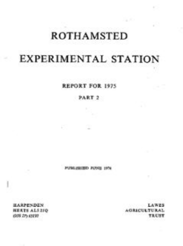
Rothamsted Experimental Station Report for 1975 Part 2


ROTHAMSTED
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PART 2

Full Table of Content

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The Invertebrate Fauna of the Park Grass Plots

II. Surface Fauna

C. A. EDWARDS, C. G. BUTLER and J. R. LOFTY

Introduction

The Park Grass experiment, begun in 1856, was designed to find out how various manurial treatments affect the productivity of old pasture. Prior to the experiment, the land had been in grass for several centuries and seemed to have a uniform vegetation. Originally, there were 20 plots ranging in area from one-half to one-eighth of an acre but some of these have since been subdivided. The unreplicated treatments compared the yields of hay from plots that received no manure with those from others that received organic manure (farmyard and fishmeal); a range of mineral fertilisers only; a range of nitrogenous fertilisers only and a range of mixed mineral and nitrogenous fertilisers with different levels of nitrogen. The nitrogen was in two main forms, nitrate of soda and sulphate of ammonia. In the original experiment, two plots received organic manure and two none, but, seven years after the beginning of the experiment (1863) no more manure was given to one of the organic manure plots (Plot 2). As a result of the treatments some plots became acid and the sward deteriorated, so from 1903, lime was applied regularly to the southern half of most plots. In 1965, each plot was subdivided again into two, giving four plots treated in the following ways:

Lime added from 1903	(a) Lime added to maintain the pH as in 1965. (b) Lime added to give a pH as close to 6·0 as possible.
No lime added until 1965	(c) Lime added to the more acid plots to give a pH as close to 5·0 as possible. (d) No lime added.

Nevertheless, the pH of the various plots is still very variable, ranging from: (a) plots from 4·6 to 7·5, (b) plots from 4·9 to 7·3, (c) plots from 4·4 to 6·0 and (d) plots from 3·8 to 6·0. The treatments have greatly influenced the very varied flora of the plots, which includes grasses, clovers and weeds. The botanical composition of the subplots has been studied annually at regular intervals through the year since 1900; it changes seasonally and there is also a gradual more permanent change (Brenchley, 1935, 1969; Williams, 1974). The numbers of plant species range from only two per plot (11/1d) up to to 30 (12a), the greatest diversity still being in the unmanured plots although these yield poorly.

The effects of the treatments on the soil fauna were reported last year (Edwards & Lofty, 1975). The present paper assesses their influence on the surface-active fauna. Many invertebrates spend part of their life-cycles at or near the soil surface, but this investigation has been confined to slugs and snails (Mollusca), millipedes (Diplopoda), centipedes (Chilopoda), spiders (Araneae), springtails (Collembola), bugs (other than aphids) (Hemiptera-Heteroptera), beetles (Coleoptera), and ants (Hymenoptera).

There are no satisfactory methods of assessing populations of surface-active invertebrates accurately. This is mainly due to the difficulty of extracting or separating the animals from the vegetation amongst which they live. We used two methods in an

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attempt to minimise errors. The first, which involved trapping animals in containers buried in the soil (pitfall traps), depends upon the animals falling into the traps as they move over the soil surface. Therefore, the number of animals trapped depends not only upon the size of the populations but also upon the type and degree of activity of particular animals. Activity in turn depends upon weather conditions (especially temperature), soil moisture, the physiological state of the animals, and the general habitat surrounding the trap. In the Park Grass plots, the major variable was the habitat, because the flora differs considerably in diversity and rate of growth between plots. Weather and other physical factors tend to affect all plots more or less equally. Hence, the numbers trapped in the different plots were likely to depend most upon diversity, density and height of the flora, and the differences to be greatest in the months immediately before the hay was cut.

The other method used was to suck the animals from an enclosed unit area with a portable modified vacuum cleaner. This gave a much better estimate of the fauna in different plots but also had certain drawbacks. Even powerful suction does not extract all the animals from dense foliage because some invertebrates can cling to plants and debris and resist being sucked up much more than others.

Methods

Plots 1b, c, d; 2a, d; 7b, c; 8b, c; 9a, b, c, d; 14b, c; 17b, c, and 18a, b, c, d, were sampled in two ways. In each plot, eight 5 cm diameter by 10 cm deep white plastic containers were sunk into the holes taken for soil samples in 1973, with their rims flush with the soil surface. Each container was covered by a snap-on lid when not in use. Once a month, from June 1973 to May 1974, the lids were removed at 12 noon, a small quantity of 50% industrial alcohol added and the containers left open until noon the following day, when they were replaced by empty substitute containers with lids. The catches were taken to the laboratory and transferred to vials for storage in 70% alcohol until they could be sorted and identified.

In June 1974, two random half-metre square quadrats in each of the same sub-plots were sampled using a portable suction sampler powered by a JLO Type 35 two-stroke engine. Each quadrat was surrounded by a collapsible 1 m high plywood barrier before sampling. The quadrat was systematically traversed with the nozzle of a flexible tube with a 6 cm aperture, for 3 min, and the invertebrates collected in a porous paper bag inserted in the collection container of the sampler. The air speed at the nozzle was 300 kph.

Animals were transferred to 70% industrial alcohol in the laboratory to await sorting and identification.

Maximum and average crop heights, and density at ground and flower level were assessed by eye in June 1974. The crop data used were total dry matter (t ha^{-1}) for both cuts in 1974, and the number of plant species assessed by the Rothamsted Botany Department in June 1973. Cuts were taken on 13 June and 15 September 1973 and 21 June and 13 December 1974. The pH data used were calculated from results of various assessments by the Rothamsted Chemistry Department (*Rothamsted Report for 1963*, 244–247; *for 1971*, Part 2, 177–180). Some of the pH data for 'a' and 'd' sub-plots date back to 1959, but are believed to differ little from present levels. Some of the acid plots have developed a surface 'mat' which differs in pH from the soil immediately beneath; the pH of this layer has not been used and pH values given are for the 0–7·5 cm layer of soil. The values for percentage nitrogen and organic carbon and ppm of P and K used in the correlations were those in the *Rothamsted Report for 1963*.

All the data presented must be considered with these reservations in mind before conclusions as to the direct and indirect effects of the fertiliser treatments on the surface fauna are made.

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Results

(1) General. The total numbers of animals caught in pitfall traps June 1973–May, 1974 are summarised in Table 1 and the correlation coefficient between these data and crop soil characteristics are given in Tables 2 and 3. The numbers of animals in samples obtained by suction samplings on 18/19 June 1974 are given in Table 4. The weather conditions during the sampling period are summarised in Table 5. Correlation coefficients between the faunal data and crop and soil characteristics are given in Table 6. Any significant correlations were plotted as histograms or scatter diagrams (Figs. 1–12). Only spiders, springtails and beetles were identified to species and the relative abundance of the different species is summarised in Figs. 13–15. The phenology of the different groups and species are illustrated in Figs. 16–23.

(2) Effects of treatments. Assessment of the influence of the treatments on populations of surface-living fauna was extremely difficult. These animals spend at most only part of their life in the soil, so it is probable that soil characteristics have little direct effect on their numbers.

Any differences in populations between plots were most likely to be caused by differences in plant diversity, density or height, all of which influence the available food and living space and also the microclimate in which these animals live.

Two features of the Park Grass experiment did not favour great differences in the number and diversity of animals between plots. First, the layout of the experiment is very complex (Edwards & Lofty, 1975), with plots 12·6 to 25·2 m wide and with different lengths. In such small plots movements of many of the surface-active invertebrates is likely between plots. Furthermore, several of the species of spiders that were most abundant in the catches such as *Dicymbium nigrum*, *Tiso vagans*, *Savignya frontata*, *Erigone dentipalpis*, *E. atra*, *Bathyphantes gracilis* and *Lepthyphantes tenuis* are all common aeronauts (Locket & Millidge, 1953) and thus likely to appear on any plot. Second, the influence of the foliage changes seasonally, being at a maximum in June and early September immediately prior to cutting, and having a minimum effect in autumn and winter when the grass in most plots is short. Hence, attempts to correlate numbers of animals caught or sampled with crop characteristics are most likely to be successful in samples taken immediately prior to harvest. Species that are most numerous in autumn, winter or spring are probably less affected by crop characteristics than those that are most abundant in summer. For this reason, separate correlations were made for each month of the pitfall trapping, although the individual monthly correlations are not given in the Tables.

Probably due to the difficulties in population assessment, the effects of the different treatments produced few significant effects. Unfortunately, even when significant correlations were obtained, there was usually some doubt as to the real cause and the observations require further experimental work to verify their significance.

The relative numbers of arthropods from different groups caught by pitfall trapping differed considerably from those collected by the suction apparatus. In particular, spiders which were the second most numerous group in the pitfall samples, occurred very infrequently in the suction samples, and beetles, which were the next most common arthropods in the pitfall samples, were scarce in suction samples. It seems unlikely that such large differences can occur only because spiders and beetles are more active, and hence more readily caught in pitfall traps. Probably, the spiders were able to cling to foliage and detritus and to remain in crevices in the soil and so avoid being sucked up and the beetles remain concealed in soil cracks and crevices. These differences illustrate the difficulty of assessing populations of surface-living arthropods.

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TABLE 1

Treatment	Plot No.	Numbers: Mollusca	Diplododa	Chilopoda	Araneae	Collembola	Hemiptera	Coleoptera	Hymenoptera	Diptera	Lepidoptera	Total: All Invertebrates
N_1	1b	0	5	2	328	544	20	86	23	151	0	1159
	c	0	0	0	277	624	32	76	20	141	0	1170
	d	0	0	0	278	1368	67	39	66	191	0	2009
None	2ab	2	6	0	419	1996	2	108	24	155	0	2712
	cd	0	1	0	297	792	8	64	60	137	1	1360
P	4/1a	0	7	0	387	652	9	92	10	120	0	1277
	b	1	4	0	326	296	16	88	14	95	0	840
	c	3	0	0	217	352	9	83	28	108	1	801
	d	1	2	0	275	160	5	107	38	136	0	724
N_2P	4/2a	0	1	1	325	828	6	71	21	212	1	1466
	b	0	3	0	337	852	5	87	12	164	0	1460
	c	0	4	3	279	1268	10	89	10	100	0	1763
	d	0	4	6	333	1400	10	68	43	192	0	2056
PK	7b	0	3	2	428	928	27	127	9	144	0	1668
	c	0	2	0	347	904	8	150	14	111	1	1537
PNaMg	8b	0	5	1	474	1508	2	106	15	126	0	2237
	c	0	1	1	326	692	1	126	22	144	0	1313
N_2PKNaMg	9a	0	5	1	459	1668	79	193	20	184	0	2609
	b	0	0	4	461	1160	19	168	15	173	0	2000
	c	0	1	1	428	948	10	123	7	98	0	1616
	d	0	0	0	463	2360	3	129	18	181	0	3154
N_2PNaMg	10a	0	2	1	463	828	13	104	6	152	0	1569
	b	0	2	3	591	852	4	125	6	93	1	1677
	c	0	0	1	517	1296	7	214	14	103	1	2153
	d	0	0	0	578	1424	5	139	33	161	0	2340
N_2PKNaMg	11/1a	1	1	1	426	332	3	168	14	191	0	1137
	b	0	1	0	479	288	10	90	8	144	0	1020
	c	0	1	0	516	100	1	172	7	108	0	905
	d	0	0	0	318	380	2	87	13	298	1	1099
N_2PKNaMg (Silicate of Soda)	11/2b	0	4	2	390	680	1	183	10	156	0	1426
	c	0	1	2	470	576	3	190	7	116	0	1365
None	12ab	0	4	2	468	1096	18	111	47	146	1	1893
	cd	0	5	4	414	320	10	98	24	135	0	1010
FYM and fishmeal	13a	0	3	1	138	488	6	55	16	114	0	821
	b	1	9	2	206	868	10	68	19	151	0	1334
	c	0	4	3	324	280	4	107	422	188	0	1332
	d	1	1	3	363	192	8	106	27	138	1	840
N_2*PKNaMg	14b	0	2	1	436	544	111	87	15	169	0	1365
	c	0	0	0	510	496	17	152	14	151	0	1340
N_1*PKNaMg	16a	0	5	1	596	628	64	132	21	236	1	1684
	b	1	0	0	523	348	18	144	11	174	0	1219
	c	0	0	0	389	508	2	84	28	147	1	1159
	d	0	0	0	395	476	3	113	12	142	1	1142
N_1*	17b	0	5	2	338	1092	0	80	17	116	0	1650
	c	0	1	0	305	580	1	100	16	115	0	1118
N_2KNaMg	18a	0	2	0	136	272	34	121	45	169	0	779
	b	0	5	0	420	276	6	114	41	185	0	1047
	c	0	3	0	505	840	2	89	15	163	0	1617
	d	0	4	1	433	1628	0	45	10	189	0	2310
Total		11	6565	52	19111	38988	711	5458	1407	7413	12	79728

