DIURNAL VARIATIONS IN THE VERNAL INVERTEBRATE POPULATION OF A CENTRAL OKLAHOMA PRAIRIE

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QUANTITATIVE RANDOM samples of the population of an animal community differ in their composition somewhat according to time of day and weather influences. In order to determine whether there was any one time of day at which maximum numbers of all invertebrate groups could be obtained, a series of collections at three-hourly intervals was made on four calm, warm, spring days. The present study should furnish, also, some evidence concerning the existence of a diurnal rhythm in vernal prairie invertebrate life.

METHODS

In the herbs, fifty sweeps with an insect net of 14-inches diameter was the unit of collection. For the ground stratum, a piece of sod, one-half square foot in area and about 4 inches deep was brought to the laboratory in a closed container and thoroughly examined for invertebrate life.

Collections were made every three hours for 24 hours beginning 9:30 a.m. on April 13, 1928; 12:30 p.m. on April 15; 11:30 a.m. on April 23; and 6:15 a.m. on May 2. On the late afternoon of April 13, a strong wind began to blow, which so affected the collection at 9:30 p.m. that the series was discontinued through the night. On the other three days, the weather remained quiet and practically without clouds throughout the 24 hours. A total of 1806 animals was taken in the ground collections and 2498 animals in the herb collections .

THE PRAIRIE COMMUNITY IN ITS VERNAL ASPECT

During the period when the four series of collections were made, the population was increasing both in the herbs and in the ground stratum. Table I gives the total population of the eight square feet sampled during each cycle of collection. It is considered that 50 sweeps is equivalent to a census of 12 square feet of herbs. The collections of April 23 contained two ants' nests, whose occurrence obscured the seasonal trend as shown by the data. The last column, Table I, gives the series' total less all ants collected. It is seen from an examination of Table I that all four series of collections were made during a single society which was moving toward its peak throughout the period of observation.

TABLE I

Total number of animals per square foot taken in each 24-hour cycle with collections every three hours, Chickasha, Oklahoma, prairie.

Date 1928	Total number in herbs taken in 8 collections	Total number in ground taken in 8 collections	Total number per sq. foot	Total less ants
4/13	36	218	254	187
4/15	42	648	690	248
4/23	52	1670	1722	656
5/2	87	1130	1217	663

TABLE II

Percentage composition of collections of vernal soil animals, taken in each 24-hour cycle with collections every three hours, Chickasha, Oklahoma, prairie.

Date 1928	Ants	Earth worms	Beetles	Lepid. larvae	Mites	Hemipt. Nymphs	Centi-pedes	Misc.
4/13	32	6	17	1	9	11	1	23
4/15	68	0	8	7	3	2	0	12
4/23	64	12	4	2	3	2	2	11
5/2	74	7	1	4	1	2	3	8
Total	67	8	5	3	3	3	2	9

TABLE III

Percentage composition of collections of vernal herb animals, taken in each 24-hour cycle with collections every three hours, Chickasha, Oklahoma, prairie.

Date 1928	Flies	Leaf-hoppers	Aphids	Leaf-hop.Nym.	Spiders	Hemipt.	Hymen.	Misc.
4/13	17	49	21	1	4	3	1	4
4/15	33	13	29	4	6	8	1	6
4/23	44	19	10	0	9	7	3	8
5/2	21	20	12	19	6	4	3	15
Total	28	22	16	9	6	5	2	12

Tables II and III indicate the make-up of the vernal prairie community in 1928. In each table, the percentage composition based on all thirty collections called the "total" is given as well as the percentage composition of each cycle of eight collections. It appears that the vernal society was characterized by a preponderance of minute ants and white earthworms on the ground (Table II) and by Diptera, leafhoppers, and aphids in the herbs (Table III).

