*

The non-random distribution of natural populations is well known. It has been found to obtain in plant communities, particularly in grassland (Blackman 1935), and, amongst many examples in animal communities, Salt and Hollick (1946) demonstrated a non-random distribution of elaterid larvae, mainly *Agriotes sputator* (L), in pasture. In a micro-distribution study, these workers were also able to establish an aggregated distribution for this species within an area of 1 sq.yard. In the present study, the high values of 'F' obtained in many of the analyses of plot differences indicate that these differences were consistent from one occasion to another, and thus it can be concluded that the population/

population was not distributed at random over the uncultivated area. The horizontal distribution must therefore have been determined by the operation of one or more controlling influences.

At Glasgow the distribution of the animals within each plot was not studied in detail, but, with only two exceptions, (Total Acaridiae and Total Hemiedaphic Collembola), the interplot variation exceeded the variation occurring within each plot.

In Plot 1, Onychiurus species were particularly prominent, and both O. uliginatus and O. spinularius have been noted by Gisin (1952) as occurring in damp soil and particularly in woodland. The euedaphic Collembolan society of Plot 3 was characterised by the abundance of Isotomodes productus and Folsomia candida both of which were present in Gisin's dry meadow synusia (1943). Comparatively little interplot variation occurred in the population of hemiedaphic Collembola, and the composition of this community at Glasgow was not unlike Gisin's Brachystomella parvula of meadow and moors. One additional point might be considered of interest and that is the apparent avoidance of Plot 1 by Folsomia quadrioculata; for only one individual was taken from this plot. Although the total population of this species was so low that statistical treatment seemed hardly justified, it is interesting to recall that both Hammer (1937) and Weis Fogh (1948) found this species to be more abundant in drier habitats.

The/

The interplot variation encountered in the Oribatei was also highly significant. Here again the greatest differences were usually apparent in the comparison of Plot 1 with Plot 3. Most of the Oribatei encountered have been found by other workers to be forms exhibiting great ecological plasticity. Nevertheless it was strange to find that M. semirufus, a species which Strenzke (1952) found to favour damp soils, was significantly more abundant in Plot 3 than in Plot 1, and was thus associated with high populations of the xerophyte - I. productus.

While a similar distribution was apparent in the Mesostigmatic population, here it was less marked, and apparently due mainly to the Rhodacaridae, the total population of this family being significantly greater in Plot 3 than in Plot 1.

The present investigation was not primarily designed to study the effect of comparatively small environmental differences, consequently, the precise nature of the factors responsible for the horizontal distribution cannot be established, although some possible factors can be suggested. The prominence of the xerophytic Collembolan, I. productus, in Plot 3, and the abundance in Plot 1 of Onychiurus species, at once suggests an orientation in response to moisture conditions, with the implication of moist conditions in Plot 1. Unfortunately evidence directly opposite in character is revealed by the distribution of M. semirufus. The chemical analyses of the plots revealed no major differences, but considerable differences were apparent in the botanical composition, for the turf of Plot 1 was not so thick, and Poa pratensis (L)

was/

was much more abundant here than in the other 3 plots. Thus, there may have been a direct or indirect relationship between the fauna, and the composition of the sward. In fact the very "thinness" of the sward in Plot 1 might well have been responsible for the lower population of the predominantly hemiedaphic Oribatei. Finally, the relative proximity of the plots to the trees may have exerted a considerable influence, for the shade probably induced differences in the micro-climate of Plot 1.

D. Seasonal and Annual Fluctuation

The seasonal fluctuation of the soil population has been found by most workers to consist mainly of an increase from low summer populations towards maxima occurring during the autumn or early winter, although many investigators have also observed a low mid-winter population which was subsequently followed by a smaller increase during early spring.

In all general studies of micro-arthropoda the seasonal fluctuation has been found to be most evident in Collembola, and the accumulated evidence from a number of investigations, especially those of Glasgow (1939) and Agrell (1941) indicates that the main factors influencing the seasonal abundance of these insects are conditions of moisture and temperature. Accordingly, the autumn and early winter increase probably occurs in response to improving moisture conditions, whilst low mid-winter populations are possibly the result of low temperatures, or of excessive moisture, or of both. Seasonal fluctuations have also been observed in Acarine populations, but only Oribatei have been studied in any detail, and/

and the work of Riha (1951), and Strenzke (1952), indicates that here also climatic conditions exert some influence, although other factors may also determine the seasonal abundance of these mites.

It is therefore generally agreed that a great part of the seasonal fluctuation is due directly to changing climatic conditions. Weis Fogh (1948) whilst not minimizing the importance of this factor, suggested that the autumn increase might also be due to increased food supply, for plant debris could be expected to be more abundant during that season.

The data obtained in the present study are sufficient to indicate the general seasonal trend of the population in Glasgow, and in many groups and species this has been found to be similar to that reported in other localities.

The seasonal differences were, on the whole, most marked in the Collembolan population. These animals were found to be most abundant in October and December, and least numerous in April. Furthermore, the samples of June, 1951, whilst not strictly comparable, indicate a low summer population, for having made allowance for the deviation in depth, it can be seen that the population during that month was not widely different from that of April, 1952, and was certainly much lower than the October and December populations.

This type of fluctuation appears to be common in the Collembolan populations of British mineral soils. The earlier workers (e.g. Thompson 1924, and Edwards 1929), noted low summer and high autumn populations/

populations, and Ford (1935) found that during the period October to May the population rose to a December maximum, and dropped sharply to a low level in January. A smaller increase was apparent in February, and this was followed by a gradual decrease to May. Glasgow (1939) also observed high October and December populations. Macfadyen (1952) found that the fluctuations in fenland were rather different, for here the maximum population occurred in February (*Molinia* areas) or May (*Deschampsia* areas), whilst in the *Juncus* areas the population was low at all times, although a slight increase was apparent in July.

Similarly, in Continental surveys, autumn or early winter maxima appear to be quite general (e.g. Frenzel 1936, Weis Fogh 1948 and Schaller 1949a), but in wet soils in Holstein, Strenzke (1949), found that some species attained their maximum in July.

In the present study, a point of some importance arises from the statistical analyses of the seasonal differences, for while the observed differences were great, statistical significance was not always evident. Accordingly, although the trend of a population curve towards a peak and the subsequent drop to a minimum, seems to provide sufficient evidence to establish the approximate location of the period of greatest abundance, it would nevertheless seem undesirable to place great weight on small observed fluctuations.

Amongst the *Acari*, well defined seasonal fluctuations occurred only in *Oribatei*. The highest populations of adult *Oribatei* occurred/

occurred in October and February, and the lowest in December and April. The high October and low April populations thus indicate a fluctuation similar to that of Collembola, but the low December population was not generally evident in the latter group.

This December drop was most marked in Punctoribates punctum, the December population of this species being significantly lower than those of October 1951 and February 1952. It was also quite evident in the analysis of Oribella species, although here the increase to February was not significant. There are indications to suggest that climatic conditions alone were not sufficient to account for this December drop, for, if the higher populations of February and October 1952 are considered in relation to the prevailing meteorological conditions, the climatic conditions which obtained during November and December 1951 could hardly be considered adverse to these animals. The following abstract of meteorological data recorded at Renfrew (about 2 miles distant in the same valley) serves to illustrate this point:-

MONTH	Sept. 1951	Oct. 1951	Nov. 1951	Dec. 1951	Jan. 1952	Feb. 1952	Mar. 1952	Apl. 1952	Sept. 1952	Oct. 1952
Total Rain mm.	73	20	159	158	127	32	66	46	77	111
Mean Air Temp. oF	55.3	50.2	46.1	41.2	33.3	38.5	43.3	48.2	51.0	46.9

From/

From this abstract it will be seen that falling temperatures could hardly have been responsible for the drop, for lower temperatures obtained during January and February, and, although excessive moisture might be regarded as a possible cause, this is also unlikely for the soil was never waterlogged and most of the species encountered were noted by Strenzke to prefer medium damp or wet conditions, and were in any case euryplastic in relation to moisture.

Rayski (1945) encountered little seasonal variation in the Oribatid populations in Eastern Scotland, but his samples embraced the surface herbage. Again, the December drop was not apparent in Macfadyen's habitats. In Holstein, however, Strenzke (1952) found that the population of the upper soil began to decrease in December, but this was accompanied by an increase of the population in the lower soil. In the brown earth and rendzina soil near Vienna, Riha (1951) found that the seasonal fluctuation of adult Oribatei was characterized by two prominent minima; these occurred in February or March, and in September, and at these times a decrease of population was evident in all soil strata. Maxima occurred in May, and in October or November. Riha considered that this fluctuation was not entirely determined by climatic conditions and she obtained evidence to suggest that the two minima were related to the propagation rhythm of the animals and occasioned by a movement of the animals to other habitats (litter, dead wood, etc.) for copulation and egg laying.

At/

At Glasgow there was a general increase of adult *Oribatei* between December and February. This was most marked in *P. punctum*, for in this species the February population was 6 times that of December, and the difference was significant statistically. In view of the lengthy life cycles of *Oribatei*, this increase could hardly have been due to reproduction in a stationary population. Some movements of adult mites therefore must have occurred during this time. These may have merely been movements to and from the deeper soil, but, there is some indirect evidence to suggest that a migration to other habitats, similar to that described by Riha, might have occurred. The possibility of such a migration or Oribatids to litter and surface herbage, or to other habitats, and the incidence of immature instars in these habitats presents an important and interesting subject for future investigation.

PART II.

THE EFFECTS OF CULTIVATION AND INSECTICIDE TREATMENTS.

I. INTRODUCTION

The main part of the following account is concerned with the responses of the population described in the preceding paper to the synthetic insecticides D.D.T. and B.H.C., applied separately and together. However, as it was found necessary to incorporate the materials by cultivation, the effect of digging and reseeding had first to be assessed, and, in addition, a fallow treatment was included, for it was thought that this would provide information on the influence of surface vegetation and would furnish data for a comparison of the value of cultural and chemical methods for the control of soil *Arthropoda*.

II. REVIEW OF PREVIOUS WORK

A number of workers have investigated the fauna of arable land, and the results of these studies indicate that, in this biotope, the population is less dense, less complex, and more evenly distributed vertically than in old grassland. In certain cases, differences of a qualitative nature have also been observed. Most of these differences appear to be related to the amount and disposition of the organic matter, and to the moisture conditions in the soil. Thus, Morris (1922a, 1927) noted that the addition of farm yard manure to the arable soil of Broadbalk and Barn fields at Rothamsted resulted in a great increase in both numbers of species and individuals in the invertebrate population; in fact, the population of insects in the dunged plots of Broadbalk exceeded that of a Cheshire pasture previously investigated by the same worker (1920). Thompson (1924) observed that the removal of the turf resulted in a drastic reduction of the soil fauna which she attributed to a removal of the food supply and to the creation of temporary drought conditions in the upper soil. She further observed that, in cultivated land, the population of the surface 3" hardly exceeded those in strata down to the 9" level, and in certain cases the population even increased with depth down to this point. However, when such land was recolonized by weeds the population increased in density and variety, and a surface concentration again became apparent. Thus, although there is a tendency for arable populations to be less dense than those of pasture, this is not invariably so, and, in addition to the observations/

observations of Morris noted above, a notable exception is to be found in the results of Edwards (1929). He recorded that the population of an arable soil on a light drift area was not much lower than that of a pasture soil on the same deposit, and was considerably greater than the populations of pasture soils on sedentary, boulder clay, and alluvial areas. In this case, the high arable population was due mainly to Tullbergia quadrispina, a species which Gisin (1943), found to be characteristic of newly sown grassland.

With regard to the insecticide treatment of soil, there obtains a very extensive literature on the use of D.D.T. and B.H.C. for the control of specific soil Arthropod pests. The latter substance, in particular, is well known as an extremely efficient soil insecticide, and, at a rate roughly equivalent to 1 lb. of the gamma isomer per acre, is widely used for the control of Elaterid and Tipulid larvae and many other soil pests (e.g. Jameson, Thomas and Woodward, 1947; Dawson and Escritt 1946; and Shaw, 1945). Although probably less efficient as a soil insecticide, D.D.T. is extensively applied in agricultural pest control, and in North America it has been widely used for the control of the soil dwelling larvae of the Japanese Beetle (Popilio japonica), e.g. Fleming and Maines (1953). Both insecticides have been shown to be extremely persistent in soil. Jameson and Peacock (1952), noted that when crude B.H.C. (13% gamma isomer) was worked into the surface 6" of a loam soil at the rate of 8 lbs. per acre, the material was lost at an exponential rate of 50% per annum. Fleming and Maines (1953) observed that when D.D.T. was used at a rate equivalent to 25 lbs. per acre, 97% and 44% of the original/

original material could be recovered from the soil after 1 and 8 years respectively.

Despite their widespread use in plant protection little detailed work has been directed to the possible repurcussions of these substances on the soil microcosm. Keller (1951) investigated the influence of a proprietory product containing a mixture of D.D.T. and B.H.C. on the fauna of litter and soil in woodland near Frankfort. The material was applied as a surface spray at the rate of 15 g. per 400 m^2, and he reported that, within 4 days, the Arthropoda were completely exterminated in the underlying litter and soil to a depth of 15 cm. Recolonization was said to be rapid, and the rate varied indirectly with the horizontal distance from the edge of the treated area. At a point 6 m. from the edge of the plot it was complete in 23 days. In Russia, Grigor'eva (1952) noted that phytophagous and predacious species in soil were very susceptible to B.H.C. even at low concentrations. On the other hand she found that saprophagous species increased under the influence of low concentrations and were only adversely affected by high dosages.

Baudissin (1952) studied the responses of soil microarthropoda to surface applications of various plant protecting chemicals in two arable fields near Kiel. He reported that B.H.C. had a destructive effect on Acari and Collembola, and this persisted for 5 - 7 weeks in heavy soil, and for 6 - 8 weeks in light soil. A proprietary preparation containing D.D.T. and B.H.C. was noted to have an initial toxic action which lasted for 14 days, but subsequently it appeared to have a stimulating effect. In a complementary study of the same soil, Weber (1953) reported that soil dwelling insect larvae, Diplopoda, and Oligochaeta/

Oligochaeta were adversely affected by both B.H.C. alone and by the combined preparation. The combined preparation appeared to be more toxic to earthworms than B.H.C. alone, but in relation to diplopods and insects the reverse appeared to obtain.

Richter (1953), investigated the effects of various insecticides on the soil and litter microarthropoda of a number of forest habitats near Berlin. Although the ground vegetation was sparse, surface applications of B.H.C. dusts had little effect, but surface treatments with suspension and emulsion formulations of this insecticide caused reductions of mites and *Collembola* which remained apparent for at least 4 months. When B.H.C. dusts were thoroughly incorporated with the soil, by cultivation, severe reductions of all forms were obtained, and the effect persisted for at least ten months. Soil treated in this way was seen to be toxic to *Drosophila* after two years. When B.H.C. dust was roughly dug in and not thoroughly mixed with the soil, it appeared to have a stimulating effect and caused an increase of *Oribatei* and *Collembola*. D.D.T. was reported to cause a reduction of *Acari* and *Collembola*, both when applied to the surface as an emulsion, and when hoed into the soil as a dust.

It is appropriate also to consider, briefly, the more important literature dealing with the effects of these insecticides on mixed Arthropod communities generally. It is well known that under certain conditions insecticide treatments can lead to profound and lasting changes in the composition of Arthropod communities, a notable example being the rise of the Fruit Tree Red Spider (*Metatetranychus ulmi* (Koch)) to pest status since the introduction of tar distillate ovicides, (vide Massee and Steer, 1929, and Blair and Groves, 1952). Following the/

the widespread use of the persistent chlorinated hydrocarbons, undesirable changes in the composition of communities have become increasingly common, and it is significant to note that the Review of Applied Entomology (Series A) for 1949 contained no fewer than 35 references to reports of increases of various species following the use of D.D.T., and 8 to similar phenomena attributable to treatment with B.H.C.

In the case of D.D.T., the most frequent are reports of increased populations of Tetranychid mites. Following its use in orchards for the control of Codling Moth (<u>Cydia pomonella L</u>), infestations of these mites have been widely reported from both Europe and America (Schneider, 1945; Steiner, Arnold and Summerland, 1944, and many others). Similarly in Citrus groves, treatment with this insecticide has commonly led to infestations of <u>Paratetranychus citri</u> Macgregor, (e.g. Ebeling, 1945), while it has also been reported that D.D.T. favours various <u>Aphididae</u> (e.g. Ebeling, 1945), some <u>Coccidae</u> (e.g. Debach and Bartlett, 1951) and certain <u>Lepidoptera</u> (e.g. Chandler 1946; and Newson and Smith 1949).

Disruptions following the use of B.H.C. have been less common, but heavier populations of various species after treatment have been reported. Examples are the reports of Gains and Young (1948) who observed heavy populations of Tetranychid mites on treated cotton, and Gains and Dean (1947), who considered that the Cotton Bollworm, <u>Heliothis armigera</u> (Hb.), was favoured by this substance.

Most workers have attributed these outbreaks to the differential susceptibilities of predators, parasites and prey to the materials employed./

employed. There is much evidence to support this view, and the detailed work of Lord (1949 a,b) on fruit tree communities in Nova Scotia is worthy of special note. He observed that D.D.T., and several other substances commonly used in plant protection had extremely adverse effects on various predacious mites and insects. Many of these he considered to be valuable agents for the natural control of Coccids and Tetranychids. Similarly, Debach and Bartlett (1951) studied the influence of insecticides on the intricate biological control mechanism of Citrus communities. These workers concluded that chemical treatments were likely to affect natural control adversely, not only by their toxic and repellant action on parasite and predator populations, but also by starvation of beneficial species, due to the drastic reduction of host and prey populations.

Whilst not minimizing the importance of predators, a somewhat different assessment was made by Hueck, Kuenen, Boer and Draafsel (1952). Having observed an increase of M.ulmi on D.D.T. treated trees in an orchard from which predators had been eliminated, these workers found that, in laboratory cultures, low concentrations of D.D.T. caused an increase in the egg production of this mite. The results of two of their experiments were highly significant statistically, although in others the observed increase in egg production was not significant, and at higher concentrations there was an indication of toxicity.

From this résumé it will be seen that the reaction of Arthropod communities in general to insecticide treatments presents an interesting and important problem; and that hitherto, studies of such/

such phenomena have been mainly concerned with orchard communities. The soil population appeared to present a convenient community for a quantitative study of these changes, and moreover it also seemed desirable to obtain information on the particular nature of the response of soil microarthropoda themselves to these widely used materials.

III. METHODS OF STUDY

A. Field Investigation.

This consisted of the examination of soil samples taken from the plots of a randomized block experiment in which there were 4 replicates of 6 treatments. These treatments, allocated at random within each block, were as follows:-

1. Uncultivated:- representing the original condition of the area.
2. Control:- cultivated and reseeded.
3. Fallow:- cultivated and kept free from vegetation.
4. D.D.T.:- Cultivated, and soil treated with 2 ozs. per sq. yd. of 2% crude D.D.T. dust (75 - 80% p.p.' isomer), then reseeded.
5. B.H.C.:- cultivated, and soil treated with 2 ozs. per sq. yd. of crude B.H.C. dust (13% gamma isomer), then reseeded.
6. D.D.T. + B.H.C.:- cultivated, and soil treated with 2 ozs. per sq. yd. 2% crude D.D.T., and 2 ozs. per sq. yd 2% crude B.H.C., then reseeded.

The plots were reseeded with 1 oz. per sq. yd. of Perennial Ryegrass (Lolium perenne). Each plot was six feet square, and within the blocks the plots were separated by an uncultivated interval of 12 ft., the blocks themselves being $13\frac{1}{2}$ feet apart. A diagram of the experiment is given in Part I (Fig. I, p 33).

In the case of treatments 2 - 6, the plots were dug over roughly in early January, 1951, and then left to weather until late April. Cultivation was then resumed and continued until a fine/

fine tilth was obtained. The insecticides, previously mixed with silver sand to facilitate even distribution, were applied on the 17th May, 1951, and thoroughly mixed with the soil to a depth of 9", the control and fallow plots being treated with sand alone. The plots were then sown, lightly raked, and rolled twice with a heavy roller. The control and fallow plots all received the same initial cultivations, and, whenever possible, the operations were arranged so that all the plots concerned received an approximately equal amount of cultivation on each occasion. This was considered necessary in order to minimize the possible influence of time of cultivation. The area was mown when necessary, and the fallow plots were kept bare by periodic hoeing of the surface soil.

The sampling and extraction techniques used have already been described. Recapitulating, the sampling programme consisted of two, 2" diameter cores per plot taken on the following dates:- 9th June, 1951, 16th Oct. 1951, 14th Dec. 1951, 20th Feb. 1952, 18th April, 1952, and 17th Oct. 1952. The June samples were subdivided to represent two strata, viz. 0-3", and 3-9" deep, while subsequent samples were only 6" deep and undivided.

B. Laboratory Observations.

1. Toxicity tests.

The desirability of supplementary laboratory observations on the relative susceptibilities of the major Arthropod groups, to the insecticides used, became evident after a preliminary examination of the field population in Autumn, 1951. The technique used was that divised by Martin and Wain (1945), and consists of preparing standard solutions/

solutions of the insecticides in a volatile solvent (e.g. acetone), and pipetting required quantities on to filter paper. The solvent evaporates quickly, leaving a deposit of known weight on the filter paper. For the purpose of these tests, standard acetone solutions of pure p.p'. D.D.T., and 99% gamma B.H.C. (Lindane) were prepared, and used at various rates to treat circles of filter paper 2" in diameter. The Arthropoda to be tested were confined on these papers in 2" diameter Petri dishes. The number of animals used in each test varied and was dependent largely upon the ease by which they could be extracted alive. To eliminate the possibility of testing resistant strains, animals from insecticide treated plots were not used, and the material was collected from untreated areas, and in some cases from other localities.

2. Observations on the effects of D.D.T. in the absence of predators.

The necessity of these observations became apparent after the publication of the work of Hueck et.al (1952) on the influence of D.D.T. on the oviposition rate of *M. ulmi*; for it was thought that the increase of Collembola, which had been observed in the D.D.T. plots, might possibly be due to a similar phenomenon. Owing to the experimental difficulties of culturing sufficient numbers of Collembola under strictly controlled conditions, and the great random variation which obtains in populations reared by less stringent methods, the assessment of this factor constitutes a major problem, and the observations undertaken in the present study were not eminently successful. Attempts were first made to culture *Onychiurus* species and *Tullbergia krausbaueri* on moist filter paper in small dishes. Various food materials were tried, and the most attractive appeared to/

to be moist decaying potato tuber fragments. Although eggs were laid in some cultures the method was too uncertain for experimental purposes. Similar difficulties were experienced with H. denticulata on decaying beech leaves. This method was then abandoned and experiments in which Collembola were reared in an environment from which predatory forms had been eliminated by sterilization were laid down. The first of these, in which H. denticulata was kept in sterile compost was a complete failure owing to the non-survival of animals. In the second, T. krausbaueri, and Onychiurus species were reared in a sterile soil composed of equal parts by weight of farmyard manure, and light soil. After sterilization in an autoclave, 150 gm. quantities of this material were mixed with 4 different rates of 2% crude D.D.T. dust, and placed in 3" pots. 50 individuals of Onychiurus spp. and 50 individuals of T. krausbaueri were than added to each pot and the tops of the pots covered with cellophane. After perforating the cellophane covers with a fine needle, the pots were placed in petri dishes of water in a closed wooden box, and kept in a glasshouse at 18°C. The rates of application (wt. of 2% D.D.T. dust per 150 gm soil) were as follows:- 0 (control), 0.1 gm., 0.2 gm., and 0.4 gm. There were 4 replicates. After 15 weeks the animals were extracted by means of a series of Tullgren funnels.

IV. RESULTS

A. Field Investigation

1. Early Effects. June 1951

The details of the population at this time (23 days after treatment with the insecticides) are given in Census Table 1... Appendix III. For reasons previously noted these samples were considered separately, and, in the method of analysis adopted, degrees of freedom were apportioned as follows:-

Treatments	5
Blocks	3
Interaction treatments x blocks	15
Depth	1
Interaction depth x treatments	5
Interaction depth x blocks	3
Interaction depth x blocks x treatments	15
Total	47

The plot totals for analysis were obtained by summing the square roots of the populations of the upper samples (0 - 3"), and the square roots of half the populations of the lower samples (3 - 9"). Each sample population thus represented the number of animals per 154.4 cc.s. of soil; there were 4 such samples (i.e. 2 upper and 2 lower) in each plot, so that the treatment totals represented the number of animals per 16 x 154.4 cc.s of soil. In Table 1. the treatment densities are represented as a percentage/

TABLE I

COMPARISONS OF POPULATIONS IN THE UPPER 9" OF SOIL, JUNE 1951

Control Populations = 100.0

Group or Species	Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	199.2	40.8	155.4	35.4	46.1
Total Euedaphic Collembola	192.7	41.8	167.3	35.4	49.1
Total Tullberginae	245.7	57.1	391.4	28.6	54.3
Tullbergia krausbaueri	280.9	95.2	61.9	33.3	42.9
Tullbergia crassicuspis	178.6	0	885.7	21.4	71.4
Total Onychiurus spp.	310.0	80.0	160.0	70.0	65.0
Isotomodes productus	78.7	19.1	23.4	23.4	44.7
Folsomia candida	237.5	12.5	50.0	50.0	12.5
Total Hemiedaphic Collembola	231.2	43.7	100.0	31.2	31.2
Total Oribatei	160.2	114.1	51.9	92.2	74.3
Punctoribates punctum	101.5	96.2	48.1	90.1	71.8
Minunthozetes semirufus	277.3	150.0	68.2	86.4	90.9
Total Oribella spp.	225.0	150.0	62.5	150.0	100.0
Total Immature Oribatei	425.0	25.0	50.0	75.0	25.0
Total Acaridiae	620.0	100.0	140.0	200.0	220.0
Rhizoglyphus echinopus	933.3	66.7	200.0	166.7	200.0
Total Other Acaridiae[1]	150.0	150.0	50.0	250.0	250.0
Total Mesostigmata	200.0	51.7	78.3	63.3	33.3
Total Rhodacaridae	158.3	38.9	88.9	66.7	36.1
Rhodacarellus epyginialis	148.4	29.0	87.1	48.4	35.5
Tot. Known Pred. Mesostigmata[2]	283.3	116.7	50.0	66.7	50.0
Total Pergamasus spp.	266.7	100.0	100.0	100.0	0
Total Immature Mesostigmata	185.7	57.1	71.4	64.3	14.3

[1] Total of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

[2] Total of 5 species:- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus and Hypoaspis aculeifer.

percentage of the control density, and the results of the analyses of square root transformed data are summarized in Table 2, standard errors being given when significant values of 'F' were obtained.

Much random variation was encountered and at this time the population generally was at a low level, consequently comparatively few significant treatment comparisons were evident. With some exceptions, the 'observed' trend of the results consisted of a drastic reduction of populations due to cultivation alone, and further smaller reductions in the fallow and insecticide treated plots. In most cases significant differences were obtained only in comparisons of the uncultivated population with those of one or more of the cultivated plots. There were however exceptions; thus, in the case of Total *Mesostigmata*, whilst the uncultivated population was significantly higher than those of all the other plots, the population of the plots treated with D.D.T. + B.H.C., was significantly lower than those of both the control and the plots treated with D.D.T. alone. In the *Rhodacaridae* the comparison uncultivated with control was not significant, but a significant reduction was evident when the control and D.D.T. + B.H.C. populations were compared. In both Total *Mesostigmata*, and Total *Rhodacaridae* the fallow populations were significantly lower than those of the controls.