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TABLE 2 *Correlation coefficients between crop and soil characteristics and spider populations—(Pitfall traps)*

	June Yield 1st cut (t/ha)	September Yield 2nd cut (t/ha)	Yield Both cuts (t/ha)	June 1974 Maximum crop height (cm)	June 1974 Average crop height (cm)	June 1974 Crop density (%)	No. of plant species	pH	Soil N (%)	Soil P (ppm)	Soil K (ppm)	Soil carbon (%)
Erigone dentipalpis	0·3041	0·1922	0·2892	0·3987	0·3587	−0·4375	−0·0207	−0·0180	−0·0940	−0·1228	0·5147	−0·1110
Erigone atra	0·5579	0·0845	0·4406	0·1184	0·3316	−0·2066	−0·6130	−0·3755	0·3186	0·5628	0·1241	0·4869
Oedothorax fuscus	0·1776	0·0360	0·1433	0·0605	0·0360	−0·0951	−0·0323	0·2697	0·1739	0·0309	0·2577	0·0912
Oedothorax retusus	0·0548	0·2040	0·1088	0·3324	0·1014	−0·3150	0·1557	0·5463	0·1294	−0·0819	0·3577	−0·0838
Pachygnathadegeeri	−0·5071	−0·2572	−0·4609	−0·2781	−0·4948	0·2678	0·3982	0·5192	0·1537	−0·2507	−0·0414	0·0109
Bathyphantes gracilis	0·0902	0·1611	0·1206	0·0546	0·1105	−0·0485	0·1257	0·1615	−0·0402	−0·0148	−0·1215	−0·0799
Agyneta decora	−0·2001	−0·2648	−0·2366	−0·1580	−0·2526	−0·1451	0·3160	−0·0281	−0·1851	−0·1768	0·0090	−0·2618
Pardosa palustris	−0·5963	−0·4559	−0·5935	−0·5610	−0·6167	0·5000	0·3129	0·2339	0·0532	−0·2490	−0·3000	−0·0212
Lepthyphantes tenuis	0·0820	0·1071	0·0965	0·0219	0·0779	−0·1679	−0·0772	0·1821	0·0811	−0·0185	−0·0602	−0·0195
Dicymbium nigrum	−0·2090	0·1774	−0·0950	0·1743	−0·0371	−0·0829	0·4529	0·3504	−0·1850	−0·3955	−0·0822	−0·3983
Meioneta beata	−0·4295	−0·2681	−0·4072	−0·4478	−0·4085	0·3147	0·4769	−0·1644	−0·1021	−0·2077	−0·3187	−0·0840
Savignya frontata	0·5384	0·2040	0·4662	0·4056	0·3847	−0·3930	−0·2887	−0·0642	0·0145	0·1315	0·3904	0·0109
Total (all spiders)	0·3657	0·0742	0·2951	0·1778	0·2133	−0·3170	−0·2230	−0·0082	0·2189	0·2071	0·3514	0·2235

TABLE 3 *Correlation coefficients between crop and soil characteristics and soil animal populations—(Pitfall traps)*

	June Yield 1st cut (t/ha)	September Yield 2nd cut (t/ha)	Yield both cuts (t/ha)	June 1974 Maximum crop height (cm)	June 1974 Average crop height (cm)	June 1974 Crop density (%)	No. of plant species	pH	Soil N (%)	Soil P (ppm)	Soil K (ppm)	Soil carbon (%)
Collembola												
Isotoma viridis	−0·0075	−0·2913	−0·1062	−0·2302	−0·1057	0·1040	−0·6147	−0·5014	0·0817	0·4447	−0·0190	0·2195
Lepidocyrtus cyaneus	−0·3268	−0·3002	−0·3409	−0·3303	−0·3236	−0·0720	0·1811	0·0413	−0·1461	−0·2127	−0·1604	−0·1697
Sminthurides pumilis	−0·1105	−0·0450	−0·0957	−0·0923	−0·1297	−0·2095	−0·2048	0·1253	0·2326	−0·0250	−0·0003	0·1379
Sminthurinus aureus	0·0034	0·1331	0·0485	0·1679	0·0741	0·0282	0·2212	0·2937	0·1635	−0·0680	−0·0444	0·0450
Bourletiella hortensis	−0·0987	0·0102	−0·0680	0·0413	−0·0025	0·1054	0·3501	0·0170	−0·2123	−0·2047	−0·0164	−0·2446
Other Collembola species	−0·0661	−0·2003	−0·1172	−0·2402	−0·1385	−0·1164	−0·4777	−0·2276	0·1398	0·2738	−0·1160	0·2479
Total Collembola sp.	−0·2286	−0·3232	−0·2776	−0·3445	−0·2834	−0·1040	−0·3166	−0·1690	0·0733	0·1124	−0·1276	0·1066
Coleoptera												
Staphylinidae adults	0·5876	0·3343	0·5427	0·1554	0·2927	−0·1126	−0·1189	−0·1297	0·2416	0·4742	0·1746	0·3949
Carabidae adults	0·5727	0·4214	0·5617	0·3286	0·4771	−0·3344	−0·1439	−0·0820	0·2274	0·2203	0·1020	0·2812
Staphylinidae Carabidae larvae	0·2696	0·2422	0·2794	0·4291	0·2590	−0·2378	0·1021	0·2090	−0·0812	−0·0114	0·4833	−0·1057
Feronia madida	0·4867	0·3256	0·4662	0·2348	0·3711	−0·2031	−0·1097	−0·0476	0·1572	0·1831	0·0471	0·2011
Philonthus cognatus	0·2715	0·1063	0·2342	−0·0819	−0·0266	−0·0277	0·0805	−0·1330	−0·0074	0·2581	0·1243	0·1081
Total Coleoptera sp.	0·4774	0·5129	0·5236	0·2742	0·3146	−0·2332	0·0442	0·0984	0·1899	0·2887	0·1725	0·1912
Hymenoptera	−0·1850	0·0969	−0·1016	0·1554	0·0555	−0·3032	0·2080	0·3597	−0·0298	−0·4135	0·4271	−0·1364
Diptera	0·0606	0·1388	0·0917	0·1287	0·1831	−0·1440	−0·4186	−0·1365	0·0470	0·0118	0·2436	0·0687
Total arthropods (Arachnida + Hexapoda)	0·3469	0·2413	0·3354	0·2429	0·2219	−0·2691	−0·1107	0·0365	0·1597	0·1799	0·4407	0·1555

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TABLE 4

Numbers of animals collected by suction sampling per half square metre, August 1974

Treatment	Plot No.	*Isotoma notabilis*	*Isotoma viridis*	*Entomobrya nicoleti*	*Lepidocyrtus cyaneus*	*Heteromurus nitidus*	*Sminthurides pumilis*	*Sminthurides aureus*	*Bourletiella hortensis*	*Sminthurus viridis*	*Dicyrtoma minuta*	*Sminthurinus elegans*	Total	Araneae	Hemiptera	Coleoptera (adults)	Coleoptera (larvae)	Diptera	Hymenoptera	Total	Grand Total
N_1	1b	238	57	161	1316	0	31	16	6	22	0	0	1847	6	8	1	0	1	11	27	1874
	c	3	15	16	160	0	34	0	6	97	0	0	331	1	9	2	0	7	4	23	354
	d	147	136	87	1421	4	0	5	4	4	0	0	1808	17	60	5	1	6	65	154	1962
None	2ab	0	0	0	79	0	89	9	43	34	12	0	266	0	0	1	0	1	3	5	271
	cd	1	2	8	38	3	2	43	4	59	0	3	163	7	4	1	0	5	1	18	181
P	4/1a	5	107	3	178	0	27	66	77	139	6	0	608	8	13	5	2	3	16	47	655
	b	2	226	0	403	0	439	105	372	140	6	0	1693	11	15	1	13	2	8	50	1743
	c	20	43	0	200	0	51	106	101	144	17	0	682	4	2	1	1	4	8	20	702
	d	1	1	8	16	0	4	5	1	21	2	0	59	0	5	1	0	2	15	23	82
N_2P	4/2a	0	66	1	462	0	240	35	5	83	21	0	913	4	2	1	3	9	15	34	947
	b	9	137	0	141	2	32	7	3	20	0	0	351	3	7	1	3	5	11	30	381
	c	13	26	0	618	0	97	168	96	207	0	0	1225	5	14	3	3	4	12	41	1266
	d	0	35	0	6	0	0	1	4	5	1	0	52	6	2	1	1	4	5	19	71
PK	7b	3	144	0	232	0	101	69	0	118	6	5	678	6	8	5	7	4	12	42	720
	c	3	59	0	163	0	30	24	58	25	4	0	366	3	5	1	3	4	5	21	387
PNaMg	8b	6	243	0	348	0	85	20	580	295	0	0	1577	3	6	3	11	3	14	40	1617
	c	2	169	2	217	1	165	183	165	292	7	0	1203	5	5	1	1	6	6	24	1227
$N_2PKNaMg$	9a	1	10	0	33	2	2	6	12	141	0	0	207	2	4	3	3	8	7	27	234
	b	4	51	0	205	0	19	16	25	20	4	1	345	2	0	6	6	6	15	35	380
	c	0	23	0	42	0	6	3	8	10	0	0	92	2	0	0	2	3	3	10	102
	d	0	60	0	12	0	0	0	0	0	0	0	72	5	3	2	0	8	5	23	95
N_2NaMg	10a	3	34	2	78	0	24	49	0	63	0	0	253	10	1	5	0	0	3	19	272
	b	29	314	0	904	0	144	17	22	16	3	1	1477	2	2	1	0	10	19	34	1511
	c	9	21	0	277	1	0	19	0	16	0	0	343	2	6	1	0	4	1	14	357
	d	0	18	0	27	0	22	25	30	23	0	0	145	1	10	0	0	8	10	29	174
$N_3PKNaMg$	11/1a	0	1	0	9	0	0	6	0	18	0	0	34	0	4	0	0	7	4	15	49
	b	7	12	0	53	0	15	32	15	56	0	0	190	0	4	2	5	5	7	23	213
	c	9	49	9	132	0	177	24	39	169	2	0	610	9	6	3	1	5	13	37	647
	d	0	58	0	0	0	0	0	0	1	0	0	59	3	11	5	5	6	3	33	92
$N_3PKNaMg$ (*Silicate of Soda*)	11/2b	7	27	0	48	0	1	8	0	122	0	0	213	6	0	1	7	36	0	50	263
	c	76	41	0	42	0	54	11	25	3	2	0	254	4	1	0	0	16	10	31	285

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None	12ab	0	10	0	43	0	23	18	12	21	0	0	127	2	7	0	3	4	20	36	163
	cd	0	16	2	72	0	0	0	2	5	0	0	97	2	1	0	0	1	5	9	106
FYM and fishmeal	13a	8	43	0	417	0	68	68	4	193	7	3	811	15	2	0	4	15	7	43	854
	b	1	114	0	87	0	6	64	3	98	0	6	379	1	4	0	0	9	0	14	393
	c	66	11	0	106	0	112	190	87	165	6	0	743	8	2	0	0	7	4	21	764
	d	24	47	0	3	0	35	85	61	106	0	0	361	3	5	0	0	7	7	22	383
N_2*PKNaMg	14b	11	12	0	157	0	129	115	2	89	10	0	525	1	0	0	2	11	11	25	550
	c	0	5	0	109	0	29	63	5	45	8	0	264	1	3	2	2	5	6	19	283
N_1*PKNaMg	16a	0	25	2	198	0	189	185	4	91	5	0	699	9	2	1	0	7	4	23	722
	b	9	37	5	58	0	24	19	2	21	39	0	214	5	1	0	1	18	18	43	257
	c	71	102	35	188	8	105	196	22	53	7	0	487	15	1	1	1	5	6	29	516
	d	0	27	8	45	0	80	62	0	106	6	5	339	6	4	0	6	7	20	43	382
N_1*	17b	0	4	29	278	0	131	51	6	112	14	0	625	4	8	2	5	10	13	42	667
	c	1	6	24	59	0	48	51	0	12	3	4	208	1	2	1	3	4	4	15	223
N_2KNaMg	18a	0	36	0	33	0	2	0	15	9	0	0	95	2	3	0	0	4	5	14	109
	b	55	25	0	690	0	165	104	107	66	0	0	1212	3	3	1	0	7	13	27	1239
	c	2	11	1	24	4	67	2	0	20	1	0	132	1	16	0	0	2	4	23	155
	d	1	7	2	6	0	14	3	1	2	0	0	36	1	16	1	1	7	4	30	66
Total		847	2750	405	10453	25	3118	2354	2034	3577	199	28	25470	217	297	72	106	322	426	1476	26946