It is noticeable (Tables II and III) that those groups in both herb and ground which are numerically important in the first series maintain their relative position throughout, thus indicating by the predominance of leafhoppers, aphids, Diptera, and ants in all collections, that the entire period comes within a single biotic season. As the season progresses, the population of the ground becomes less diversified, as indicated by the greater percent of ants and by the lesser percent of miscellaneous forms (Table II). In contrast, the population in the herbs was becoming more diversified in that the percentage belonging to any one group of invertebrates was not increasing, while the miscellaneous group was becoming of more relative importance (Table III). As the herb vernal society advanced, groups of fore-runners of the estival society apparently took the place of some of the disappearing members of the typically vernal herb invertebrates, thus increasing the diversity of the population, considered from the point of view of large groups of animals.

Since information as to the year-round activity of the animals making up this vernal society is not available, it is impossible to classify them on the basis of their period of influence and activity. However, a secondary classification based on their number and apparent potency in the vernal society can be used. Influents (Table IV) are animals which because of their abundance, size, activity, or some combination of these values, are judged to be important forces in determining the seasonal condition of the whole biotic community; subinfluents are animals of lesser importance when judged by the same criteria.

TABLE IV

Influents and subinfluents of the vernal prairie society, 1928, Chickasha, Oklahoma. Constituents of lesser importance are omitted.

INFLUENTS	SUB-INFLUENTS
Herb	Herb
Hylemyia cilicrura Rond. fly	*Hylemyia parva* Desv. fly
Meromyza americana Fitch fly	*Sepsis vicaria* Wlk. fly
Pseudoleria pectinata Lw. fly	*Botanobia coxendix* Fitch. fly
Misc. Cicadellidae nymphs	*Euscelis obscurinervis* (Stal.) leaf-hopper
Cicadula 6-notata Fall. leaf-hopper	*Deltocephalus inimicus* Say leaf-hopper
Eugnathodus abdominalis V.D. leaf-hopper	*Deltocephalus spicatus* DeL. leaf-hopper
Agallia sanguinolenta Prov. leaf-hopper	*Aconuna* sp. leaf-hopper
Coenosia lata Walk. fly	*Dikraneura abnormis* Welsh. leaf-hopper
Hylemyia cinerella Fall. fly	Misc. Lepidopterous larvae
Madiza cinerea Lw. fly	*Nysius minutus* Uhl. Hemipteran
Misc. Aphidae (mainly Genus Macrosiphum)	*Galgupha aterrima* Malloch Hemipteran
Misc. grasshopper nymphs	*Polymerus basalis* Reut. Hemipteran
Misumessus (*asperatus* ? Htz) spider	*Lygus apicalis* Fieb. Hemipteran
Tetragnatha laboriosa Htz. spider	*Nabis ferus* L. Hemipteran
Nysius californicus Stal. Hemipteran	*Nabis alternatus* Parsh. Hemipteran
Labopidea allii Kngt. Hemipteran	*Thyanta custator* Fab. Hemipteran
Sinea diadema Fab. Nymphs Hemipteran	*Mecidea longula* Stal. Hemipteran
Chaetocnema pinguis Lec. flea-beetle	*Blissus leucopterus* Say Hemipteran
Oxyopes sp. ? spider	*Epiera prompta* Htz. spider
Misc. Hemipteran nymphs	*Oxyopes salticus* Htz. spider
	Euryopis (*scriptipes* ? Htz.) spider
	Phalacrus simplex Lec. beetle
	Phyllotreta pusilla Horn. beetle
	Marxia stellata Htz. beetle
	Dictyna muraria Em. spider
	Dendryphantes capitatus Peck. spider
	Pardosa pauxilla Montg. spider
	Misc. mites
	Singa truncata Banks spider
	Ceraticelus sp. spider
	Tibellus oblongus Walck. spider
	Hippodamia convergens Guer. beetle
	Ceratomegilla fuscilabris Muls. beetle
	Diabrotica duodecempunctata Say beetle
Ground	Ground
Pheidole vinelandica Mayr. ant	Misc. small Myriapods
Solenopsis molesta Say ant	Misc. mites
Monomorium minimum Buck. ant	*Tachyporus jocosus* Say beetle
Pheidole sp. ant	Misc. Hemiptera and nymphs
Misc. young earthworms	Misc. beetle larvae (mainly Carabidae)
Lasius niger var. *neoniger* Emery ant	Misc. Lepidopterous larvae.
Crematogaster victima var. *missouriensis* Pergande ant	
Triplectrus merula Germ. beetle	
Stenopalpus conjunctus Say beetle	
Tachistodes testaceus Dej. beetle	
Blapstinus moestus Melsh. beetle	