In many analyses, a significant value was obtained for the interaction of treatments with depth, thus indicating that the responses of the populations to the treatments were not the same in/

TABLE 2

ANALYSIS OF VARIANCE. DATA OF 9th JUNE 1951.

1. Treatment Totals of Square Root Transformed Data, Values of 'F' for Treatment Comparisons and Standard Errors of Treatment Totals.
2. Values of 'F' for the Interaction of Treatments with Depth.

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	Treats. 'F'[1]	S.E.[2]	Inter. 'F'[3]
Total Collembola	52·623	21·142	34·360	35·604	20·115	24·060	3·60*	6·515	1·93
Total Euedaphic Collembola	50·609	19·073	30·615	32·441	17·421	21·563	3·44*	6·684	<1
Total Tullberginae	28·693	10·499	14·691	23·030	6·121	10·267	2·09	-	1·74
Tullbergia krausbaueri	22·930	10·499	11·785	8·174	4·414	6·121	3·97*	3·311	1·25
Tullbergia crassicuspis	10·544	0	6·220	18·756	1·707	4·560	1·67	-	1·68
Total Onychiurus spp.	19·548	8·560	8·212	11·588	7·571	6·702	2·60	-	<1
Isotomodes productus	13·235	3·732	13·550	7·346	5·675	9·452	1·02	-	1·59
Folsomia candida	7·396	0·707	4·853	2·000	2·414	1·000	1·35	-	<1
Total Hemiedaphic Collembola.	17·761	5·000	9·300	9·681	3·414	3·121	4·78**	2·536	4·53*
Total Oribatei	53·568	47·761	45·038	29·426	40·601	36·768	1·38	-	6·93**
Punctoribates punctum	32·274	32·927	33·399	21·530	31·834	26·923	<1	-	5·39**
Minunthozetes semirufus	30·069	22·481	17·904	13·031	14·880	16·977	1·91	-	4·54*
Total Oribella spp.	11·624	7·535	6·121	3·828	6·828	3·450	2·09	-	7·76***
Total Immature Oribatei	8·236	1·000	2·707	1·000	1·707	1·000	2·18	-	3·84*
Total Acaridiae	14·699	4·121	3·414	4·853	5·785	7·681	2·36	-	1·41
Rhizoglyphus echinopus	12·756	1·707	2·414	4·439	3·146	4·535	2·06	-	1·75
Total Other Acaridiae[4]	2·707	2·414	2·000	1·000	2·639	3·146	<1	-	<1
Total Mesostigmata	36·195	14·617	23·005	19·117	16·854	10·078	13·10***	2·500	3·49*
Total Rhodacaridae	22·274	6·864	15·487	13·217	13·273	7·121	5·44**	2·460	<1
Rhodacarellus epyginialis	17·995	4·639	12·237	10·803	8·985	6·535	2·26	-	<1
Total Known Predacious Mesostigmata[5]	12·095	5·242	3·828	2·000	2·707	1·707	9·00***	1·125	3·99*
Total Pergamasus spp.	6·146	2·414	2·121	2·000	1·707	0	1·67	-	4·23*
Total Immature Mesostigmata	14·362	5·828	9·078	6·414	5·346	1·414	3·95*	2·182	8·99***

1. Degrees of freedom:- $n_1 = 5$, $n_2 = 15$. Significance levels indicated thus:- $p = 0·05$*, $p = 0·01$**, $p = 0·001$***.
2. 15 D.F. Values of $\sqrt{2}t$:- p0·05, 3·013; p0·01, 4·167; p0·001, 5·759.
3. Degrees of freedom:- $n_1 = 5$, $n_2 = 15$
4. Totals of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.
5. Totals of 5 species:- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus, and Hypoaspis aculeifer.

in both strata, and that as a result of this the nature of the vertical distribution of the animals might have been altered by the treatments. Cases in which this interaction was significant were examined further, and the results are recorded in Tables 3 and 4. In Table 3 it will be seen that significant reductions due to cultivation were confined to comparisons between upper populations, and the data in Table 4 indicates that in some cases, and particularly in the Cribatei, there was a tendency towards a more even vertical distribution of animals in the cultivated plots. Appreciable populations of M. semirufus and P. punctum were encountered, and in both these species a more even vertical distribution was evident in the cultivated soil. In the latter species, moreover, the populations in the lower stratum of all cultivated plots, with the exceptions of those treated with D.D.T. were significantly higher than the lower stratum populations of the uncultivated plots, and it is strange to note that in this stratum the D.D.T. populations was significantly lower than that treated with B.H.C. In the remaining groups and species recorded in Table 4, and particularly in the case of hemiedaphic Collembola, the occurrence of a significant interaction of treatments with depth could be attributed largely to the paucity or absense of animals in the lower stratum of all plots.

2. Subsequent Trends. October 1951-October 1952

The details of the population on the 5 subsequent sampling occasions, viz. October and December 1951 and February, April and October, 1952, are presented in Census Tables II - VI...

Appendix/

TABLE 3

INTERACTION OF TREATMENTS WITH DEPTH

Analysis of Upper and Lower Population Densities

Treatment Totals of Square Root Transformed Data

Group or Species	Depth	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	'F'[1]	S.E.[2]
Total Hemiedaphic	0-3"	15·347	5·000	9·300	5·146	1·000	1·414	5·62**	2·277
Collembola	3-9"	2·414	0	0	4·535	2·414	1·707	1·71	-
Total	0-3"	43·672	30·973	26·824	18·665	18·827	19·084	3·43*	5·347
Oribatei	3-9"	9·896	16·788	19·214	10·761	21·774	17·684	2·27	-
Punctoribates	0-3"	28·446	20·142	20·179	13·376	14·782	13·484	1·52	-
punctum	3-9"	3·828	12·785	13·220	8·154	17·052	13·439	3·70*	2·429
Minunthozetes	0-3"	24·716	15·297	8·210	7·863	7·095	10·124	4·21*	3·315
semirufus	3-9"	5·353	7·184	9·694	5·168	7·785	6·853	<1	-
Total	0-3"	10·210	4·414	3·000	3·828	2·000	0	6·31**	1·376
Oribella spp.	3-9"	1·414	3·121	3·121	0	4·828	3·450	1·85	-
Total Immature	0-3"	8·236	1·000	1·000	0	0	1·000	3·24*	1·754
Oribatei	3-9"	0	0	1·707	1·000	1·707	0	1·44	-
Total	0-3"	22·946	5·863	10·913	7·414	6·551	2·000	9·52***	2·360
Mesostigmata	3-9"	13·249	8·754	12·092	11·703	10·303	8·078	1·86	-
Total Known[3]	0-3"	8·974	2·414	0	1·000	1·000	0	8·91***	1·146
Pred. Mesostigmata	3-9"	3·121	2·828	3·828	1·000	1·707	1·707	1·34	-
Total	0-3"	6·146	1·707	0	1·000	0	0	3·28*	1·320
Pergamasus spp.	3-9"	0	0·707	2·121	1·000	1·707	0	1·43	-
Total Immature	0-3"	12·655	2·000	4·732	2·000	1·000	0	9·77***	1·487
Mesostigmata	3-9"	1·707	3·828	4·346	4·414	4·346	1·414	1·12	-

1. Degrees of freedom:- $n_1 = 5$, $n_2 = 15$. Significance levels indicated thus:- p0·05*, p0·01**, p0·001***

2. 15 D.F. Values of $\sqrt{2}\,t$:- p0·05, 3·013; p0·01, 4·167; p0·001, 5·759.

3. Totals of 5 species:- *Veigaia nemorensis*, *Pergamasus runiger*, *P. misellus*, *Digamasellus reticulatus*, and *Hypoaspis aculeifer*.

TABLE 4

INTERACTION OF TREATMENTS WITH DEPTH

Percentage of Sampled Population (9" Deep) Located in the Upper 3" of Soil

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Hemiedaphic Collembola	89.2	100.0	100.0	43.7	20.0	40.0
Total Oribatei	87.6	59.1	50.5	50.5	29.5	39.2
Punctoribates punctum	92.5	57.1	55.7	46.0	29.7	39.4
Minunthozetes semirufus	84.4	57.6	31.8	46.7	39.5	47.5
Total Oribella spp.	88.9	41.7	37.5	100.0	16.7	0
Total Immature Oribatei	100.0	100.0	25.0	0	0	100.0
Total Mesostigmata	57.5	32.3	31.7	17.0	23.7	10.0
Tot. Known Pred. Mesostigmata[1]	70.6	42.9	0	33.3	25.0	0
Total Pergamasus spp.	100.0	66.7	0	33.3	0	-
Total Immature Mesostigmata	88.5	25.0	42.9	20.0	11.1	0

[1] Total of 5 species:- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus and Hypoaspis aculeifer.

Appendix III. The samples taken at these times were all the same size, and, initially, the populations of a number of the more important groups and constituent species were each subjected to a single grand analysis over all five occasions; further examinations being undertaken when the results of the initial analysis indicated such a course to be necessary. In the case of the groups and species selected for analysis, the treatment totals of the untransformed data for each sampling occasion are presented in Summary Tables A - E (Appendix II). The 120 plot totals for analysis were obtained by summing the square roots of the 2 original sample populations in each plot, and the 119 total degrees of freedom thus available were apportioned as follows:-

Treatments	5
Blocks	3
Times of sampling	4
Treatments x blocks	15
Blocks x times	12
Treatments x times	20
Treatments x blocks x times	60

The mean square for treatments x blocks was used as the denominator for assessing the significance of treatment differences, and the 2nd order interaction (treatments x blocks x times) mean square was used as the denominator for assessing the significance of the treatments x times interaction.

A comparison of the average populations of each treatment is presented in Table 5. Here the average populations of each treatment/

TABLE 5

DATA OF OCTOBER 1951 - OCTOBER 1952

COMPARISONS OF AVERAGE POPULATIONS

Control populations = 100.0

Group or Species	Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	120.5	20.4	210.3	33.3	85.1
Total Euedaphic Collembola	127.1	18.0	229.8	22.5	74.7
Total Tullberginae	150.0	27.8	457.7	38.6	130.4
Tullbergia krausbaueri	178.4	31.8	179.9	34.8	45.1
Tullbergia crassicuspis	71.2	21.2	1497.5	58.7	462.5
Total Onychiurus spp.	145.3	15.8	217.0	22.3	58.7
Isotomodes productus	85.7	8.5	52.2	8.5	57.3
Folsomia candida	132.8	17.2	96.9	15.6	22.4
Total Hemiedaphic Collembola	105.9	21.8	153.4	64.4	112.1
Total Oribatei	366.0	58.5	60.4	29.2	36.1
Punctoribates punctum	243.1	57.5	54.9	38.6	44.4
Minunthozetes semirufus	419.0	51.3	41.8	22.1	19.0
Total Oribella spp.	596.3	29.6	122.2	18.5	18.5
Total Immature Oribatei	500.0	96.3	74.1	22.2	81.5
Total Acaridiae	171.2	42.0	52.0	22.0	290.0
Rhizoglyphus echinopus	377.1	33.3	143.7	45.8	39.6
Total Other Acaridiae[1]	122.3	44.1	30.2	16.3	349.5
Total Mesostigmata	203.2	56.0	37.4	29.3	12.4
Total Rhodacaridae	217.6	40.2	47.2	19.5	11.9
Rhodacarellus epyginialis	232.1	37.0	79.0	18.5	14.8
Tot. Known Pred. Mesostigmata[2]	274.1	44.4	29.6	57.4	14.8
Total Pergamasus spp.	284.8	54.5	36.4	87.9	15.1
Total Immature Mesostigmata	144.4	90.1	34.6	27.2	9.9

[1] Total of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

[2] Total of 5 species:- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus and Hypoaspis aculeifer.

treatment over the 5 occasions (untransformed data) are represented as a percentage of the respective control populations. The significance of these differences is noted in Table 6, where the results of the statistical analyses outlined above are summarized. Here, values of 'F' for the treatment comparisons, and for the interaction of treatments with time, are given. The treatment totals over the 5 occasions noted in this table refer to square root transformed data, and, in cases where a significant value of 'F' was obtained for treatment comparisons, the standard errors are given.

These results can be conveniently dealt with under two headings (a) Main effects, i.e. overall treatment differences, and (b) The interaction of treatments with time. In Table 6, the analysis of the differences between treatment totals is an assessment of the significance of the average response of the population over the 5 occasions, while the value of 'F' for the interaction treatments x times is a measure of the significance of the extent to which the effectiveness of the treatments varied according to the time of sampling. A significant value for this interaction indicates that the effectiveness of the treatments varied significantly from one occasion to another; consequently, in such cases, further examination was necessary.

a. Main Effects (overall treatment differences)

Of the results noted in Tables 5 and 6, the more important are as follows:-

1. Collembola

a. With the exception of *I. productus* and *T. crassicuspis*, there/

TABLE 6

ANALYSIS OF VARIANCE, OCTOBER 1951 - OCTOBER 1952 DATA

1. Treatment Totals of Square Root Transformed Data, Values of 'F' for Treatment Comparisons, and Standard Errors of Treatment Totals.
2. Values of 'F' for the Interaction of Treatments with Time.

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	Treats 'F'[1]	S.E.[2]	Inter 'F'[3]
Total Collembola	258.519	106.177	236.278	343.545	132.163	210.864	22.48***	18.287	1.82*
Total Euedaphic Collembola	224.250	82.443	200.236	306.405	93.323	165.804	16.02***	21.075	1.39
Total Tullberginae	135.654	54.973	113.999	238.125	67.232	123.250	11.32***	19.368	1.49
Tullbergia krausbaueri	118.556	45.719	90.908	116.984	49.580	56.693	10.77***	10.213	1.66
Tullbergia crassicuspis	29.494	14.560	42.676	167.674	28.024	95.856	4.19*	28.608	<1
Total Onychiurus spp.	93.902	26.569	87.931	129.118	29.378	59.865	4.57**	18.726	<1
Isotomodes productus	79.976	18.852	84.947	57.972	18.706	48.068	4.49*	13.550	1.51
Folsomia candida	69.839	19.481	73.544	68.540	19.069	26.947	4.32*	12.959	1.49
Total Hemiedaphic Collembola	115.293	46.874	109.747	136.252	81.431	111.580	13.24***	8.365	2.47**
Total Oribatei	216.048	83.532	109.688	85.227	57.046	65.033	10.01***	18.473	2.56**
Punctoribates punctum	96.245	44.038	57.270	44.179	30.443	39.047	4.02*	11.684	2.78**
Minunthozetes semirufus	137.542	34.091	60.465	29.735	20.238	18.860	14.13***	12.071	2.43*
Total Oribella spp.	60.422	7.414	18.948	20.610	4.414	4.414	6.66**	8.266	2.62**
Total Immature Oribatei	52.778	17.134	17.974	16.650	4.828	12.346	3.15*	9.388	<1
Total Acaridiae	88.123	42.557	60.617	56.634	25.925	63.021	2.64	-	1.97*
Rhizoglyphus echinopus	58.939	10.878	20.693	32.167	14.064	13.242	3.06*	10.469	1.02
Total Other Acaridiae[4]	39.901	34.768	40.013	29.507	12.543	53.072	1.34	-	1.65
Total Mesostigmata	158.700	82.095	111.460	64.301	56.004	30.628	18.89***	10.473	1.56
Total Rhodacaridae	104.377	36.015	68.865	40.036	20.624	14.382	10.12***	10.613	<1
Rhodacarellus epyginialis	72.547	19.726	48.120	34.880	11.974	9.732	7.71***	8.754	<1
Total Known Predacious[5] Mesostigmata	65.442	17.720	33.380	12.242	25.691	8.000	15.16***	5.369	1.13
Total Pergamasus spp.	50.672	13.478	22.276	10.146	24.478	5.000	14.72***	4.243	<1
Total Immature Mesostigmata	59.947	42.874	47.595	22.974	18.974	6.828	16.54***	4.940	<1

1 Degrees of freedom :- $n_1 = 5$, $n_2 = 15$. Significance levels indicated thus:- $p = 0.05$*, $p = 0.01$**, $p = 0.001$***

2 15 D.F. Values of $\sqrt{2}t$:- p 0.05, 3.013; p 0.01, 4.167; p 0.001, 5.759.

3 Degrees of freedom :- $n_1 = 20$, $n_2 = 60$

4 Total of 3 species :- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

5 Total of 5 species :- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus and Hypoaspis aculeifer.

there was an observed reduction in the population due to cultivation and re-seeding alone. This reduction was greatest in T. krausbaueri where the average population of the uncultivated plots was 78% greater than the control. In the case of I.productus and T.crassicuspis cultivation alone resulted in observed population increases of 17% and 40% respectively. In no case, however, was there a statistically significant difference between the uncultivated and control populations.

b. In all cases fallowing resulted in severe population reductions, and with one exception, viz. T. crassicuspis, which showed a non-significant reduction, the populations in the fallow plots were significantly lower than those in the control.

c. With the exception of I. productus and F. candida, treatment with D.D.T. resulted in observed increases in the population. Taking Collembola as a whole, the population in the D.D.T. plots was 110% greater than that of the control. The greatest increase however was shown by T. crassicuspis; the population of this species in the D.D.T. plots being nearly 15 times that of the control. In the latter case however the variation was so great that this difference was only significant at the 5% probability level. The differences between the control and D.D.T. populations were statistically significant in the following cases:- Total Collembola, Total Euedaphic Collembola, Total Tullberginae, T. crassicuspis, and Total Hemiedaphic Collembola.

d. In all cases, treatment with B.H.C. resulted in a marked reduction of the population, and, with the exception of Total Tullberginae and T. crassicuspis, the populations of the B.H.C. plots/

plots were significantly lower than those of the control. Moreover in the analyses of major groups viz. Total Collembola, Total Euedaphic Collembola, and Total Hemiedaphic Collembola, the population of the B.H.C. plots was significantly lower than those of all the other plots in the experiment, with the exception of those receiving the fallow treatment.

e. In all cases the populations treated with D.D.T. + B.H.C. were observed to be higher than those treated with B.H.C. alone. In the analyses of Total Collembola, and Total Euedaphic Collembola, the populations of the plots receiving both insecticides did not differ significantly from the control, were significantly higher than those treated with B.H.C. alone, and significantly lower than those treated with D.D.T. alone. Only in one case, viz. *T. krausbaueri* was the D.D.T. + B.H.C. population significantly lower than the control.

2. Acari, Oribatei

Unlike Collembola, the responses of these mites to the treatments were such that significant differences between the population totals over all occasions were infrequent; this being particularly so in relation to the influence of insecticides. However the results of the analyses of Oribatid populations were outstanding by virtue of the frequent occurrence of significant values for the time x treatments interaction, and thus their responses to the treatments have to be assessed in relation to the results of the further examination described below. The overall effects of the treatments can first be summarized briefly as/

as follows.

a. Cultivation resulted in a great reduction of the population and in all cases the control populations were significantly lower than those of the uncultivated plots.

b. While the populations of the fallow plots were in all cases lower than the controls, in no case was this difference significant.

c. With the exception of Total Oribella species, treatment with D.D.T. resulted in an 'observed' reduction of the population. However, no significant differences could be attributed to this treatment.

d. Severe reductions in the population were observed in the B.H.C. plots, but only in the case of M. semirufus was the difference control - B.H.C. significant.

e. The D.D.T. + B.H.C. population was always less than that of the control, but this difference was significant only in the analysis of M. semirufus. When compared with B.H.C. population, the population of the plots receiving both insecticides showed a further reduction only in the case of M. semirufus; in the case of immature Oribatei it was considerably higher, whilst in the remaining cases it was either similar or slightly higher. In no case was there a significant D.D.T. + B.H.C. - B.H.C. comparison.

3./

3. Acari, Acaridiae

The examination of the data for this group of mites yielded significant results only in the analysis of R. echinopus, and here the uncultivated population was the only one which differed significantly from that of the control. The remaining non-significant responses were briefly as follows:-

a. Cultivation alone reduced the population. (This reduction was due almost entirely to the response of R. echinopus).

b. A further general reduction was apparent as a result of fallowing.

c. In the case of R. echinopus the D.D.T. treated population was 44% higher than the control, whilst the population of "Other Acaridiae" was reduced by this treatment.

d. In all cases treatment with B.H.C. resulted in a reduced population.

e. The R. echinopus population was low in the D.D.T. + B.H.C. plots, but "Other Acaridiae" attained their greatest abundance in these plots. This high level however could be attributed to the occurrence of a large aggregate of these mites in D.D.T. + B.H.C. plot of Block 4 in October 1952.

4. Acari, Mesostigmata

a. Cultivation alone was observed to cause a reduction in the population of all these mites, the total density of the Mesostigmatic population of the uncultivated soil being more than twice that of the control. Significant control - uncultivated comparisons were evident in all but two cases; the exceptions being/

being *R. epyginialis* and Total Immature *Mesostigmata*.

b. Fallowing resulted in a further general reduction, but significant fallow - control comparisons occurred only in the analysis of Total *Rhodacaridae*, and *R. epyginialis*.

c. The populations of the D.D.T. plots were in all cases observed to be lower than control. In the analyses of Total *Mesostigmata*, Total Known Predacious *Mesostigmata*, and Total Immature *Mesostigmata*, the reduction due to D.D.T. was significant. In the analysis of *Pergamasus* species this difference did not quite attain the 5% level of significance, whilst in Total *Rhodacaridae*, and *R. epyginialis* it was not significant.

d. A reduction due to B.H.C. was evident in all cases, and was significant in all cases except Total Known Predacious *Mesostigmata*, and Total *Pergamasus* species. In the latter species the observed reduction attributable to this treatment was only 12%.

e. The lowest populations of *Mesostigmata* obtained in the plots treated with both insecticides, and in all cases the population of the D.D.T. + B.H.C. plots were significantly lower than the control. In the analysis of Total *Mesostigmata*, and Total Immature *Mesostigmata* this population was significantly lower than those of all the other plots except those treated with B.H.C. Furthermore, significant reductions in comparisons with populations treated with B.H.C. alone were evident in the analyses of Total Known Predacious *Mesostigmata* and Total *Pergamasus* species.

b./

b. The interaction of treatments with time

In a number of analyses significant values of 'F' were obtained for the interaction of treatments with time, thus indicating that the response to the treatments varied significantly according to the time of sampling. Hence, in these cases, overall analyses of treatment differences are in themselves inadequate. Where appropriate therefore, the data were analysed separately for each of the five occasions, and, depending on the results of this, a further examination was made, particularly in relation to the question of recolonization. In this paper, this term is used in a wide sense to designate a process whereby a community is restored to its original condition, and hence not of necessity consisting of an increase of population. The possibility of the occurrence of progressive changes of at least two types has to be considered, viz. the recolonization of the re-seeded control plots, possibly leading to the restoration of the uncultivated community; and the recolonization of the insecticide treated plots, possibly resulting in approximations to the control or even to the uncultivated population. It is also important to note that whilst the absence of significant recolonization (over the October 1951 - October 1952 period) is shown by a non-significant interaction of treatments with time, the occurrence of a significant value for the latter is not necessarily an indication of the significance of the former, for other changes, e.g. further divergence, could influence the value of this mean square.

Where/

Where an initial comparison of the treatment responses of October 1951 with those of October 1952, suggested the possibility of recolonization, or further divergence, an assessment of the significance of these changes was made. This was done by tabulating the October 1952 and October 1951 populations for each plot (transformed data), and using the differences (October 1952 minus October 1951) as a measure of the annual rate of change of the populations of each plot. A "between plots" analysis was then made, and the significance of treatment differences assessed.

The main results of these examinations can be summarized as follows:-

Collembola

1. Total Hemiedaphic Collembola (Fig. 1. Tables 7 and 8)

This was the only constituent group of "Total Collembola" in which the times x treatment interaction was significant.

a. The analysis of the October 1951 data revealed no significant comparison.

b. At no time was there a significant difference between the uncultivated and control populations.

c. The fallow population was significantly lower than the control on the last 4 sampling occasions.

d. The D.D.T. treated population was observed to be higher than the control at all times, but this difference was only significant in April, 1952.

e. Treatment with B.H.C. induced significant reductions only in April and October 1952.

f./

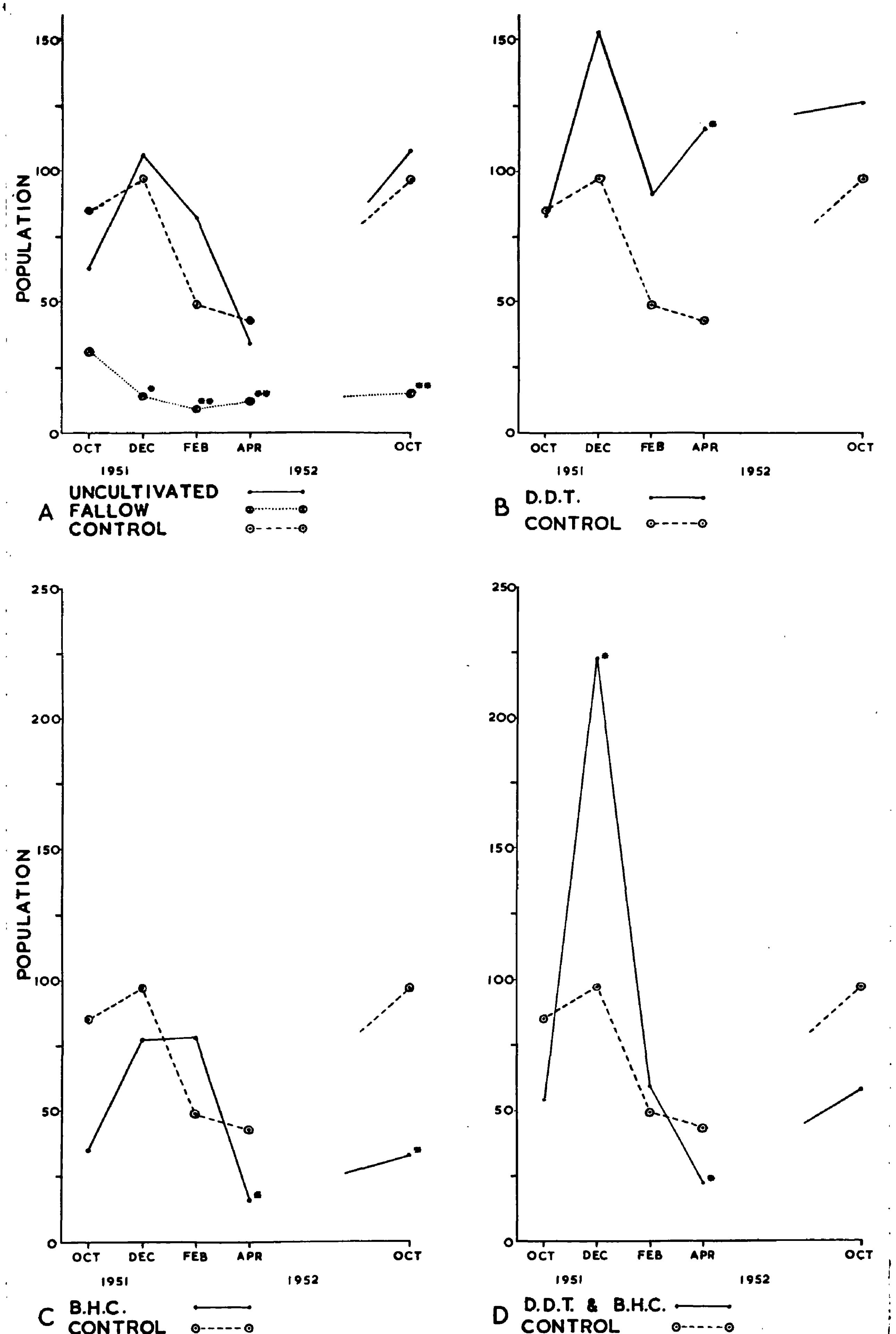

FIG 1. INTERACTION OF TREATMENTS WITH TIME. TOT. HEMIEDAPHIC COLLEMBOLA.
Points differing significantly from control indicated thus:-
p - 0.05*, p - 0.01**

TABLE 7

INTERACTION OF TREATMENTS WITH TIME

TOTAL HEMIEDAPHIC COLLEMBOLA

Population Comparisons for 5 Occasions

Date	Total Control Population	Treatment Comparisons Control = 100.0				
		Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Oct. 51	85	74.1	36.5	97.6	41.2	63.5
Dec. 51	97	109.3	14.4	157.7	79.4	229.9
Feb. 52	49	167.3	18.4	185.7	159.2	120.4
Apr. 52	43	79.1	27.9	269.8	37.2	51.2
Oct. 52	97	111.3	15.5	129.9	34.0	59.8

TABLE 8

INTERACTION OF TREATMENTS WITH TIME

TOTAL HEMIEDAPHIC COLLEMBOLA

A. ANALYSIS OF SQUARE ROOT TRANSFORMED DATA FOR 5 OCCASIONS

Treatment Totals

Date	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
Oct. 51.	21.616	14.958	24.582	23.655	15.911	20.652	1.71	-
Dec. 51.	28,795	8.878	22.912	30.634	21.955	40.639	5.88^{**}	4.372
Feb. 52	23.985	5.650	18.568	23.741	20.940	20.479	5.18^{**}	2.991
Apr. 52	12.968	7.560	18.363	27.730	8.974	10.828	9.26^{***}	2.478
Oct. 52	27.929	9.828	25.322	30.492	13.651	19.582	5.44^{**}	3.521

B. ANALYSIS OF ANNUAL RATES OF CHANGE OF SQUARE ROOT TRANSFORMED POPULATIONS

Treatment Totals

Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]
+6.313	-5.130	+0.740	+6.837	-2.260	-0.470	1.15

[1] Degrees of freedom :- n_1 - 5, n_2 - 15. Significance levels indicated thus:- p - 0.05*, p - 0.01**, p - 0.001***.

