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The Arthropod Soil Fauna of a Tall Grass Prairie and Adjoining Pasture

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Abstract. Soils of a native tall grass prairie and an adjoining grazed pasture in central Oklahoma were studied in an effort to determine some of the major groups of Arthopoda represented in the microfauna, and to see what effect, if any, moderate grazing had upon the animals present. During a period of 12 months, 132 cylindrical samples of soil approximately 3 inches deep and 1.6 inches in diameter were taken. Half came from each area. Animals were separated from the soil by the use of Tullgren funnels. Soil temperatures, moisture content, and volume weight of samples were recorded. From the prairie soil 2,792 animals were taken, and from the pasture 1,263. Major groups, in order of decreasing abundance, were mites other than oribatids, oribatids, Collembola, and ants. Other groups represented were Protura, Symphyla, Iapygidae, thrips, Myriapoda, spiders, pseudoscorpions, and insect larvae. Factors favoring the microfauna in the prairie were generally higher moisture conditions, the abundance of dead plant material at the surface, and the lower volume weight, or less compaction, of the soil. The evidence indicated considerable vertical migration in response to moisture conditions on the part of the oribatid mites, and non-random distribution, particularly with reference to the Collembola.

Few studies have been made on the animal populations of the soil in Oklahoma. Shackleford (1942) made contributions concerning the general population, and Fisher (1937) studied the ecology of the ants. The present study of the arthropod fauna in an undisturbed prairie and in an adjoining pasture was undertaken in an attempt to determine what groups of animals were represented in these habitats in central Oklahoma, and to see what effect, if any, moderate grazing had upon the animals present.

Methods

The areas studied are located in McClain County, Oklahoma, southwest of Norman along State Highway 9, approximately five miles from the south end of the bridge across the Canadian River. The highway formerly curved to the south at this point, but was relocated and straightened a number of years ago. A field of about four acres was fenced off from the pasture and for several years had not been subject to grazing pressure except by occasional stray livestock. There was no evidence that this field had been burned recently. At the time of the study the plot was typical of the tall grass prairie of the region (Figure 1).

Collections were made twice a month from September, 1948, through August, 1949, except during January. Soil samples were taken in a hollow cylinder, one end of which was sharpened to facili-

Figure 1. Left, general aspect of the prairie; right, general aspect of the pasture.

tate driving it into the ground. This cylinder, 153 mm. long and 44 mm. in diameter, was pushed or driven into the ground until it contained a column of soil 75 mm. to 100 mm. in height. The sampler and soil were then removed by a twisting motion. The length of the soil sample was measured and recorded so that the approximate volume of soil could be calculated.

Three samples were taken from the prairie and from the pasture on each collecting trip. In each instance, they were taken along a straight line at intervals of three paces, and collection points were chosen so as to be distributed eventually through the whole area. During the autumn months the more closely grazed areas of the pasture were studied. In the spring and summer, the first two samples from the pasture were taken from closely grazed areas and the third from one of the clumps of taller grass in the vicinity of the first two samples.

In the laboratory the sample was weighed in its paper bag container. The soil was then removed from the bag and placed upon a fine 18 x 14 mesh wire screen, and the screen was placed upon a Tullgren funnel (Haarlov, 1947). The light and heat source in each funnel consisted of one 15 watt electric bulb. Most of the animals that were able to escape made their way out of the soil during the first twenty-four hour period, but not all samples could be treated alike. The very moist samples were given a longer and slower treatment; in order to prevent the soil from baking and sealing in the animals, the soil was allowed to dry at room temperature for six to eight hours before turning on the lights.

As the animals were driven from the soil by the light and heat, they passed into glass funnels and from them into vials of alcohol. They were removed from the alcohol under a binocular dissecting microscope at a magnification of 30 diameters, sorted, and stored in glass vials. During the sorting both light and dark backgrounds were used.