DIURNAL VARIATIONS IN THE INVERTEBRATE POPULATION

In analyzing the hourly changes in population, only the herb collections were considered. The population of the ground is in patches and not uniform; for example, ants' nests and groups of young, white earthworms may

be taken in one collection and not in others quite irrespective of the time of collection.

Table V gives the herb population per 50 sweeps for the three-hourly collections. The first four items of the table show the diurnal rhythm of the total herb population on each of the days of collection. The next item of the table is an average of the data for these herb totals. It will be seen that there are two peaks visible in a curve derived from the average herb population and also in curves for each of the dates of collection, except the one for April 13 which terminates at the rising of a high wind early in the evening. Of these periods of abundance, one occurs about noon or in the early afternoon, the other and usually greater one about midnight. It is noteworthy that the data for each of the three complete cycles of three-hourly collections have the same two periods of abundance.

Items 7 to 10, Table V, give the herb population as analyzed into the principal groups of invertebrates present. The average of the four collections made at a given hour is recorded. It is seen that the two largest groups in the herbs, the Diptera and Cicadellidae, each has a curve with two peaks, but that in the Diptera the midnight peak is the higher, while

TABLE V

Diurnal variations in the vernal herb population, Chickasha, Oklahoma, prairie. The unit is the number of animals taken in 50 sweeps of an insect net of 14 inches diameter. The averages are based on the number of forms collected at a given hour in each of the four 24-hour cycles.

	Hours when collections were made							
	6	9	noon	3	6	9	midn.	3
(1) 4/13 herb total	16	65	63	110	55	12	--	--
(2) 4/15 herb total	58	36	106	59	80	69	76	23
(3) 4/23 herb total	70	41	91	78	45	73	114	116
(4) 5/2 herb total	97	96	159	105	115	166	164	140
(5) Aver. herb total	60.3	59.5	104.8	88	73.8	80	118	93
(6) Aver. Diptera	13.7	15.5	23.5	15	21	33	50.7	38
(7) Aver. Cicadellidae and nymphs	19.3	21.5	35	37.5	19.5	31	30.7	24
(8) Aver. aphids	21.3	10.3	20.5	15	17.5	9.7	8.3	6
(9) Aver. spiders	4.3	3.3	8	5.3	3	4	8	8.7
(10) Aver. Hemiptera and nymphs	2.3	3.5	9	4.3	5	6	5.7	2.6
(11) Aver. *Hylemyia cilicrura* Rond.	7.3	3.3	6	2.8	3.8	9	24	4.7
(12) Aver. *Meromyza americana* Fitch	.3	2.3	2	1	.8	2	7.7	0
(13) Aver. *Pseudoleria pectinata* Lw.	0	1	3.3	2	1.8	2.5	.7	5.7
(14) Aver. *Chaetocenema pinguis* Lec.	.3	0	0	1.5	.5	1.8	1	0
(15) Aver. *Sinea diadema* nymphs	.3	.8	.3	.3	.8	1.3	.3	.3
(16) Aver. *Nysius californicus* Stal.	1.2	0	1.8	1	1.3	.7	2	2.3
(17) Aver. *Labopidea allii* Kngt.	0	.8	4	0	0	0	.7	0
(18) Aver. *Misumessus asperatus* Htz.	1.3	1.8	2	2.5	3	1.7	2	1.3
(19) Aver. *Tetragnatha laboriosa* Htz.	2	1	1.5	.8	1.3	1	1	0

in the Cicadellid curve the early afternoon peak is the higher. The three next most populous herb groups are the aphids, the spiders, and the Hemiptera. The aphids show some irregularity in numbers from hour to hour, but no population peaks. The spiders and Hemiptera have a two-humped curve with the larger peak about noon. Apparently, the day-light peak of the total herb population curve is due to a simultaneous increase in the number of Cicadellidae, spiders, and Hemiptera, while the larger midnight peak is due to an increase in numbers of Diptera in the after-dark collections. Moreover, it is interesting to note that there was a lesser daytime peak for the Diptera and a lesser night-time peak for the Cicadellidae, spiders, and Hemiptera.