[2] 15 D.F. Values of $\sqrt{2}t$:- p - 0.05, 3.013; p - 0.01, 4.167; p - 0.01, 5.759.

f. An interesting response was evident in the population treated with the mixture of both insecticides. This population increased in December, 1951, to a point 130% higher than the control, the difference here being significant at the 5% probability level. The population then fell, and in February was similar to the control, while in April it was significantly lower than the latter. Finally, in October 1952, the D.D.T. + B.H.C. population was still lower than the control only at this time the difference was not significant.

g. When compared with the responses in October 1951, the results for D.D.T. and for B.H.C. in October 1952, suggested some slight further divergence from the control. The analysis of rates of annual change, however, revealed no significant difference.

Oribatei

1. Punctoribates punctum (Fig.2. Tables 9 and 10)

a. Significant differences were obtained only in the analyses of the October 1951 and October 1952 data.

b. In October 1951, the uncultivated population was over 3 times heavier than the control, the difference here being significant at the 1% probability level. This was the only occasion on which the uncultivated - control comparison was significant. The seasonal fluctuation of the control was much less marked than that of the uncultivated population.

c. The fallow population was at all times lower than the control but on no occasion were the differences significant.

d. The D.D.T. population differed significantly from the control only/

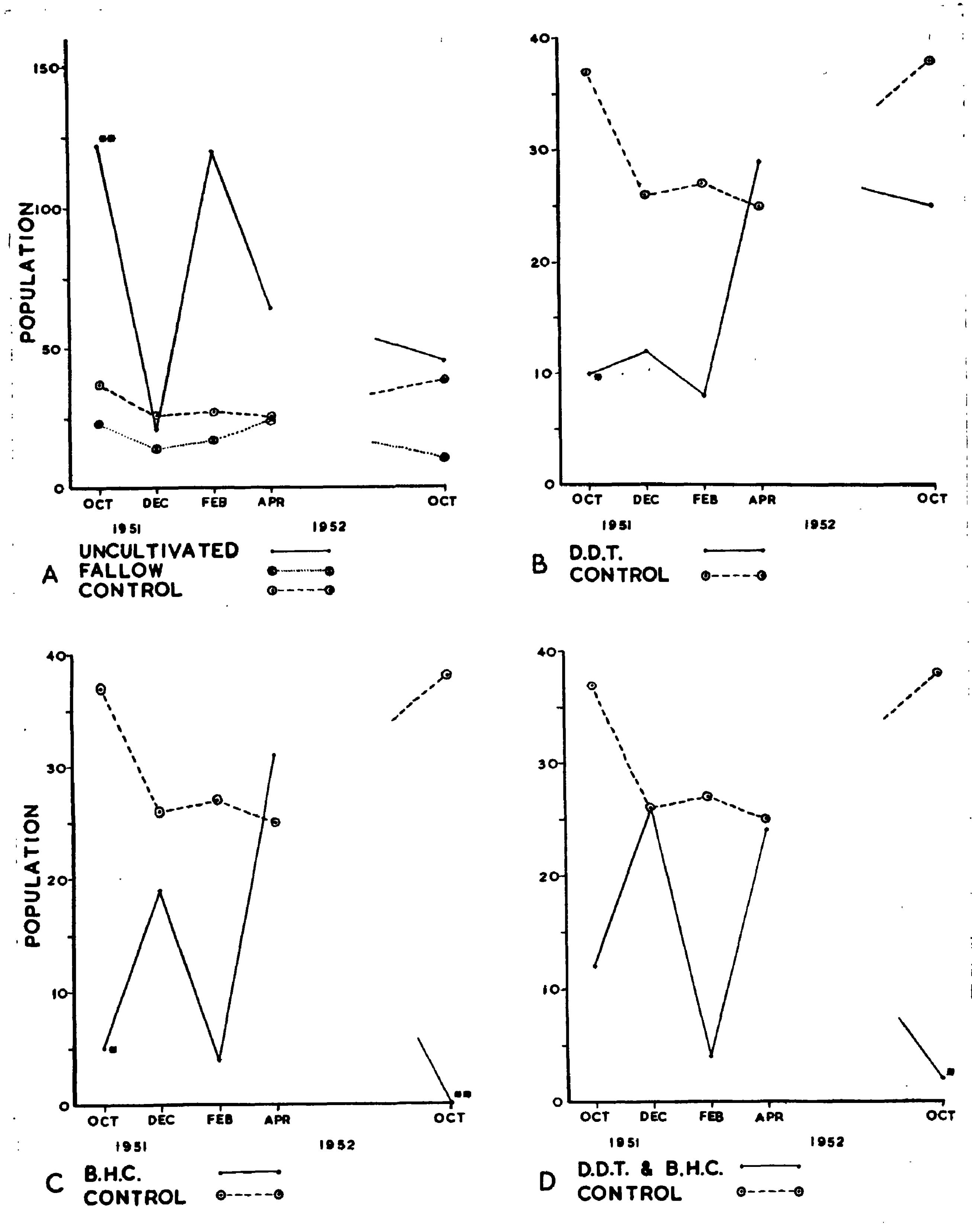

FIG. 2. INTERACTION OF TREATMENTS WITH TIME. PUNCTORIBATES PUNCTUM. Points differing significantly from control indicated thus:- p - 0.05*, p - 0.01**

TABLE 9

INTERACTION OF TREATMENTS WITH TIME

PUNCTORIBATES PUNCTUM

Population Comparisons for 5 Occasions

Date	Total Control Population	Treatment Comparison Control=100.0				
		Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Oct. 51	37	329.7	62.2	27.0	13.5	32.4
Dec. 51	26	80.8	53.8	46.1	73.1	100.0
Feb. 52	27	444.4	63.0	29.6	14.8	14.8
Apr. 52	25	256.0	96.0	116.0	124.0	96.0
Oct. 52	38	118.4	26.3	65.8	0	5.3

TABLE 10

INTERACTION OF TREATMENTS WITH TIME

PUNCTORIBATES PUNCTUM

A. ANALYSIS OF SQUARE ROOT TRANSFORMED DATA FOR 5 OCCASIONS

Treatment Totals

Date	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
Oct. 51	27.827	10.049	14.625	4.000	3.732	6.796	12.12***	2.622
Dec. 51	10.145	7.792	9.636	8.292	8.553	13.245	<1	-
Feb. 52	22.522	8.614	8.422	5.414	2.732	4.000	2.19	-
Apr. 52	19.119	11.519	13.032	14.448	15.426	13.592	1.28	-
Oct. 52	16.632	6.064	11.555	12.025	0	1.414	5.77**	2.729

B. ANALYSIS OF ANNUAL RATES OF CHANGE OF SQUARE ROOT TRANSFORMED POPULATIONS

Treatment Totals

Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
-11.195	-3.985	-3.070	+8.025	-3.732	-5.382	4.43*	2.971

[1] Degrees of freedom :- n_1 - 5, n_2 - 15. Significance levels indicated thus:- p - 0.05*, p - 0.01**, p - 0.001***.

[2] 15 D.F. Values of $\sqrt{2}t$:- p - 0.05, 3.013; p - 0.01, 4.167; p - 0.001, 5.759.

only in October 1951, when it was 73% lower than the latter. In April 1952 this population was observed to be 16% higher than the control, but in October 1952 a non-significant decrease of 34% was apparent.

e. The B.H.C. population was significantly lower than the control in October 1951 and October 1952. On intermediate occasions no significant differences were apparent, whilst in April 1952, the population receiving this treatment attained a point 24% higher than the control.

f. The D.D.T. + B.H.C. population was significantly lower than the control only in October 1952. In October 1951 the observed reduction of 68% was barely significant. Much fluctuation was evident in this population for it was similar to the control in December 1951 and in April 1952, while these two maxima were separated by a low February population.

g. The analysis of annual rates of change revealed significant treatment comparisons. A comparison of the square root transformed data showed that whilst the control population in October 1952 was slightly lower than in October 1951 (in the original data a slight increase was apparent), the D.D.T. population increased considerably during this period. Taking direction into consideration, the change in the D.D.T. population differed significantly from those of all the other treatments. No other comparison was significant.

2. Minunthozetes semirufus (Fig.3. Tables 11 and 12)

a. The analyses revealed significant treatment responses at all times/

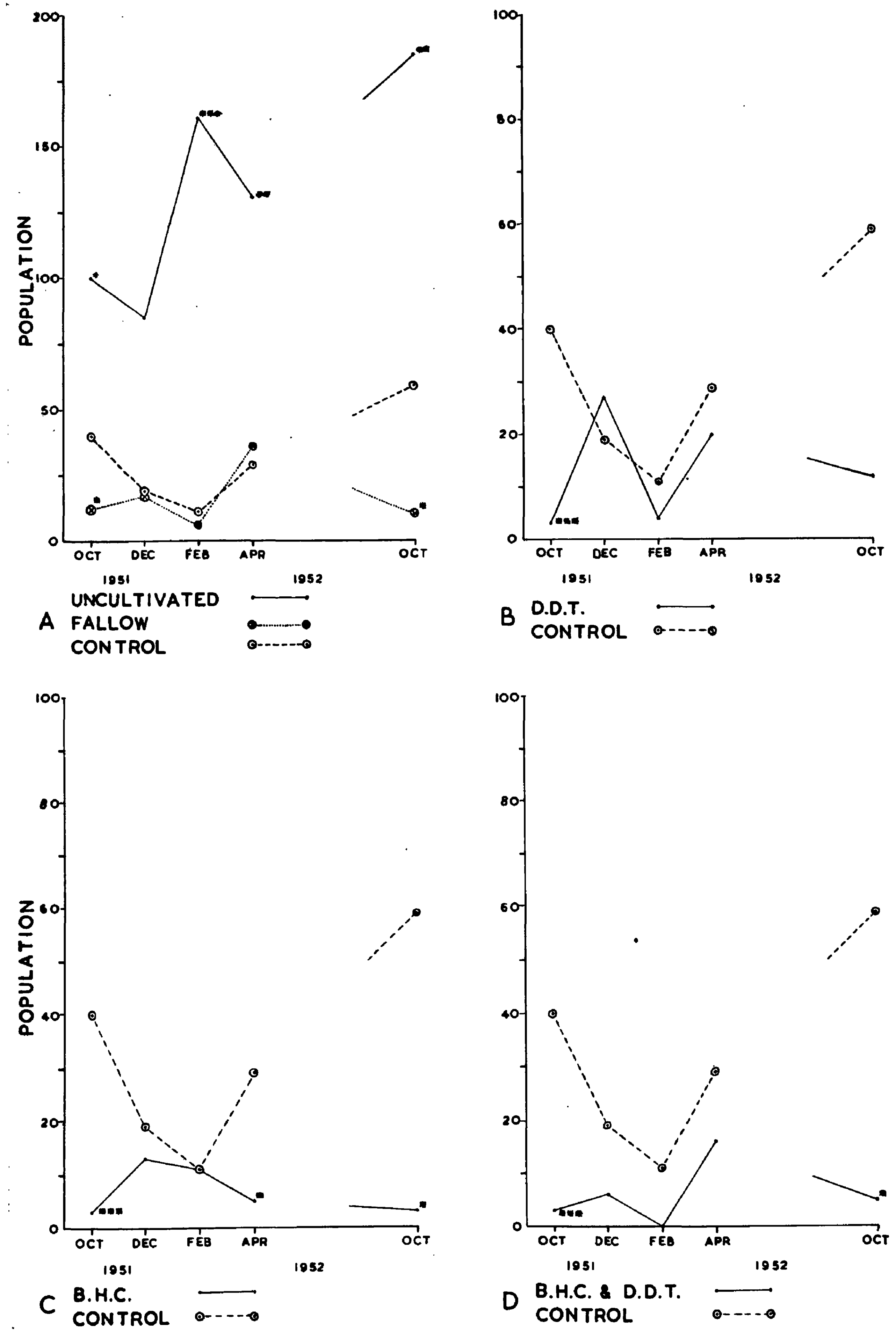

FIG. 3. INTERACTION OF TREATMENTS WITH TIME. MINUNTHOZETES SEMIRUFUS
Points differing significantly from control indicated thus:-
p - 0.05*, p - 0.01**, p - 0.001***

TABLE II

INTERACTION OF TREATMENTS WITH TIME

MINUNTHOZETES SEMIRUFUS

Population Comparisons for 5 Occasions

Date	Total Control Population	Treatment Comparisons Control = 100.0				
		Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Oct. 51	40	250.0	30.0	7.5	7.5	7.5
Dec. 51	19	447.4	89.5	142.1	68.4	31.6
Feb. 52	11	1463.6	54.5	36.4	100.0	0
Apr. 52	29	451.7	124.1	69.0	17.2	55.2
Oct. 52	59	313.6	16.9	20.3	5.1	8.5

TABLE 12

INTERACTION OF TREATMENTS WITH TIME

MINUNTHOZETES SEMIRUFUS

A. ANALYSIS OF SQUARE ROOT TRANSFORMED DATA FOR 5 OCCASIONS

Treatment Totals

Date	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
Oct. 51	25.745	6.732	16.936	1.732	1.732	1.732	16.92***	2.448
Dec. 51	20.012	8.464	8.528	8.936	5.882	4.828	1.67	-
Feb. 52	28.172	4.146	6.382	2.732	6.382	0	13.93***	2.729
Apr. 52	28.225	10.921	12.906	10.650	3.828	10.064	7.48**	2.988
Oct. 52	35.388	3.828	15.713	5.685	2.414	2.236	12.55***	3.674

B. ANALYSIS OF ANNUAL RATES OF CHANGE OF SQUARE ROOT TRANSFORMED POPULATIONS

Treatment Totals

Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]
+9.643	-2.904	-1.223	+3.953	+0.682	+0.504	1.32

[1]Degrees of freedom:- n_1- 5, n_2- 15. Significance levels indicated thus:- p - 0.05*, p - 0.01**, p - 0.001***.

[2]15 D.F. Values of $\sqrt{2}t$:- p - 0.05, 3.013; p - 0.01, 4.167; p - 0.01, 5.759.

times except December 1951.

b. The uncultivated population was at all times higher than the control and, with the exception noted above, these differences were significant.

c. The fallow population was significantly lower than control only in October 1951 and October 1952. In April 1952 this population was observed to be higher than the control, but at other times non-significant reductions were apparent.

d. In October 1951, the D.D.T. population was significantly lower than the control. In December 1951, this population was seen to exceed the control (non-significantly) whilst at other times non-significant reductions were observed.

e. The B.H.C. population was significantly lower than the control on occasions other than December 1951 and February 1952. On the latter occasion these two populations were similar.

f. In October 1951 and October 1952 significant reductions could be attributed to treatment with D.D.T. + B.H.C. On other occasions comparisons with the control revealed non-significant reductions.

g. The analysis of annual rates of change revealed no significant treatment differences.

3. <u>Total Oribella sp.</u> (Tables 13 and 14)

a. The analyses revealed significant treatment comparisons on all occasions except February and April 1952.

b. The uncultivated population was at all times higher than the control, but significantly so only in October 1951 and October 1952.

c. The control population was low at all times, and on no occasion were/

TABLE 13

INTERACTION OF TREATMENTS WITH TIME

TOTAL ORIBELLA SPP.

Population Comparisons for 5 Occasions

Date	Total Control Population	Treatment Comparisons Control = 100.0				
		Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Oct. 51	5	740.0	80.0	340.0	20.0	40.0
Dec. 51	5	300.0	20.0	120.0	20.0	0
Feb. 52	6	450.0	0	33.3	50.0	0
Apr. 52	6	350.0	16.7	116.7	0	50.0
Oct. 52	5	1220.0	40.0	20.0	0	0

TABLE 14

INTERACTION OF TREATMENTS WITH TIME

TOTAL ORIBELLA SPP.

A. ANALYSIS OF SQUARE ROOT TRANSFORMED DATA FOR 5 OCCASIONS

Treatment Totals

Date	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
Oct. 51	15.178	4.000	3.828	7.878	1.000	2.000	5.66**	2.197
Dec. 51	6.708	1.000	3.000	6.000	1.000	0	3.53*	1.500
Feb. 52	9.587	0	4.828	2.000	2.414	0	2.80	-
Apr. 52	9.921	1.000	4.146	3.732	0	2.414	2.69	-
Oct. 52	19.028	1.414	3.146	1.000	0	0	8.21***	2.584

B. ANALYSIS OF ANNUAL RATES OF CHANGE OF SQUARE ROOT TRANSFORMED POPULATIONS

Treatment Totals

Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]
+3.850	-2.586	-0.682	-6.878	-1.000	-2.000	2.41

[1] Degrees of freedom:- n_1 - 5, n_2 - 15. Significance levels indicated thus:- p - 0.05*, p - 0.01**, p - 0.001***.

[2] 15 D.F. Values of $\sqrt{2}t$:- p - 0.05, 3.013; p - 0.01, 4.167; p - 0.001, 5.759.

were these significant differences attributable to fallowing or to insecticide treatments.

d. The analysis of annual rates of change revealed no significant treatment comparisons.

Total Acaridiae (Tables 15 and 16)

The significant times x treatments interaction obtained in the analysis of Total Acaridiae, was not evident in the analysis of the constituents of this group. In Table 16, it will be seen that the interaction was due mainly to the significant differences between the uncultivated population and those treated fallow, B.H.C. and D.D.T. + B.H.C. in April 1952. On no other occasion were there any significant differences.

B. Laboratory Observations

1. Toxicity tests

The results of the laboratory toxicity tests with D.D.T. and B.H.C. are presented in Tables 17 and 18.

D.D.T. appeared to have no effect on the arthropleon Collembola tested, and even when the pure p.p'. isomer was applied in prodigious quantities no toxic symptoms were observed but D.D.T. was found to be toxic in varying degrees to all the mites tested. Predatory gamasids showed a reaction within a few minutes of being placed on a treated surface. Their movements became progressively slower, and the first pair of legs were seen to be continually rubbed against the mouth appendages. In this way their reaction was reminiscent of the "Cleaning symptoms" of insects poisoned by this substance. Although all the mites became severely paralysed after/

TABLE 15

INTERACTION OF TREATMENTS WITH TIME

TOTAL ACARIDIAE

Population Comparisons for 5 Occasions

Date	Total Control Population	Treatment Comparisons. Control = 100.0				
		Undug	Fallow	D.D.T.	B.H.C.	D.D.T. B.H.C.
Oct. 51	132	45.4	26.5	22.7	26.5	40.9
Dec. 51	16	337.5	156.2	143.7	43.7	118.7
Feb. 52	23	165.2	4.3	173.9	39.1	13.0
Apr. 52	4	225.0	25.0	275.0	50.0	25.0
Oct. 52	75	356.0	57.3	34.7	2.7	864.0

TABLE 16

INTERACTION OF TREATMENTS WITH TIME

TOTAL ACARIDIAE

ANALYSIS OF SQUARE ROOT TRANSFORMED DATA FOR 5 OCCASIONS

Treatment Totals

Date	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	'F'[1]	S.E.[2]
Oct. 51	19.126	15.930	28.379	14.538	13.861	16.551	1.82	-
Dec. 51	17.385	10.757	8.700	12.124	4.236	11.009	2.44	-
Feb. 52	10.513	1.000	6.583	14.200	3.828	3.000	2.36	-
Apr. 52	6.414	1.000	3.414	6.414	2.000	1.000	3.09*	1.430
Oct. 52	34.685	13.870	13.541	9.358	2.000	31.461	2.16	-

[1] Degrees of freedom:- n_1 - 5, n_2 - 15. Significance levels indicated thus p - 0.05*

[2] 15 D.F. p - 0.05, $\sqrt{2}t$ = 3.013

TABLE 17

LABORATORY TOXICITY TESTS WITH D.D.T. (Pure p.p′. Isomer)

Proportion of Dead and Moribund Animals

d - dead; m - moribund. Denominator = number of animals used for test.

Species	Wt. of desposit on substrate (µ gms per 19.6 cm²)					Exposure Time (Hours)
	0	5	10	20	40	
<u>Collembola</u>						
Tullbergia krausbaueri Test1	1d/10	0/10	0/10	1m/10	-	24
do Test2	2m/10	2m/10	0/10	0/10	3m/10	24
Tullbergia quadrispina	1m/10	-	1m/10	3m/10	0/10	24
Onychiurus spp. Test1	0/10	0/10	0/10	0/10	-	24
do Test2	0/10	-	-	-	0/10	72
do Test3	1d/20	-	-	-	0/20	72
Hypogastrura denticulata	0/20	-	-	-	0/20	72
Isotomodes productus	0/10	-	-	-	0/10	48
<u>Oribatei</u>						
Minunthozetes semirufus Test1	0/10	8d 2m/10	-	-	7d 3m/10	24
do Test2	1d/20	19d 1m/20	-	-	-	72
do Test3	0/20	17d 3m/20	-	-	-	72
Punctoribates punctum Test1	0/10	4d 6m/10	-	-	-	24
do Test2	0/10	7d 3m/10	-	-	-	72
<u>Acaridiae</u>						
Acarus siro	0/20	-	-	20m/20	-	48
Rhizoglyphus echinopus	2m/20	-	-	20m/20	-	48
<u>Mesostigmata</u>						
Pergamasus runciger Test1	0/10	10m/10	10m/10	-	-	48
do Test2	1d/10	-	-	10d/10	-	72
Parasitidae spp. (from litter)	0/20	-	-	20m/20	-	48
Laelaptidae spp. (from litter)	0/10	-	-	10m/10	-	48

TABLE 18

LABORATORY TOXICITY TESTS WITH LINDANE (99% gamma B.H.C.)

Proportion of Dead and Moribund Animals
d - dead; m - moribund. Denominator = number of animals used for test.

Species	Wt. of deposit on substrate (μ gms per 19.6 cm²)					Exposure Time (Hours)
	0	0.25	0.5	1.00	2.00	
Collembola						
Tullbergia krausbaueri Test1	1d/10	1d 9m/10	10m/10	10m/10	2d 8m/10	24
do Test2	6m/10	10m/10	-	3d 7m/10	-	48
do Test3	3m/20	12d 8m/20	-	-	-	48
Tullbergia quadrispina	2m/10	8d 2m/10	-	10m/10	-	48
Onychiurus spp. Test1	0/10	10m/10	-	-	-	48
do Test2	2m/20	16d 4m/20	-	-	-	72
Hypogastrura denticulata	0/20	8d 12m/20	-	-	-	72
Oribatei						
Minunthozetes semirufus Test1	0/10	8d 2m/10	-	-	-	24
do Test2	0/10	10d/10	-	-	-	48
Punctoribates punctum	0/10	10d/10				48
Acaridiae						
Acarus siro	3d/20	20d/20	-	-	-	48
Rhizoglyphus echinopus	0/20	20m/20	-	20m/20	-	24
Mesostigmata						
Pergamasus runciger Test1	0/10	10m/10	-	-	-	24
do Test2	1d/10	10d/10	-	-	-	48
Parasitidae spp. (from litter)	0/20	20d/20	-	-	-	48
Laelaptidae spp. (from litter)	1m/20	17d 3m/20	-	-	-	48

after being in contact with D.D.T. for about 24 hours, their death was often delayed and slight movements were commonly detected after several days.

There can be little doubt that Collembola are susceptible to B.H.C. Without exception, these insects were paralysed almost immediately after being placed on a treated substratum. This paralysis was in most cases prolonged, and slight movements were frequently observed after several days contact with the insecticide. Thus, in tests which were prolonged, a high proportion of the control animals became moribund before the complete death of treated individuals. When Collembola paralysed by B.H.C. were placed on an insecticide free surface they were not seen to recover. All the mites tested were also susceptible to B.H.C. and although their immediate reaction was less severe than that of Collembola, the prolonged paralysis was less frequent.

Owing to extraction difficulties, living Rhodacaridae were not collected in sufficient numbers for replicated tests, but periodic observations on small numbers of these mites indicated that they were susceptible to both insecticides. Similarly small numbers of T. crassicuspis, appeared to be little affected by D.D.T. and highly susceptible to B.H.C.

The results of the laboratory comparison of the toxicity to Collembola of B.H.C. alone, and D.D.T. + B.H.C. are given in Table 19. Under the conditions of the test there was no indication of any antagonism between the two insecticides. As in the case of those/

TABLE 19

LABORATORY TOXICITY COMPARISON OF B.H.C. ALONE AND D.D.T. & B.H.C. ON COLLEMBOLA

Proportion of Dead and Moribund Animals
d - dead; m - moribund, Denominator = number of animals used for test.