After the soil had been treated from 24 to 36 hours, it was removed from the funnel and placed in the paper bag from which it had come. The soil that had dropped into the vials was removed from the alcohol by filtration, dried, and placed in the proper bag. The bag was then reweighed to determine water loss during the treatment, and the amount of water lost was divided by the dry weight of the bag and soil to find the percentage loss.

Environmental Factors

Vegetation and Soil Conditions

The vegetation and soil conditions in the prairie and pasture were compared by Kelting (1954). In the prairie he found that *Andropogon scoparius* (little bluestem), *Panicum virgatum* (switch grass), and *Sorghastrum nutans* (Indian grass) were codominants. The average living cover during the summer of 1950 was 41.8 percent. In the pasture *A. scoparius* and *S. nutans* were the dominant grasses; living cover was 55.9 percent. A number of plant indicators of disturbance were listed. Kelting's comparison showed that ". . . the grazed pasture possessed (1) a greater amount of *A. scoparius,* (2) a greater total number of species, (3) an increased percentage of living cover, but (4) a much smaller amount of dead material". Figure 2 shows clearly this difference in the amount of dead plant material at the surface of the soil. Also evident in this figure are the loose, granular nature of the prairie soil and the tight, hard-packed surface of the pasture soil.

The pH values for the top six inches were determined three times during Kelting's study. The greatest difference existed in the spring of 1950 when the prairie soil had a pH of 6.3 and the pasture 5.8. At no time was there a difference great enough to exert any pronounced effect upon the microfauna. The pasture was found to have a significantly greater amount of organic carbon in the top six inches of soil. The presence of more living roots in the pasture was suggested as a possible explanation of this difference.

Soils

A soil map made available by the United States Soil Conservation Service showed both the prairie and pasture to be Class III land,

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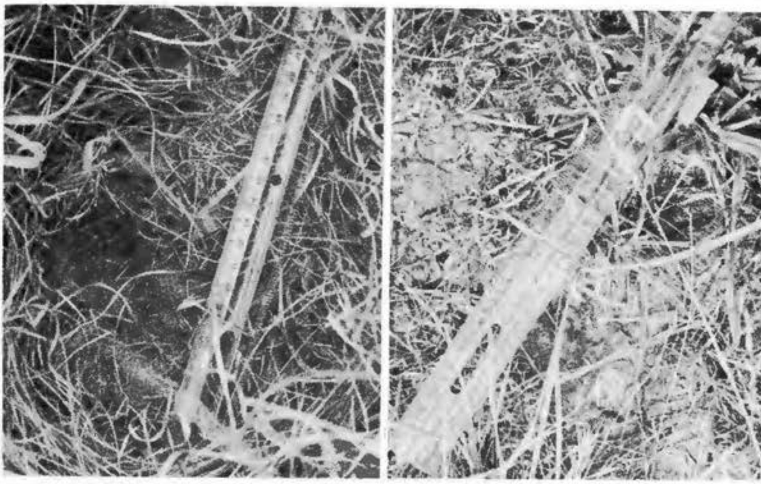

Figure 2. Left, surface of the prairie; right, surface of the pasture.

described as gently rolling, with external drainage that is "good to free but not excessive" (USDA Yearbook, 1938). Slope percentage values for each area were 4 percent. The soils were the Renfrow silt loam, the Quinlan very fine sandy loam, and in the pasture the Zaneis very fine sandy loam. All of the samples came from these three soils.

Compaction

At the time the soil sample was taken the length of the column in the sampler was determined, and the volume of the soil removed was computed. After the dry weight was determined, the weight in grams was divided by the volume in cubic centimeters to find the volume weight. Results from the three specimens taken in each area were averaged and compared (Table 1). Complete data on these and other measurements are available elsewhere (Rogers, 1951). The pasture soil consistently showed a higher volume weight. These results were verified by Kelting.

