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13. This work is aided by grant No. T-77 from the American Cancer Society, and by a gift from Mollie E. Swinney. We wish to acknowledge assistance in this work by J. M. Smith and H. C. Coffey.

30 December 1959

Distortion of the Pyramid of Numbers in a Grassland Insect Community

Abstract. An intermediate size class of the insect component of a natural community contained more individuals than did a small size class, altering the expected ecological pyramid of numbers. The anomaly resulted from the presence of an abundant immigrant species, and it is suggested that departures from the normal pyramid might, in general, imply external disturbance.

Of the various possible ecological pyramids, the one based on the numbers of individuals per size class is the most easily obtained. However, in it the ecological implications are not so clear as in pyramids based on biomass or energy, or pyramids in which the species are grouped according to trophic level, and it is accordingly comparatively little used. Nevertheless, the size-frequency distribution is probably a basic datum which will eventually be incorporated in the main theory of community structure and organization.

As part of an ecological investigation of a grassland insect community, the size-frequency distribution of the components was ascertained for a series of samples collected 14 July 1958 and for a second series taken 21 July 1958 (Table 1). In each case, eight independent samples of 25 sweeps each were secured in the upland herbaceous vegetation of an abandoned field (*1*) by sweeping with an 18-in. canvas net; each set includes all samples obtained on that day. The samples were taken at widely separated localities on the field, and were calibrated for area by comparing the numbers of adult individuals of a key species taken in the net with the number determined by direct counts within frames of known dimensions. The total area covered by each series of eight samples was estimated at approximately 90 m^2.

The sweepings were carefully sorted in the laboratory with the aid of a microscope (*2*), so the smaller size classes are satisfactorily represented in the samples. Although this sweep sampling technique is not adequate for large, active insects, these are insignificant in number as compared to the small and sedentary species, and their under-representation in our samples does not materially affect the conclusions we have drawn.

The striking fact about the size-frequency distribution for both sets of samples is the large numbers of individuals in the 4.6- to 6.5-mm class (Table 1). In every sample, this number exceeds that in the next smaller (2.6- to 4.5-mm) class. This results in a top-heavy pyramid of numbers (Fig. 1*a*). Since insects from 0.6 to 10.5 mm in size made up the overwhelming bulk of all the animals that were taken in the sweep samples, this anomalous size distribution applies as well to the entire fauna of the herbaceous stratum of the field.

Examination of the species composition of the 4.6- to 6.5-mm class shows that it is largely made up of adult individuals of the meadow spittle bug, *Philaenus leucophthalmus* (L.) (Table 1). In fact, exclusion of the *Philaenus* material from consideration in the pyramid of numbers restores that size class to normal proportions (Fig. 1*b*).

It is therefore of interest to note that the vast majority of adult *Philaenus leucophthalmus* on the field are of exogenous origin. As the cultivated crops of clover and alfalfa in the surrounding countryside are cut, these insects move into the grassland in such numbers as to dominate the local fauna during most of the growing season. In both 1958 and 1959, essentially all adult *Philaenus* present in mid-July had come into the field from the outside, the small "native" populations having fallen nearly to zero by the end of June. So far as we know, no other important species taken in the sweep samples behaves in this way.

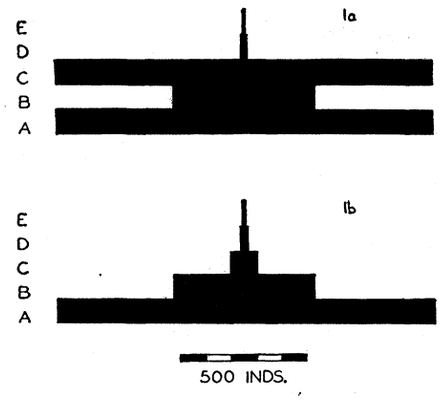

Fig. 1. Ecological pyramids of numbers for the insects of the herbaceous stratum in an old-field upland grassland community, Edwin S. George Reserve, Livingston County, Mich., based on a series of sweep samples collected 21 July 1958. (1*a*) Pyramid for total sample; 1*b*, pyramid after removal of all specimens of the spittlebug, *Philaenus leucophthalmus*. Size classes (in mm): *A*, 0.6–2.5; *B*, 2.6–4.5; *C*, 4.6–6.5; *D*, 6.6–8.5; *E*, 8.6–10.5.

In 1957 (when samples of the sort described here were not taken), *Philaenus* was estimated to be approximately 10 times as abundant on the field as in 1958, and the pyramid of numbers would then presumably have been even more distorted than that shown in Fig. 1*b*.

Table 1. Size-frequency distribution of insects taken in two series of sweep samples from an old-field upland grassland community, Edwin S. George Reserve, Livingston County, Mich., in July 1958. The numbers in parentheses refer to *Philaenus leucophthalmus* (L.); the other numbers refer to all the insects in the class.

Sample No.	Size class category (mm)				
	0.6–2.5	2.6–4.5	4.6–6.5	6.6–8.5	8.6–10.5
			July 14		
1	25	7	16 (15)	0	0
2	100	12	40 (31)	2	1
3	56	28	134 (127)	3	0
4	75	16	43 (36)	2	3
5	70	24	72 (63)	1	1
6	219	17	102 (95)	4	2
7	52	12	36 (31)	3	0
8	81	42	71 (64)	1	0
Total	678	158	514 (462)	16	7
			July 21		
1	230	104	185 (165)	3	4
2	102	31	159 (150)	6	2
3	169	100	147 (139)	5	2
4	209	89	215 (195)	2	2
5	242	54	186 (167)	6	1
6	306	68	186 (173)	2	3
7	86	66	169 (156)	2	1
8	131	42	233 (222)	4	0
Total	1475	554	1480 (1367)	30	15

Clearly, the introduction of a "foreign" element in an established community can disturb its structure sufficiently to have a noticeable effect upon the pyramid of numbers. We suggest that communities showing marked deviations from the expected size-frequency distribution (in which the number of individuals tends to vary inversely with size) have probably been subject to some external disturbance, the nature of which might be revealed through study of the anomalous size class or classes (*3*).