Dosages:- B.H.C. alone - 0.25µ gms. Lindane per 19.6 cm^2.
D.D.T. & B.H.C. - 0.25µ gms. Lindane & 5µ gms. pp'.D.D.T per 19.6cm^2.

Species		0	B.H.C.	D.D.T.+B.H.C.	Exposure Time.
Tullbergia krausbaueri	Test 1	1m/10	10m/10	1d 9m/10	24
do	Test 2	1m/10	6d 4m/10	8d 2m/10	48
Tullbergia quadrispina		2d/10	10d/10	9d 1m/10	48
Onychiurus spp.	Test 1	0/20	10d 10m/20	8d 12m/20	48
do	Test 2	2m/20	5d 15m/20	9d 11m/20	72
Hypogastrura denticulata		0/20	16d 4m/20	18d 2m/20	72

TABLE 20

EFFECT OF D.D.T. ON COLLEMBOLA IN PREVIOUSLY STERILIZED SOIL

Treatment Total Populations after 15 Weeks (Initial Population = 50)

Species	Treatments. Wt. of 2% crude D.D.T. dust (g.) per 150g. of soil				'F'[1]
	0	0.1	0.2	0.4	
Onychiurus spp.	2748	2449	1583	2302	<1
Tullbergia krausbaueri	860	695	461	714	<1

[1] Obtained in analysis of square root transformed data.
Degrees of freedom:- n_1 - 3, n_2 - 12.

those treated with B.H.C. alone, insects placed on a surface treated with the mixed insecticide became paralysed almost immediately.

2. The effect of D.D.T. on Collembola in the absence of predators

The results of the analysis of treatment differences in the test of the influence of D.D.T. on *Collembola* in sterilized soil are summarized in Table 20. Treatment differences were not significant, but owing to the magnitude of the variation, the results were inconclusive.

V. DISCUSSION

A. The Influence of Cultural Operations

1. Cultivation and Reseeding

In June 1951, it was seen that these operations resulted initially in a substantial reduction of the population of all the major groups. At this time the uncultivated population was at a low level, and statistical significance was not established in all the analyses. Thus, the reductions of Total Collembola and Total Euedaphic Collembola were rather short of the 5% significant standard, and, at species level, the only Collembolan showing a significant reduction was Tullbergia krausbaueri. Only one species was seen to increase (non-significantly) as a result of reseeding; this was Isotomodes productus a form reputed to be favoured by drier conditions (Gisin 1943). In a number of instances, the destructive action of cultivation was significantly more effective in relation to the population of the upper stratum. While this could be largely attributed to the virtual absence of the animals concerned in the lower stratum of all plots, in the dominant Oribatei there was a distinct tendency towards an increase of population in the lower soil of the reseeded control. This increase was significant in Punctoribates punctum. In this way, the prominent surface concentration of Oribatei which obtained in the uncultivated soil was not evident after cultivation. Hence, although considered to be predominantly hemiedaphic in character, unlike the hemiedaphic forms of Collembola, the Oribatei were nevertheless able to live in the lower soil.

There/

There can be little doubt that the majority of Collembola recovered quickly from this decimation. In October 1951, with the exception of T. krausbaueri, the dominant species were seen to be more abundant in the control plots, and, in December 1951, T. krausbaueri was more numerous in these plots. In the overall analyses of the October 1951 - October 1952 data, there were no significant differences between the Collembolan populations of the uncultivated and control plots. In the analyses of euedaphic Collembola there was no significant interaction of treatments with time, and, in the hemiedaphic forms, where this interaction was significant, further analyses revealed that at no time was there a significant uncultivated - control difference. However, the absence of a statistically significant difference does not constitute a proof of similarity, indeed, there is much evidence to the contrary, for non-significant differences of some magnitude were observed, and of these the more important can be mentioned briefly. In both euedaphic and hemiedaphic forms the seasonal fluctuation was observed to be rather more violent in the control, and particularly so in relation to the decrease of population, which occurred between December and February. An interaction of this type was not contrary to expectation, for the thick "mat" of vegetation and the concentration of moist organic matter in the surface soil of the uncultivated plots would almost certainly have constituted a more effective buffer against changing climatic conditions than the comparatively thin sward of the control. Again, except in December 1951, Tullbergia krausbaueri was observed to be much less numerous in the control plots, and in the overall comparison the uncultivated population of this species was

78% greater than the control.

Thus while all the Collembola made an initial recovery from the effects of cultivation, there was evidence to suggest that, after December 1951, the divergence of the control and uncultivated populations was renewed, and particularly so, in relation to T. krausbaueri. In the absence of statistically significant differences however this evidence must be regarded as inconclusive.

The Oribatei were not seen to recover in this way. In the overall analyses of the October 1951 - October 1952 results, the uncultivated population was in all cases significantly higher than the control, the average Oribatid population of the uncultivated soil during this period being $3\frac{1}{2}$ times that of the control. Here however the magnitude of the differences between the uncultivated and control populations varied significantly from one occasion to another. In October 1951 all the Oribatei analysed were significantly less abundant in the control than in the uncultivated plots, but in December 1951 no significant differences were apparent. In the case of Punctoribates punctum and in Oribella species, the December result was clearly due solely to the marked decrease of the uncultivated population. Between December and February an increase in the population of all species occurred in the uncultivated soil, this was not evident in the control, so that in all cases greater divergence was observed in February than in December. In Minunthozetes semirufus, the uncultivated - control difference was significant in February, April and October 1952, in Oribella species this difference was significant in October 1952 but not in February and April, while in Punctoribates punctum, differences on these/

these last three sampling occasions were not significant. In February and April, however, the uncultivated population of this species was seen to be very much greater than the control. Hence in all the Oribatei, the approximations of the control and uncultivated populations were temporary and due almost entirely to seasonal changes in the uncultivated plots; the differences between the total Oribatid population of the uncultivated and control plots in October 1951, and in October 1952, were almost identical, and P. punctum was the only species in which the uncultivated and control populations did not differ significantly from each other in October 1952. In the latter species, the comparatively small difference in October 1952 was due solely to a decrease of this species in the uncultivated plots. This decrease was accompanied by an increase of M. semirufus in these plots. The analyses of annual rates of change in Oribatei revealed no significant uncultivated – control differences. There was therefore no evidence of a recovery of Oribatei in the control plots, and with the exception of P. punctum, the destructive influence of cultivation and reseeding remained apparent 17 months after sowing. Furthermore, the approximation of the populations of P. punctum was due to a non-significant annual decrease in the uncultivated soil and not to an increase in the control.

In relation to Acaridiae, conclusive results were obtained only for R. echinopus. Cultivation and reseeding induced a non-significant reduction of this species in June but in the overall analysis of the data obtained on subsequent occasions, the uncultivated population was/

was 277% greater than the control, and this difference was significant. There was no evidence of recolonization by this species. In the case of the total population of the three species comprising "Other Acaridiae" the random variation was so great that no definite conclusions can be drawn.

The Mesostigmata also showed no evidence of recovery. In the overall comparison of the annual period, October 1951-52, all the species analysed were seen to be less abundant in the control, and, except in Rhodacarellus epyginialis and immature Mesostigmata, these differences were significant. In none of the Mesostigmata was there a significant interaction of treatments with time, and, during the annual period under consideration the average Mesostigmatic population of the uncultivated soil was 103% greater than the control, and, in the case of the average population of the five species known to be predacious the corresponding difference was 174%.

Thus both Collembola and Acari were initially reduced by cultivation, and whilst Collembola made a rapid, if not a permanent, recovery, the Acari did not. It is probable that the differential rate of recovery was due in part to the greater capacity of Collembola for rapid reproduction. In fact, in the original habitat, the seasonal fluctuation of Collembola could be regarded as periods of partial destruction due to adverse climatic conditions interspersed by phases of rapid recolonization. For this reason alone Collembola would be expected to make a more rapid recovery than the slow breeding Oribatei. However, long life cycles and slow reproduction were not common to all the Acari encountered, so that some other factors must/

must have been operative. Moreover, even in forms with a long life cycle, some degree of recolonization could have occurred within a period of 17 months. It would seem therefore that the newly sown environment was less favourable to Acari than the uncultivated plots. A comparison, in February 1952, of that factor measured by loss on ignition, indicates that there was little difference in the total amount of organic matter in the upper 6" of the control and uncultivated soil. However, Franz (1943) considered that R. echinopus did not feed directly on plant debris but on material previously conditioned by bacteria. Hence for at least one of the species concerned, the quality of the organic material could have been a limiting factor. Moreover, the organic material in the control soil would be more evenly distributed in the profile, and the surface concentration of moist organic matter would be less pronounced in these plots. In consequence of this, and of the comparative thinness of the newly sown sward, microclimatic differences would obtain. This factor was probably of particular importance in relation to the Oribatid population. Thus, being unable to recover rapidly from adverse physical conditions, populations of these mites, even if individually they were more tolerant of such conditions than Collembola, would nevertheless encounter better conditions in the more stable habitat of the uncultivated soil. In East Scotland, Rayski (1945) also found the Oribatid populations of leys to be much lower than those of old pasture, and he considered ploughing and reseeding to be a valuable means of controlling the anoplocephaline parasites which these/

these mites transmit to sheep.

Summing up, there were little qualitative differences between the microarthropod communities of the uncultivated and reseeded control plots, for, apart from certain _Acari_ of infrequent occurrence, the species represented in the uncultivated soil were also found in the control, and vice versa. The main long term quantitative difference attributable to reseeding was a reduction of the Acarine population, although there was also evidence to suggest an overall reduction of certain _Collembola_, particularly _Tullbergia krausbaueri_. The evidence is consistent with the view that these differences were due in part to a change of microclimatic conditions brought about by the redistribution of the organic matter in the reseeded plots.

2. _Fallowing_

With the exception of _Tullbergia crassicuspis_ the populations of the Collembolan groups and species were significantly lower in the fallow plots than in the control. In the case of mites, however, the reseeding operation itself caused a permanent reduction, so that, when compared with the control, the effect of fallowing was less marked. In the overall analyses of _Acari_ significant differences between control and fallow populations occurred only in the analyses of Total _Rhodacaridae_ and _Rhodacarellus epyginialis_. In the separate analyses of _Oribatei_ significant control - fallow differences occurred only in relation to _Minunthozetes semirufus_ (October 1951 and October 1952). As measured by loss on ignition there was little difference in the organic matter content of any of/

of the plots. The absence of surface vegetation therefore probably caused no great reduction in the amount of food material available for saprophytic forms, and the reductions of population in these plots were probably due to the adverse physical conditions of the bare soil.

B. The Influence of Insecticides

In June 1951, owing to the destructive influence of cultivation on a population near its seasonal minimum, the effects of the insecticide treatments were not well marked, although in some groups, significant reductions were evident in the B.H.C. or in the D.D.T. ~~and~~ plus B.H.C. treated plots, or in both, e.g. hemiedaphic Collembola, Rhodacaridae, and immature Mesostigmata. For this reason, the reactions of the population to insecticides have to be discussed mainly in the light of the information collected on the 5 occasions during the year October 1951 - October 1952.

Dealing first with the results of the overall analysis of this data (Table 6), the treatment comparisons depict the average effect of the materials on the groups and species concerned during this period. It is important to note that significant interactions of treatments with time were revealed only in the analyses of hemiedaphic Collembola, and adult Oribatei. Hence, in the euedaphic species of Collembola, and in the Mesostigmata, the non-significance of this interaction precludes the occurrence of significant progressive, or retrogressive, population changes in any of the treated plots during the year under consideration.

In/

In the overall comparison, severe reductions of Collembola and Acari were evident in the plots treated with B.H.C; but marked reductions attributable to D.D.T. occurred only in Acarine populations. In the case of plots receiving B.H.C. alone significant reductions were evident in all the Collembolan populations analysed except Total Tullberginae and Tullbergia crassicuspis. In Acari, significant responses to this insecticide were not so frequent, but nevertheless were evident in several analyses, e.g. Minunthozetes semirufus, Total Mesostigmata, and Total Rhodacaridae. The destructive influence of D.D.T. was observed in many Oribatei, and in all the Mesostigmata, but in the overall analyses, significant reductions were evident only in relation to Total Mesostigmata, Total Known Predacious Mesostigmata, and Total Immature Mesostigmata.

Of supreme interest are the responses of the Collembolan populations to the D.D.T. and D.D.T. + B.H.C. treatments. In the case of D.D.T. alone, the average Collembolan population of the plots so treated was 110% higher than the control, and this difference was highly significant statistically. Similar increases were evident in many of the constituent groups and species, although a non-significant reduction was observed in Isotomodes productus, and Folsomia candida was little affected. The greatest increase was that of Tullbergia crassicuspis; the D.D.T. population of this species being 15 times that of the control. Statistically, the D.D.T. increase was significant in the following analyses:- Total Collembola/

Collembola, Total Euedaphic Collembola, Total Tullberginae, Tullbergia crassicuspis and Total Hemiedaphic Collembola.

The response of Collembola to the mixture of both insecticides indicated that, in the field, the presence of D.D.T. reduced the destructive influence of B.H.C. on these insects. Thus, in the overall analyses, only in relation to Tullbergia krausbaueri and Folsomia candida was the D.D.T. + B.H.C. population significantly lower than the control. In the analyses of Total Collembola and Total Euedaphic Collembola this population was significantly higher than that treated with B.H.C. alone, and significantly lower than that treated with D.D.T. alone. In the case of hemiedaphic Collembola,the average response was such that, although the population receiving both insecticides, did not differ significantly from that receiving D.D.T. alone, it was nevertheless significantly higher than the population treated with B.H.C. alone. Although not always statistically significant this trend was apparent in all Collembola, for, in every case, the D.D.T. + B.H.C. population was intermediate in density when compared with those treated with the two insecticides separately.

This antagonistic action was seen only in the field. Under the conditions of the laboratory tests, the mixed insecticides and B.H.C. alone were equally toxic to Collembola in isolation. The field result therefore could hardly have been due to chemical or physiological interactions. In support of this it can be noted that Itzerott (1951) observed a synergistic effect when the two insecticides/

insecticides were assayed with Calandra granaria (L). Again, in the field, this antagonism only occurred to a marked and significant degree in relation to Collembola. There was some slight and non-significant evidence of its occurrence in populations of some Cryptostigmatic mites, but in the Mesostigmata evidence of a response opposite in character was obtained. In the overall comparison, the populations of the Mesostigmatic groups and species were in all cases observed to be lower in the D.D.T. + B.H.C. plots than in either of the plots receiving these insecticides separately. Statistically, the D.D.T. + B.H.C. population of these mites was in all cases significantly lower than the control, and, in the analyses of Total Known Predacious Mesostigmata and Pergamasus species, was also significantly lower than the population receiving B.H.C. alone. Thus, although a synergic effect was not evident, the mixed insecticides were nevertheless more toxic to the field population of predatory Mesostigmata than B.H.C. alone.

In previous studies, resurgences of this type have been most often attributed to a destruction of predators and parasites, and in a number of investigations this conclusion has been supported by evidence of reduced populations of carniverous and other entomophagous species. It can also be noted that resurgences of this nature can be expected on purely theoretical grounds. In a mathematical thesis, Volterra (1928) enunciated the law of the disturbance of averages, stating that, in a community of two species, one a predator, the other its prey; if individuals are uniformly destroyed in proportion/

proportion to their number, the average population of the prey will increase, and that of the predator will diminish. Hence, on this basis, even when predator and prey are equally susceptible, the prey would eventually be favoured by insecticide treatments. When the prey is less susceptible, the resurgence should therefore be accentuated.

In the present study there is abundant evidence to indicate that the significant increase of Collembola in the D.D.T. treated plots was due to a reduction of predatory pressure. This evidence can be recounted as follows:-

(a) Laboratory observations showed that at least 5 Mesostigmatic species commonly occurring in the field, preyed actively on Collembola.

(b) Laboratory tests showed that while Collembola were completely unaffected by D.D.T. even at the highest concentrations, this substance was definitely toxic to all the Mesostigmata examined.

(c) In the field, the total population of the 5 Mesostigmatic species known to feed on Collembola was significantly reduced by treatment with D.D.T.

Other predacious organisms, particularly Staphylinidae species are known to feed on Collembola (MacLagan, 1932, Weis Fogh, 1948) but these were not collected in sufficient numbers to make a quantitative assessment of their reaction to the treatments.

The response of Collembola in the plots treated with D.D.T. + B.H.C. is not only consistent with this explanation but also provides supporting evidence. Thus, when compared with the population/

population receiving B.H.C. alone, the residual population of Collembola in the D.D.T. + B.H.C. plots would have been favoured by the additional protection against predators offered by D.D.T., for the population of predacious Mesostigmata in the D.D.T. + B.H.C. plots was significantly lower than that in plots treated with B.H.C. alone. Thus, in every comparison, the presence of D.D.T. was associated with an increase of Collembola and a decrease of predacious Mesostigmata.

Unlike that of the euedaphic forms, the analysis of hemiedaphic Collembola revealed a significant interaction of treatments with time. The nature of this interaction is depicted in Fig. 1 and Tables 7 and 8. In October 1951, the B.H.C. population showed a non-significant reduction when compared with the control, this population then increased so that a smaller reduction was apparent in December. In February a drop, probably related to climatic conditions, was evident in the control, this did not occur in the B.H.C. population so that at this time the latter was 59% greater than the control (the difference was not significant). Subsequently the B.H.C. population fell so that in April and October 1952 it was significantly lower than the control. The trend of the B.H.C. population to February was probably due to the B.H.C. being washed into the soil during autumn and winter, so that the amount of insecticide in the extreme surface soil became progressively less. Although not significant, the increase in comparison with the control in February is consistent with Volterra's proposition. Being favoured by the initial destruction of predators, the B.H.C. population/

population was able to maintain its December level. The subsequent retrogression of the B.H.C. population, although surprising, is not devoid of explanation. The remarkable efficiency of B.H.C. as a soil insecticide is thought to be due to its slight volatility, thus, although the material would be washed into the deeper soil by precipitation during autumn and winter, rising spring temperatures would probably cause the emanation of toxic vapour and so lead to a renewed toxicity in the extreme surface.

The increase associated with D.D.T. was less marked in hemiedaphic Collembola than in the euedaphic forms. Although evident in the overall analysis, in the separate analyses, the increase was not apparent in October 1951, and was significant only in April 1952. Again this was probably due to the insecticide being washed into the soil so that the concentration of D.D.T. and consequently the protection against predators, was less in the extreme surface than in the deeper soil.

The trend of hemiedaphic Collembola in the D.D.T. + B.H.C. plots can also be explained on similar lines. The remarkably steep rise to the high December population was probably facilitated by the diminished toxicity of B.H.C. attributable to leaching, and by the initial destruction of predators by both insecticides. Furthermore, the significant increase of April 1952 in the D.D.T. plots, suggests that the concentration of the latter insecticide remained sufficiently high in the surface habitat, to afford, in addition, a more lasting protection.

With/

With regard to the question of recolonization, and the persistence of insecticidal influence in relation to hemiedaphic Collembola, the periodic approximations of the B.H.C., D.D.T. + B.H.C. and control populations were only temporary and in both treatments significant reductions were evident in April 1952. In the case of B.H.C. alone, this renewed toxicity persisted, and a significant effect was apparent in October 1952. In the case of D.D.T., and D.D.T. + B.H.C., the effects of treatment were neither significant in October 1951 nor in October 1952, and the analyses of annual rates of changes did not reveal any significant difference. Thus, the effects of B.H.C. alone were still evident in October 1952, but the results in relation to the persistence of the D.D.T., and D.D.T. + B.H.C. treatments were inconclusive.

Although showing a significant interaction, violent resurgences were not encountered in the Oribatei. First it can be noted that in Oribella species the control population was low at all times, and there were no significant differences attributable to insecticide treatments. In the two dominant species, Punctoribates punctum, and Minunthozetes semirufus, all insecticide treated populations were significantly lower than the control in October 1951. (In P. punctum the difference due to D.D.T. + B.H.C. was barely significant).

With the exceptions noted below, the results for these two species on the three intermediate sampling occasions were inconclusive. The populations were at all times low, many of the fluctuations of treated populations were irregular in character, and the changing status/

status of the treated populations was, to a large extent, due to a decrease of control populations. The only significant difference attributable to insecticide treatment occurred in the April analysis of M. semirufus where the B.H.C. population was significantly lower than the control. In October 1952 significant reductions attributable to B.H.C. and to D.D.T. + B.H.C. were again apparent in both species, but the difference due to D.D.T. was not significant. Only in P. punctum did the analysis of annual rates of change reveal a significant control - D.D.T. comparison; the difference being due to an increase of the D.D.T. population. In October 1951, D.D.T. caused a significant reduction of 73% in the population of this species, while in October a non-significant reduction of 34% was apparent. Thus in this annual comparison there was significant evidence of recolonization. The recovery of this species was first apparent in April 1952 when the D.D.T. treated population was seen to be 16% greater than the control. Subsequently some retrogression was observed but the recovery was sufficiently well maintained to produce the significant evidence of recolonization noted above.

Recapitulating, the bulk of the evidence in the present study indicates that the increase of Collembola associated with the presence of D.D.T. was due to the reduction of the predatory pressure of Mesostigmata. The only occasion on which a significant reduction of predacious Mesostigmata was not accompanied by an increase of Collembola was in the comparison of the uncultivated and reseeded control plots, and here the reduction of predators was/

was accompanied by major physical changes in the environment. Whilst most workers have attributed reactions of this type to the destruction of predators and parasites, other factors have also been suggested as contributory causes. Hueck et al (1952) observed that low concentrations of D.D.T. caused an increase in the oviposition rate of Fruit Tree Red Spider (Metatetranychus ulmi). In some experiments this increase was significant statistically, and at high rates a toxic effect was apparent. Baudissin (1952) found that treatment with D.D.T. + B.H.C. caused an increase in the population of soil Acari and Collembola after an initial toxic effect lasting for about two weeks. The increase was not well marked, and the investigation did not include observations on the effect of D.D.T. alone, neither were predatory mite populations assessed. Baudissin conjectured that this increase was due to a "chemotactic stimulation" by residual quantities of D.D.T., and a physiological response was implied. No evidence was advanced in support of this explanation. Richter also observed an increase in D.D.T. + B.H.C. treated populations of Acari and Collembola in forest soil. He hazarded no explanation but subscribed to Baudissin's views. In the present study, observations on the responses of Collembola to D.D.T. in sterile soil produced negative results, but owing to the great variation which obtained, these results were inconclusive. However there are other grounds to suppose that Collembola are not directly affected by D.D.T. in this way. Davis (1952) in experiments with Tetranychus multisetis McG, observed that, shortly after contact/

contact with D.D.T., the mites became highly active and moved over greater distances than untreated individuals. The treated animals became widely scattered in their habitat and the dispersion resulted in a higher reproductive potential, and hence in an earlier attainment of the asymptotic population. Thus the increased reproduction of isolated colonies of Tetranychids in contact with D.D.T. could be attributed to an irritant effect of sub-lethal doses. The evidence of Davis indicates that the effect of D.D.T. on the reproduction rate of the mite is indirect, and related to density factors, whilst the data of Hueck et al, although not inconsistent with this explanation, suggests a response of a physiological nature.

Although the possibility of a reaction of this type being partly responsible for the increase of Collembola in the present study cannot be completely eliminated, hitherto, there has been no positive demonstration of a response of this nature on the part of these insects, and most of the evidence is opposed to its occurring. Observations on Collembola in contact with D.D.T. showed their reactions to be quite unlike those described for Tetranychidae; the animals showed no sign of increased activity, neither was there any evidence of toxicity, even at prodigious dosages.

The possibility of the increase of Collembola being due to a reduction of competition for space and food has also to be considered; the potential competitors being the Acaridiae and Oribatei.

The analyses of Acaridiae revealed no significant responses to insecticide treatments, and, although a non-significant reduction of/

of the three species comprising 'Other *Acaridiae*' was apparent in the D.D.T. plots, *Rhizoglyphus echinopus* on the other hand was seen to be more abundant in these plots. Thus there was no consistent association of low Acarid with high Collembolan populations, and therefore no indication of competition between these groups.

With regard to *Oribatei*, most of the evidence is consistent with the view that these mites exerted little influence on *Collembola*. In the overall analyses of *Oribatei*, the reductions observed in the D.D.T. plots were not significant, and, in the separate analyses, the effect of D.D.T. was not always well marked, and was significant only in October 1951. Moreover, in the comparison of plots treated B.H.C. with those receiving D.D.T. + B.H.C. the significant increases of *Collembola* in the plots treated with both insecticides were not associated with significant reductions of *Oribatei*. On a number of occasions, these mites were actually more abundant in the plots receiving both insecticides.

Although the more significant associations were those between *Collembola* and the Mesostigmatic mites known to be predacious, it is important to consider the *Rhodacaridae* - the dominant Mesostigmatic mites - in relation to these insects.

The reaction of these mites to D.D.T. was not significant,but their potential influence cannot be discounted, for the trends of their population in both the D.D.T. and the D.D.T. + B.H.C. plots were similar to those of the known predators. These are amongst the few mites which are found in the lower soil; both Frenzel (1936) and Willman (1935, 1936) noted this, and not only do the June results/

results subscribe to this view, but these mites were also found in large numbers by the writer, in soil below the 3" level at Auchincruive, Ayrshire, and at Lephinmore, Argyll. The food habits of these mites are not known, although the structure of their mouth parts suggests a predatory habit. It is probable therefore that the Rhodacarids exert some influence on the deep living Collembola particularly the Tullberginae.

In relation to the problem posed by vertical distribution, Weis Fogh (1948) observed that the predacious Mesostigmata were near surface swellers, similarly in Glasgow, in June 1951, Mesostigmata other than Rhodacaridae were more dense in the upper soil (the difference was not significant). On the whole therefore the activities of these mites would be expected to have little influence on Collembola in the deeper soil. The smallest of the Mesostigmata known to be predacious was Digamasellus reticulatus; this did not occur in sufficient numbers at Glasgow in June 1951 to provide useful evidence of its vertical distribution, but at Lephinmore, Argyll, this species was found in considerable numbers below the $1\frac{1}{2}$" level, and it was not uncommon below the 3" point where it occurred with Rhodacaridae and Tullberginae. Thus this species at least is capable of penetrating the deeper soil in search of prey.

In conclusion, this study has shown that when incorporated with soil at rates commonly used in commercial practice, both D.D.T. and B.H.C. induce marked and persistent quantitative changes in the microarthropod population. The action of B.H.C. is sufficient to/

to warrant some concern about adverse long term effects on soil fertility which might occur as a result of a general decimation of saprophagous species by this widely used soil insecticide. With regard to the use of D.D.T. the risk of favouring phytophagous *Collembola* is obvious, and while our knowledge is insufficient to make an authoritative assessment of its long term influence on soil fertility, the disequilibrium precipitated by this substance, and the responses of the population to the mixed insecticides, emphasize the need for an ecological approach to problems of pest control. On the other hand, the investigation also reveals that treatments with these materials provide a valuable technique for studying the population dynamics of Arthropod communities in the field.

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VII. SUMMARY.