Temperature

Soil temperatures were taken at a depth of approximately 3 inches. Air temperatures were taken at a height of 4 feet in a shaded location. The soil temperature was higher in the pasture on all but three occasions. Since these exceptions all occurred during November and December, it seems probable that the better insulated prairie soil does not cool as rapidly as the pasture soil when the seasonal air temperatures decline. The highest temperature recorded in the pasture soil was 99° F. (July 25) and in the prairie soil was 79° F. (September 17, July 25). The lowest temperature recorded in both areas was 40° F. (February 12, prairie; December 31, pasture).

Table 1
Summary of Major Groups of Arthropods Collected, With Dates of Collection and Temperature, Moisture, and Volume Weight of Prairie and Pasture Soils

	Oribatoidea		Other Acarina		Collembola		Formicidae		Temperature (degrees F.)			Moisture[2] (percent lost)		Volume Weight[2] (gm/cc)	
Date	Pr	Pa[1]	Pr	Pa	Pr	Pa	Pr	Pa	Pr	Pa	Air	Pr	Pa	Pr	Pa
September 4	17	0	59	2	2	0	35	0	78	92	94	2.0	1.5	1.29	1.43
September 17	14	1	54	15	4	0	2	5	79	96	88	1.8	2.0	1.23	1.47
September 30	11	1	83	8	1	0	2	0	72	82	85	1.6	1.9	1.36	1.51
October 19	16	1	88	8	1	0	3	3	62	77	78	2.4	1.1	1.30	1.57
November 4	21	6	40	12	1	1	1	0	62	68	69	8.1	6.6	1.35	1.54
November 19	37	3	60	22	5	1	0	0	51	49	42	5.0	3.7	1.25	1.54
November 30	42	0	119	6	5	1	10	0	46	53	58	10.0	9.6	1.32	1.61
December 16	69	12	39	3	8	3	0	1	50	50	50	14.2	15.2	1.35	1.41
December 31	46	19	92	19	8	7	0	0	43	40	44	12.8	10.6	1.27	1.43
February 12	9	0	9	0	1	0	0	0	40	51	61	19.2	19.5	1.16	1.49
February 19	24	30	37	11	8	4	0	0	47	56	65	19.2	19.0	1.41	1.44
March 5	30	7	17	6	13	0	1	1	52	60	74	16.3	14.3	1.25	1.46
March 19	46	16	61	11	5	1	0	0	44	45	57	11.1	10.4	1.29	1.44
April 3	59	23	98	8	3	1	0	19	49	50	45	14.2	14.1	1.24	1.49
April 16	37	12	52	24	29	3	5	2	52	72	75	13.8	9.7	1.30	1.49
May 3	7	4	14	4	10	5	0	2	68	73	75	17.3	15.2	1.26	1.48
May 21	2	32	39	43	4	17	0	4	70	81	82	19.2	13.2	1.38	1.25
June 13	25	8	21	38	7	53	39	4	75	85	87	21.7	15.2	1.27	1.43
June 27	49	13	96	27	11	22	32	15	77	87	88	13.1	14.2	1.31	1.37
July 12	47	47	172	208	23	29	18	5	75	94	86	4.9	3.7	1.22	1.42
July 25	49	31	113	42	38	2	21	27	79	99	91	3.0	1.8	1.25	1.45
August 16	77	32	179	103	10	12	12	16	77	82	87	11.8	9.7	1.13	1.36
Totals	734	298	1,542	620	197	162	181	104					Averages	1.28 ±.015	1.46 ±.017

[1]Pr = prairie; Pa = pasture.
[2]Averages of 3 samples in each instance.

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There was a much closer relationship between the soil temperature and the air temperature in the pasture than in the prairie (Table 1).

On the basis of this study, it appears that dry weather accentuates the temperature differences between the two areas, due at least in part to the insulating and moisture conserving effects of the vegetation and organic debris covering the prairie. When temperature alone is considered in relation to animal collections, there is no important correlation.