TABLE 5

Weather conditions during trapping

Date of trapping	June 11/12 1973	July 17/18 1973	Aug. 13/14 1973	Sept. 10/11 1973	Oct. 12/13 1973	Nov. 13/14 1973	Dec. 12/13 1973	Jan. 17/18 1974	Feb. 14/15 1974	March 14/15 1974	April 9/10 1974	May 16/17 1974
Temperature (°C)												
Air maximum	20·7	17·0	26·4	17·9	11·6	10·2	8·5	9·4	7·9	7·0	18·0	19·2
Air mean	14·4	13·3	19·9	12·3	8·9	6·9	5·2	6·6	4·9	4·5	10·6	15·3
Air minimum	8·0	9·5	13·5	6·7	6·2	3·7	1·8	3·9	2·0	2·1	3·2	11·4
Rainfall (mm)	0·0	1·7	0·0	0·0	0·0	0·2	1·9	trace	12·8	3·3	trace	trace
Sunshine (h)	6·9	2·6	12·2	3·7	4·0	4·3	3·1	0·9	4·9	2·5	9·5	6·0

TABLE 6

Correlation coefficients between crop and soil characteristics and soil animal populations—(Suction sampling)

	June Yield 1st cut (t/ha)	September Yield 2nd cut (t/ha)	Yield both cuts (t/ha)	June 1974 Maximum crop height (cm)	June 1974 Average crop height (cm)	June 1974 Crop density (%)	No. of plant species	pH	Soil N (%)	Soil P (ppm)	Soil K (ppm)	Soil carbon (%)
Arachnida												
Aranea	−0·0412	0·0057	−0·0281	0·0754	0·1014	−0·0809	−0·0532	0·0845	0·0042	0·0070	0·0289	−0·0268
Collembola												
Isotoma notabilis	−0·1021	−0·0636	−0·0962	−0·0410	−0·0730	0·0942	0·0207	0·0561	−0·0798	−0·2261	−0·0825	−0·1216
Isotoma viridis	−0·1499	−0·0198	−0·1160	−0·0936	−0·1613	0·0248	0·0727	0·2492	0·0096	0·1116	−0·1407	−0·0522
Entomobrya nicoleti	−0·2459	−0·1663	−0·2362	−0·0999	−0·1685	0·1305	0·0495	0·0890	−0·1556	−0·3280	−0·1316	−0·2185
Lepidocyrtus cyaneus	−0·2747	−0·2158	−0·2741	−0·2436	−0·2817	0·1363	0·0845	0·2170	−0·1088	−0·1865	−0·1832	−0·1676
Heteromurus nitidus	−0·0747	−0·1669	−0·1116	0·0546	0·0177	−0·0780	−0·0512	−0·1701	−0·2234	−0·1532	0·1703	−0·1796
Sminthurides pumilis	−0·0511	0·0048	−0·0356	0·0206	−0·0971	0·1070	0·1934	0·3631	0·1708	0·0694	0·0240	0·0387
Sminthurinus aureus	0·0760	0·2547	0·1426	0·2988	0·1322	−0·0393	0·1403	0·2600	−0·0898	0·0390	0·1802	−0·1752
Bourletiella hortensis	−0·2419	−0·0128	−0·1807	−0·0932	−0·2345	−0·0476	0·1659	0·2369	0·1202	0·1237	−0·1757	0·0407
Sminthurius viridis	0·0324	0·2872	0·1220	0·1862	0·1160	−0·0362	0·2340	0·2891	0·0188	0·0748	−0·1367	−0·0597
Dicyrtoma minuta	0·0743	0·1649	0·1106	0·1324	0·0561	0·0245	0·1143	0·3743	0·0805	−0·0377	0·2229	−0·0424
Sminthurides elegans	0·0618	0·2744	0·1390	0·2979	0·2509	−0·2270	0·1928	0·2198	−0·0157	−0·2456	0·1363	−0·1381
Total Collembola	−0·2514	−0·0768	−0·2095	−0·1215	−0·2376	0·0988	0·1819	0·3585	−0·0351	−0·0847	−0·1715	−0·1464
Insecta												
Hemiptera	−0·2331	−0·2510	−0·2558	−0·2047	−0·1748	−0·0367	0·0268	−0·0255	−0·1463	−0·1369	−0·0466	−0·1445
Coleoptera (adults	−0·0031	0·0034	−0·0011	−0·1301	−0·0859	0·0127	−0·2347	−0·0028	0·0333	0·1557	−0·0327	0·1001
Coleoptera (larvae)	0·0520	0·2405	0·1203	0·2119	0·0955	−0·1262	0·0141	0·3088	0·1375	0·0941	0·0591	0·0915
Diptera	0·4662	0·4263	0·4857	0·3845	0·4856	−0·2129	−0·2486	0·1297	0·0979	0·0330	0·1491	0·1006
Hymenoptera	−0·2331	−0·2510	−0·2558	−0·2047	−0·1748	−0·0367	0·0268	−0·0255	−0·1463	−0·1369	−0·0466	−0·1445
Total arthropods (except Collembola)	−0·0829	−0·0753	−0·0862	−0·0476	−0·0051	−0·1117	−0·0622	0·0635	−0·0786	−0·0827	0·0073	−0·0828
Total Arthropods	−0·2491	−0·0784	−0·2083	−0·1207	−0·2322	0·0914	0·1748	0·3527	−0·0378	−0·0864	−0·1670	−0·1466

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The most valuable of the results obtained were the assessment of the diversities of the fauna on this old grassland site and the phenology of some of the species of arthropods that lived in it.

Yield was the crop characteristic that was correlated with numbers of some species of arthropods most strongly.

Although there was a tendency for overall pitfall catches of spiders to be positively correlated with the June yield ($r = 0{\cdot}3657$), the only strong correlation was between the catches of spiders in May ($r = 0{\cdot}5984$), the month prior to cutting, and the yield, in June.

Numbers of *Erigone atra* (Fig. 4) and to a lesser extent, of *E. dentipalpis*, were also positively correlated with yield, as were those of *Savignya frontata*. Numbers of two species of spiders, *Pardosa palustris* (Fig. 2) and *Pachygnatha degeeri* (Fig. 3) were negatively correlated with yield. Other species showing weaker negative correlations with yield included *Meioneta beata*, *Agyneta decora*, *Oedothorax fuscus* and *Dicymbium nigrum*. Clearly, *crop height* was the most important factor influencing this correlation, because wherever there was a strong correlation with yield there were also correlations with the mean and maximum heights of the crop. *Crop density* could also be positively correlated with numbers of a few species, particularly *Meioneta beata*, *Pardosa palustris* and *Erigone dentipalpis*.

There was little association between yield, crop height or density and the numbers of springtails caught (Table 3) although numbers of most Collembola species tended to be negatively correlated with crop yield and height.

More beetles of most species were trapped in plots with high grass yields (Fig. 5) and in particular, many more carabid beetles (Fig. 6) and staphylinid beetles (Fig. 7) were caught in high-yielding plots.

Conversely, more ants were caught in low-yielding plots (Fig. 8) with short grass (Fig. 9).

There were no significant correlations between plant characteristics and the numbers of arthropods collected by suction trapping (Table 6). By far the most numerous arthropods in the suction samples were Collembola (Table 4) but there were few correlations with the numbers of the animals collected in pitfall traps. Numbers of Collembola tended to be negatively correlated with yield for isotomid and entomobryid Collembola, but positively with yield for sminthurid Collembola. These differences may be related to the habits of these springtails, the first two families occurring mainly at ground level and the latter mainly on foliage.

Few correlations were obtained between soil characteristics and arthropod populations; and when they occurred they were probably due to indirect influence on crop growth. Soil pH was positively correlated with the numbers of two species of spiders, *Oedothorax fuscus* ($r{=}0{\cdot}5192$) and *O. retusus* ($r{=}0{\cdot}5463$) and negatively with those of one species of springtail, *Isotoma viridis* ($r = -0{\cdot}5014$).

The level of soil phosphorus was positively correlated with numbers of one species of spider, *Erigone atra* and one species of springtail, *Isotoma viridis*, and the level of soil potassium seemed to have different effects on different groups of arthropods. This soil characteristic was positively correlated with the numbers of six species of spiders trapped in July; these were *Oedothorax fuscus* ($r = 0{\cdot}5129$), *O. retusus* ($r = 0{\cdot}5518$), *Pachygnatha degeeri* ($r = 0{\cdot}5721$), *Erigone dentipalpis* ($r = 0{\cdot}6544$), *E. atra* ($r = 0{\cdot}4731$) and *Savignya frontata* ($r = 0{\cdot}5806$). Potassium had little influence on the numbers of springtails trapped, if anything the correlation was negative. There was a tendency for the level of potassium and numbers of ants ($r = 0{\cdot}4271$) and beetle larvae ($r = 0{\cdot}4833$) to be positively correlated; these latter effects may be direct because these arthropods spend most of their lives in soil.

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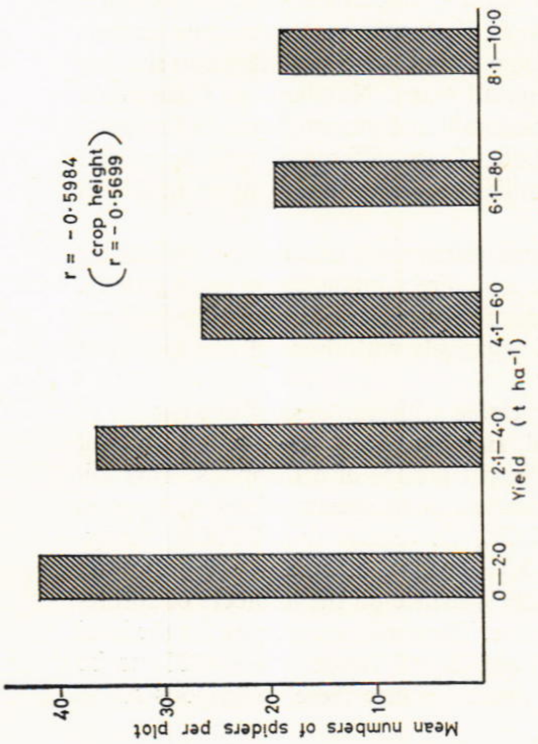

FIG. 1. Relationship between total numbers of spiders trapped and yield (June 1973).

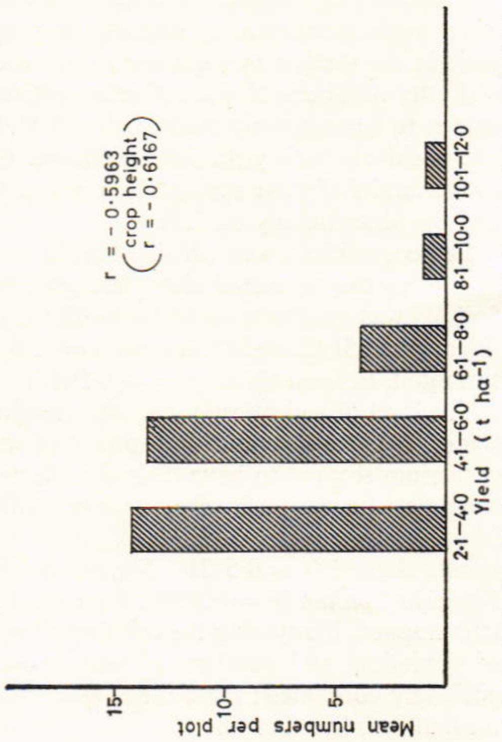

FIG 2. Relationship between numbers of *Pardosa palustris* and yield (June 1973).

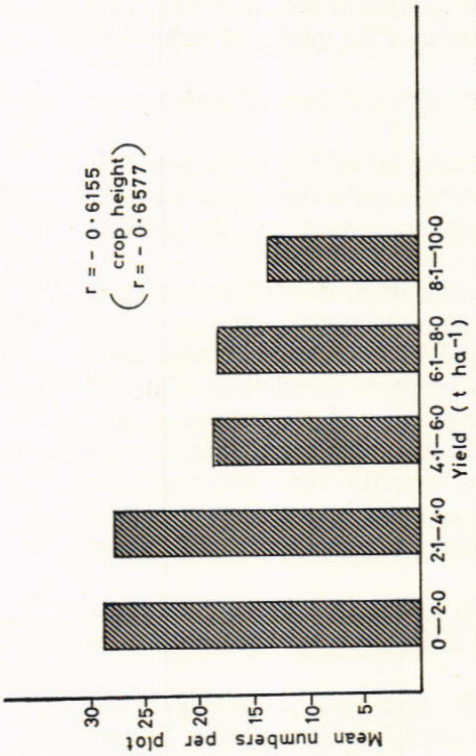

FIG. 3. Relationship between numbers of *Pachygnatha degeeri* and yield (June 1973).