The soil microarthropoda, mainly Collembola and Acari, of old grassland at Glasgow were investigated, special attention being paid to the effects on the population of cultural operations and treatments with D.D.T. and B.H.C. The data were obtained by examining soil samples taken on six occasions from the plots of a 6 x 4 randomized block field experiment. The treatments were as follows:- (1) Uncultivated. (2) Reseeded Control. (3) Fallow. (4) Reseeded + D.D.T. (5) Reseeded + B.H.C. and (6) Reseeded + D.D.T. + B.H.C. The animals were extracted with a flotation apparatus and the field work was supported by laboratory observations. The results are presented in two parts: Part I. dealing with the fauna of the uncultivated plots, and Part II. with the effects of cultivation and insecticide treatments.

PART I.

1. The literature on extraction techniques, ecological surveys, and on the biology of Collembola and Acari is reviewed.
2. The qualitative results include a list of species and notes on the biology and distribution of the dominant and other interesting species encountered.
3. The community included the following Acari new to science:- (a) Rhodacarellus epyginialis, (b) Digamasellus reticulatus and (c) Platyseius n.sp. The first species also represents a genus new to Britain. Descriptions of (a) and (b) are included in Appendix/

Appendix I (Taxonomy), and description of (c) will be given by Dr. Owen Evans in a forthcoming paper.

4. The following species are noted as new to Britain:-

A. Collembola

(I) Onychiurus uliginatus, Gisin. (II) Onychiurus spinularius, Gisin (III) Tullbergia crassicuspis, Gisin.

B. Acari

(I) Pergamasus misellus, Berlese. (II) Lasioseius penicilliger, Berlese

5. A note on the occurrence in the cultivated soil of Eulohmannia ribagai, Berlese is also included. This mite represents the Eulohmanniidae (Oribatei), a family hitherto unrecorded for Britain.

6. The quantitative composition of the community is tabulated.

7. Statistical analyses of samples taken in June, 1951, showed the population densities of a number of groups and species to be significantly greater in the 0-3" than in the 3-9" layer of soil. In no case was the density of the lower stratum population significantly greater than that in the surface layer of soil.

8. The results of statistical analyses showed that the animals were not dispersed horizontally over the uncultivated area in a random distribution.

9. A considerable seasonal fluctuation was encountered during the year October, 1951-52, and the statistical significance of the differences is noted. Collembola were more abundant in October and December than in February and April, but the adult Oribatei were least abundant in December. It is concluded that the fluctuation of Collembola was determined by climatic conditions, but/

but the seasonal variation of Oribatei could not be explained in this way. It is suggested these mites undertake periodic migrations and evidence is cited to indicate that these movements may be associated with the propagation rhythm of the animals.

10. Laboratory observations on cultures of living animals have confirmed and added to the results of previous workers on the feeding habits of various species. Five Mesostigmatic mites were observed to be predators of Collembola, these included D. reticulatus n.sp.

PART II.

The literature on the effects on the soil population of cultivation and insecticides is reviewed, and a brief account of work on the influence of insecticides on other mixed Arthropod communities is given.

A. The Effect of Cultural Operations

1. Observations in June 1951 (23 days after sowing) revealed a general reduction attributable to cultivation and reseeding. This was significant in the analyses of Total Collembola and Total Mesostigmata, but not in Total Oribatei.

2. In a number of cases significant interactions of treatments with depth were noted in June 1951. This was well marked in Oribatei; and in Punctoribates punctum, reseeding resulted in a significant increase of the population in the 3-9" layer of soil.

3. Collembola were seen to recover, and on subsequent occasions there were no significant differences between the reseeded and uncultivated/

uncultivated populations of these insects.

4. Over the year October 1951-52, the total populations of Oribatei and Mesostigmata were significantly lower in the reseeded than in the uncultivated plots. In Oribatei there were significant interactions of treatments with time, but these could not be attributed to recolonization.

5. In comparisons of fallow and reseeded control populations in June 1951 the only group showing a significant reduction in the fallow plots was the Rhodacaridae (Mesostigmata). On subsequent occasions, however, fallowing was seen to cause marked, and in many cases significant, reductions of Collembola. The effect of fallowing was less marked in the Mesostigmata, and least so in relation to Oribatei.

B. The Effect of Insecticide Treatments

1. Owing to the heavy reductions caused by cultivation and reseeding, comparisons of insecticide treated plots with the reseeded control in June 1951 did not reveal many significant differences, and the results noted below are based mainly on the data obtained during the year October 1951-52.

2. Treatment with 2 ozs. per square yard of 2% D.D.T. (75-80% pp' isomer) caused severe reductions of Acari, particularly Mesostigmata. The reduction was statistically significant in a number of Acarine groups and species, and only in the case of Punctoribates punctum (Oribatei) was there significant evidence of recolonization. D.D.T. caused a marked increase of Collembola, and in many cases this was statistically significant.

3./

3. Treatment with 2 ozs. per square yard of 2% B.H.C. (13% gamma isomer) caused severe, and in most cases, significant reductions of all microarthropoda. There was no significant evidence of recolonization, but in hemiedaphic Collembola a temporary recovery was noted.

4. Treatment with a mixture of both insecticides (2 oz. D.D.T. and 2 oz. B.H.C. per square yard), caused severe reductions of Acari, and in the analyses of Mesostigmatic populations, the mixed insecticides were, in some cases, significantly more destructive than B.H.C. alone. In relation to Collembola however, the mixed insecticides were in many cases significantly less destructive than B.H.C. alone.

5. Laboratory toxicity tests showed that D.D.T. and B.H.C. were toxic in a varying degree to representative species of the three major Acarine groups encountered. Collembola, however, were completely unaffected by D.D.T., but were highly susceptible to B.H.C. There was no evidence of any antagonism between the two insecticides in laboratory tests with Collembola.

6. The evidence is consistent with the view that the increase of Collembola in the D.D.T. plots, and the antagonistic effect of the mixture of both insecticides on these insects in the field, was due to a reduction by D.D.T. of the predatory pressure of Mesostigmata.

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APPENDIX I.

TAXONOMY

I. FAMILY RHODACARIDAE, OUDEMANS 1902. (ACARI, MESOSTIGMATA)

This family was originally erected to accommodate the single genus Rhodacarus. Two further genera were discovered by Willman (1935), and the family can now be defined as follows:-

Small, elongate, lightly chitinized mites, less than 550 μ in length. In many cases a constriction is apparent between the podosma and the opisthosoma, although this might be indistinct, especially in mounted material. The palpal tarsus carries a trifurcate seta, and the dorsal shield is divided into anterior and posterior portions approximately equal in length. Ventrally, a more lightly chitinized area extends forwards from the sternal plate, so that, in the male, the genital opening appears to be located some way back in the sternal plate. The peritreme is short reaching a point between Coxae II and III.

The three known genera can be separated with the following key:-

1. Leg I. without claw .... Rhodacarus Oudemans 1902.
   Leg I. with claw .... 2.
2. Claw on Leg I. pedunculate ...... Rhodacarellus Willman 1935
   Claw on Leg I. sessile .... Rhodacaropsis Willman 1935 (not yet recorded for Britain)

RHODACARELLUS EPYGINIALIS n.sp.

Female

Dorsal shield (Fig. 1) 400 - 420 μ in length, and 180 - 190 μ wide at the broadest point. The shield is divided into two approximately equal portions, the anterior part having four small depressions/

depressions near its centre. The epistome (Fig. 3C) has 3 long central points. Ventrally (Fig. 2) the sternal shield bears 3 pairs of setae and pores in the more heavily chitinized section, and a single pair of setae in the lightly chitinized anterior part. The posterior margin of the sternal shield is strongly emarginate. The most distinctive character of the species is the epyginial plate which is rounded posteriorly, and extends forwards as an acute triangle with its apex in line with a point slightly in front of the anterior margin of the third coxae. The ventri-anal plate carries 4 pairs of pre-anal setae.

The chelicerae (fig. 3A) have a fixed digit with 5 teeth and a pilus dentilis, the movable digit being tridentate. Tarsus I. (Fig 3B) is typical for the genus; the claws being borne on a pre-tarsus, Leg II. is unarmed.

Male

In size and chaetotaxy the dorsal shield is similar to that of the female. The ventral armature is illustrated in Fig. 4; the sternal shield having 5 pairs of setae, and 3 pairs of pores. The ventri-anal plate carries 6 pairs of setae, 3 anal setae, and a pair of small pores. Leg II. (Fig 5B) is armed with a prominent process on the femur and small truncated cone-like projections are located on the genu, tibia, and tarsus. The chelicerae (Fig. 5A) have a fixed digit with 5 teeth and a pilus dentilis, and a bidentate movable digit with a slender spermatophoral process.

The Holotype female, Allotype male, and paratypes are deposited in the British Museum (Nat. Hist.)

II./

II. FAMILY ASCAIDAE OUDEMANS AND VOIGTS 1905 (ACARI, MESOSTIGMATA)

Genus Digamasellus Berlese, 1905

In this genus the seta on the palpal tarsus has two tines. Vitzthum (1941) however locates this genus in the Gamasolaelaptidae Oudemans 1939 - a family in which this seta is trifurcate. The whole sub-order however is badly in need of revision, and for the time being it seems more appropriate to include Digamasellus in the family Ascaidae - group distinguished by the presence of a bifurcate seta on the palpal tarsus, and a dorsal shield divided into anterior and posterior portions approximately equal in length.

Digamasellus reticulatus n. sp.

Female

Dorsal shield 290 - 300 µ in length, and 160 - 165 µ wide at the broadest point (Fig. 7). The shield is divided into approximately equal anterior and posterior portions and 4 small depressions are located near the centre of the anterior shield.

A distinct reticulation is apparent over the whole of the dorsal surface. The epistome (Fig. 6B) has 3 central points. Ventrally (Fig.8) the sternal plate bears 4 pairs of setae, and 3 pairs of minute pores. The epyginial plate is broad and truncated posteriorly, while the metapodal plates are well developed and, in most specimens distinctly thorn shaped. In addition to 3 anal setae, the ventri-anal plate carries 5 pairs of setae and is reticulated. The posterior setae ("Endborsten" of Leitner, 1949) are rigid, the inner pair being much longer than the outer. The chelicerae (Fig. 6A) have a fixed digit with 4 teeth and a pilus dentilis, the movable digit being tridentate.

Male - unknown/

Male - unknown.

In the arrangement adopted in Leitner's key, D. reticulatus can be located near D. perpusillus Berlese, (the type species and differs from the latter mainly in the chaetotaxy and shape of the ventri-anal plate, and also by virtue of its possessing well developed metapodal plates and reticulated shields.

The Holotype female and paratypes are deposited in the British Museum (Nat. Hist.).

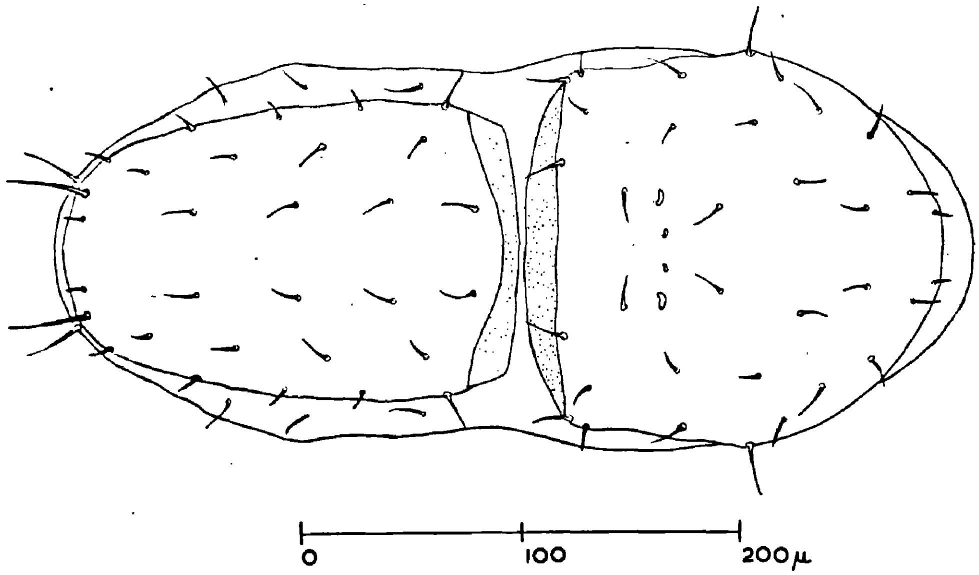

FIG. I. Rhodacarellus epyginialis. Female. Dorsal.

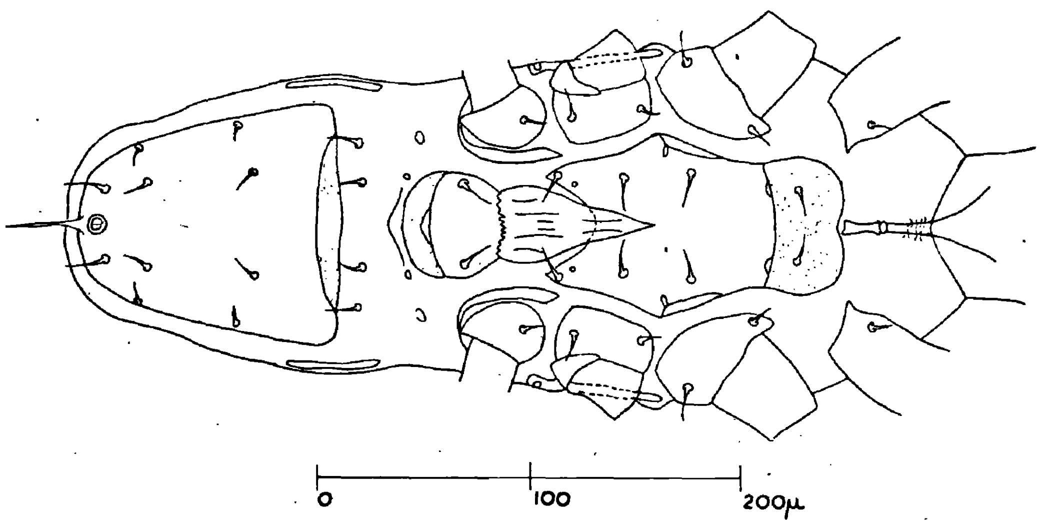

FIG. 2. Rhodacarellus epyginialis. Female. Ventral.

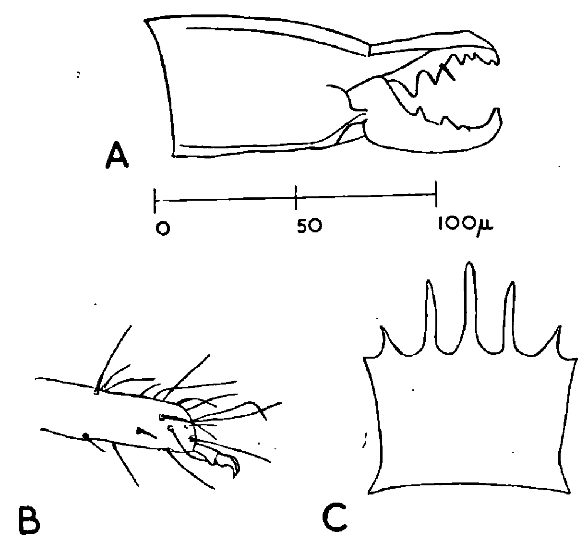

FIG. 3. Rhodacarellus epyginialis. Female.
A. Chela.
B. Tarsus I.
C. Epistome.

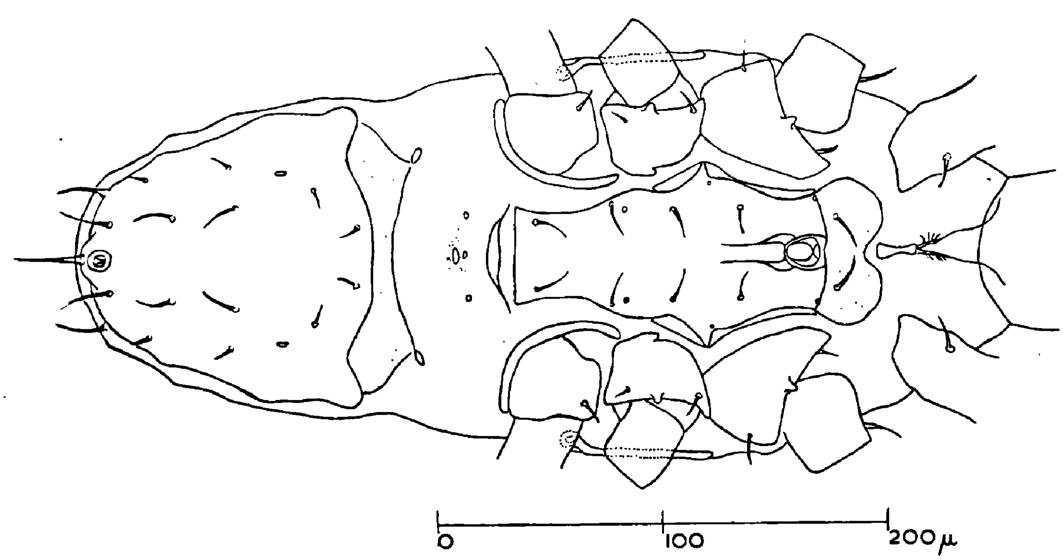

FIG. 4. Rhodacarellus epyginialis. Male. Ventral.

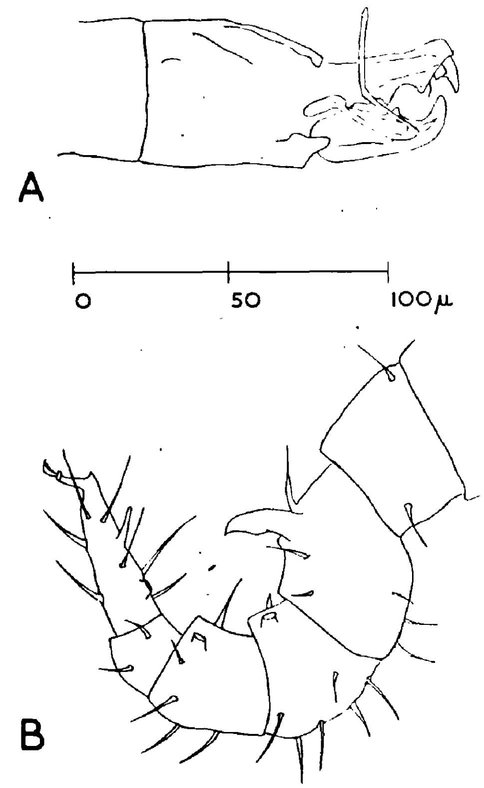

FIG. 5. Rhodacarellus epyginialis. Male
A. Chela.
B. Leg I.

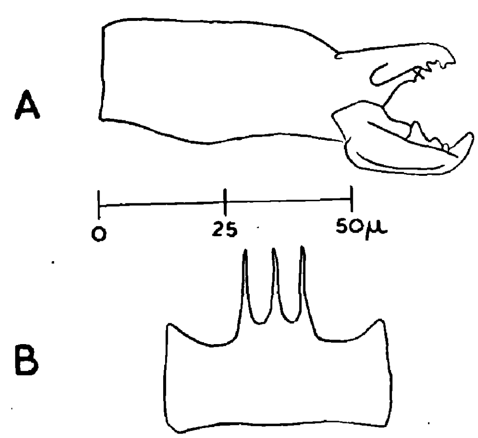

FIG. 6. Digamasellus reticulatus. Female.
A. Chela.
B. Epistome.

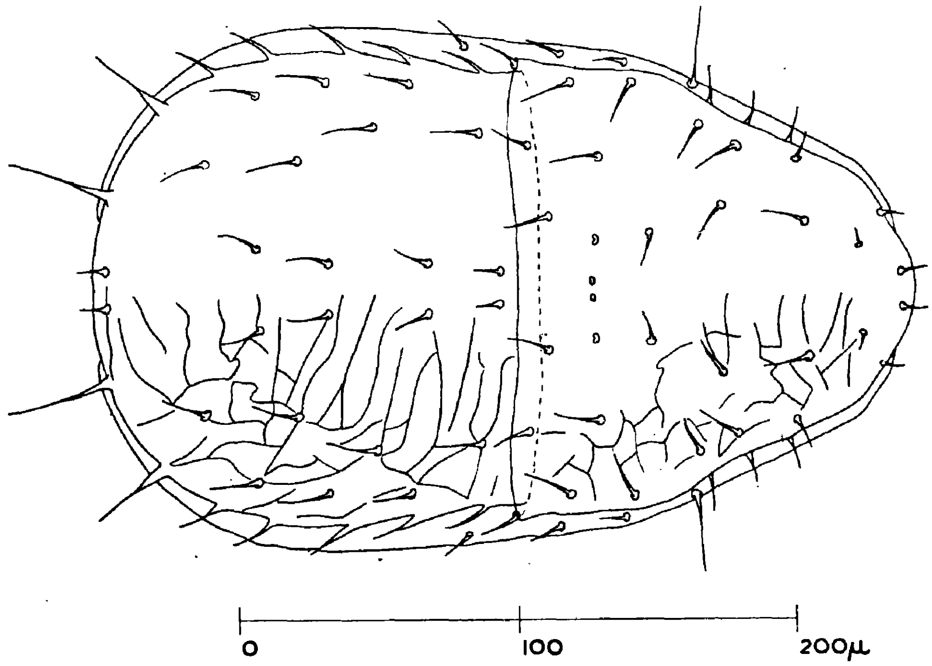

FIG. 7. Digamasellus reticulatus. Female. Dorsal.

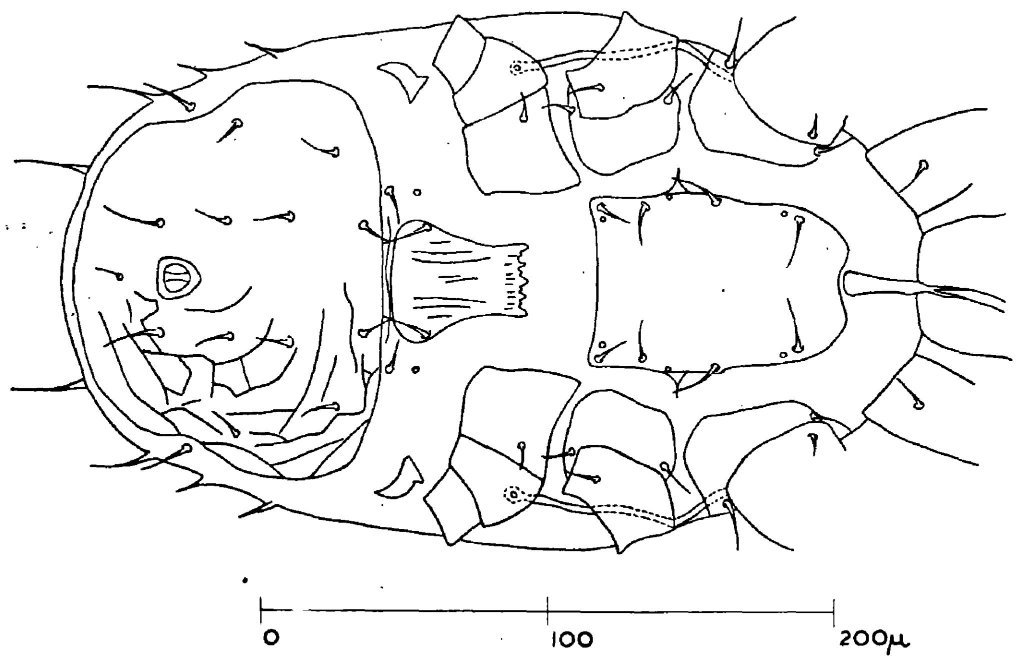

FIG. 8. Digamasellus reticulatus. Female. Ventral.

APPENDIX II.

SUMMARY TABLES A-E.

TABLE F, CHEMICAL ANALYSIS.

SUMMARY TABLE A

TREATMENT TOTALS 16th OCTOBER 1951

(Number of Animals in 8 Samples)

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	407	77	467	775	96	238
Total Euedaphic Collembola	343	33	370	679	54	171
Total Tullberginae	147	18	108	467	29	97
Tullbergia krausbaueri	132	15	76	146	21	27
Tullbergia crassicuspis	6	3	21	305	6	70
Total Onychiurus spp.	83	5	91	122	6	29
Isotomodes productus	42	5	76	34	3	42
Folsomia candida	69	5	81	50	16	3
Total Hemiedaphic Collembola	63	31	85	83	35	54
Total Oribatei	331	50	106	58	16	38
Punctoribates punctum	122	23	37	10	5	12
Minunthozetes semirufus	100	12	40	3	3	3
Total Oribella spp.	37	4	5	17	1	2
Total Immature Oribatei	42	4	13	9	5	14
Total Acaridiae	60	35	132	30	35	54
Rhizoglyphus echinopus	40	3	11	8	2	3
Total 'Other Acaridiae'[1]	20	32	121	22	33	51
Total Mesostigmata	159	52	86	31	22	9
Total Rhodacaridae	87	9	37	18	6	5
Rhodacarellus epyginialis	34	4	17	15	4	5
Tot. Known Pred. Mesostigmata[2]	26	8	13	1	6	1
Total Pergamasus spp.	13	6	7	1	5	0
Total Immature Mesostigmata	30	27	21	10	8	1

[1] Total of 3 species:- Acarus siro, Coelognathus castellanii, and Glycyphagus destructor.

[2] Total of 5 species:- Veigaia nemorensis, Pergamasus runciger, P. misellus, Digamasellus reticulatus and Hypoaspis aculeifer.

SUMMARY TABLE B

TREATMENT TOTALS 14th DECEMBER, 1951.

(Number of Animals in 8 Samples)

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	449	104	426	945	164	548
Total Euedaphic Collembola	337	82	324	771	78	313
Total Tullberginae	79	39	94	544	37	158
Tullbergia krausbaueri	64	32	80	152	22	46
Tullbergia crassicuspis	15	4	14	373	13	112
Total Onychiurus spp.	94	13	73	145	22	44
Isotomodes productus	61	8	104	23	9	93
Folsomia candida	98	22	50	59	10	18
Total Hemiedaphic Collembola	106	14	97	153	77	223
Total Oribatei	178	47	67	59	35	41
Punctoribates punctum	21	14	26	12	19	26
Minunthozetes semirufus	85	17	19	27	13	6
Total Oribella spp.	15	1	5	6	1	0
Total Immature Oribatei	28	5	6	5	0	5
Total Acaridiae	54	25	16	23	7	19
Rhizoglyphus echinopus	42	10	7	8	7	4
Total 'Other Acaridiae'[1]	12	15	9	15	0	15
Total Mesostigmata	137	36	48	26	11	5
Total Rhodacaridae	68	16	21	16	2	2
Rhodacarellus epyginialis	38	6	8	14	0	1
Tot. Known Pred. Mesostigmata[2]	31	5	7	1	3	2
Total Pergamasus spp.	26	4	2	1	3	1
Total Immature Mesostigmata	13	10	14	4	3	0

[1,2] Details as in Table A.

SUMMARY TABLE C

TREATMENT TOTALS 20th FEBRUARY, 1952.