Moisture

Generally, the soil of the prairie contained more moisture than that of the pasture (Table 1). When both areas were very dry, there was little difference between them, but following spring rains the prairie was much more moist than the pasture. With less litter cover in the pasture, the evaporation rate was undoubtedly greater, and the run-off more rapid.

The prairie soil had the highest moisture content on June 13, 1949; 104 animals were taken. The pasture soil showed the highest moisture content on February 12, following a month of ice cover; no animals were taken. From June 13 to July 25, the soil moisture in both areas declined rapidly until conditions were very dry. During this period the numbers of animals collected were greater than at any other time during the study. It may be that this increase represented a seasonal reproductive growth, and it is also probable that as conditions in the surface litter became more xeric the population moved downward into the upper layers of the soil. This would mean that the apparent low populations when the soil was very moist might actually be due to the fact that the increasing moisture had caused or allowed the animals to go upward out of the soil into the litter. Since the litter was not sampled, this can not be verified at this time.

Climate

No attempt was made to make precipitation records at the site. The average of the two weather stations in Norman, about nine miles away, was considered to be accurate enough for the objectives of this study, since the actual moisture in the soil was of primary interest. A year with greater contrast in moisture conditions would have been hard to choose. During the months of September, October, November, and December, there accumulated a precipitation deficit of nearly 11 inches. During this time it was necessary to use a sledge hammer to drive the sampler into the soil. In January the weather stations recorded over 7 inches of precipitation, about 5 inches above normal, most of which was in the form of sleet and glaze ice. May and June were very wet, with a total rainfall of 21 inches. In contrast to the 10 inches in June, there was less than one inch of precipitation in July. The 2.5 inches in August were about normal. These variations are reflected in the differences in soil moisture recorded for the various samples.

Temperatures were about normal, with the exception of January, when they averaged about 5.5 degrees lower than usual for this month.

The Fauna

A difficulty encountered in the study of the Arthropoda of prairie soils is the lack of taxonomic information. Some of these groups have been the subject of taxonomic works in other parts of the country, but few collections have been made in Oklahoma. It was the opinion of several of the authorities consulted that many new species would have to be described. One mite was believed to represent a new family. For this reason, the following discussions consider the major groups collected, with specific identifications given in only a few instances. A summary of the major groups is included in Table 2.

Table 2
Summary of Animal Collections

Animals	Prairie	Pasture	Total
Symphyla (*Symphylella* and *Symphylellopsis*)	12	2	14
Myriapoda	2		2
Arachnida			
Spiders	3	3	6
Chelonethida (pseudoscorpions)	2		2
Acarina			
Oribatoidea	734	298	1,032
Others	1,542	620	2,162
Hexapoda			
Protura (*Eosentomon* and *Proturentomon*)	19	14	33
Iapygidae (*Parajapyx minimus*)	16	14	30
Collembola			
Poduridae	165	75	240
Entomobryidae	18	80	98
Sminthuridae	14	7	21
Thysanoptera	11	2	13
Hemiptera, immature	1	1	2
Homoptera			
Coccidae	13	14	27
Immature		1	1
Coleoptera	7	1	8
Larvae	6	4	10
Lepidoptera larvae	3		3
Diptera larvae	35	8	43
Hymenoptera			
Larvae	1		1
Bethylidae (*Pseudisobrachium* sp.)	1		1
Formicidae			
Solenopsis texana	162	75	237
Brachymyrmex sp.	18	25	43
Dorymyrmex pyramicus	1		1
Crematogaster lineolata punctulata		4	4
Unidentified larvae	6	15	21
Totals	2,792	1,263	4,055

Acarina

Oribatoidea. Oribatid mites comprised about one-third of the 3,194 Acarina collected. They were found in prairie soil each time a collection was made, and were missing from the pasture soil on only three occasions. Of the total number taken, 734 were from the prairie and 298 from the pasture. This seems to indicate a marked preference for the prairie conditions.