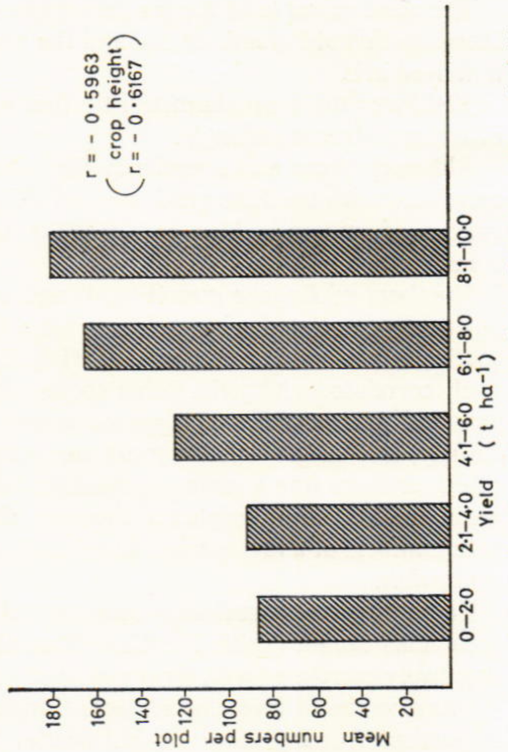

FIG. 4. Relationship between numbers of *Erigone atra* and yield (June 1973).

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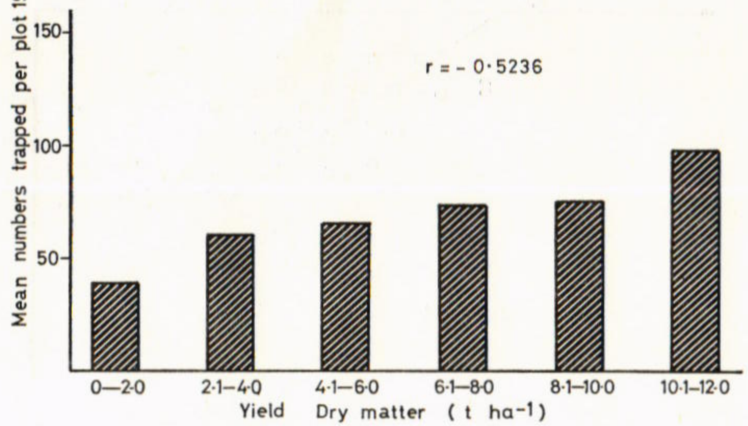

FIG. 5. Relationship between total numbers of beetles trapped and yield.

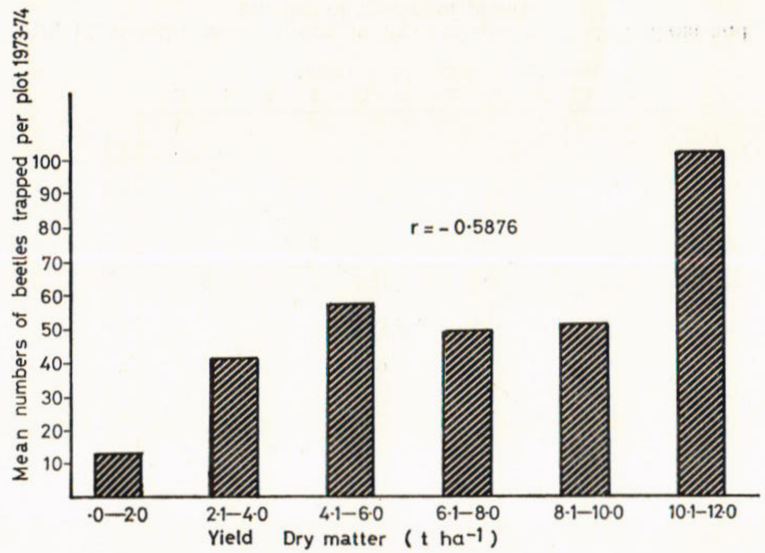

FIG. 7. Relationship between total staphylinid beetles trapped and yield.

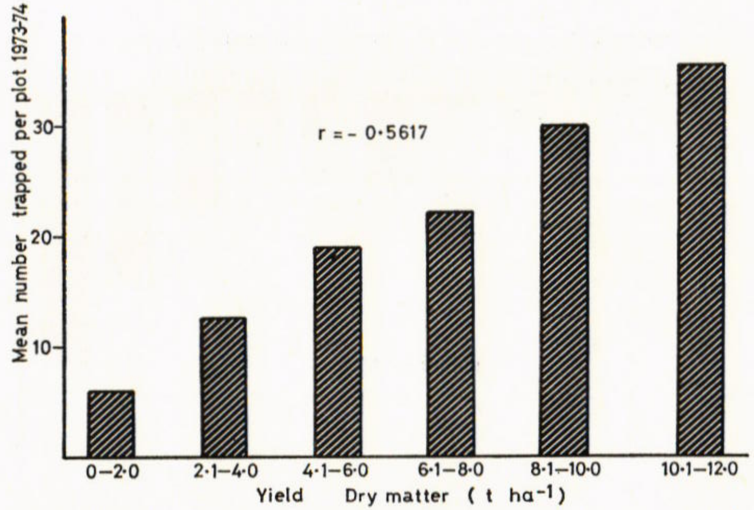

FIG. 6. Relationship between total numbers of carabid beetles trapped and yield.

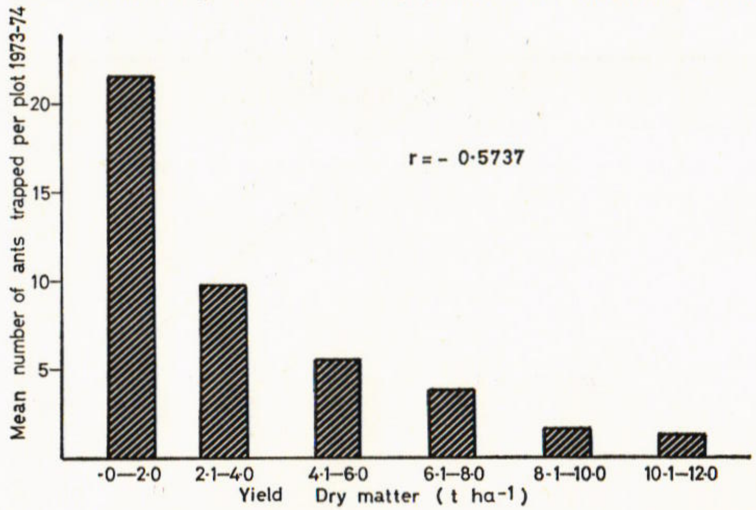

FIG. 8. Relationship between total numbers of ants trapped and yield.

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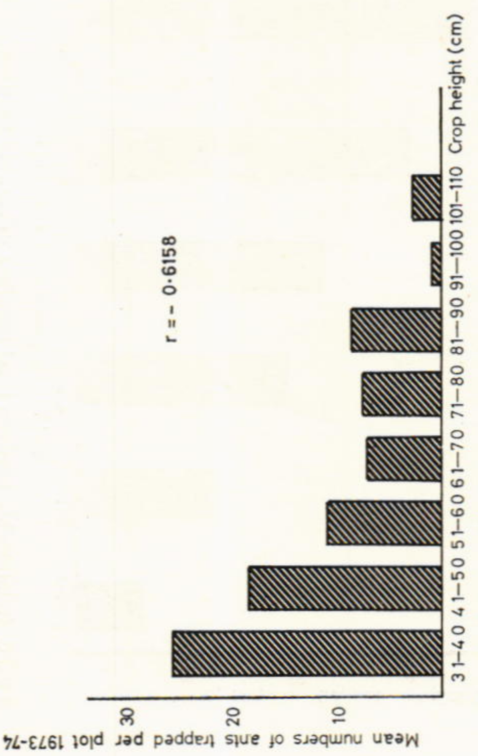

FIG. 9. Relationship between numbers of ants and crop height.

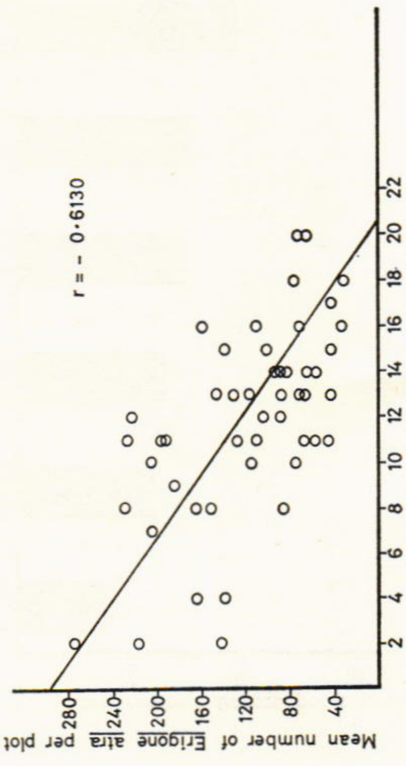

FIG. 10. Numbers of *Erigone atra* v. plant species diversity.

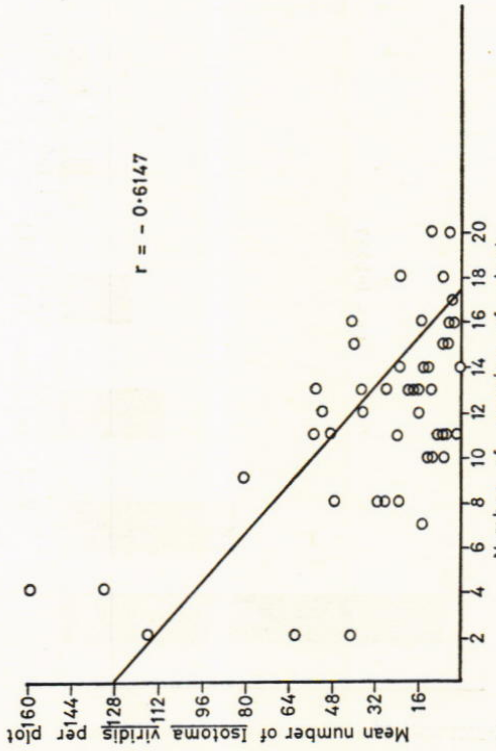

FIG. 11. Relationship between numbers of *Isotoma viridis* and numbers of species of plant.

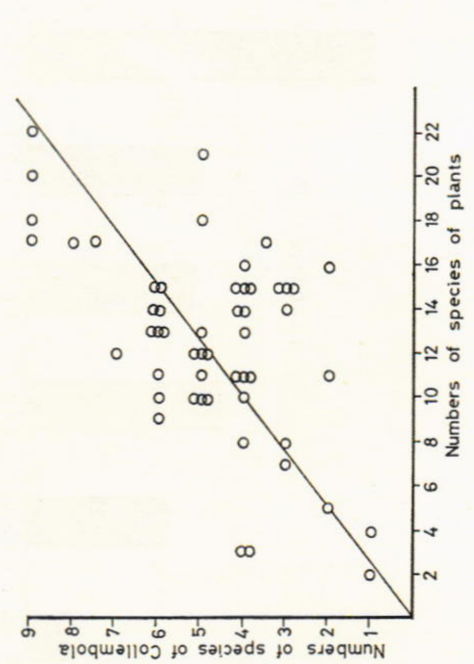

FIG. 12. Relationship between numbers of species of Collembola and number of species of plant.

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Floral diversity seemed to have little influence on numbers of soil arthropods. Numbers of only one species of spider, *Erigone atra* (Fig. 10) and one species of springtail, *Isotoma viridis* (Fig. 11) were strongly negatively correlated with plant diversity, and for both species the fewer the species of plant present the greater the numbers of individuals trapped. Of the three groups of animals that were identified to species, only for the Collembola was floral diversity correlated with the number of species caught (Fig. 12). This is not surprising, because whereas many springtails feed on plant material, all spiders and all but a few carabid and staphylinid beetles are carnivorous.

(3) Phenology. Few detailed studies have been made on the fauna of old pasture. The intensity of our sampling on Park Grass (392 pitfall traps for each of 12 monthly samples) yielded considerable data on the phenology of the fauna, particularly of the spiders. Unfortunately, pitfall traps have considerable disadvantages in assessing relative abundance, because their effectiveness depends on the activity of the animals trapped, and they selectively sample the fauna. For instance, although more male than female spiders of many species tended to be caught, this is not necessarily indicative of the actual sex ratios, because males move around to search for mates and females also move around searching for oviposition sites and so each sex may be trapped more readily at certain times in their life cycles. Similarly, it is probable that a greater proportion of those spiders that actively hunt their prey (such as the species of *Pardosa* and *Pachygnatha*) are likely to be caught than of the less mobile species that snare their prey. Nevertheless, such large numbers of some species of spiders and other arthropods were caught that a good indication of the seasonal abundance of these species was obtained.