(Number of Animals in 8 Samples)

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	340	54	200	561	132	193
Total Euedaphic Collembola	255	43	143	458	53	122
Total Tullberginae	92	20	51	256	36	71
Tullbergia krausbaueri	69	14	32	90	22	17
Tullbergia crassicuspis	15	5	16	161	13	51
Total Onychiurus spp.	58	12	26	110	9	23
Isotomodes productus	65	7	39	39	6	17
Folosomia candida	40	3	25	53	2	11
Total Hemiedaphic Collembola	82	9	49	91	78	59
Total Oribatei	405	40	55	21	26	12
Punctoribates punctum	120	17	27	8	4	4
Minunthozetes semirufus	161	6	11	4	11	0
Total Oribella spp.	27	0	6	2	3	0
Total Immature Oribatei	31	6	3	1	1	1
Total Acaridiae	38	1	23	40	9	3
Rhizoglyphus echinopus	37	1	22	37	9	2
Total 'Other Acaridiae'[1]	1	0	1	3	0	1
Total Mesostigmata	142	30	52	31	18	5
Total Rhodacaridae	69	8	21	22	8	3
Rhodacarellus epyginialis	60	2	16	21	1	1
Total Known Pred. Mesostigmata[2]	38	2	11	6	6	0
Total Pergamasus spp.	23	0	5	4	6	0
Total Immature Mesostigmata	21	7	13	2	2	0

[1,2] Details as in Table A.

SUMMARY TABLE D

TREATMENT TOTALS 18th APRIL, 1952

(Number of Animals in 8 Samples)

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	150	30	166	411	34	99
Total Euedaphic Collembola	115	17	118	287	18	71
Total Tullberginae	48	12	40	197	15	53
Tullbergia krausbaueri	35	12	25	49	15	9
Tullbergia crassicuspis	12	0	8	148	0	43
Total Onychiurus spp.	30	2	19	45	0	6
Isotomodes productus	12	0	41	27	2	8
Folsomia candida	23	3	17	18	1	4
Total Hemiedaphic Collembola	34	12	43	116	16	22
Total Oribatei	274	82	75	64	42	53
Punctoribates punctum	64	24	25	29	31	24
Minunthozetes semirufus	131	36	29	20	5	16
Total Oribella spp.	21	1	6	7	0	3
Total Immature Oribatei	12	8	1	2	0	1
Total Acaridiae	9	1	4	11	2	1
Rhizoglyphus echinopus	8	0	2	11	2	1
Total 'Other Acaridiae'[1]	1	1	2	0	0	0
Total Mesostigmata	76	48	65	15	14	3
Total Rhodacaridae	37	11	36	6	7	1
Rhodacarellus epyginialis	31	6	22	6	7	1
Total Known Pred. Mesostigmata[2]	13	9	7	5	3	1
Total Pergamasus spp.	11	8	6	4	3	1
Total Immature Mesostigmata	14	25	12	3	3	0

[1,2] Details as in Table A.

SUMMARY TABLE E

TREATMENT TOTALS 17th OCTOBER, 1952

(Number of Animals in 8 Samples)

Group or Species	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.
Total Collembola	508	49	280	544	86	231
Total Euedaphic Collembola	394	30	181	416	53	172
Total Tullberginae	201	16	85	266	29	114
Tullbergia krausbaueri	171	11	51	38	12	20
Tullbergia crassicuspis	9	5	21	211	15	94
Total Onychiurus spp.	94	7	38	114	18	43
Isotomodes productus	71	5	33	30	5	8
Folsomia candida	25	0	19	6	1	7
Total Hemiedaphic Collembola	108	15	97	126	33	58
Total Oribatei	364	29	121	54	5	9
Punctoribates punctum	45	10	38	25	0	2
Minunthozetes semirufus	185	10	59	12	3	5
Total Oribella spp.	61	2	5	1	0	0
Total Immature Oribatei	22	3	4	3	0	1
Total Acaridiae	267	43	75	26	2	648
Rhizoglyphus echinopus	54	2	6	5	2	9
Total 'Other Acaridiae'[1]	213	41	69	21	0	639
Total Mesostigmata	193	29	97	27	37	21
Total Rhodacaridae	85	20	44	13	8	8
Rhodacarellus epyginialis	25	12	18	8	3	5
Total Known Pred. Mesostigmata[2]	40	0	16	3	13	4
Total Pergamasus spp.	21	0	13	2	12	3
Total Immature Mesostigmata	39	4	21	9	6	7

[1,2] Details as in Table A.

TABLE F

CHEMICAL ANALYSIS 20th FEBRUARY, 1952

Item \ Plots	Undug	Fallow	Control	D.D.T.	B.H.C.	D.D.T. B.H.C.	
Loss on Ignition (per Cent)	10.4	11.3	11.7	10.6	9.8	11.0	BLOCK 1
p.H. (Water)	5.85	5.54	5.85	5.98	5.92	5.80	
Available P_2O_5 (μ gms per 100 gms)	2.0	4.0	4.0	12.0	2.0	3.0	
Available K_2O (μ gms per 100 gms)	12.0	8.0	17.0	12.0	10.0	13.0	
Loss on Ignition (Per Cent)	11.5	9.6	11.2	11.5	10.3	11.5	BLOCK 2
p.H. (Water)	5.50	5.53	5.78	5.68	5.88	5.72	
Available P_2O_5 (μ gms per 100 gms)	5.0	3.0	4.0	2.0	3.0	2.0	
Available K_2O (μ gms per 100 gms)	17.0	11.0	12.0	11.0	8.0	11.0	
Loss on Ignition (Per Cent)	9.4	11.6	10.5	9.1	9.7	9.3	BLOCK 3
p.H. (Water)	5.54	5.64	5.64	5.72	5.74	6.04	
Available P_2O_5 (μ gms per 100 gms)	2.0	4.0	3.0	3.0	2.0	2.0	
Available K_2O (μ gms per 100 gms)	9.0	7.0	11.0	8.0	9.0	11.0	
Loss on Ignition (Per Cent)	8.0	9.9	9.5	9.1	10.7	8.0	BLOCK 4
p.H. (Water)	5.44	5.95	5.58	5.64	5.82	5.54	
Available P_2O_5 (μ gms per 100 gms)	0.8	3.0	1.0	0.8	1.0	1.0	
Available K_2O (μ gms per 100 gms)	8.0	7.0	10.0	9.0	15.0	11.0	

TABLE I

Census of 9th June 1951

Mean Number of Animals per Sample

2 upper (0-3") and 2 lower (3-9") samples per plot

BLOCK 1

Group or Species	Undug 0-3"	Undug 3-9"	Fallow 0-3"	Fallow 3-9"	Control 0-3"	Control 3-9"	D.D.T. 0-3"	D.D.T. 3-9"	B.H.C. 0-3"	B.H.C. 3-9"	D.D.T.+B.H.C. 0-3"	D.D.T.+B.H.C. 3-9"
1 INSECTA Total	19.5	26.5	6.5	2.0	7.0	3.0	5.0	3.5	3.0	4.0	1.5	3.0
2 Protura	.	.	.	.	.	.	.	.	.	.	.	.
3 Collembola Total	19.0	26.0	6.0	2.0	6.5	3.0	4.5	3.0	2.0	3.5	1.5	3.0
4 Hypogastrura denticulata	1.0	.	.	.	.	.	.	.	.	.	.	0.5
5 Brachystomella parvula	.	.	0.5	.	0.5	.	.	.	.	.	.	.
6 Friesea mirabilis	1.0	.	.	.	.	.	.	0.5	.	.	1.0	.
7 Onychiurus [illegible]	1.5	3.0	3.0	.	1.0	0.5	.	0.5	1.5	0.5	.	0.5
8 Onychiurus spinularius	2.0	12.5	0.5	.	.	0.5	1.0	1.0	.	1.0	.	1.0
9 Undet. Onychiurus spp	.	1.0	.	.	.	.	.	.	.	.	.	.
10 Tullbergia krausbaueri	5.5	4.5	1.0	2.0	1.0	1.0	2.0	.	0.5	2.0	0.5	.
11 Tullbergia quadrispina	.	.	.	.	.	.	.	.	.	.	.	.
12 Tullbergia crassicuspis	1.5	0.5	.	.	.	.	.	0.5	.	.	.	.
13 Isotoma viridis	3.0	.	0.5	.	2.0	.	1.0	.	.	.	.	.
14 Isotomodes productus	.	3.0	0.5	.	.	.	.	.	.	.	.	0.5
15 Folsomia candida	0.5	1.5	.	.	.	1.0	.	.	.	.	.	.
16 Folsomia garretti	1.0	.	.	.	.	.	.	.	.	.	.	.
17 Folsomia quadrioculata	.	.	.	.	1.0	.	.	.	.	.	.	0.5
18 Lepidocyrtus cyaneus	[illegible]	.	.	.	.	.	.	.	.	.	.	.
19 Undet. Collembola	[illegible]	.	.	.	1.0	.	0.5	0.5	.	.	.	.
20 PSOCOPTERA	.	.	.	.	.	.	.	.	.	.	.	.
THYSANOPTERA												
21 Aptinothrips rufus	.	.	.	.	.	.	.	.	.	.	.	.
22 Undet. Thripidae spp	.	.	.	.	.	.	.	0.5	.	.	.	.
23 Phlaeothripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
HEMIPTERA												
24 Aphididae spp	.	.	.	.	.	.	.	.	.	.	.	.
25 Other Hemiptera	.	.	.	.	.	.	.	.	0.5	.	.	.
COLEOPTERA (Adults)												
26 Staphylinidae spp	.	.	.	.	0.5	.	.	.	.	0.5	.	.
COLEOPTERA (Larvae)												
27 Staphylinidae spp	.	.	.	.	.	.	.	.	.	.	.	.
28 Chrysomelidae sp	.	0.5	.	.	.	.	.	.	.	.	.	.
29 Elateridae sp	.	.	.	.	.	.	.	.	.	.	.	.
30 Curculionidae spp	.	.	0.5	.	.	.	.	.	.	.	.	.
DIPTERA (Larvae)												
31 Tendipedidae spp	.	.	.	.	.	.	.	.	0.5	.	.	.
32 Cyclorrhapha spp	.	.	.	.	.	.	0.5	.	.	.	.	.
DIPTERA (Pupae)												
33 Orthorrhapha sp	0.5	.	.	.	.	.	.	.	.	.	.	.
34 Cyclorrhapha spp	.	.	.	.	.	.	.	.	.	.	.	.
ARACHNIDA AND OTHER ARTHROPODA												
35 Araneida	.	.	.	.	.	.	.	.	.	.	.	.
36 Acari Total	19.0	9.5	5.5	4.0	5.0	8.0	4.5	5.0	7.0	8.0	3.0	4.0
37 Oribatei Total	10.5	2.0	3.5	1.0	2.5	4.5	1.5	1.5	5.0	3.0	2.0	2.5
38 Eulohmannia ribagai	.	.	.	.	.	.	.	.	.	.	.	.
39 Hypochthonius rufulus	.	.	.	.	.	.	.	.	.	.	.	.
40 Ceratozetes gracilis	1.0	1.0	.	.	0.5	.	.	.	.	.	.	.
41 Achipteria coleoptrata	.	.	1.0	.	.	.	.	.	.	.	0.5	.
42 Euzetes globulus	.	.	.	.	.	.	.	.	.	.	.	.
43 Punctoribates punctum	5.0	.	.	1.0	2.0	0.5	1.0	0.5	1.0	1.5	.	1.5
44 Minunthozetes semirufus	3.0	1.0	1.0	.	.	3.0	0.5	1.0	3.0	0.5	1.5	0.5
45 Oppia clavipectinata	.	.	1.0	.	.	.	.	.	0.5	.	.	.
46 Oribella lanceolata	1.0	.	.	.	.	.	.	.	.	.	.	.
47 Oribella paolii	.	.	0.5	.	.	.	.	.	0.5	0.5	.	.
48 Scutovertex sculptus	.	.	.	.	.	.	.	.	.	.	.	0.5
49 Immature Oribatei	0.5	.	.	.	.	1.0	.	.	.	0.5	.	.
50 ACARIDIAE Total	3.5	1.0	1.0	.	0.5	0.5	2.0	0.5	1.5	1.5	1.0	.
51 Acarus siro	.	.	.	.	.	.	.	.	.	.	.	.
52 [illegible] castellanii	.	.	1.0	.	.	.	.	.	.	.	1.0	.
53 Rhizoglyphus echinopus	3.5	1.0	.	.	.	0.5	2.0	0.5	1.5	.	.	.
54 Glycyphagus destructor	.	.	.	.	0.5	.	.	.	.	1.5	.	.
55 MESOSTIGMATA Total	4.5	6.5	1.0	3.0	2.0	3.0	1.0	3.0	0.5	3.5	.	1.5
56 Rhodacarus roseus	0.5	.	.	.	0.5	.	.	.	.	.	.	.
57 Rhodacarellus epygynialis	1.0	4.5	.	1.5	0.5	0.5	.	2.5	0.5	1.0	.	.
58 Veigaia nemorensis	.	.	0.5	.	.	0.5	0.5	.	.	1.0	.	.
59 Pergamasus runciger	.	.	.	.	.	.	.	.	.	.	.	.
60 Pergamasus misellus	.	.	.	0.5	.	.	.	.	.	.	.	.
61 Pachylaelaps sp	.	.	.	.	.	0.5	.	.	.	.	.	.
62 Digamasellus reticulatus	.	.	.	.	.	.	.	.	.	.	.	.
63 Arctoseius cetratus	.	0.5	.	.	.	.	.	.	.	.	.	.
64 Cosmolaelaps claviger	.	0.5	.	.	.	.	.	.	.	.	.	.
65 Lasioseius penicilliger	.	.	.	.	.	.	.	.	.	.	.	.
66 [illegible]	.	.	.	.	.	.	.	.	.	.	.	.

BLOCK 2

Group or Species	Undug 0-3"	Undug 3-9"	Fallow 0-3"	Fallow 3-9"	Control 0-3"	Control 3-9"	D.D.T. 0-3"	D.D.T. 3-9"	B.H.C. 0-3"	B.H.C. 3-9"	D.D.T.+B.H.C. 0-3"	D.D.T.+B.H.C. 3-9"
1 INSECTA Total	24.0	8.5	0.5	1.0	0.5	10.5	7.0	66.5	0.5	2.5	7.0	6.0
2 Protura	.	.	.	.	.	.	.	.	.	.	.	.
3 Collembola Total	19.0	8.0	.	1.0	0.5	10.5	7.0	66.5	0.5	2.5	7.0	6.0
4 Hypogastrura denticulata	.	.	.	.	.	.	.	2.0	.	.	.	.
5 Brachystomella parvula	0.5	.	.	.	.	.	.	1.0	0.5	.	.	.
6 Friesea mirabilis	0.5	.	.	.	.	.	0.5	.	.	0.5	.	0.5
7 Onychiurus [illegible]	3.5	.	.	.	.	1.0	.	2.0	.	.	.	.
8 Onychiurus spinularius	.	1.0	.	0.5	.	4.0	.	8.0	.	1.0	.	3.5
9 Undet. Onychiurus spp	.	.	.	.	.	.	.	.	.	.	.	.
10 Tullbergia krausbaueri	5.5	5.0	.	0.5	0.5	2.0	1.5	0.5	.	.	3.0	0.5
11 Tullbergia quadrispina	.	0.5	.	.	.	.	.	.	.	.	.	.
12 Tullbergia crassicuspis	1.0	1.0	.	.	.	3.0	4.0	50.5	.	.	.	1.0
13 Isotoma viridis	0.5	.	.	.	.	.	.	.	.	.	.	.
14 Isotomodes productus	.	.	.	.	.	.	1.0	1.5	.	.	3.5	0.5
15 Folsomia candida	.	.	.	.	.	0.5	.	1.0	.	.	0.5	.
16 Folsomia garretti	2.0	.	.	.	.	.	.	.	.	.	.	.
17 Folsomia quadrioculata	5.5	.	.	.	.	.	.	.	.	.	.	.
18 Lepidocyrtus cyaneus	.	.	.	.	.	.	.	.	.	.	.	.
19 Undet. Collembola	.	0.5	.	.	.	.	.	.	.	1.0	.	.
20 PSOCOPTERA	.	0.5	0.5	.	.	.	.	.	.	.	.	.
THYSANOPTERA												
21 Aptinothrips rufus	.	.	.	.	.	.	.	.	.	.	.	.
22 Undet. Thripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
23 Phlaeothripidae spp	1.0	.	.	.	.	.	.	.	.	.	.	.
HEMIPTERA												
24 Aphididae spp	.	.	.	.	.	.	.	.	.	.	.	.
25 Other Hemiptera	.	.	.	.	.	.	.	.	.	.	.	.
COLEOPTERA (Adults)												
26 Staphylinidae spp	.	.	.	.	.	.	.	.	.	.	.	.
COLEOPTERA (Larvae)												
27 Staphylinidae spp	.	.	.	.	.	.	.	.	.	.	.	.
28 Chrysomelidae sp	.	.	.	.	.	.	.	.	.	.	.	.
29 Elateridae sp	.	.	.	.	.	.	.	.	.	.	.	.
30 Curculionidae spp	.	.	.	.	.	.	.	.	.	.	.	.
DIPTERA (Larvae)												
31 Tendipedidae spp	3.5	.	.	.	.	.	.	.	.	.	.	.
32 Cyclorrhapha spp	.	.	.	.	.	.	.	.	.	.	.	.
DIPTERA (Pupae)												
33 Orthorrhapha sp	.	.	.	.	.	.	.	.	.	.	.	.
34 Cyclorrhapha spp	0.5	.	.	.	.	.	.	.	.	.	.	.
ARACHNIDA AND OTHER ARTHROPODA												
35 Araneida	.	.	0.5	.	.	.	.	.	.	.	.	.
36 Acari Total	101.0	18.5	29.0	26.5	6.0	26.0	12.5	7.0	11.5	22.5	11.5	20.5
37 Oribatei Total	78.0	15.0	28.0	24.5	5.0	17.0	11.5	1.0	11.5	19.0	10.0	16.5
38 Eulohmannia ribagai	.	.	.	1.0	.	.	.	.	.	.	.	.
39 Hypochthonius rufulus	.	.	.	.	.	.	.	.	.	.	.	.
40 Ceratozetes gracilis	.	.	.	.	.	.	.	.	.	.	.	0.5
41 Achipteria coleoptrata	6.5	2.0	.	.	0.5	0.5	0.5	.	.	1.5	.	.
42 Euzetes globulus	0.5	0.5	.	.	.	.	0.5	.	0.5	0.5	.	.
43 Punctoribates punctum	25.5	4.0	15.0	16.0	1.0	3.5	5.5	1.0	7.0	12.0	6.0	10.0
44 Minunthozetes semirufus	37.0	8.0	10.5	4.5	2.5	7.5	4.0	.	3.5	4.0	3.5	4.0
45 Oppia clavipectinata	.	.	0.5	.	0.5	1.0	.	.	0.5	1.0	0.5	0.5
46 Oribella lanceolata	0.5	.	0.5	.	.	.	0.5	.	.	.	.	.
47 Oribella paolii	1.5	0.5	1.0	2.0	0.5	1.5	0.5	.	.	.	.	1.5
48 Scutovertex sculptus	1.5	.	0.5	1.0	.	0.5	.	.	.	.	.	0.5
49 Immature Oribatei	5.0	.	.	.	.	0.5	.	.	.	.	.	.
50 ACARIDIAE Total	8.0	1.0	0.5	.	0.5	0.5	.	.	.	0.5	1.5	0.5
51 Acarus siro	.	.	.	.	.	.	.	.	.	.	.	.
52 [illegible] castellanii	0.5	.	.	.	.	.	.	.	.	.	.	.
53 Rhizoglyphus echinopus	7.5	1.0	.	.	0.5	0.5	.	.	.	0.5	1.5	0.5
54 Glycyphagus destructor	.	.	0.5	.	.	.	.	.	.	.	.	.
55 MESOSTIGMATA Total	14.5	2.5	0.5	2.0	0.5	8.0	1.0	6.0	.	3.0	.	3.0
56 Rhodacarus roseus	2.0	.	.	.	.	.	.	.	.	.	.	.
57 Rhodacarellus epygynialis	1.0	1.0	.	.	0.5	7.0	0.5	5.0	.	1.0	.	2.0
58 Veigaia nemorensis	0.5	.	.	.	.	.	.	.	.	.	.	.
59 Pergamasus runciger	.	.	.	.	.	0.5	.	.	.	.	.	.
60 Pergamasus misellus	.	.	.	.	.	.	.	.	.	.	.	.
61 Pachylaelaps sp	1.0	.	.	.	.	0.5	.	.	.	.	.	0.5
62 Digamasellus reticulatus	.	.	.	.	.	.	.	.	.	.	.	.
63 Arctoseius cetratus	.	.	.	.	.	.	.	.	.	.	.	.
64 Cosmolaelaps claviger	.	.	.	.	.	.	.	.	.	.	.	.
65 Lasioseius penicilliger	.	.	.	.	.	.	.	.	.	.	.	.
66 [illegible]	.	.	.	.	.	.	.	.	.	.	.	.

BLOCK 3

Group or Species	Undug 0-3"	Undug 3-9"	Fallow 0-3"	Fallow 3-9"	Control 0-3"	Control 3-9"	D.D.T. 0-3"	D.D.T. 3-9"	B.H.C. 0-3"	B.H.C. 3-9"	D.D.T.+B.H.C. 0-3"	D.D.T.+B.H.C. 3-9"
1 INSECTA Total	29.5	14.5	2.0	6.5	17.5	3.5	2.5	3.5	6.0	6.5	6.0	1.5
2 Protura	.	.	.	.	.	.	.	.	.	.	.	.
3 Collembola Total	26.0	14.0	2.0	6.0	17.5	3.0	2.5	3.5	5.0	6.0	6.0	1.0
4 Hypogastrura denticulata	.	.	.	.	0.5	.	.	.	.	.	.	.
5 Brachystomella parvula	1.0	.	.	.	0.5	.	.	0.5	.	.	.	.
6 Friesea mirabilis	.	.	.	.	2.0	.	.	.	.	1.0	.	.
7 Onychiurus [illegible]	2.0	.	.	.	.	0.5	0.5	.	.	.	0.5	.
8 Onychiurus spinularius	.	2.0	.	1.0	.	.	.	.	.	0.5	.	.
9 Undet. Onychiurus spp	.	.	.	.	.	.	.	.	.	.	.	0.5
10 Tullbergia krausbaueri	6.5	0.5	2.0	1.0	1.5	2.0	.	.	.	.	.	.
11 Tullbergia quadrispina	.	0.5	.	.	.	.	.	.	.	.	.	.
12 Tullbergia crassicuspis	.	6.0	.	.	2.0	0.5	.	0.5	.	1.5	.	0.5
13 Isotoma viridis	1.0	.	.	.	0.5	.	.	.	.	0.5	.	.
14 Isotomodes productus	8.0	2.5	.	4.0	9.0	.	1.5	1.5	4.0	1.5	6.5	.
15 Folsomia candida	6.0	1.5	.	.	1.0	.	.	1.0	1.0	1.0	.	.
16 Folsomia garretti	1.0	.	.	.	.	.	.	.	.	.	.	.
17 Folsomia quadrioculata	.	0.5	.	.	.	.	0.5	.	.	.	.	.
18 Lepidocyrtus cyaneus	.	.	.	.	.	.	.	.	.	.	.	.
19 Undet. Collembola	0.5	0.5	.	.	0.5	.	.	.	.	.	.	.
20 PSOCOPTERA	.	.	.	.	.	.	.	.	.	.	.	.
THYSANOPTERA												
21 Aptinothrips rufus	1.5	0.5	.	.	.	.	.	.	.	.	.	.
22 Undet. Thripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
23 Phlaeothripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
HEMIPTERA												
24 Aphididae spp	.	.	.	.	.	.	.	.	.	.	.	.
25 Other Hemiptera	.	.	.	.	.	.	.	.	.	.	.	.
COLEOPTERA (Adults)												
26 Staphylinidae spp	.	.	.	.	.	.	.	.	.	.	.	.
COLEOPTERA (Larvae)												
27 Staphylinidae spp	1.0	.	.	.	.	.	.	.	.	.	.	.
28 Chrysomelidae sp	.	.	.	.	.	.	.	.	.	.	.	.
29 Elateridae sp	.	.	.	0.5	.	.	.	.	.	.	.	.
30 Curculionidae spp	.	.	.	.	.	.	.	.	.	.	.	.
DIPTERA (Larvae)												
31 Tendipedidae spp	0.5	.	.	.	.	0.5	.	.	.	.	.	0.5
32 Cyclorrhapha spp	.	.	.	.	.	.	.	.	.	0.5	.	.
DIPTERA (Pupae)												
33 Orthorrhapha sp	.	.	.	.	.	.	.	.	.	.	.	.
34 Cyclorrhapha spp	0.5	.	.	.	.	.	.	.	.	.	.	.
ARACHNIDA AND OTHER ARTHROPODA												
35 Araneida	.	.	.	.	.	.	.	.	.	.	.	.
36 Acari Total	55.0	10.5	24.5	12.0	24.5	16.5	4.0	7.5	9.0	26.0	6.0	17.0
37 Oribatei Total	44.5	3.0	21.0	7.5	22.5	14.5	2.0	3.0	6.5	21.0	5.0	15.0
38 Eulohmannia ribagai	.	.	.	.	.	.	.	.	.	.	.	.
39 Hypochthonius rufulus	.	.	.	.	.	.	.	.	.	.	.	.
40 Ceratozetes gracilis	2.0	.	.	.	.	.	.	.	.	.	.	.
41 Achipteria coleoptrata	.	0.5	1.0	1.0	1.0	.	.	.	.	2.0	.	.
42 Euzetes globulus	.	.	1.0	.	.	.	.	.	.	.	.	.
43 Punctoribates punctum	27.5	1.0	13.5	3.5	16.0	12.0	1.0	2.0	5.0	14.5	4.0	8.5
44 Minunthozetes semirufus	6.5	0.5	2.5	2.5	2.0	2.5	0.5	0.5	1.0	2.0	1.0	4.0
45 Oppia clavipectinata	2.0	0.5	2.5	.	1.5	.	.	0.5	.	1.0	.	0.5
46 Oribella lanceolata	0.5	0.5	.	.	0.5	.	0.5	.	.	0.5	.	0.5
47 Oribella paolii	3.5	.	0.5	0.5	.	.	.	.	0.5	1.0	.	1.0
48 Scutovertex sculptus	1.5	.	.	.	0.5	.	.	.	.	.	.	0.5
49 Immature Oribatei	3.0	.	.	.	0.5	.	.	.	.	.	.	.
50 ACARIDIAE Total	1.0	.	.	.	.	.	1.0	.	.	.	.	.
51 Acarus siro	0.5	.	.	.	.	.	.	.	.	.	.	.
52 [illegible] castellanii	.	.	.	.	.	.	0.5	.	.	.	.	.
53 Rhizoglyphus echinopus	0.5	.	.	.	.	.	0.5	.	.	.	.	.
54 Glycyphagus destructor	.	.	.	.	.	.	.	.	.	.	.	.
55 MESOSTIGMATA Total	7.5	7.5	3.5	4.0	2.0	2.0	1.0	4.5	2.5	5.0	1.0	2.0
56 Rhodacarus roseus	1.5	1.5	2.0	0.5	1.0	0.5	0.5	2.0	1.5	3.0	.	1.0
57 Rhodacarellus epygynialis	3.0	5.0	.	2.0	0.5	.	.	0.5	.	0.5	1.0	1.0
58 Veigaia nemorensis	.	.	.	.	.	.	.	.	.	.	.	.
59 Pergamasus runciger	0.5	.	.	.	.	.	.	1.0	.	.	.	.
60 Pergamasus misellus	0.5	.	0.5	.	.	.	.	.	.	.	.	.
61 Pachylaelaps sp	.	.	.	.	.	.	.	.	0.5	.	.	.
62 Digamasellus reticulatus	0.5	.	.	.	.	.	.	.	.	.	.	.
63 Arctoseius cetratus	.	.	.	.	.	.	.	.	.	.	.	.
64 Cosmolaelaps claviger	.	.	.	.	.	.	.	.	.	.	.	.
65 Lasioseius penicilliger	.	.	.	.	.	.	.	.	.	.	.	.
66 [illegible]	0.5	0.5	0.5	.	.	0.5	.	.	.	.	.	.