The smallest collections were recorded on four occasions (September 4, 17, 30, and October 19) when the soil was very dry and hot in both areas, and on two occasions (February 12 and May 3) when the moisture content was very high. In February the soil temperature was low; in May it was fairly high. The largest collections were made December 16, April 3, July 12, and August 16. On the first two and the last of these dates the water loss from the soil was between 10 percent and 15 percent; on the third date the soil was rather dry. The soil temperatures were 50° F. on the first two dates, and ranged from 75° F. to 94° F. on the last two. Temperature, therefore, apparently has no direct effect on population fluctuations in the soil layer studied, but moisture conditions probably are important.

Jacot (1936) and Krull (1938) found that the vertical distribution of mites was influenced by moisture. In the present study, the variations in numbers were probably due, at least in part, to migrations upward and downward in response to moisture changes. This would explain the small collections and some of the higher collections, but would not account for the large populations in July. Strenzke (1951, 1952) stated that during the warmer seasons oribatids were mostly in the litter and uppermost soil layers and that they were in greatest abundance during the late summer and fall. This seasonal fluctuation in oribatid populations has been attributed to movements associated with the reproductive cycle (Sheals, 1957).

Other Acarina. Of the Acarina other than Oribatoidea, 1,542 were collected from the prairie and 620 from the pasture. Most of these animals were small, white, and quite delicate. From their appearance one would expect them to be very sensitive to dehydration, and this may explain their greater numbers in the prairie where the tall grass and thick layer of litter afforded protection. Also the greater amount of dead material may offer a larger supply of food.

If the pasture population alone is considered, it shows a definite suggestion of a seasonal increase during the summer months. There is a hint of such an increase in the prairie population, but the large variations in the collections make any general increase difficult to discern. The fluctuations in the prairie probably reflect vertical migrations in response to moisture changes, non-random distribution, or both. Sheals (1957) reported the horizontal distribution of mites in a plot of uncultivated grassland was not random.

Mites of the genus *Antennophorus* parasitized many of the ants collected.

Collembola

Of the 359 Collembola collected, 197 came from the prairie and 162 from the pasture. In the prairie the Poduridae comprised 84 percent of the Collembola population, the Entomobryidae 9 percent, and the Sminthuridae 7 percent. In the pasture the population was composed of 49 percent Entomobryidae, 46 percent Poduridae, and 5 percent Sminthuridae.

Very few of these animals were taken at first, but during the spring and summer months there was a marked increase and at the same time rather wide fluctuations in the numbers collected. There is no apparent correlation between the fluctuations and either temperature or moisture. There is a strong indication that the variations were due to the sampling of a population that was not evenly dispersed. This is shown in the results of the collection on July 12 when 25 Entomobryidae were collected from the pasture sample taken from soil in a clump of the taller grass. These were all apparently of one species and of uniform size and color. Such an aggregated population of Collembola was described by Glasgow (1939), and Sheals (1957) reported the horizontal distribution of Collembola was not random.

There is also the possibility of seasonal reproductive increases influencing the fluctuations. Ford (1937, 1938) reported population maxima in December and February in grass tussocks. The present collections showed no such maxima during these months in the soil; they did show larger numbers to be present during spring and summer months. Sheals (1957) believed these seasonal fluctuations could be attributed directly to climatic conditions. Bellinger (1954) thought temperature and rainfall were important but that they did not exercise a direct effect. He reported the largest populations to occur in spring and late summer, but he found each species had its own pattern of fluctuation. He also found that species differed in the extent to which they penetrated the soil as opposed to the superficial litter.

In view of the relatively small numbers taken and the probability that a non-random distribution was being sampled, it is impossible to draw any conclusions as to whether any of the Collembola preferred either prairie or pasture as a habitat.