The most important factor affecting the activity of the arthropods was the temperature. This relationship is clear when the total numbers of arthropods trapped is compared with the mean daily temperature (Fig. 16). However, when catches of individual species of arthropods were compared, large numbers were often trapped when temperatures were comparatively low (Figs. 19–23). Hence, pitfall catches, although unsatisfactory, can be used to obtain some indication of seasonal abundance. Most spiders were caught in August and fewest in December (Fig. 17) but only a few of the less numerous species showed this pattern with a single summer peak; most species differed markedly from this. The number of months in which particular species were caught ranged from only one month a year to every month (Fig. 18). These patterns of occurrence will be discussed in relation to currently available information on the phenology of spiders.

The seasonal occurrence of different species of spiders fell into several distinct patterns:

(a) Species that had a distinct summer peak population (Fig. 19). These included: *Pachygnatha degeeri* which has been reported to have a peak at the end of May to early June (Locket, 1975), with which our data agree; *Pardosa palustris* which is believed to have peak populations of males in May and females throughout spring and summer (Locket, 1975), which our data confirm; *Dicymbium nigrum* recorded as having adults in spring, summer and autumn (Locket & Millidge, 1953) and *Agyneta decora* and *Alopecosa pulverulenta* for which we know of no records of seasonal abundance (Fig. 20). Other less common species with peak summer populations were: *Xysticus cristatus* which has been stated to have adult males in spring and early summer and adult females most of the summer (Locket & Millidge, 1951), a conclusion our data fully support; *Tiso vagans*, the adults of which are believed to occur from spring to autumn (Locket & Millidge, 1953)—our data support this but show a distinct peak of adult males in April; *Trochosa terricola*, adults of which are reported throughout the year especially autumn and spring (Locket & Millidge, 1951)—our data show a distinct peak in April and May, which is much more in agreement with the reported peak in April (Locket, 1975).

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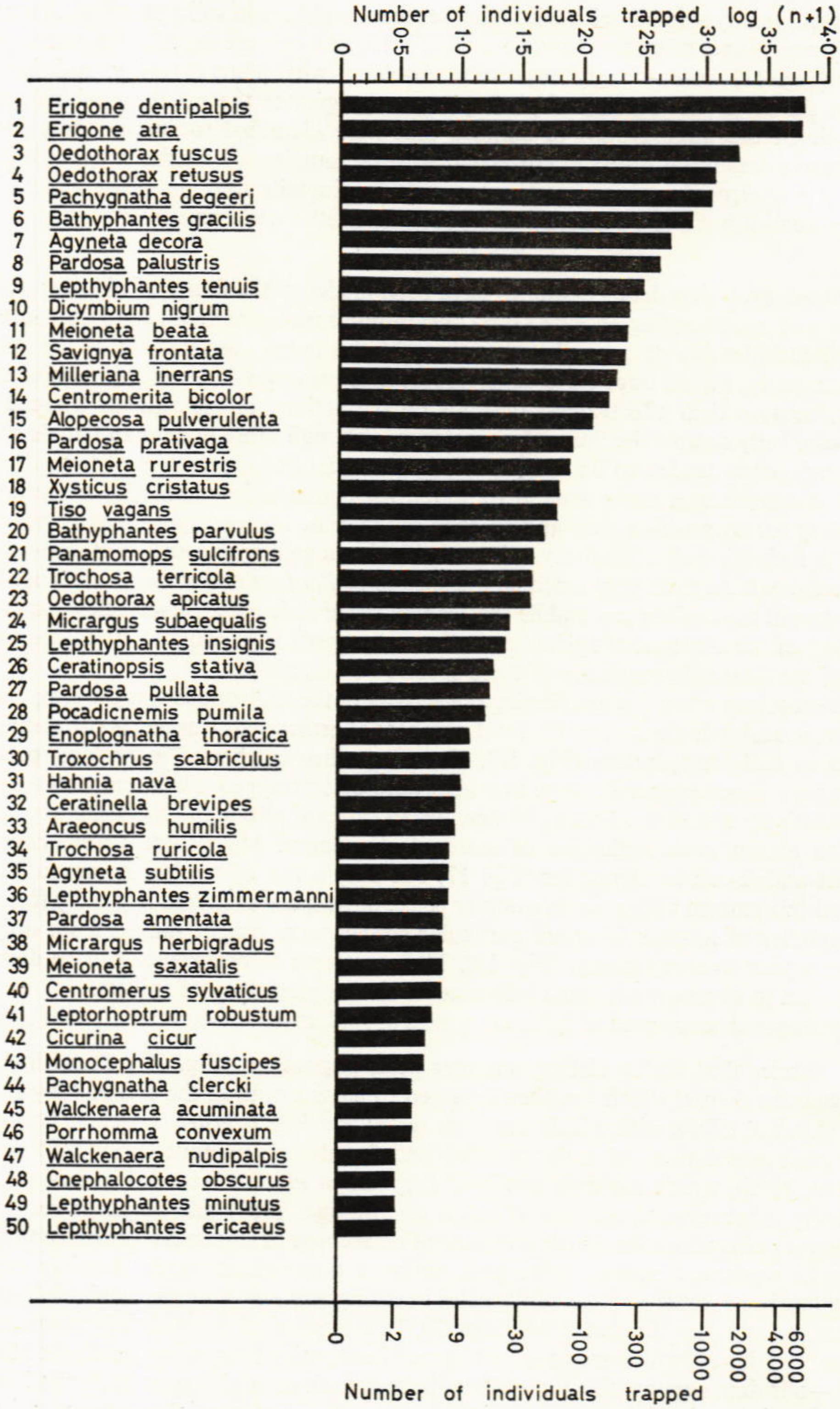

FIG. 13. Relative abundance of the more common spiders caught in pitfall traps 1973–1974.

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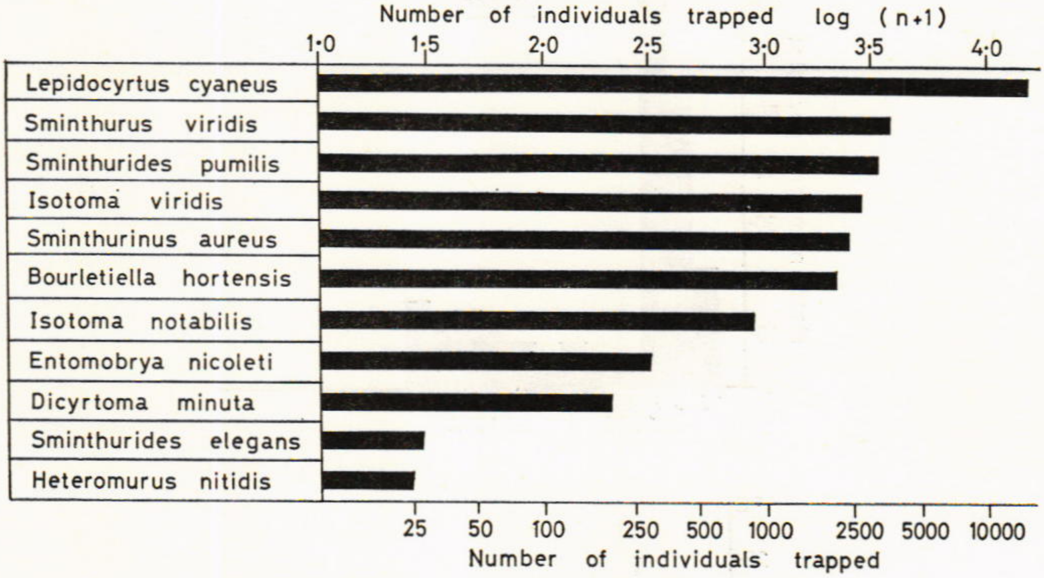

FIG. 14. Relative abundance of Collembola caught in pitfall traps.

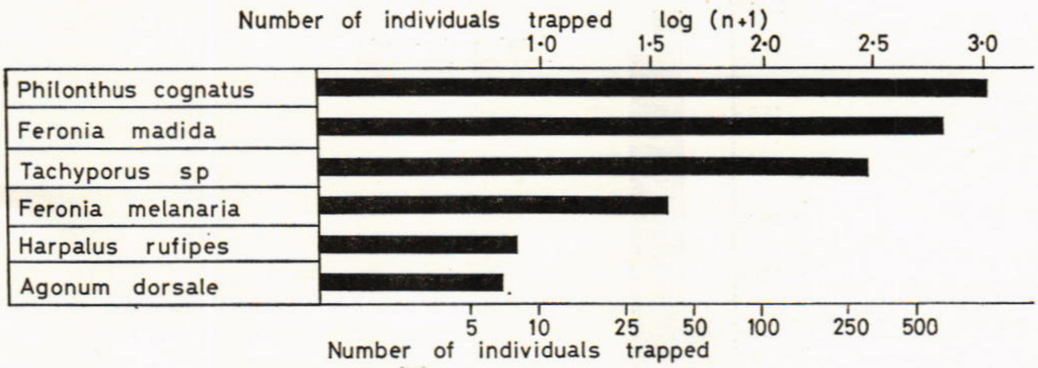

FIG. 15. Relative abundance of beetles caught in pitfall traps.

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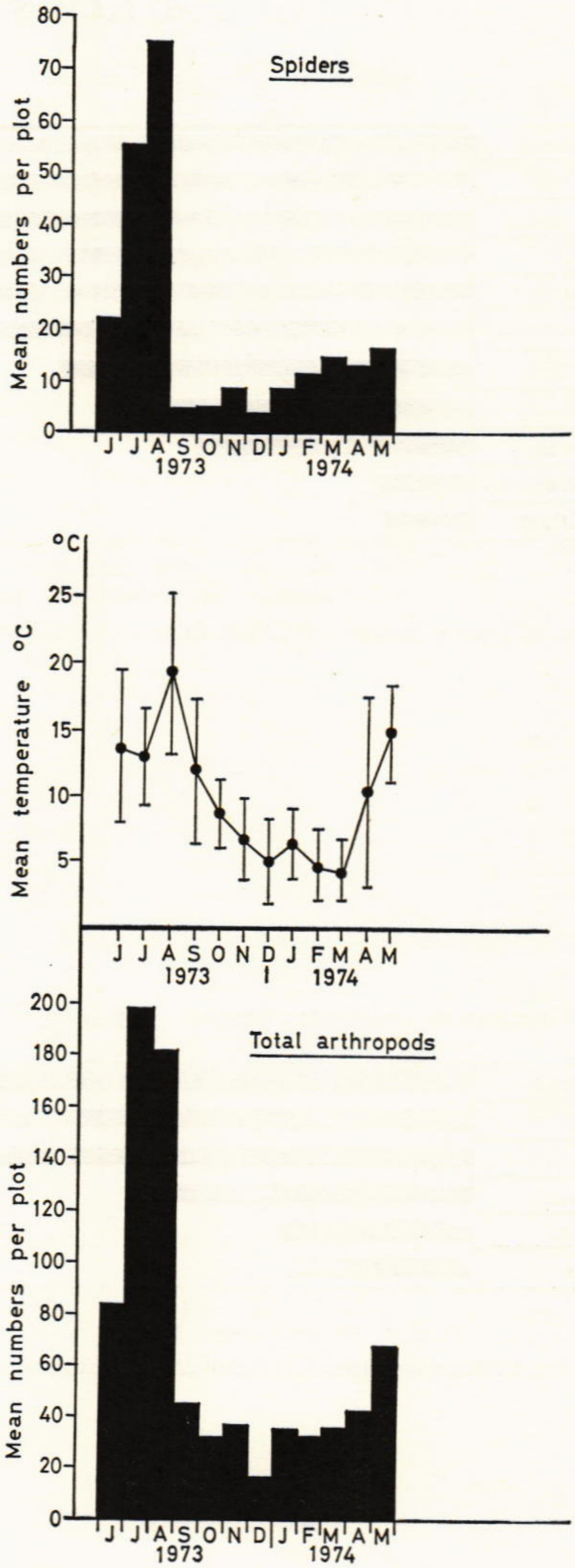

FIGS. 16 and 17. Numbers of arthropods trapped through the year.