The question arises whether or not the distribution of individual species would show these two peaks or whether certain species contribute to one peak, while other species contribute to the other peak. Items 11 to 19, Table V, give the distribution of abundant individual species. It is seen that the two periods of abundance occur for the individual species as well as for the group.

SIGNIFICANCE OF DIURNAL DIFFERENCES

Since there are certain forms which are taken more abundantly by day in quantitative prairie collecting in spring and certain forms more abundant by night, it would seem that an entirely adequate estimate would have to be based on two samples, one between noon and three o'clock and one between midnight and three in the morning. However, it will be remembered that forms having a midnight peak also have lesser maxima in the daytime. Therefore, if only one collection can be taken, the period between noon and three would give a representative sample.

What does abundance in a quantitative sample indicate? It probably indicates that the animal is easily detachable from its position and that it is not in an active, motile condition. If it were active, it would have escaped the net by flying or leaping. It is not hard to account for the increase in Diptera, Cicadellidae, spiders, and Hemiptera in the night collections since, due to absence of light with which to see approaching objects and to lowered temperature, their activity would be diminished. However, it is not so apparent why the hours from noon until three in the afternoon should be a period of relative inactivity. This was the period in the spring when temperatures were at their daily maximum and humidities at their daily minimum. The maximum temperature on May 2, the last day of collection, was 79 degrees F at three o'clock with a humidity of 35 percent. It would appear that the vernal prairie invertebrates are most active during the warming-up hours of the morning, and during the cooling-off hours of the afternoon, while during the period of maximum heat and maximum cold they were relatively inactive.

Another factor which might influence the herb population is the diurnal migration of forms to the upper herbs and to the base of the herbs. When in the former position they would contribute to the sweepings. While in the latter, they would be found in the ground collections. One would anticipate that the periods of minimum numbers in the herbs would correspond with the time of maximum abundance on the ground. The only groups found to an appreciable extent in the herbs and also among the grass roots on the ground surface were the Hemiptera and Hemipteran nymphs. No such reciprocal relation was evident. The herb stratum during

the vernal period did not show its greatest annual luxuriance, so that the absence of migration between strata may be a vernal characteristic only.

SUMMARY

1. The invertebrate population of a central Oklahoma prairie during the period April 13 to May 2, 1928, was in its vernal society as shown by the fact that its population was steadily increasing toward the vernal maximum, and the groups of invertebrates comprising it were approximately constant in their percentage relationship to the whole community.

2. The vernal society was characterized by ants, and minute white earthworms on the ground and Diptera, leafhoppers, and aphids in the herbs.

3. The total herb population during this period, when sampled by sweeping at three-hourly intervals, reached its daily maximum between midnight and three a.m. and had a second lesser peak between noon and three p.m.

4. Diptera, Cicadellidae, spiders, and Hemiptera showed this same curve with two peaks. In the case of the Diptera, the maximum came at night. In the case of the other groups, the maximum came at the time of the daylight peak.

5. The most abundant species of Diptera, spiders, and Hemiptera showed similarly a two-peaked curve.

6. Since periods when quantitative collections are large represent times when invertebrates are relatively inactive, the data seemed to indicate a diurnal rhythm of activity in vernal, prairie insect life, the periods of greatest inactivity corresponding to the coldest and hottest parts of the 24-hour cycle.

7. The data presented no evidence of extensive migration between sod and herbs on the part of any group or species of vernal invertebrates.

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