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FEEDING ACTIVITIES OF SOIL MACROARTHROPODS AT THE PAWNEE SITE, 1971

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ABSTRACT

A 1-m^2 plot of shortgrass prairie was tagged in July 1971 with ^{32}P; and samples of roots, soil, and soil arthropods were counted for radioactivity. Two species of insects, namely *Margarodes hiemalis* and *Rhyssemus* adults, had the highest activity densities after corrections were made for soil activity.

Of the total radioactivity available to the soil arthropods, about 0.01% was ingested. However, the estimate is probably nominal in relation to season-long feeding activities which would be much higher under more favorable moisture conditions.

INTRODUCTION

During 1970 and 1971 considerable effort was expended in studying a wide range of aboveground invertebrates in the U.S. IBP Grassland Biome (Blocker and Reed, 1971; Pieper, Connaughton, and Fitzenrider, 1971; McDaniel, 1971; Dickinson and Leetham, 1971; and Blocker, Reed, and Mason, 1971). The only study of belowground macroarthropods (Lloyd and Grow, 1971) showed high numbers ranging from 50 to 150/m^2 of certain insect families such as Margarodidae and Scarabaeidae. The food preferences of root grazing macroarthropods of the grassland are unknown except for those that are reported as agricultural pests, e.g., Scarabaeidae in New Zealand (Kelsey, 1951), Australia (Ehrlich, 1965; Davidson, Wiseman, and Wolfe, 1970), and the United States (Anonymous, 1972; Fleming, 1968; Schumacher, 1959). The food preferences of few root grazers of grasses have been studied as extensively as those of the destructive *Coselytra zealandica* (White) in New Zealand (Radcliffe, 1970, 1971; Sutherland, 1971).

Radionuclide tracers have been used to identify food plants of terrestrial invertebrate consumers (Maddox and Resnik, 1969; Odum and Kuenzler, 1963; Reichle and Crossley, 1965; Shure, 1970). Because of the great biomass and energetically important status of the root material in the entire ecosystem (averaging 900 to 1000 g/m^2), a large population of roots was tagged for radioactivity to determine uptake, if any, by the soil-dwelling macroarthropods. This paper presents results of a preliminary study during June 1971.

METHODS AND MATERIALS

Field Site

This study was conducted on the Pawnee Site, the Intensive Site location of the U.S. IBP Grassland Biome, located about 12 miles northeast of Nunn,

Colorado, and 25 miles south of Cheyenne, Wyoming. A study area on Ascalon soil was chosen inside the outermost fence of the radiation facility of Whicker and co-workers located in the NE¼, T10N, R66W, Section 34. The vegetational composition of the area was predominantly *Bouteloua gracilis* (blue grama) with an admixture of other grass species (Table 1). A 3 m × 3 m area was roped off, and a 1-m^2 area within was selected for tagging.

Tagging and Sampling Procedures

Some 2 mCi of ^{32}P (H_3PO_4 in HOH) were applied with disposable hypodermic syringes to the axillary region of individual grass stems. Care was taken to avoid spilling any isotope on the ground or litter in order that only stems and roots would be tagged. To prevent loss of tagged material from the site a large enclosure or cage (1.5 m on a side) was placed over the vegetation.

To sample for soil arthropods, all aboveground material was trimmed from one-fourth of the site each sample period, and samples of roots and soil to a depth of 12 to 13 cm were removed for rinsing and extraction. Belowground arthropods were obtained by a modification of the Salt and Hollick (1944) flotation technique, using a magnesium sulfate solution as the flotation agent. Insects were sorted from debris by the use of forceps and kept in 80% alcohol in vials for radiological counting and identification.

Counting Techniques

Samples were sorted to species, where possible, and counted in two ways. A preliminary screening was made by liquid scintillation counting (samples were placed in counting vials containing water and were counted for 10 min each). The liquid scintillation counter (Nuclear Chicago Mark II) detected the Čerenkov radiation emitted by the water molecules which were excited by the beta radiation from the ^{32}P.

Table 1. Plant composition by percent of weight, Pawnee Site. Study plot for ^{32}P-labeled root-feeding arthropods, June 1971.