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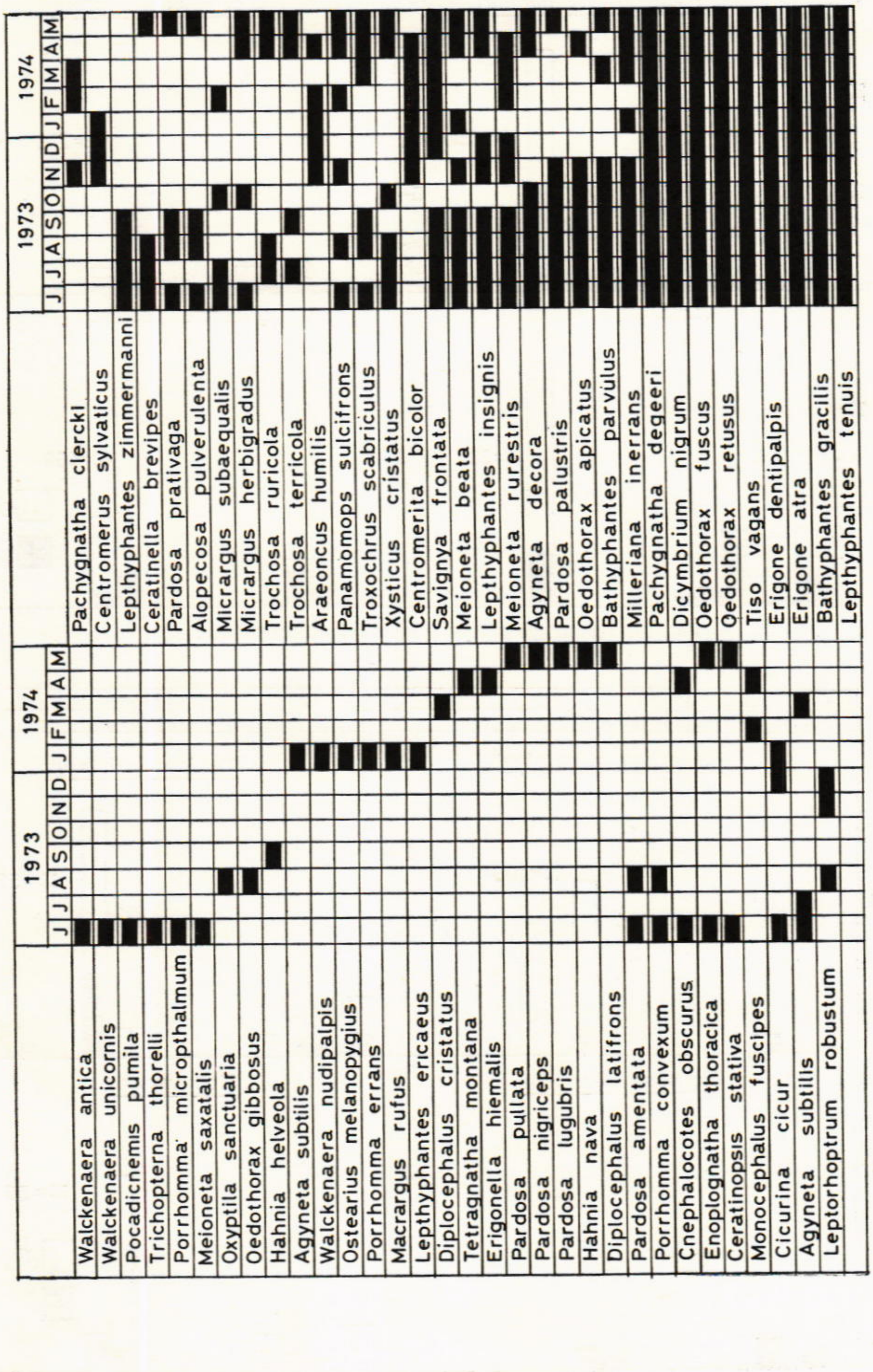

FIG. 18. Seasonal occurrence of 65 species species of spiders on Park Grass.

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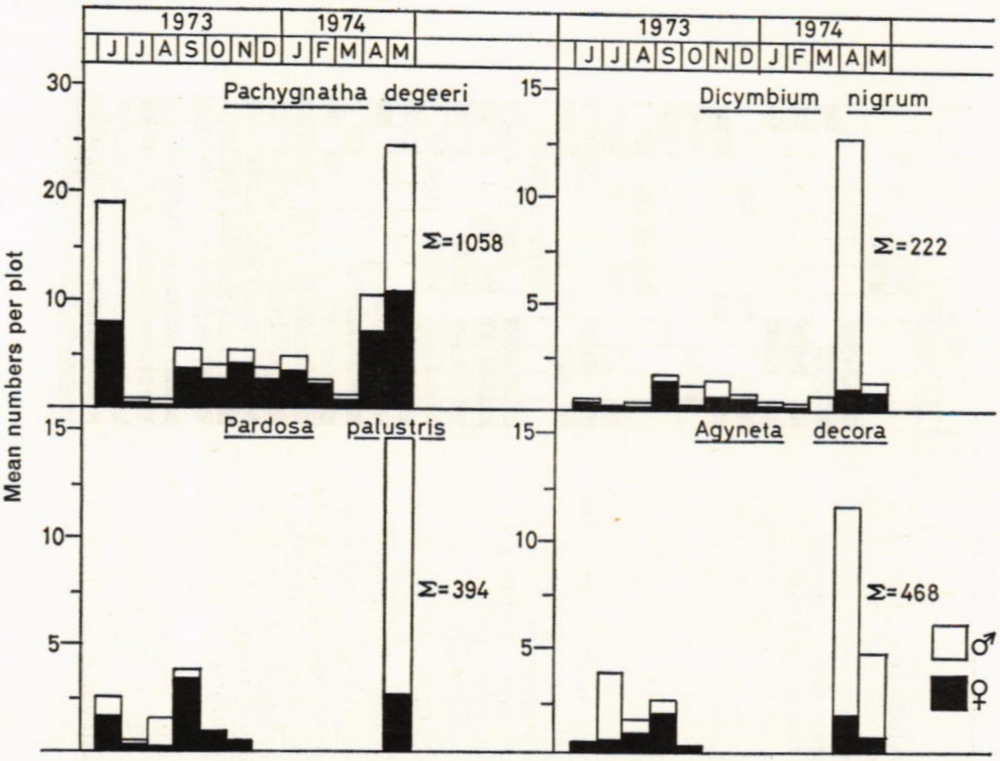

FIG. 19. Percentage of total spiders caught per month.

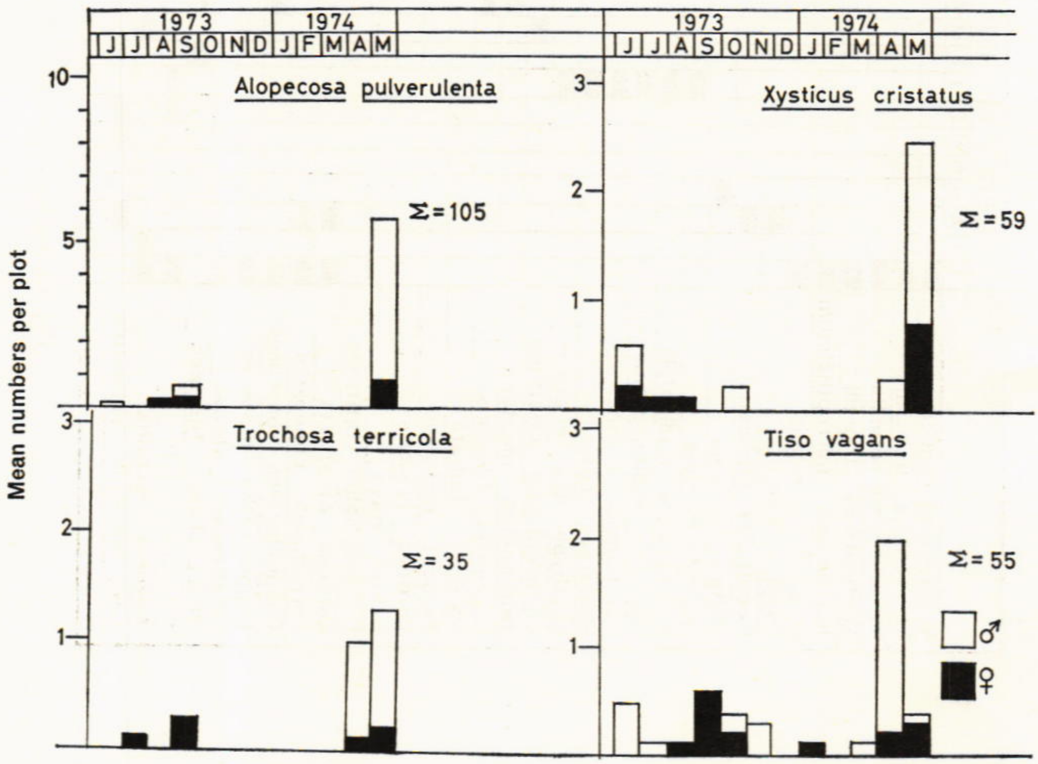

FIG. 20. Percentage of total spiders caught per month.

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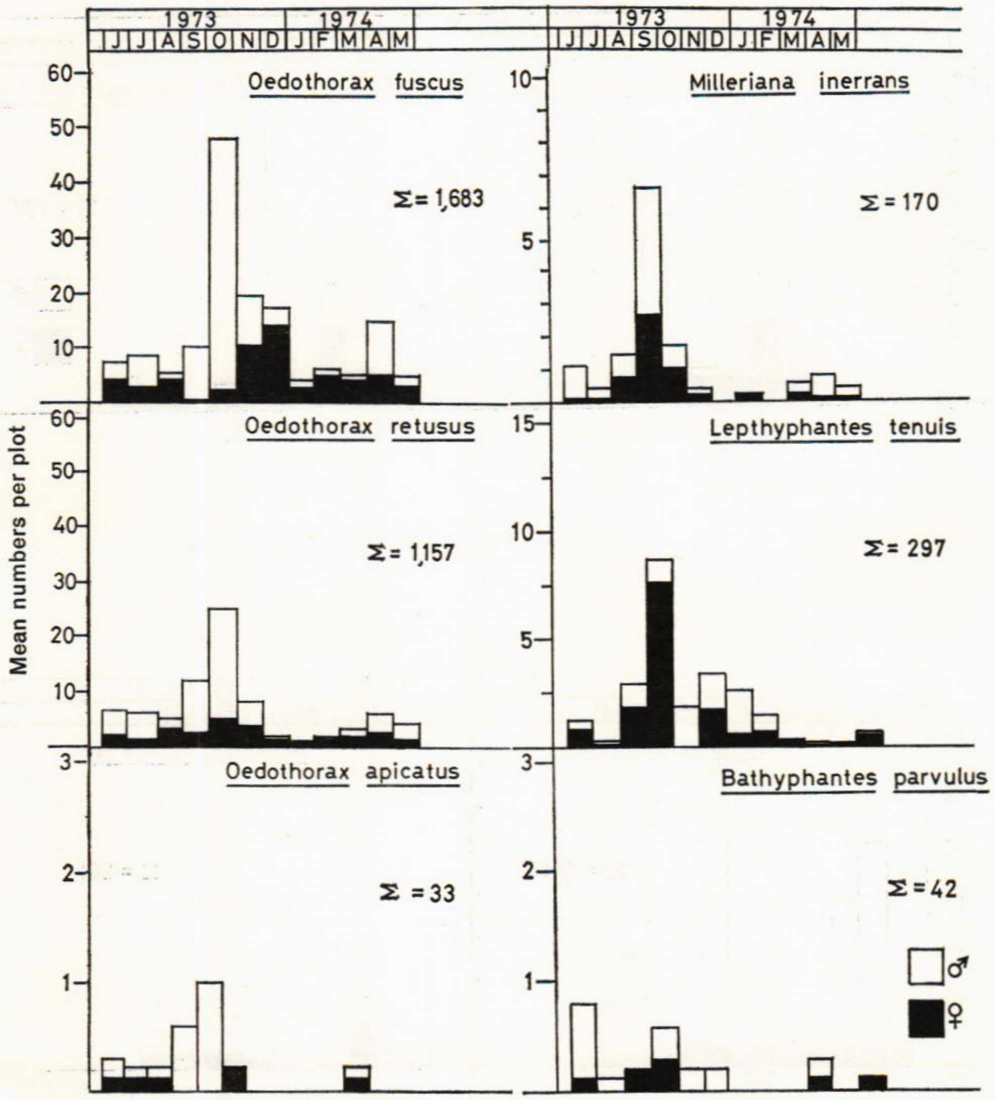

FIG. 21. Percentage of total spiders caught per month.