Formicidae

The four genera of ants which were collected were identified by

Dr. M. R. Smith, of the United States National Museum. Of these, four specimens of *Crematogaster lineolata punctulata* Emery and one specimen of *Dorymyrmex pyramicus* (Rog.) were collected. These numbers can not be considered representative, since the larger size and more rapid movements of these animals undoubtedly allowed more of them to escape during the process of taking the sample and during its treatment in the funnel.

An unidentified species of *Brachmyrmex* was collected from both the prairie and the pasture. The largest collection (13) was taken from a clump of *Andropogon scoparius* in the pasture on July 27. Another collection of 10 was made in the prairie on November 30. Again all ten came from the same sample. This aggregation is, of course, to be expected in a population of social insects.

Solenopsis (*Diplorhoptrum*) *texana* Emery occurred in much larger numbers; 162 were taken from the prairie and 75 from the pasture. Many of the collections were of only one or two specimens, but in ten different samples twelve or more were found.

There is indication of correlation between soil temperature and the occurrence of ants in this soil layer. During the period of this study, as soil temperatures decreased the ants became less numerous in the collections. Only three were collected from December through March; two of these were in March.

Symphyla

Fourteen Symphyla were collected. Twelve of these came from prairie soil, and one of the two from the pasture came from a sample taken in a clump of tall grass. It is probable that only a small fragment of the symphylan population was sampled, since other workers have stated they found these animals much more abundant in the second six inches of the soil (Morris, 1922; Edwards, 1929; Salt, *et al.*, 1948).

Dr. A. E. Michelbacher, who examined these specimens, reported that two genera were present, *Symphylella* and *Symphylellopsis*. Only one of the specimens sent to him was an adult, and it was his opinion that it represented a new species.

Symphyla were collected during every month during the study with the exception of September and December. The numbers collected do not appear to be associated with either soil temperature or moisture, but the sample is too small to make it possible to reach definite conclusions. Michelbacher (1939) found that the distribution of *Symphylella subterranea* did not seem to be affected by the higher vegetation.

Protura

Thirty-three specimens of Protura, 19 from the prairie and 14 from the pasture, were collected. Two genera were present. These were identified by Miss Grace Glance, of the United States National Museum, as *Eosentomon* and *Proturentomon*. Several of the specimens were immature and others were damaged in collection or transfer. It is not known whether they represent new species. Protura have chewing mouth parts and according to Ewing (1940) both adults and nymphs feed on decayed organic matter. The National Museum had no other Protura from Oklahoma in its collection.

Iapygidae

The Iapygidae also were examined by Miss Glance. All of the thirty specimens were determined to be *Parajapyx minimus* Swenk. The distribution was nearly equal between prairie and pasture. The largest collection was made on May 21; 11 were taken, 9 from the pasture and 2 from the prairie. Seven of the pasture specimens came from the sample taken in a clump of grass, but this was the only occasion on which such an aggregation was found.

Miscellaneous

Several different types of insect larvae were collected (Table 2). Of these, dipteran larvae were most numerous with Coleoptera larvae, Lepidoptera larvae, immature hemipterans, and immature homopterans occurring in smaller numbers. It is probable that larger numbers of larvae would have been taken if a different method had been employed.

A few thrips were found, including two members of the family Urothripidae. Of the 13 specimens, 11 came from the prairie and most of them were collected during the fall months. Coccidae were found in both areas throughout the year in about equal numbers.

Except for the Acarina, the arachnids were poorly represented. The only spiders taken were small, due to the small mesh of the screens, and there were only six. Two pseudoscorpions (Chelonethida) were found in the prairie soil.

Small numbers of several other groups were collected. These included 2 myriapods and 8 small Coleoptera, including Carabidae, Scarabeidae, Scaphidiidae, Staphylinidae, and Elateridae. These beetles are subject to doubt, because of the possibility that they could have flown into the separating funnels while the soil was being processed.

One parasitic wasp, determined by C. F. W. Muesebeck of the National Museum to be *Pseudisobrachium* sp., was collected August 16.