Species	Common Name	Plant Composition (% wt)
Agropyron smithii *Aristida longiseta* *Buchloe dactyloides*	Western wheatgrass Red three-awn Buffalo grass	2
Bouteloua gracilis	Blue grama	94
Carex heliophila	Sun sedge	2
Vulpia (Festuca) octoflora	Six-weeks fescue	2

Samples found to have activity above background were then counted on a low background Beckman/Sharp Low Beta II gas-flow planchet counter, with ca. 20% counting efficiency. Samples of larger arthropods were counted with a G-M tube and Ortec scaler with 10% efficiency.

RESULTS AND DISCUSSION

On 7 June 1971 in the early afternoon, 1 m^2 of grass was tagged; approximately 1800 shoots were contained in this plot, each receiving ca. 1.1 μCi.

Samples of roots, crowns, and soil ($\frac{1}{4}$ m^2 sections 12 to 13 cm depth) were removed 2, 7, 11, and 16 days after tagging, then were rinsed and extracted. A wide range of insect groups was obtained on all four sample dates, but only four major insect groups (and egg cases) were consistently labeled during the 16-day period (Fig. 1). The major groups consisted of *Rhyssemus* n. sp. adults (Scarabaeidae), assorted insect larvae (Scarabaeidae, Staphylinidae, and Elateridae), *Margarodes hiemalis* with and without a covering, and egg cases (Orthoptera). No specimens were labeled until between the second and seventh day with the exception of *Rhyssemus* adults which, 2 days after tagging the grass, had activity densities (disintegrations per min per gram dry weight) in excess of 1000. Because the *Margarodes* nymphs, with or without wax covering, were individuals of the same species, it seemed likely that the removable covering had been separated from some of the specimens and lost during the extraction process.

Several samples of crowns, roots, and green material were taken earlier in the study, but only those taken on 23 June 1971 are shown (Fig. 1). There was a small amount of contamination of soil, averaging 6.1×10^3 dpm/g. Because of the possibility of external contamination of the insects, the curves of Fig. 1 were drawn with the soil activity subtracted from each of the labeled species.