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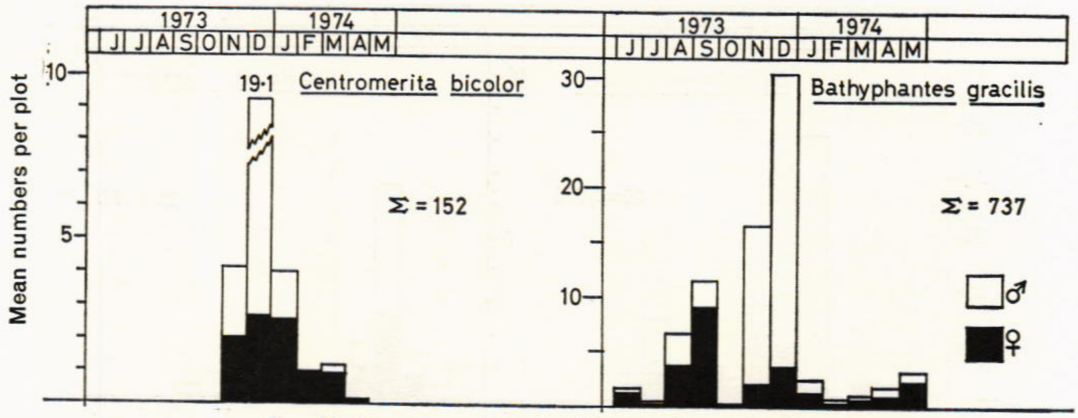

FIG. 22. Percentage of total spiders caught per month.

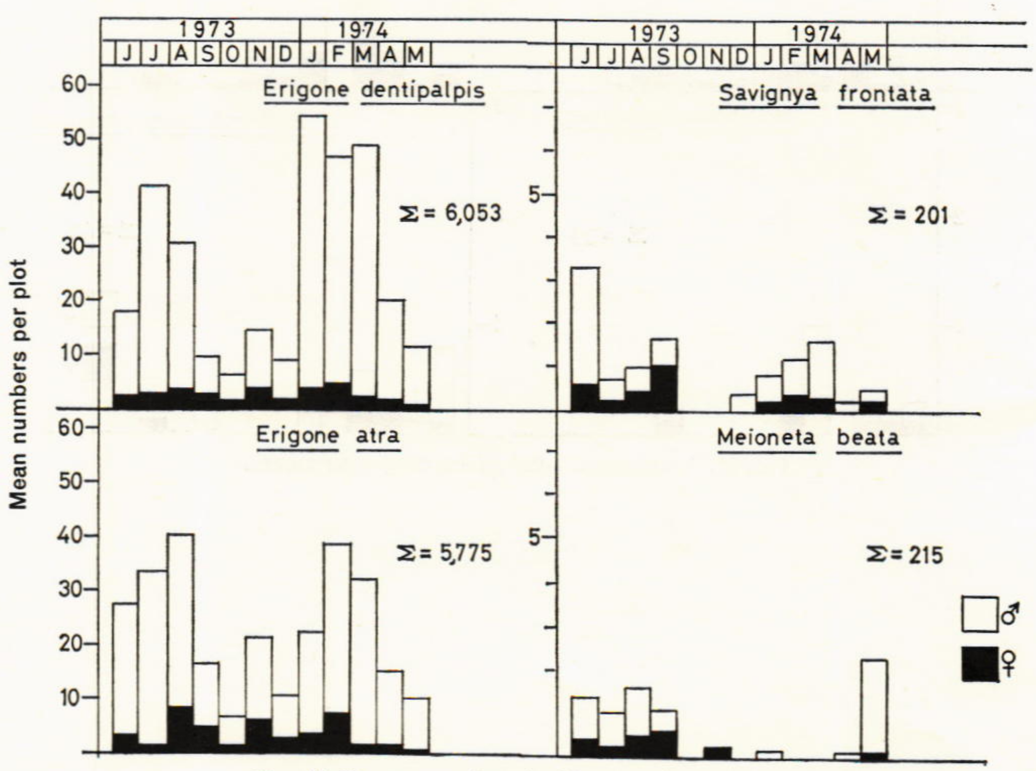

FIG. 23. Percentage of total spiders caught per month.

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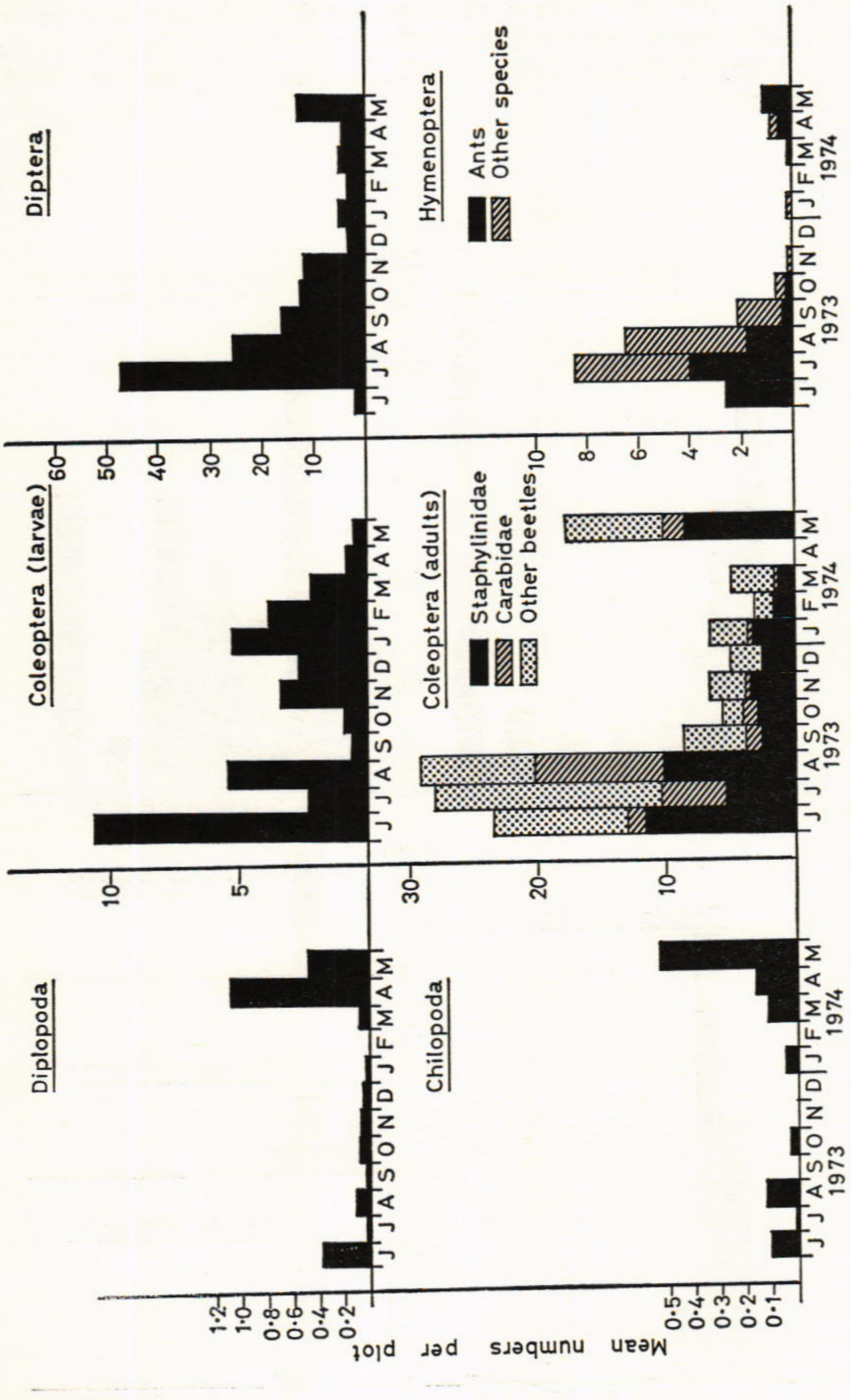

FIG. 24a. Numbers of millipedes and centipedes trapped. FIG. 24b. Numbers of beetles and larvae trapped. FIG. 24c. Numbers of flies and ants trapped.

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(b) Species with peak populations in autumn (Fig. 21). Three species for which we recorded distinct peak populations in autumn, *Oedothorax fuscus*, *O. retusus* and *Lepthyphantes tenuis* have been stated to be common all the year round (Locket & Millidge, 1953). Three other species which we caught most commonly in autumn, *O. apicatus*, *Milleriana inerrans* and *Bathyphantes parvulus*, are believed to be most common in spring and summer (Locket & Millidge, 1953). *O. apicatus* and *M. inerrans* are believed to be rare.

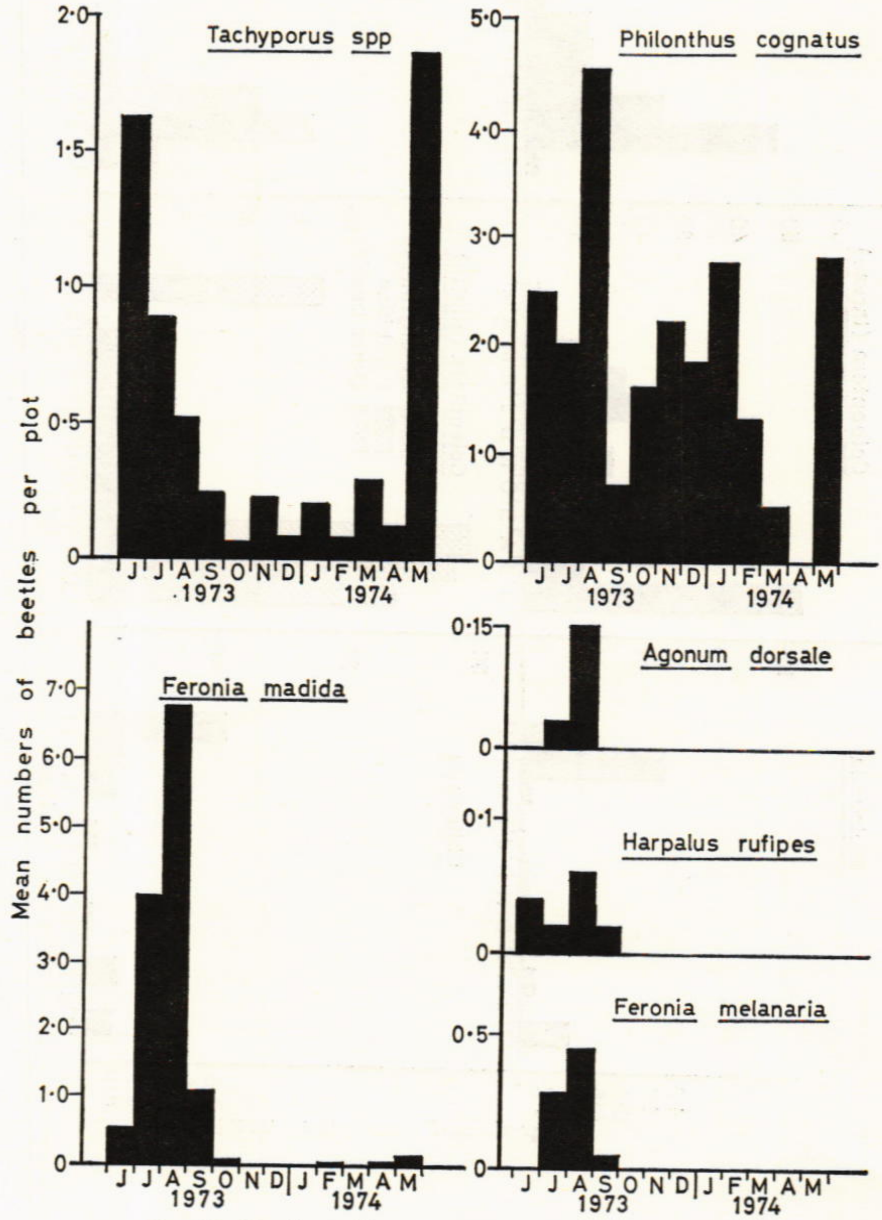

FIG. 25. Numbers of individual species of beetles caught.

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(c) Species with population peaks in winter (Fig. 22). Two species had very distinct peak catches in December; these were *Bathyphantes gracilis*, stated to occur throughout the year with a peak in January (Locket, 1975) and *Centromerita bicolor* which was recorded between December and February (Locket, 1975).

(d) Species with population peaks in late summer and early spring (Fig. 23). Three species stated to be found throughout the year (Locket & Millidge, 1953) were caught in much larger numbers at these two periods. These were *Erigone dentipalpis* and *E. atra*, both of which were very numerous, and *Savignya frontata*. A fourth species *Meioneta beata* which has been reported as scarce, and with a seasonal abundance which has not been assessed, was present in fairly large numbers.

Millipedes (Diplopoda) and centipedes (Chilopoda) (Fig. 24a) were not very numerous in the pitfall traps but were most common in spring.

Beetle larvae were trapped all the year round, most occurring in June; (Fig. 24b) many of these larvae spend much of their time in soil. Peak populations of adult beetles were trapped two months later, but the seasonal abundance of the different species differed. *Tachyporus* sp. was most numerous in May and June (Fig. 25) whereas peak catches of *Philonthus cognatus* occurred from June and August and most *Pterostichus madida*, *P. melanaria*, *Agonum dorsale*, and *Harpalus rufipes* were caught in August. These data agree with the phenology of beetles in cereal fields (Jones, Personal communication).