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23 February 1960

Uptake of Glucose from Solution by the Solitary Coral, Fungia

Abstract. The removal of glucose from solution in sea water by the coral, *Fungia*, has been followed with D-glucose-C^{14}. From 15 to 37 percent of the sugar in 200 ml of solution is taken up per hour from concentrations of 1 to 40 mg/liter. This rate of uptake provides sufficient material to account for the maintenance metabolism of the coral at sugar concentrations of 3.75 to 7.25 mg/liter.

The observations to be reported were made using D-glucose-C^{14} added to the sea water in which individual corals were maintained. The concentration of labeled material was estimated at suitable intervals by evaporating 0.5 ml samples on planchets and counting with a thin-window Geiger tube. Each determination was made in quintuplicate. Although self-absorption in dried sea water samples is considerable, dilution curves indicated a linear relation between the counting rate and the concentration of labeled glucose.

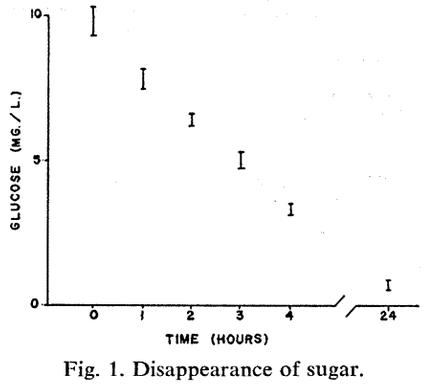

Fig. 1. Disappearance of sugar.

Fig. 1 illustrates the disappearance of added sugar in a typical set of observations. The volume of the solution was 200 ml. Uptake occurred in the same fashion in the presence of streptomycin (50 mg/liter). The rate of disappearance in darkness was comparable to that observed in diffuse sunlight. The radioactivity in 200 ml of solution maintained as a blank did not change over a 24 hour period.

The radioactive carbon which disappears from solution during a 4 hour period can be recovered in a sodium hydroxide digest of the animal. After 24 hours, a portion of the C^{14} remaining in the sea water diffuses from an acid to a base medium in a diffusion chamber, suggesting the presence of $C^{14}O_2$. Thus *Fungia* is apparently capable of removing glucose from solution at low concentrations and using it as a source of energy.

Table 1 lists the observed rate of uptake at various initial concentrations of glucose. The volume in each case is 200 ml of solution. A concentration of 1 mg/liter probably does not represent a lower limit for effective uptake but is rather a limit imposed by the specific activity of the labeled sugar. At this concentration, the observed rate was 5.3 ± 0.68 count/min.

It is of interest to consider whether this process is potentially significant as a source of nutrients for the animal. Animals were kept in darkness, and oxygen consumption was determined by the Winkler method. Individuals ranged in wet weight from 21.4 to 48.0 gm, and oxygen consumption ranged from 0.11 to 0.22 ml per individual per hour at a temperature of 26°C (0.047 ± 0.015 ml/gm hr). These figures imply that the equivalent of 0.15 to 0.29 mg of carbohydrate per hour must be acquired by an individual to support maintenance metabolism.

From the observations presented in Table 1, we may assume a rate of removal of 20 percent per hour for the carbohydrate present in 200 ml of sea water. An ambient concentration of 3.75 to 7.25 mg/liter is thus sufficient to account for the observed oxygen consumption. No figures are available for naturally occurring concentrations of carbohydrate for waters near Oahu. Lewis and Rakestraw (*1*) reported concentrations of an unidentified carbohydrate as high as 7.9 mg/liter in filtered sea water samples from coastal lagoons near San Diego. Their determinations for more open waters are considerably lower.

Table 1. Removal of glucose from sea water by *Fungia*.

Initial concn. of glucose (mg/liter)	Amount removed in first hour (%)	Amount removed (mg)
1.0	15*	0.03
1.0	28*	.06
1.0	25*	.05
1.0	20*	.04
4.0	29	.23
4.0	31	.25
4.0	37	.30
4.0	25	.20
10.0	30	.60
10.0	16	.32
10.0	23	.46
10.0	22	.44
40.0	16	1.28
40.0	22	1.46

* Calculated from determinations after 2 hours.

Values reported for total dissolved organic material (*2, 3*) are approximately 5 mg/liter for open water. Unfortunately, our information concerning the character of this dissolved organic material is modest (*4*). However, we need not limit our speculations to the carbohydrate fraction of this material since many invertebrates are capable of removing amino acids from dilute solution (*5, 6*). Unpublished observations indicate that this is also true of *Fungia*.

If we assume that the naturally occurring carbohydrate in sea water is utilizable and is taken up at the rate observed for glucose, *Fungia* can obtain sufficient material to account for maintenance metabolism in selected locations. If we make similar assumptions concerning all the dissolved organic material, a favorable location need not be stipulated. Information to support these assumptions is not available. However, the hypothesis that dissolved organic material may provide a significant fraction of the food of aquatic animals deserves further investigation (*7*).

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7 March 1960