BLOCK 4

Group or Species	Undug 0-3"	Undug 3-9"	Fallow 0-3"	Fallow 3-9"	Control 0-3"	Control 3-9"	D.D.T. 0-3"	D.D.T. 3-9"	B.H.C. 0-3"	B.H.C. 3-9"	D.D.T.+B.H.C. 0-3"	D.D.T.+B.H.C. 3-9"
1 INSECTA Total	10.0	8.5	6.5	3.5	20.0	4.5	2.0	13.0	1.0	2.5	1.0	5.0
2 Protura	.	.	.	.	.	.	.	.	.	.	.	.
3 Collembola Total	9.0	8.5	6.5	3.0	19.5	4.5	2.0	12.0	1.0	2.5	1.0	4.5
4 Hypogastrura denticulata	.	.	.	.	0.5	.	1.0	0.5	.	.	.	.
5 Brachystomella parvula	.	.	.	.	.	.	.	.	.	.	.	.
6 Friesea mirabilis	.	1.0	1.0	.	.	.	.	.	.	.	.	.
7 Onychiurus [illegible]	.	.	.	0.5	.	.	0.5	1.5	.	0.5	.	.
8 Onychiurus spinularius	.	2.5	0.5	2.0	.	2.5	.	1.0	.	2.0	.	0.5
9 Undet. Onychiurus spp	.	.	.	.	.	.	.	.	.	.	.	.
10 Tullbergia krausbaueri	2.0	.	3.5	.	2.0	0.5	.	3.5	1.0	.	0.5	.
11 Tullbergia quadrispina	.	.	.	.	.	.	.	.	.	.	.	.
12 Tullbergia crassicuspis	1.0	1.5	.	.	.	1.5	.	6.0	.	.	.	3.5
13 Isotoma viridis	.	.	0.5	.	.	.	0.5	.	.	.	.	.
14 Isotomodes productus	2.0	3.0	.	.	14.5	.	.	.	.	.	.	0.5
15 Folsomia candida	.	.	.	0.5	1.5	.	.	.	.	.	.	.
16 Folsomia garretti	.	.	.	.	.	.	.	.	.	.	.	.
17 Folsomia quadrioculata	2.0	0.5	1.0	.	.	.	.	.	.	.	.	.
18 Lepidocyrtus cyaneus	.	.	.	.	0.5	.	.	.	.	.	.	.
19 Undet. Collembola	2.0	.	.	.	0.5	.	.	.	.	.	0.5	.
20 PSOCOPTERA	.	.	.	.	.	.	.	.	.	.	.	.
THYSANOPTERA												
21 Aptinothrips rufus	.	.	.	.	.	.	.	0.5	.	.	.	.
22 Undet. Thripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
23 Phlaeothripidae spp	.	.	.	.	.	.	.	.	.	.	.	.
HEMIPTERA												
24 Aphididae spp	.	.	.	.	.	.	.	.	.	.	.	.
25 Other Hemiptera	.	.	.	.	.	.	.	.	.	.	.	.
COLEOPTERA (Adults)												
26 Staphylinidae spp	.	.	.	.	.	.	.	0.5	.	.	.	.
COLEOPTERA (Larvae)												
27 Staphylinidae spp	0.5	.	.	.	.	.	.	.	.	.	.	.
28 Chrysomelidae sp	.	.	.	0.5	.	.	.	.	.	.	.	.
29 Elateridae sp	.	.	.	.	.	.	.	.	.	.	.	.
30 Curculionidae spp	.	.	.	.	.	.	.	.	.	.	.	0.5
DIPTERA (Larvae)												
31 Tendipedidae spp	.	.	.	.	.	.	.	.	.	.	.	.
32 Cyclorrhapha spp	.	.	.	.	0.5	.	.	.	.	.	.	.
DIPTERA (Pupae)												
33 Orthorrhapha sp	.	.	.	.	.	.	.	.	.	.	.	.
34 Cyclorrhapha spp	0.5	.	.	.	.	.	.	.	.	.	.	.
ARACHNIDA AND OTHER ARTHROPODA												
35 Araneida	.	.	.	.	.	.	.	.	.	.	.	.
36 Acari Total	17.5	10.5	17.5	17.0	27.5	23.0	13.0	27.0	7.5	27.5	14.5	15.5
37 Oribatei Total	9.5	0.5	17.0	15.0	22.0	15.0	12.0	21.0	5.0	24.0	13.0	12.5
38 Eulohmannia ribagai	.	.	.	.	.	.	.	.	.	.	.	.
39 Hypochthonius rufulus	.	.	0.5	.	.	.	.	.	.	.	.	.
40 Ceratozetes gracilis	.	.	.	.	0.5	.	0.5	.	.	1.0	.	.
41 Achipteria coleoptrata	.	.	1.0	.	.	.	.	.	0.5	0.5	0.5	.
42 Euzetes globulus	.	.	.	.	0.5	.	0.5	.	.	.	.	0.5
43 Punctoribates punctum	3.5	.	7.5	6.5	17.5	11.0	[illegible]	[illegible]	4.0	13.5	8.5	8.5
44 Minunthozetes semirufus	5.0	.	5.0	7.0	2.5	2.0	2.0	6.5	.	5.0	3.5	2.0
45 Oppia clavipectinata	.	.	2.5	0.5	0.5	0.5	1.0	.	.	.	.	.
46 Oribella lanceolata	.	.	.	1.0	0.5	.	0.5	.	.	1.5	.	.
47 Oribella paolii	1.0	.	.	.	.	1.0	0.5	.	.	1.5	.	1.5
48 Scutovertex sculptus	.	0.5	.	.	0.5	.	.	.	.	.	.	.
49 Immature Oribatei	.	.	0.5	.	.	.	.	1.0	.	1.0	0.5	.
50 ACARIDIAE Total	.	1.0	0.5	0.5	0.5	.	.	.	1.0	0.5	1.5	1.0
51 Acarus siro	.	0.5	.	.	.	.	.	.	.	.	0.5	.
52 [illegible] castellanii	.	.	.	.	.	.	.	.	.	.	.	.
53 Rhizoglyphus echinopus	.	0.5	0.5	0.5	.	.	.	.	.	0.5	.	1.0
54 Glycyphagus destructor	.	.	.	.	0.5	.	.	.	1.0	.	1.0	.
55 MESOSTIGMATA Total	8.0	9.0	.	1.5	5.0	7.5	1.0	6.0	1.5	3.0	.	2.0
56 Rhodacarus roseus	.	.	.	.	.	0.5	.	.	.	.	.	.
57 Rhodacarellus epygynialis	0.5	7.0	.	1.0	1.5	5.0	0.5	4.5	1.5	3.0	.	1.5
58 Veigaia nemorensis	.	.	.	.	.	.	.	.	.	.	.	.
59 Pergamasus runciger	2.0	.	.	.	.	0.5	.	.	.	.	.	.
60 Pergamasus misellus	0.5	.	.	.	.	.	.	.	.	.	.	.
61 Pachylaelaps sp	.	.	.	.	.	.	.	.	.	.	.	0.5
62 Digamasellus reticulatus	.	.	.	.	.	.	.	.	.	.	.	.
63 Arctoseius cetratus	0.5	.	.	.	.	.	.	.	.	.	.	.
64 Cosmolaelaps claviger	.	0.5	.	.	.	.	.	.	.	.	.	.
65 Lasioseius penicilliger	.	0.5	.	.	.	.	.	.	.	.	.	.
66 [illegible]	.	0.5	.	0.5	.	.	.	.	.	.	.	.

TABLE II.

CENSUS OF 16th OCTOBER 1951.

Mean Number of Animals per Sample

(2 samples per plot)

	GROUP OR SPECIES	BLOCK 1.						BLOCK 2.						BL		
		UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+B.H.C.	UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+B.H.C.	UNDUG	FALLOW	CONTR
1	INSECTA Total	70.5	17.5	93.0	52.0	16.0	17.0	42.0	14.0	31.5	149.5	14.5	14.5	75.0	7.0	79.5
2	PROTURA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5
3	COLLEMBOLA Total	70.5	16.0	87.5	50.5	11.5	16.0	40.0	9.0	28.0	148.5	13.5	14.5	71.5	6.5	73.5
4	Hypogastrura denticulata	3.0	-	1.5	2.5	-	3.0	2.0	1.0	0.5	0.5	-	0.5	-	-	-
5	Brachystomella parvula	5.0	-	-	2.5	0.5	-	1.0	-	3.0	0.5	3.5	2.0	2.5	-	2.0
6	Friesia mirablis	1.5	-	1.0	-	-	-	1.0	-	1.0	-	-	-	5.0	0.5	1.5
7	Onychiurus uliginatus	20.5	1.0	20.5	12.5	1.0	-	4.0	-	4.0	2.0	2.0	2.0	4.0	0.5	5.5
8	Onychiurus spinularius	6.0	-	-	1.0	-	-	-	-	2.5	4.0	-	1.0	-	-	2.0
9	Undet Onychiurus spp.	2.0	-	5.0	0.5	-	1.0	-	-	-	-	-	-	-	-	-
10	Tullbergia krausbaueri	25.0	2.5	6.5	19.0	1.5	7.0	15.5	4.0	7.5	21.5	4.0	3.0	18.0	-	15.0
11	Tullbergia quadrispina	-	-	4.0	-	-	-	4.5	-	1.0	0.5	-	-	-	-	0.5
12	Tullbergia crassicuspis	0.5	0.5	3.0	1.5	-	-	1.0	-	-	105.0	1.5	3.0	1.5	0.5	1.0
13	Isotoma viridis	0.5	4.0	17.0	3.0	3.0	0.5	1.5	1.0	1.0	5.5	1.0	3.0	1.0	2.5	1.0
14	Isotomodes productus	-	-	1.5	-	-	1.0	3.5	-	2.5	6.0	0.5	-	14.5	1.0	29.5
15	Folsomia candida	6.0	1.5	20.0	6.5	3.0	0.5	5.0	0.5	3.5	2.5	1.0	-	22.5	0.5	8.0
16	Folsomia garretti	-	-	5.0	-	-	-	-	-	-	-	-	-	1.0	-	2.0
17	Folsomia quadrioculata	-	2.5	-	1.5	-	-	1.0	-	-	-	-	-	1.0	-	2.5
18	Lepidocyrtus cyaneus	-	-	-	-	0.5	-	-	1.0	-	-	-	-	0.5	-	3.0
19	Undet. Collembola	0.5	4.0	2.5	-	2.0	3.0	-	1.5	1.5	0.5	-	-	-	1.0	-
20	PSOCOPTERA	-	-	-	-	0.5	0.5	-	-	-	-	-	-	-	-	-
	THYSANOPTERA															
21	Aptinothrips rufus	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-
22	Undet Thripidae sp.	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-
23	Phlaeothripidae sp	-	-	-	0.5	-	-	-	-	-	-	-	-	0.5	-	-
	HEMIPTERA															
24	Aphididae spp	-	-	-	-	2.5	-	-	-	-	-	1.0	-	-	-	-
	COLEOPTERA (Adults)															
25	Staphylinidae spp	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-
26	Hydrophylidae sp	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
	COLEOPTERA (Larvae)															
27	Caribidae spp	-	-	0.5	0.5	-	-	-	-	-	1.0	-	-	-	-	-
28	Staphylinidae spp	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	0.5
29	Curculionidae spp	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	0.5
	DIPTERA (Larvae)															
30	Petauristidae sp	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-	-
31	Tendipedidae spp.	-	1.0	2.5	-	1.0	-	1.5	5.0	2.0	-	-	-	1.5	0.5	1.
32	Cyclorrhapha spp.	-	0.5	1.0	0.5	-	-	-	-	0.5	-	-	-	0.5	-	2.5
	DIPTERA (Pupae)															
33	Cyclorrhapha spp.	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
	ARACHNIDA AND OTHER ARTHROPODA															
34	ARANEIDA	1.0	-	-	-	-	-	0.5	-	-	-	-	-	-	-	0.
35	ACARI Total	40.0	16.5	55.0	8.5	13.0	10.5	91.0	19.0	29.5	16.5	11.5	2.5	103.0	19.5	59.5
36	ORIBATEI Total	12.5	0.5	12.5	1.0	0.5	3.5	57.0	11.5	12.5	3.5	3.0	2.0	72.0	8.5	23.
37	Hypochthonius rufulus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	Ceratozetes gracilis	-	-	0.5	-	-	-	1.0	-	-	-	-	-	1.0	0.5	-
39	Achipteria coleoptrata	-	-	1.0	-	-	0.5	3.5	-	-	-	-	-	-	-	0.
40	Euzetes globulus	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-
41	Punctoribates punctum	6.5	-	1.5	-	0.5	-	12.5	7.5	3.5	-	1.5	2.0	30.0	2.0	11.
42	Minunthozetes semirufus	4.0	-	3.0	-	-	-	17.0	2.0	7.5	-	-	-	21.5	2.0	7.5
43	Oppia clavipectinata	0.5	0.5	2.0	-	-	-	3.0	-	-	0.5	-	-	3.5	0.5	-
44	Oribella lanceolata	0.5	-	-	-	-	-	2.5	-	1.0	1.5	0.5	-	5.5	0.5	-
45	Oribella paolii	0.5	-	1.0	0.5	-	-	4.0	1.0	-	-	-	-	2.5	0.5	-
46	Scutovertex sculptus	-	-	-	-	-	-	-	-	0.5	-	-	-	1.0	0.5	0.
47	Phthiracarus anonymum	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	0.
48	Immature Oribatei	0.5	-	3.5	0.5	-	3.0	12.5	1.0	-	1.5	1.0	-	6.5	1.0	3.
49	Undet. Oribatei	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-
50	ACARIDIAE Total	14.5	7.0	32.0	4.5	9.0	4.0	10.5	3.5	10.0	3.0	3.0	-	2.5	4.0	19.
51	Acarus siro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	Coelognathus castellanii	2.0	5.5	27.0	4.0	9.0	4.0	2.5	3.5	10.0	3.0	2.5	-	2.5	4.0	18.
53	Rhizoglyphus echinopus	12.5	1.5	5.0	0.5	-	-	7.5	-	-	-	0.5	-	-	-	0.
54	Glycyphagus destructor	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	1.
55	MESOSTIGMATA Total	12.5	8.5	10.5	2.0	3.5	2.0	22.5	4.0	6.0	6.5	5.0	0.5	26.5	6.5	16.
56	Rhodacarus roseus	4.5	-	-	0.5	0.5	-	9.0	-	-	0.5	0.5	-	9.0	2.5	10.
57	Rhodacarellus epsyinialis	2.0	-	0.5	0.5	-	0.5	2.0	0.5	3.0	5.5	2.0	0.5	6.0	1.0	1.
58	Veigaia nemorensis	3.0	-	0.5	-	-	-	-	-	-	-	-	-	1.0	-	-
59	Pergamasus runciger	0.5	2.0	1.5	-	0.5	-	2.0	-	-	-	0.5	-	1.5	-	-
60	Pergamasus misellus	-	-	0.5	-	0.5	-	0.5	-	0.5	-	-	-	1.5	0.5	-
61	Pachylaelaps sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	Digamasellus reticulatus	-	-	1.0	-	-	0.5	0.5	-	-	-	-	-	0.5	-	-
63	Arctoseius cetratus	0.5	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-
64	Arctoseiopsis minutus	-	-	-	-	-	-	-	-	-	0.5	0.5	-	0.5	-	-
65	Cosmolaelaps claviger	-	-	-	-	-	1.0	0.5	-	-	-	-	-	-	-	-
66	Lasioseius penicilliger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Platyseius n.sp.	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
68	Hypoaspis aculeifer	-	-	0.5	-	-	-	1.0	0.5	-	-	-	-	-	-	0.
69	Eviphis ostrinus	0.5	-	-	-	-	-	0.5	-	-	-	-	-	0.5	-	-
70	Olodiscus minima	-	-	0.5	-	-	-	1.0	1.0	0.5	-	0.5	-	1.0	-	2.
71	Immature Mesostigmata	1.5	6.0	4.5	1.0	2.0	-	5.0	1.5	2.0	2.0	1.0	-	5.0	1.0	3.
72	Undet. Mesostigmata	-	0.5	-	-	-	-	-	0.5	-	-	-	-	-	1.5	-
	PROSTIGMATA															
73	Cheyletus eruditus	-	0.5	-	-	-	1.0	-	-	-	-	-	-	-	-	-
	HETEROSTIGMATA															
74	Pygmephorus sp.	0.5	-	-	1.0	-	-	1.0	-	-	1.5	0.5	-	1.5	0.5	0
75	Undet. Acari	-	-	-	-	-	-	-	-	1.0	-	-	-	0.5	-	-
76	CHILOPODA	-	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-	-
77	TARDIGRADA	-	1.5	0.5	1.0	-	1.5	-	-	-	1.0	-	-	-	-	4.
78	TOTAL ARTHROPODA	111.5	36.0	149.0	62.0	29.0	29.0	133.5	33.0	61.0	167.0	26.0	17.0	178.0	26.5	144.

TABLE III
CENSUS OF 14th DECEMBER 1951
Mean Number of Animals per Sample
(2 samples per plot)

	GROUP OR SPECIES		BLOCK 1						BLOCK 2								
			UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW	CON
1	INSECTA	Total	70·0	16·5	51·5	88·0	24·0	62·0	48·0	13·0	43·0	168·5	13·5	52·5	77·5	18·5	7
2	PROTURA		-	-	0·5	-	-	-	-	-	-	-	-	-	-	-	1
3	COLLEMBOLA	Total	67·0	14·0	47·5	80·0	21·5	61·0	42·0	12·0	39·0	167·5	13·5	51·5	73·0	16·0	7
4	Hypogastrura denticulata		10·5	1·0	-	5·0	6·5	29·0	5·0	-	3·0	0·5	-	15·5	-	-	-
5	Brachystomella parvula		6·0	-	1·5	0·5	-	5·0	4·0	-	2·0	0·5	2·5	6·0	4·0	-	1
6	Friesea mirablis		0·5	0·5	-	-	-	-	1·5	-	1·5	-	-	-	2·0	-	1
7	Onychiurus uliginatus		23·0	2·5	14·0	12·0	2·0	0·5	2·5	-	1·0	1·0	-	1·0	2·5	-	6
8	Onychiurus spinularius		6·5	1·0	-	5·0	3·5	-	3·5	2·0	3·5	2·0	2·5	3·0	1·0	0·5	3
9	Undet. Onychiurus spp		5·5	-	2·0	-	1·0	-	-	-	-	1·0	-	-	1·0	-	-
10	Tullbergia krausbaueri		7·0	4·5	7·5	30·0	0·5	4·0	14·5	4·0	10·5	6·5	4·5	5·5	1·5	4·0	12
11	Tullbergia quadrispina		-	0·5	-	-	-	-	-	-	-	-	-	-	-	1·0	-
12	Tullbergia crassicuspis		1·5	0·5	-	7·0	1·5	1·5	0·5	1·0	3·5	143·5	-	18·5	3·0	0·5	0
13	Isotoma viridis		-	-	6·0	2·5	3·5	12·0	2·0	0·5	5·5	2·5	1·0	1·0	-	-	4
14	Isotomodes productus		3·0	-	9·0	0·5	-	6·0	5·0	1·0	1·0	4·0	2·0	1·0	15·5	2·0	32
15	Folsomia candida		3·5	1·0	6·0	9·5	0·5	0·5	2·0	2·5	6·0	1·5	0·5	-	39·0	5·0	7
16	Folsomia garretti		-	-	-	-	-	-	-	-	-	-	-	-	0·5	-	1
17	Folsomia quadrioculata		-	0·5	-	0·5	-	-	0·5	-	-	1·5	-	-	1·5	2·0	-
18	Lepidocyrtus cyaneus		-	-	-	1·0	-	1·0	-	-	1·5	0·5	-	-	1·5	-	-
19	Undet. Collembola		-	2·0	1·5	6·5	2·5	1·5	1·0	1·0	-	2·5	0·5	-	-	1·0	1
20	PSOCOPTERA		-	-	-	-	-	-	-	-	-	-	-	0·5	-	-	-
	THYSANOPTERA																
21	Aptinothrips rufus		-	-	-	-	-	-	0·5	-	-	-	-	-	0·5	-	-
22	Undet. Thripidae spp		-	-	-	-	-	-	-	-	-	0·5	-	-	0·5	-	-
	HEMIPTERA																
23	Aphididae spp		1·0	-	-	2·5	0·5	-	-	-	-	-	-	0·5	-	-	-
	COLEOPTERA (Adults)																
24	Lathridiidae sp		-	-	-	-	-	-	-	0·5	-	-	-	-	-	-	-
	COLEOPTERA (Larvae)																
25	Carabidae spp		-	-	-	-	-	-	-	-	-	-	-	-	-	0·5	-
26	Staphylinidae spp.		-	-	-	-	-	-	0·5	-	-	-	-	-	0·5	-	-
27	Curculionidae spp		-	0·5	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIPTERA (Larvae)																
28	Petauristidae spp		-	-	-	-	-	-	1·0	-	-	-	-	-	-	-	-
29	Tendipedidae spp.		-	2·0	2·0	-	2·0	0·5	2·0	0·5	2·5	0·5	-	-	2·0	2·0	2
30	Cyclorrhapha spp.		2·0	-	1·0	-	-	0·5	2·0	-	1·5	-	-	-	1·0	-	1
	DIPTERA (Pupae)																
31	Cyclorrhapha spp		-	-	0·5	0·5	-	-	-	-	-	-	-	-	-	-	-
	ARACHNIDA AND OTHER ARTHROPODA																
32	ARANEIDA		-	-	0·5	-	-	-	0·5	-	-	-	-	-	-	-	-
33	ACARI	Total	15·0	12·5	17·5	18·0	5·0	7·5	83·5	20·5	11·5	27·5	8·0	13·0	48·5	11·5	18
34	ORIBATEI	Total	1·5	2·0	11·5	6·0	3·5	3·5	59·5	13·5	2·5	15·0	4·5	8·5	13·0	5·0	8
35	Hypochthonius rufulus		-	-	-	-	-	-	0·5	-	-	-	-	-	-	-	-
36	Ceratozetes gracilis		-	1·0	0·5	-	0·5	-	1·5	-	-	-	-	-	0·5	-	-
37	Achipteria coleoptrata		-	-	-	-	0·5	-	3·5	1·0	0·5	1·5	-	-	0·5	-	0
38	Euzetes globulus		-	-	-	-	-	-	1·0	0·5	-	-	-	0·5	-	-	-
39	Punctoribates punctum		-	-	5·0	1·0	-	2·5	7·5	4·5	-	1·5	1·0	4·5	2·0	2·0	3
40	Minunthozetes semirufus		-	0·5	4·0	1·5	2·5	1·0	27·0	4·5	-	10·0	3·5	1·0	5·0	3·0	4
41	Oppia clavipectinata		-	-	-	0·5	-	-	3·0	-	-	0·5	-	-	1·0	-	-
42	Oribella lanceolata		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	Oribella paolii		-	0·5	-	1·0	-	-	2·5	-	0·5	0·5	-	-	2·5	-	-
44	Scutovertex sculptus		-	-	-	-	-	-	1·5	-	1·0	-	-	-	-	-	0
45	Phthiracarus anonymum		0·5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	Immature Oribatei		1·0	-	2·0	1·0	-	-	11·5	2·5	0·5	1·0	-	2·5	1·5	-	-
47	Undet. Oribatei		-	-	-	1·0	-	-	-	0·5	-	-	-	-	-	-	-
48	ACARIDIAE	Total	2·0	5·0	2·0	3·5	0·5	3·0	10·0	5·0	4·0	4·5	2·5	3·0	14·5	1·5	0
49	Acarus siro		0·5	2·5	-	1·5	-	-	1·5	0·5	1·5	2·5	-	2·5	-	-	-
50	Caloglyphus castellanii		-	2·0	-	-	-	1·0	-	2·5	-	2·0	-	-	1·0	-	0
51	Rhizoglyphus echinopus		1·5	0·5	2·0	1·5	0·5	-	6·0	2·0	1·5	-	2·5	0·5	13·5	1·5	-
52	Glycyphagus destructor		-	-	-	0·5	-	2·0	2·5	-	1·0	-	-	-	-	-	-
53	MESOSTIGMATA	Total	11·0	5·5	3·5	3·5	-	1·0	13·0	2·0	4·0	6·5	1·0	-	21·0	8·0	9
54	Rhodacarus roseus		0·5	-	-	-	-	-	-	0·5	1·0	-	0·5	-	8·5	2·5	5
55	Rhodacarellus epygynialis		-	-	-	1·5	-	-	4·0	0·5	1·0	5·0	-	-	4·0	1·0	1
56	Veigaia nemorensis		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	Pergamasus runciger		6·5	1·5	-	-	-	0·5	2·5	-	-	0·5	0·5	-	1·5	-	0
58	Pergamasus misellus		1·5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	Digamasellus reticulatus		-	-	1·5	-	-	0·5	-	-	0·5	-	-	-	1·5	-	-
60	Arctoseius cetratus		-	-	1·0	-	-	-	1·0	-	-	-	-	-	0·5	-	-
61	Arctoseiopsis minutus		-	-	-	-	-	-	0·5	-	-	-	-	-	-	-	-
62	Alliphis halleri		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	Cosmolaelaps claviger		-	-	-	-	-	-	-	-	-	-	-	-	0·5	-	-
64	Lasioseius penicilliger		-	0·5	-	1·0	-	-	1·5	-	-	-	-	-	0·5	-	-
65	Platyseius n.sp.		0·5	-	-	-	-	-	0·5	-	-	-	-	-	-	-	-
66	Hypoaspis aculeifer		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	Dinychus tetraphyllus		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Olodiscus minima		-	-	-	0·5	-	-	-	0·5	-	-	-	-	-	0·5	-
69	Immature Mesostigmata		1·5	2·5	1·0	0·5	-	-	2·0	0·5	1·0	0·5	-	-	1·5	1·0	2
70	Undet. Mesostigmata		0·5	1·0	-	-	-	-	1·0	-	0·5	0·5	-	-	2·5	-	-
	PROSTIGMATA																
71	Cheyletus eruditus		-	-	0·5	-	-	-	-	-	-	-	-	-	-	-	-
	HETEROSTIGMATA																
72	Pygmephorus sp.		0·5	-	-	4·5	1·0	-	1·0	-	1·0	1·5	-	1·5	-	-	-
73	Undet. Acari		-	-	-	0·5	-	-	-	-	-	-	-	-	-	-	-
74	DIPLOPODA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75	PAUROPODA		-	-	-	-	-	-	-	-	-	-	-	-	0·5	-	0·
76	TARDIGRADA		-	-	-	-	-	-	-	-	-	-	-	0·5	-	-	1·
77	TOTAL ARTHROPODA		85·0	29·0	69·5	101·0	29·0	69·5	132·0	33·5	54·5	196·0	21·5	66·0	126·5	30·0	95·