Peak numbers of ants were caught in June (Fig. 24c), few being active between November and March. Peak catches of flies occurred in June.

Conclusions

Although very significantly different populations of soil arthropods occurred as a result of the fertiliser treatments, particularly in relation to the amount of lime and nitrogen applied (Edwards & Lofty, 1975), the effects of the treatments on surface-living arthropods were more indirect and much less distinct.

There have been several investigations into the composition of the soil fauna of old grassland (Edwards, 1929; Salt *et al.*, 1948; Sheals, 1957; Dhillon and Gibson, 1962; Curry, 1969) but no detailed studies of the whole of the surface-living fauna of old grassland involving identification to species level. There have been several studies of the surface-living fauna where the arthropods have been identified to families (Southwood & van Emden, 1967; Heikinheimo & Raatikainen, 1962; Morris, 1968). Presumably, this lack of data on the surface fauna has been due to the sampling difficulties. The main sampling methods usually used have been sweep-netting and hand-collecting in quadrats, or suction sampling; usually the latter has been the most satisfactory. In the two studies where all the animals caught were identified to families (Southwood & van Emden, 1967; Heikinheimo & Raatikainen, 1962), the proportions of the different groups caught did not differ greatly from those in Park Grass (Table 7). In view of the large numbers of spiders caught in pitfall traps it must be assumed that suction sampling is relatively inefficient as a means of collecting spiders from grassland.

One striking aspect of the present study is the large number of species and individuals of spiders living in old grassland. Based on pitfall trapping they were second only to springtails in abundance. Moreover, it is interesting that species of spiders such as *Pardosa palustris*, *P. prativaga* and *Troxochrus scabriculus*, that usually occur in dry places (Locket & Millidge, 1951, 1953; Locket, Millidge & Merrett, 1974), and others, such as *Milleriana inerrans* and *Leptorhoptrum robustum*, that are found in wet meadows

https://doi.org/10.23637/ERADOC-1-10

(Locket & Millidge, 1953), and still others, such as *Ceratinopsis stativa*, *Micrargus subaequalis*, *Panamomops sulcifrons* and *Bathyphantes parvulus*, that inhabit chalk and limestone grassland (Locket, Millidge & Merrett, 1974), were all present in the small area of Park Grass, which is presumably a reflection of the vegetative density and pH values artificially created by the system of management.

Several of the species caught, some in large numbers, have been reported as very local, scarce, or rare—e.g. (numbers caught in brackets) *Cicurina cicur* (4), *Ceratinopsis stativa* (17), *Micrargus subaequalis* (23), *Panamomops sulcifrons* (36), *Agyneta decora* (468), *Meioneta beata* (215) and *Lepthyphantes insignis* (21)—(Locket & Millidge, 1951, 1953; Locket, Millidge & Merrett, 1974). These results suggest that intensive collecting in particular habitats is likely to show that some of the species that appear to be scarce are plentiful in some places.

Such large numbers of spiders must be exerting a considerable predator pressure on the other arthropods that inhabit grassland and we still know little of their food, or ecological interrelationships. It has been suggested that Collembola provide a major source of food for spiders and that mowing, raking and fertilising grassland can affect interactions between spiders and springtails, often causing spiders to increase in numbers at the expense of populations of some species of springtails (Jensen *et al.*, 1973).

There has been considerable discussion on the influence of cutting or grazing grassland on the surface-active fauna (Southwood & van Emden, 1967; Morris, 1968; Jensen *et al.*, 1973; Kajak, 1962). Southwood and van Emden concluded that there was a greater density of invertebrates in cut grassland than in uncut, but Morris found that there were 3·7 times as many animals in ungrazed grassland than grazed, this applying particularly to spiders. Kajak (1962) stated that mowing grass led to a reduction in numbers of spiders and even elimination of certain species. Our data would certainly support this, fewer spiders occurring on plots with short grass, and the numbers of many species dropping sharply after the second cut in August. Species that appeared to be particularly affected by cutting included *Pardosa palustris*, *Oedothorax fuscus*, *O. retusus*, *Bathyphantes gracilis* and *Lepthyphantes tenuis*.

TABLE 7

A comparison of numbers of selected arthropod groups collected by suction sampling

	Percentage of arthropods collected		
	Park Grass	Southwood and van Emden, 1967	Heikinheimo and Raatikainen, 1962
Araneae	0·4	3·2	4·0
Collembola	44·3	10·6	26·0
Coleoptera	0·3	3·8	4·0

The main value of the present study is to demonstrate the need for a better understanding of the role of the surface-active fauna, many of which are predators (centipedes, spiders, staphylinid and carabid beetles) in controlling pests of grassland.

https://doi.org/10.23637/ERADOC-1-10

TABLE 8

Number of species of arthropods trapped on the Park Grass plots

(a) *Species of spiders*

Amaurobiidae
Amaurobius similis (Blackwall) 2 ♂♂, 0 ♀♀

Thomisidae
Xysticus cristatus (Clerck) 39 ♂♂, 20 ♀♀
Oxyptila sanctuaria (O.P.-Cambridge) 1 ♂, 0 ♀♀

Lycosidae
Pardosa palustris (Linnaeus) 286 ♂♂, 108 ♀♀
Pardosa pullata (Clerck) 16 ♂♂, 0 ♀♀
Pardosa prativaga (L. Koch) 65 ♂♂, 12 ♀♀
Pardosa amentata (Clerck) 2 ♂♂, 4 ♀♀
Pardosa nigriceps (Thorell) 1 ♂, 0 ♀♀
Pardosa lugubris (Walckenaer) 1 ♂, 0 ♀♀
Alopecosa pulverulenta (Clerck) 83 ♂♂, 22 ♀♀
Trochosa ruricola (Degeer) 4 ♂♂, 3 ♀♀
Trochosa terricola Thorell 27 ♂♂, 8 ♀♀

Agelenidae
Cicurina cicur (Fabricius) 2 ♂♂, 2 ♀♀
Hahnia nava (Blackwall) 9 ♂♂, 0 ♀♀
Hahnia helveola Simon 1 ♂, 0 ♀♀

Theridiidae
Enoplognatha thoracica (Hahn) 14 ♂♂, 0 ♀♀

Tetragnathidae
Tetragnatha montana Simon 1 ♂, 4 ♀♀
Pachygnatha clercki Sundevall 1 ♂, 2 ♀♀
Pachygnatha degeeri Sundevall 531 ♂♂, 517 ♀♀

Lynyphiidae*
Ceratinella brevipes (Westring) 7 ♂♂, 1 ♀
Walckenaera antica (Wider) 5 ♂♂, 0 ♀♀
Walckenaera nudipalpis (Westring) 2 ♂♂, 0 ♀♀
Walckenaera unicornis O.P.-Cambridge 1 ♂, 1 ♀
Dicymbrium nigrum (Blackwell) 165 ♂♂, 57 ♀♀
Pocadicnemis pumila (Blackwall) 15 ♂♂, 0 ♀♀
Oedothorax gibbosus (Blackwall) 0 ♂♂, 1 ♀
Oedothorax fuscus (Blackwall) 814 ♂♂, 869 ♀♀
Oedothorax retusus (Westring) 655 ♂♂, 502 ♀♀
Oedothorax apicatus (Blackwall) 22 ♂♂, 11 ♀♀
Trichopterna thorelli (Westring) 1 ♂, 0 ♀♀
Cnephalocotes obscurus (Blackwall) 3 ♂♂, 0 ♀♀
Ceratinopsis stativa (Simon) 15 ♂♂, 2 ♀♀
Tiso vagans (Blackwall) 41 ♂♂, 14 ♀♀
Troxochrus scabriculus (Westring) 11 ♂♂, 3 ♀♀
Monocephalus fuscipes (Blackwall) 3 ♂♂, 1 ♀
Micrargus herbigradus (Blackwall) 4 ♂♂, 2 ♀♀
Micrargus subaequalis (Westring) 15 ♂♂, 8 ♀♀
Erigonella hiemalis (Blackwall) 1 ♂, 0 ♀♀
Savignya frontata (Blackwall) 151 ♂♂, 50 ♀♀
Diplocephalus cristatus (Blackwall) 0 ♂♂, 1 ♀
Diplocephalus latifrons (O.P.-Cambridge) 0 ♂♂, 1 ♀
Araeoncus humilis (Blackwall) 8 ♂♂, 0 ♀♀
Panamomops sulcifrons (Wider) 33 ♂♂, 3 ♀♀
Milleriana inerrans (O.P.-Cambridge) 106 ♂♂, 65 ♀♀
Erigone dentipalpis (Wider) 5412 ♂♂, 641 ♀♀
Erigone atra (Blackwall) 4983 ♂♂, 802 ♀♀
Leptorhoptrum robustum (Westring) 5 ♂♂, 0 ♀♀
Ostearius melanopygius (O.P.-Cambridge) 1 ♂, 0 ♀♀
Porrhomma convexum (Westring) 1 ♂, 2 ♀♀
Porrhomma micropthalmum (O.P.-Cambridge) 1 ♂, 0 ♀♀
Porrhomma errans (Blackwall) 1 ♂, 2 ♀♀
Agyneta subtilis (O.P.-Cambridge) 1 ♂, 6 ♀♀
Agyneta decora (O.P.-Cambridge) 407 ♂♂, 61 ♀♀
Meioneta rurestris (C. L. Koch) 65 ♂♂, 7 ♀♀

* A further species, *Centromerus prudens* (O.P.—Cambridge) ♂ was trapped in December 1975.

https://doi.org/10.23637/ERADOC-1-10

Meioneta saxatalis (Blackwall) 6 ♂♂, 0 ♀♀
Meioneta beata (O.P.-Cambridge) 173 ♂♂, 42 ♀♀
Centromerus sylvaticus (Blackwall) 6 ♂♂, 0 ♀♀
Centromerita bicolor (Blackwall) 87 ♂♂, 65 ♀♀
Macrargus rufus (Wider) 1 ♂, 0 ♀♀
Bathyphantes gracilis (Blackwall) 388 ♂♂, 349 ♀♀
Bathyphantes parvulus (Westring) 26 ♂♂, 16 ♀♀
Lepthyphantes tenuis (Blackwall) 121 ♂♂, 178 ♀♀
Lepthyphantes zimmermanni Bertkau 5 ♂♂, 2 ♀♀
Lepthyphantes ericaeus (Blackwall) 1 ♂, 1 ♀
Lepthyphantes insignis O.P.-Cambridge 8 ♂♂, 13 ♀♀

(b) *Species of Collembola*

Onychiuridae
Onychiurus ambulans (L.) Stach.
Onychiurus armatus (Tullb.) Gisin.
Onychiurus edinensis Bagnall
Tullbergia denisi (Bagnall)
Tullbergia callipygos Borner
Tullbergia krausbaueri Borner

Poduridae (Hypogastruridae)
Friesia mirabilis (Tullb.)
Hypogastura denticulata (Bagnall)
Willemia sp.

Isotomidae
Folsomia candida (Willem)
Folsomia quadrioculata (Tullb.)
Folsomides sp.
Isotomodes productus (Axelson)
Isotomiella minor (Schaffer)
Isotoma notabilis (Schaffer)
Isotoma viridis Bourlet

Entomobryidae
Entomobrya nicoleti (Lubbeck)
Entomobrya nivalis (L.)
Lepidocrytus cyaneus Tullb.
Heteromurus nitidus (Templeton)
Pseudosinella sp.

Sminthuridae
Bourletiella hortensis (Fitch)
Bourletiella sp.
Dicyrtomina minuta (Fabricius)
Sminthurus viridis (L.)
Sminthurides pumilis (Krausbauer)
Sminthurinus aureus (Lubbeck)
Sminthurides elegans Cassagnau and Delamare
Sminthurinus sp.
Megalothorax sp.

(c) *Species of Coleoptera*

Carabidae
Agonum dorsale (Pp.)
Amara familiaris (Dufts.)
Amara lunicollis Schiodte.
Demetrias atricapillus (L.)
Feronia madida (F.)
Feronia melanaria (Il.)
Harpalus rufipes (D.G.)
Nebria brevicollis (F.)

Curculionidae
Alophus triguttatus (F.)
Barynotus obscurus (E.)
Barypeithes pellucidus (Boh.)
Otiorrhynchus singularis (L.)
Sitona puncticollis Steph.
Trachyphloeus aristatus Gyll.

https://doi.org/10.23637/ERADOC-1-10

Elateridae
Agriotes lineatus (L.)
Agriotes obscurus (L.)

Silphidae
Choleva oblonga Latr.
Ptomaphagus subvillosus (Goeze)

Staphylinidae
Philonthus cognatus Steph.
Philonthus varius (Gyll.)
Quedius mesomelinus (Marsh.)
Tachinus rufipes (Deg.)
Tachyporus spp.

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