Discussion

Jacot (1936), in an undisturbed plot in an abandoned field, found oribatid mites to be the most abundant soil arthropods, with other mites, Collembola, ants, Hemiptera, myriapods, thrips, and other groups, occurring in that order. Strenzke (1952) reported oribatids to be the most numerous arthropods in several habitats examined. Other workers who have found mites to be the most numerous forms in grassland soils are Strickland (1947) and Salt, *et al.* (1948). On the other hand, Thompson (1924), Ford (1935), and Baweja (1939) found Collembola to be more abundant than Acarina in grassland soils.

Various methods were used by these investigators—washing techniques, soil immersion, flotation methods, and Berlese-Tullgren funnels. It is difficult to determine whether the different results were due to differences in technique or to actual variations in the populations sampled. Probably both factors are important. Jacot believed that all methods allow many animals to escape; he did not think his methods were more than 70 percent to 80 percent accurate. His method, as well as the one used in this study, depended upon the response of the soil animals to dehydration and was therefore limited to its usefulness to collecting those animals which go downward in response to such a stimulus. Also, the degree of sensitivity to dehydration may have tended to emphasize certain groups more than others, since those which were very sensitive may have perished before they could make their way out of the soil.

The groups of arthropods found in the soils of this prairie and pasture in central Oklahoma are summarized in Table 2. A total of 4,055 animals was collected, of which 2,792 were from the prairie and 1,263 were from the pasture. In order of decreasing abundance, the major groups taken were Acarina (about one-half as many oribatids as other mites), Collembola, Formicidae, immature insects, and all other groups. It was impossible to distinguish any difference in the composition of the populations of prairie and pasture soils on the basis of these collections, but total arthropods collected in the prairie habitat outnumbered those in the pasture by a little more than two to one.

Any quantitative differences in soil populations as a result of grazing are the results of changes in environmental factors. The most important of these are probably moisture conditions, the amount of dead plant material at the surface, and the lower volume weight, or compaction, of the soil.

There are several food sources in both prairie and pasture, e.g., the roots, stems, and leaves of higher plants, fungal hyphae, and algae. Predators have the many other animals as sources of food, as well as their eggs, pupae, and possibly their feces. It is possible, however, that dead plant material makes the largest single contribution to the food supply of soil animals. Many of the mites and springtails are known to feed directly on this material, and others probably feed on the bacteria and fungi that utilize it as a source of energy. Any member of the community that depends on a food chain based upon dead plant material would therefore find more favorable conditions from the standpoint of food supply in the prairie habitat.

Moisture conditions are affected by grazing in that the lack of cover promotes run-off, decreases infiltration, and allows for greater evaporation from the surface. This may be offset somewhat by the loss of more water by interception in the tall grasses of the prairie, but moisture conditions are generally higher in the prairie. This probably accounts in part for the greater numbers collected there. Also, the better protection afforded the animals in the prairie would make it possible for them to remain in the litter after adverse conditions had forced the pasture animals down into the soil, and so it may be that the equality or superiority in numbers collected from the pasture during the summer months is only apparent. The actual difference in numbers may be even greater than these collections show.

A third factor favoring the prairie as a habitat is the compaction of the pasture soil due to trampling by livestock. Probably of importance, also, but not exerting a direct effect, are the differences in temperature conditions in the two areas. The grazed area exhibited greater daily and seasonal fluctuations in temperature.

As has been mentioned, many of the variations in these collections are probably due to factors other than environmental, such as seasonal reproductive cycles, non-random distribution of some of the groups, or vertical migration in search of food.

Many of the factors influencing the distribution of the microfauna of the soil are still unknown. More information is needed concerning life histories, breeding habits, food requirements, feces produced, and even soil displaced. This knowledge, along with identification of species and numbers present, would make possible an accurate picture of the importance of these animals. Until such information is available, the reaction of the soil microfauna on the soil cannot be fully understood.

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