TABLE IV

CENSUS OF 20th FEBRUARY 1952

Mean Number of Animals per Sample

(2 samples per plot)

	GROUP OR SPECIES		BLOCK 1						BLOCK 2								
			UNDUG	FALLOW	CONTROL	DDT.	B.H.C.	DDT+ B.H.C.	UNDUG	FALLOW	CONTROL	DDT	B.H.C.	DDT+ BHC	UNDUG	FALLOW	CO
1	INSECTA	Total	49.5	9.5	17.5	37.0	11.5	11.5	35.0	8.5	27.0	51.0	21.0	22.0	48.0	8.5	3
2	PROTURA		-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	
3	COLLEMBOLA	Total	47.0	9.0	14.0	34.5	11.5	11.5	31.0	6.6	24.0	49.0	21.0	21.5	47.0	7.0	2
4	Hypogastrura denticulata		3.5	-	-	2.0	2.0	3.5	2.5	-	-	-	2.5	3.0	-	-	
5	Brachystomella parvula		2.5	-	0.5	-	0.5	0.6	0.5	-	1.6	2.0	6.0	3.0	2.5	0.5	
6	Friesea mirabilis		4.0	0.5	1.5	3.5	-	-	6.0	-	1.0	-	0.5	-	7.0	0.5	
7	Onychiurus uliginatus		15.5	4.0	4.0	12.5	-	0.5	-	-	1.0	0.5	-	-	2.0	1.0	
8	Onychiurus spinularius		4.0	-	1.0	1.0	2.5	-	1.0	-	3.0	2.0	1.5	1.0	-	-	
9	Undet. Onychiurus spp		-	0.5	-	-	-	-	-	0.5	-	-	-	-	-	-	
10	Tullbergia krausbaueri		12.0	0.5	2.6	7.0	4.0	-	8.5	4.0	4.5	5.0	4.5	4.5	4.0	0.5	
11	Tullbergia quadrispina		-	-	1.6	-	-	-	3.5	-	-	-	-	0.5	-	0.5	
12	Tullbergia crassicuspis		0.5	1.0	0.5	1.0	-	2.0	0.5	0.5	4.6	34.0	1.0	5.5	0.5	1.0	
13	Isotoma viridis		-	0.5	1.0	0.6	1.0	3.0	0.5	-	1.0	1.0	2.5	-	-	-	
14	Isotomodes productus		3.0	0.5	-	-	1.0	-	6.0	-	1.5	2.0	1.5	0.5	12.0	1.5	
15	Folsomia candida		0.5	-	1.0	6.5	0.5	2.0	0.5	0.5	6.0	-	0.5	1.0	18.5	-	
16	Folsomia garretti		-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	
17	Folsomia quadrioculata		-	1.0	0.5	0.5	-	-	1.0	-	-	0.5	-	0.5	0.5	0.5	
18	Lepidocyrtus cyaneus		0.5	0.5	-	-	-	-	0.5	0.5	-	-	-	-	-	-	
19	Undet. Collembola		1.0	-	-	-	-	-	-	0.5	-	2.0	0.5	2.0	-	0.5	
	THYSANOPTERA																
20	Aptinothrips rufus		-	-	-	-	-	-	0.5	-	-	-	-	-	0.5	-	
21	Undet. Thripidae spp		-	-	-	-	-	-	-	-	0.5	0.5	-	-	-	-	
	HEMIPTERA																
22	Aphididae spp.		0.5	-	-	-	-	-	-	-	-	-	-	0.5	-	-	
	COLEOPTERA (Adults)																
23	Staphylinidae sp.		-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	
	COLEOPTERA (Larvae)																
24	Carabidae sp.		-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	
25	Staphylinidae sp		-	-	0.5	-	-	-	-	0.5	-	-	-	-	-	-	
	DIPTERA (Larvae)																
26	Petauristidae sp		0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	
27	Tendipedidae spp.		0.5	0.5	0.5	2.0	-	-	2.0	1.5	2.5	1.0	-	-	-	1.5	
28	Fungivoridae sp		0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	
29	Cyclorrhapha spp		0.5	-	2.5	-	-	-	0.5	-	-	-	-	-	0.5	-	
	DIPTERA (Pupae)																
30	Orthorrhapha sp		-	-	-	0.5	-	-	-	-	-	-	-	-	-	-	
31	Cyclorrhapha spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	ARACHNIDA AND OTHER ARTHROPODA																
32	ARANEIDA		0.5	-	-	-	-	-	-	-	-	0.5	-	-	-	-	
33	ACARI	Total	23.5	5.5	19.5	13.0	3.5	1.0	88.5	11.5	11.0	12.6	11.0	4.0	139.0	12.0	1
34	ORIBATEI	Total	7.5	2.0	-	0.5	1.5	0.5	61.0	8.0	6.0	5.0	6.5	2.5	111.0	5.0	
35	Hypochthonius rufulus		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
36	Ceratozetes gracilis		-	0.5	-	-	-	-	0.5	-	-	-	-	-	2.0	1.0	
37	Achipteria coleoptrata		-	0.5	-	-	-	-	2.0	-	-	1.0	2.5	0.5	5.0	0.5	
38	Euzetes globulus		-	-	-	0.5	-	-	-	0.5	-	-	-	-	2.0	-	
39	Punctoribates punctum		-	-	-	-	-	0.5	12.0	6.0	1.5	3.0	1.5	1.0	43.5	0.5	
40	Minunthozetes semirufus		5.0	-	-	-	1.5	-	32.5	1.5	1.0	0.5	2.5	-	30.0	1.5	
41	Oppia clavipectinata		2.0	-	-	-	-	-	4.5	-	1.5	-	-	0.5	11.5	-	
42	Oribella lanceolata		-	-	-	-	-	-	0.5	-	1.0	-	-	-	5.5	-	
43	Oribella paolii		-	-	-	-	-	-	1.0	-	1.0	0.5	-	-	4.5	-	
44	Scutovertex sculptus		0.5	-	-	-	-	-	0.5	-	-	-	-	-	0.5	-	
45	Immature Oribatei		-	1.0	-	-	-	-	7.5	-	-	-	-	0.5	6.5	1.0	
46	Undet Oribatei		-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	
47	ACARIDIAE	Total	4.5	-	11.0	6.5	0.5	-	13.0	-	-	1.0	4.0	0.5	1.0	-	
48	Acarus siro		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
49	Coelognathus castellanii		-	-	0.5	0.5	-	-	-	-	-	1.0	-	-	-	-	
50	Rhizoglyphus echinopus		4.5	-	10.5	6.0	0.5	-	13.0	-	-	-	4.0	0.5	1.0	-	
51	Glycyphagus destructor		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
52	MESOSTIGMATA	Total	11.5	2.0	8.5	5.5	1.5	0.5	13.5	3.0	4.5	6.5	0.5	1.0	26.5	6.5	
53	Rhodacarus roseus		1.0	-	-	-	-	-	2.0	-	-	-	-	0.5	1.5	2.0	
54	Rhodacarellus epygialis		6.5	-	2.0	4.0	-	-	4.0	-	3.0	4.5	-	0.5	6.5	-	
55	Veigaia nemorensis		0.6	-	-	-	-	-	0.5	-	-	-	-	-	5.0	-	
56	Pergamasus runciger		0.5	-	1.0	1.0	1.0	-	2.5	-	-	-	-	-	4.5	-	
57	Pergamasus misellus		-	-	-	-	-	-	1.0	-	-	0.5	-	-	1.5	-	
58	Pachylaelaps sp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	
59	Digamasellus reticulatus		-	-	2.0	-	-	-	-	-	-	-	-	-	0.5	-	
60	Arctoseius cetratus		-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	
61	Arctoseiopsis minutus		-	-	0.5	-	-	-	-	-	-	-	-	-	1.5	-	
62	Alliphis halleri		-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	
63	Cosmolaelaps claviger		-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	
64	Lasioseius penicilliger		-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	
65	Platyseius n sp		1.0	-	-	-	-	-	0.5	-	-	-	-	-	-	-	
66	Hypoaspis aculeifer		-	-	0.5	0.5	-	-	1.0	-	-	0.5	-	-	-	-	
67	Eviphis ostrinus		-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	
68	Olodiscus minima		-	0.5	0.5	-	-	-	1.0	1.5	-	-	-	-	-	2.0	
69	Immature Mesostigmata		2.0	0.5	1.0	-	0.5	-	1.0	1.5	1.5	0.5	0.5	-	3.5	1.5	
70	Undet. Mesostigmata		-	1.0	1.0	-	-	-	-	-	-	-	-	-	0.5	0.5	
	PROSTIGMATA																
71	Cheyletus eruditus		-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	
	HETEROSTIGMATA																
72	Pygmephorus sp.		-	1.0	-	0.5	-	-	1.0	0.5	0.5	-	-	-	-	0.5	
73	Undet. Acari		-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	
74	PAUROPODA		-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	
75	TARDIGRADA		1.0	-	-	1.0	0.5	-	0.5	-	-	-	0.5	0.5	-	-	
76	TOTAL ARTHROPODA		74.5	15.0	37.0	51.0	15.5	12.5	124.0	20.0	38.0	64.0	32.5	27.0	187.0	20.5	4

TABLE V

CENSUS OF 15th APRIL 1952

Mean Number of Animals per Sample

(2 samples per plot)

	GROUP OR SPECIES	BLOCK 1						BLOCK 2							
		UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW
1	INSECTA Total	21.5	3.0	16.5	42.0	6.5	5.0	21.0	7.0	17.0	73.5	3.5	11.5	29.5	3.5
2	PROTURA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	COLLEMBOLA Total	19.0	3.5	15.5	41.0	6.5	5.0	19.0	5.0	14.5	70.0	2.5	11.5	26.0	3.0
4	Hypogastrura denticulata	-	0.5	1.0	-	-	1.5	1.0	-	2.0	1.0	-	3.0	-	-
5	Brachystomella parvula	-	-	1.0	-	0.5	-	-	-	1.0	3.0	0.5	0.5	0.6	-
6	Friesea mirablis	0.8	-	-	0.5	0.5	-	3.5	-	-	1.0	-	-	3.0	-
7	Onychiurus uliginatus	8.5	0.5	2.5	5.5	-	-	2.0	-	-	-	-	1.0	-	-
8	Onychiurus spinularius	4.0	-	-	3.0	-	-	0.6	-	2.5	-	-	0.5	-	-
9	Undet. Onychiurus spp.	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-
10	Tullbergia krausbaueri	6.0	0.5	1.5	9.0	3.5	-	8.0	1.5	0.5	2.0	1.5	0.6	2.6	2.5
11	Tullbergia quadrispina	-	-	3.5	-	-	-	0.8	-	-	-	-	0.5	-	-
12	Tullbergia crassicuspis	-	-	-	4.0	-	-	-	-	-	47.5	-	2.5	5.6	-
13	Isotoma viridis	-	1.0	1.5	9.0	1.5	1.5	0.5	1.0	3.0	5.0	-	1.0	-	-
14	Isotomodes productus	-	-	1.0	1.5	0.5	1.0	2.5	-	2.0	-	-	-	2.0	-
15	Folsomia candida	-	-	2.0	2.5	-	1.0	-	1.6	1.5	3.5	0.5	-	11.5	-
16	Folsomia garretti	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-
17	Folsomia quadrioculata	-	1.0	1.5	3.5	-	-	0.8	1.0	0.5	6.0	-	-	-	-
18	Lepidocyrtus cyaneus	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-
19	Undet. Collembola	-	-	-	1.5	-	-	-	-	1.5	-	-	2.0	-	0.5
	HEMIPTERA														
20	Aphididae sp		0.6	-	-	-	-	-	-	-	-	-	-	-	-
	COLEOPTERA (Adults)														
21	Carabidae spp.	-	-	-	-	-	-	-	-	-	-	0.5	-	0.5	-
22	Staphylinidae sp	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-
23	Hydrophylidae sp.	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-
	COLEOPTERA (Larvae)														
24	Staphylinidae sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	Elateridae sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIPTERA (Larvae)														
26	Petauristidae sp	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-
27	Tendipedidae spp	1.6	1.0	0.5	1.0	-	-	0.5	0.5	1.5	2.0	0.5	-	1.5	-
28	Fungivoridae sp	-	-	-	-	-	-	0.5	-	-	-	-	-	-	0.5
29	Cyclorrhapha sp	0.5	-	0.5	-	-	-	-	0.5	0.5	-	-	-	-	-
	DIPTERA (Pupae)														
30	Orthorrhapha sp	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
31	Cyclorrhapha spp	0.5	-	-	-	-	-	1.0	-	0.5	0.5	-	-	1.0	-
	ARACHNIDA AND OTHER ARTHROPODA														
32	ACARI Total	9.0	5.5	12.0	8.0	5.5	4.5	82.5	28.5	19.5	15.0	9.0	10.0	63.5	17.5
33	ORIBATEI Total	3.0	1.0	6.0	2.5	3.0	3.5	69.0	20.0	10.5	12.0	7.0	10.0	48.5	11.0
34	Eulohmannia ribagai	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
35	Hypochthonius rufulus	-	-	-	-	0.5	-	-	-	-	-	-	-	-	-
36	Ceratozetes gracilis	-	-	-	0.5	-	-	1.0	-	-	-	-	-	1.0	-
37	Achipteria coleoptrata	-	-	-	-	0.5	-	9.0	0.5	1.0	1.5	1.0	1.0	3.0	2.0
38	Euzetes globulus	-	-	-	-	-	0.5	0.5	-	-	-	-	-	0.6	-
39	Punctoribates punctum	2.0	1.0	1.5	2.0	2.0	2.0	15.0	5.0	2.0	4.5	4.5	4.0	13.5	3.0
40	Minunthozetes semirufus	1.0	-	2.5	-	-	1.0	35.0	10.0	7.5	4.0	1.5	4.5	18.5	5.0
41	Oppia clavipectinata	-	-	-	-	-	-	1.0	-	-	-	-	-	2.5	-
42	Oribella lanceolata	-	-	1.0	-	-	-	-	-	-	-	-	-	1.5	0.5
43	Oribella paolii	-	-	-	-	-	-	2.0	-	-	1.5	-	-	4.0	-
44	Scutovertex sculptus	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-
45	Immature Oribatei	-	-	0.5	-	-	-	5.5	2.5	-	0.6	-	0.5	-	0.5
46	Undet. Oribatei	-	-	-	-	-	-	-	2.0	-	-	-	-	-	-
47	ACARIDIAE Total	0.5	0.5	0.5	2.0	0.5	0.5	2.5	-	1.5	0.5	-	-	1.0	-
48	Coelognathus castellanii	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-
49	Rhizoglyphus echinopus	0.5	-	0.5	2.0	0.5	0.5	2.5	-	0.5	0.5	-	-	0.5	-
50	Glycyphagus destructor	-	0.5	-	-	-	-	-	-	-	-	-	-	0.5	-
51	MESOSTIGMATA Total	5.5	4.0	5.0	3.0	2.0	0.5	10.0	8.5	7.5	2.5	2.0	-	13.5	6.5
52	Rhodacarus roseus	-	-	1.0	-	-	-	0.5	-	-	-	-	-	2.5	2.0
53	Rhodacarellus epygiaiahs	0.5	0.5	2.5	1.0	1.0	0.5	2.5	1.5	4.0	2.0	1.5	-	6.5	0.5
54	Pergamasus runciger	2.0	-	1.0	-	-	-	1.0	3.0	0.5	-	0.5	-	0.6	0.5
55	Pergamasus misellus	0.5	-	-	1.5	-	-	0.5	-	-	-	-	-	-	-
56	Pachylaelaps sp.	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-
57	Digamasellus reticulatus	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-
58	Hypoaspis aculeifer	-	0.5	-	0.5	-	-	0.5	-	0.5	-	-	-	-	-
59	Eviphis ostrinus	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-
60	Dinychus tetraphyllus	0.5	-	-	-	-	-	-	-	0.5	-	-	-	-	-
61	Olodiscus minima	-	-	-	-	-	-	2.5	1.0	0.5	-	-	-	1.0	0.5
62	Immature Mesostigmata	2.0	3.0	0.5	-	1.0	-	1.0	3.0	1.5	0.5	-	-	2.5	3.0
63	Undet. Mesostigmata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HETEROSTIGMATA														
64	Pygmephorus sp	-	-	0.5	0.5	-	-	1.0	-	-	-	-	-	0.5	-
65	PAUROPODA	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
66	TOTAL ARTHROPODA	30.5	10.5	29.0	50.0	12.0	9.5	103.5	35.5	36.5	88.5	12.5	21.5	93.0	21.0

TABLE VI

CENSUS OF 17th OCTOBER 1952

Mean Number of Animals per Sample

(2 samples per Plot)

	GROUP OR SPECIES	BLOCK 1						BLOCK 2						BLOC		
		UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW	CONTROL	D.D.T.	B.H.C.	D.D.T.+ B.H.C.	UNDUG	FALLOW	CONTR
1	INSECTA Total	32·5	9·0	20·0	51·5	7·0	16·0	56·5	14·5	9·8	82·0	15·0	11·0	131·0	2·0	48·
2	PROTURA	-	-	-	-	-	-	-	-	-	-	-	-	1·0	-	-
3	COLLEMBOLA Total	32·0	6·0	19·5	50·5	7·0	16·0	52·0	11·8	9·0	78·8	12·5	10·5	129·5	2·0	47·0
4	*Hypogastrura denticulata*	1·0	-	0·5	3·0	1·0	0·5	4·0	-	1·5	1·5	-	1·0	5·5	-	9·5
5	*Brachystomella parvula*	0·5	0·5	1·0	1·0	0·5	2·5	4·0	1·5	2·8	11·0	3·0	2·0	5·6	1·0	5·0
6	*Friesia mirablis*	1·5	-	0·5	0·5	-	0·5	6·0	2·0	-	-	0·5	-	-	-	-
7	*Onychiurus uliginatus*	9·5	1·0	3·0	9·5	-	-	-	-	-	2·5	1·0	-	17·5	-	-
8	*Onychiurus spinularius*	5·5	0·5	2·0	2·0	1·5	4·5	1·0	1·5	-	1·0	4·0	1·5	4·5	-	5·0
9	Undet. *Onychiurus spp*	-	-	-	-	-	-	-	-	-	0·5	-	-	6·0	-	1·0
10	*Tullbergia krausbaueri*	13·0	0·5	1·5	8·5	3·5	4·5	9·0	4·0	0·5	3·0	1·0	1·0	56·0	-	11·0
11	*Tullbergia quadrispina*	-	-	3·5	-	-	-	9·5	-	-	0·5	-	-	-	-	2·5
12	*Tullbergia krassicuspis*	-	1·0	0·5	18·0	-	-	0·5	-	3·0	46·0	0·5	4·5	0·5	-	1·0
13	*Isotoma viridis*	-	-	1·0	4·0	0·5	2·5	-	-	-	0·5	0·5	-	-	-	-
14	*Isotomodes productus*	-	-	1·0	1·0	-	-	7·0	2·0	1·5	6·0	2·0	-	26·5	0·5	9·0
15	*Folsomia candida*	0·5	-	3·5	1·5	-	1·0	7·0	-	-	0·5	-	0·5	4·5	-	2·5
16	*Folsomia geffretti*	-	-	-	-	-	-	1·5	-	-	-	-	-	-	-	-
17	*Folsomia quadrioculata*	0·5	0·5	-	1·5	-	-	2·0	0·5	-	4·5	-	-	1·5	0·8	1·5
18	*Lepidocyrtus cyaneus*	-	-	1·5	-	-	-	-	-	-	-	-	-	-	-	-
19	Undet. Collembola	-	2·0	-	-	-	-	0·5	-	-	1·0	-	-	1·5	-	1·0
20	PSOCOPTERA	-	0·5	0·5	-	-	-	-	-	-	-	-	-	-	-	-
	THYSANOPTERA															
21	*Aptinothrips rufus*	-	-	-	0·5	-	-	-	-	-	1·0	-	0·5	-	-	0·5
22	Undet. Thripidae spp	-	-	-	-	-	-	-	-	-	0·5	-	-	-	-	-
23	Phlaeothripidae spp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HEMIPTERA															
24	Aphididae spp	-	-	-	-	-	-	-	-	-	-	2·0	-	-	-	-
25	Other Hemiptera	-	-	-	-	-	-	-	-	-	1·0	-	-	-	-	-
	COLEOPTERA (Adults)															
26	Staphylinidae spp.	-	-	-	-	-	-	-	-	0·5	-	-	-	-	-	-
27	Hydrophylidae sp.	-	-	-	-	-	-	-	-	-	-	0·5	-	-	-	-
	COLEOPTERA (Larvae)															
28	Carabidae sp	0·5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Staphylinidae sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Cantharidae sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Elateridae sp	-	0·5	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Curculionidae spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DIPTERA (Larvae)															
33	Petauristidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	Tendipedidae spp.	-	0·5	-	0·5	-	-	1·5	2·5	-	-	-	-	-	-	1·0
35	Cyclorrhapha spp.	-	0·5	-	-	-	-	3·0	0·5	-	-	-	-	0·5	-	-
	DIPTERA (Pupae)															
36	Cyclorrhapha spp.	-	-	-	-	-	-	-	-	-	1·0	-	-	-	-	-
37	ARACHNIDA AND OTHER ARTHROPODA															
38	ARANEIDA	-	-	-	0·5	-	-	0·5	-	-	-	-	-	-	-	-
39	ACARI Total	14·0	3·0	10·5	7·5	1·0	4·5	68·5	9·0	11·0	15·5	5·0	8·5	143·0	16·5	51·0
40	ORIBATEI Total	4·0	-	-	0·5	-	0·5	48·0	2·5	6·0	9·0	-	-	76·5	7·5	33·0
41	*Hypochthonius rufulus*	-	-	-	-	-	-	-	-	-	-	-	-	1·0	-	-
42	*Ceratozetes gracilis*	-	-	-	-	-	-	1·5	-	-	-	-	-	2·0	-	1·0
43	*Achipteria coleoptrata*	-	-	-	-	-	-	3·0	-	0·5	3·0	-	-	3·0	0·5	0·5
44	*Euzetes globulus*	0·5	-	-	-	-	-	2·0	-	0·5	0·5	-	-	1·0	-	0·5
45	*Punctoribates punctum*	1·0	-	-	0·5	-	-	4·0	1·0	2·0	2·5	-	-	13·0	1·0	6·0
46	*Minunthozetes semirufus*	2·0	-	-	-	-	-	23·0	-	2·5	3·0	-	-	31·0	4·0	21·0
47	*Oppia clavipectinata*	-	-	-	-	-	-	0·5	-	-	-	-	-	8·5	-	2·0
48	*Oribella lanceolata*	-	-	-	-	-	-	1·5	-	-	-	-	-	10·0	-	-
49	*Oribella paolii*	0·5	-	-	-	-	-	3·5	-	-	-	-	-	5·5	1·0	-
50	*Scutovertex sculptus*	-	-	-	-	-	-	0·5	-	-	-	-	-	-	-	1·5
51	Immature Oribatei	-	-	-	-	-	0·8	8·5	1·0	0·5	-	-	-	1·5	-	0·5
52	Undet. Oribatei	-	-	-	-	-	-	-	0·5	-	-	-	-	-	1·0	-
53	ACARIDIAE Total	7·0	1·5	-	2·0	-	0·5	12·5	0·5	1·0	-	0·5	4·5	11·0	3·0	0·5
54	*Acarus siro*	0·5	1·0	-	-	-	-	-	-	-	-	-	-	-	-	0·5
55	*Coelognathus castellanii*	-	-	-	-	-	-	-	-	-	-	-	-	1·0	-	-
56	*Rhizoglyphus echinopus*	6·5	0·5	-	2·0	-	-	12·5	0·5	0·5	-	0·5	4·5	8·0	-	-
57	*Glycyphagus destructor*	-	-	-	-	-	0·5	-	-	0·5	-	-	-	2·0	3·0	-
58	MESOSTIGMATA Total	3·0	1·5	9·5	5·0	1·0	3·0	28·0	6·0	4·0	6·0	4·5	4·0	54·0	4·0	17·0
59	*Rhodacarus roseus*	0·5	-	4·0	-	-	1·0	5·0	0·5	0·5	2·0	-	0·5	23·0	3·0	6·0
60	*Rhodacarellus epygynialis*	1·0	1·0	1·0	1·0	-	-	4·5	5·0	2·0	3·0	-	2·5	7·0	-	2·5
61	*Veigaia nemorensis*	-	-	-	-	-	-	1·0	-	-	-	-	-	0·5	-	-
62	*Pergamasus runciger*	-	-	-	-	-	0·5	1·0	-	0·5	-	1·5	-	2·5	-	0·5
63	*Pergamasus misellus*	-	-	-	0·5	-	-	2·0	-	-	-	0·5	-	1·5	-	0·5
64	*Pachylaelaps sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	*Digamasellus reticulatus*	-	-	-	-	-	-	3·0	-	-	-	-	-	3·5	-	-
66	*Arctoseiopsis minutus*	-	-	-	-	-	-	1·0	-	-	-	-	-	-	-	-
67	*Alliphis halleri*	-	-	0·5	-	-	-	-	-	-	-	-	-	-	-	-
68	*Cosmolaelaps claviger*	0·5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	*Lasioseius penicilliger*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	*Hypoaspis aculeifer*	-	-	-	0·5	-	-	-	-	-	-	-	0·5	-	-	0·5
71	*Eviphis ostrinus*	-	-	0·5	-	-	-	1·0	-	-	-	0·5	-	3·0	-	1·5
72	*Dinychus tetraphyllus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	*Olodiscus minima*	0·5	-	-	-	-	-	2·0	-	-	-	-	-	2·0	2·5	-
74	Immature Mesostigmata	0·5	0·5	2·0	2·0	0·5	1·5	6·0	0·5	1·0	1·0	1·5	0·8	10·5	0·5	5·5
75	Undet. Mesostigmata	-	-	1·5	1·0	0·5	-	1·5	-	-	-	0·5	-	0·5	-	-
	PROSTIGMATA															
76	*Cheyletus eruditus*	-	-	1·0	-	-	-	-	-	-	-	-	-	1·5	-	-
	HETEROSTIGMATA															
77	*Pygmephorus spp.*	-	-	-	-	-	-	-	-	-	0·8	-	-	-	-	0·
78	Undet. Acari	-	-	-	-	-	0·5	-	-	-	-	-	-	-	-	-
79	PAUROPODA	-	-	-	-	-	-	1·0	-	-	-	-	-	-	-	-
80	TOTAL ARTHROPODA	46·5	11·0	30·5	59·5	8·0	20·5	146·5	23·5	20·5	97·5	20·0	19·5	274·0	18·5	99·5