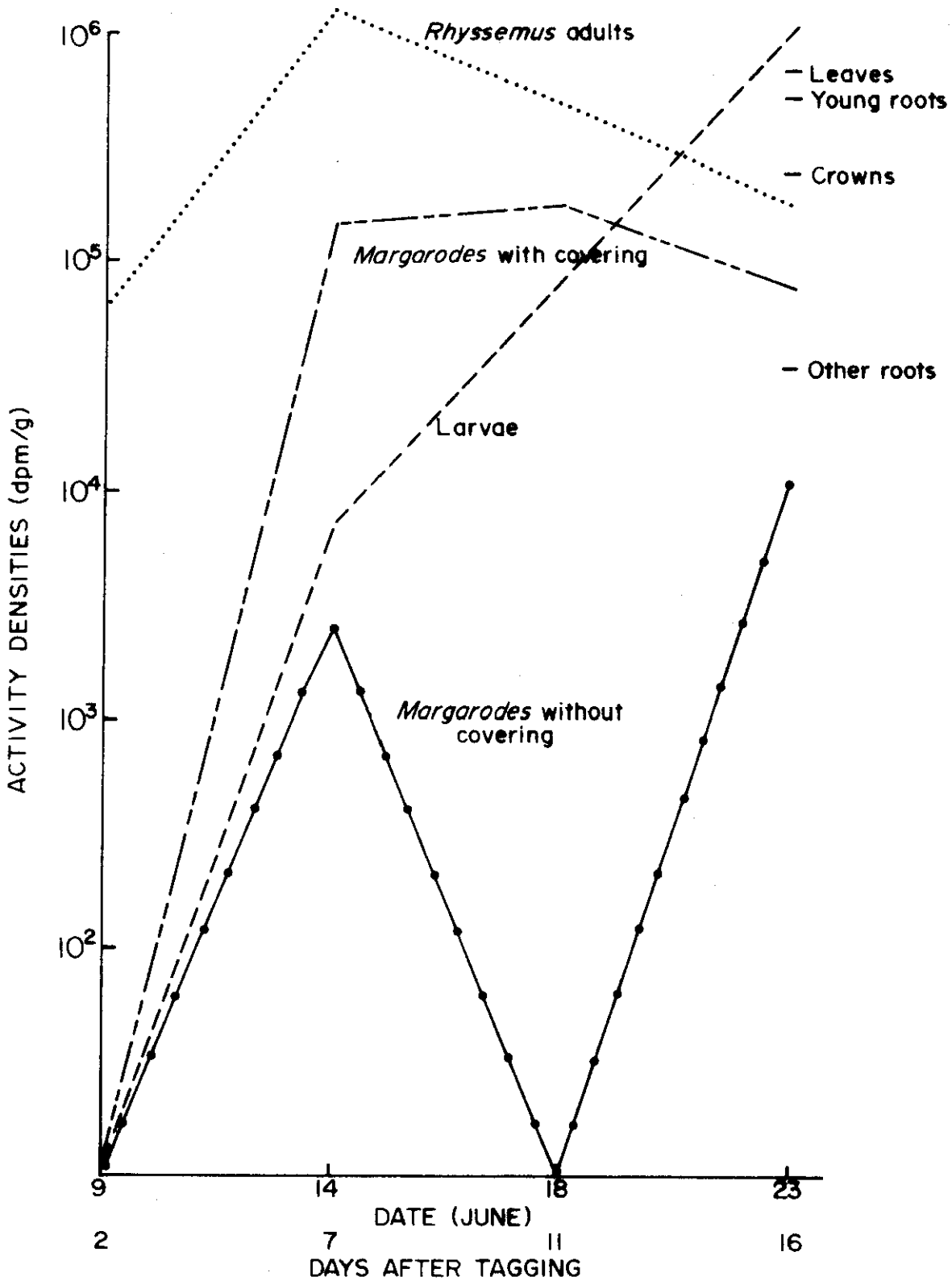

Fig. 1. Pawnee soil arthropod activity densities (soil activity subtracted). Plants were tagged on 7 June 1971.

The bulk of activity was contained in larvae (miscellaneous), Margarodids with covering, and *Rhyssemus* adults. Because larvae and Margarodids with covering were never observed aboveground (the latter are virtually nonmotile), it was inferred that they ingested considerable amounts of root material. Judging from the greater amount of radioactivity in the Margarodids with covering, it appears that some of the radioactivity might be soil-borne contamination.

The duration of sampling proved adequate to reach equilibrium for all, except larvae which seemed to be concentrating P over that of its concentration in roots or green material. Actually, the species made up of insect larvae varied quite a bit on each sample date (Table 2). Two days after tagging only *Rhyssemus* n. sp. were collected; after 7 days, 5 *Rhyssemus* n. sp. and 6 *Phyllophaga* sp. were collected. Some 11 days after tagging only 2 *Ctenicera* sp. (Elateridae) were collected, and on the 16th day after tagging, 15 *Rhyssemus* n. sp. and 1 larval Staphylinid were collected. The high activities on days 7, 11, and 16 may indicate that *Rhyssemus* n. sp., *Phyllophaga* sp., and *Ctenicera* sp. were actively feeding on root material.

The rapid rise of ^{32}P in *Rhyssemus* sp. adults up to the second sampling date (June 14) and subsequent decline over the next two sampling dates (through June 23) is more difficult to explain. These adult Scarabaeids may not be injurious to plants. They were active both in the litter-crown area and while crawling on the shoots; thus, they may have become contaminated. Ritcher (1966) gave the feeding habits of other members of the Scarabaeid subfamily Aphodiinae of which *Rhyssemus* is a member; many species are coprophagous, but *Rhyssemus* has never been found in cattle dung on the Pawnee Site. Because the scarabs were active both in the litter-crown material and on the shoots, they probably ingested a considerable amount of non-root material.

Table 2. Activity densities of Pawnee soil arthropods. Corrected dpm × g^{-1} = calculated activity, day 0 (7 June 1971).

Taxa and Number of Specimens	Sampling Date	No./ Sample	Dry Wt/ Individual	Total Wt	dpm × g^{-1}	Corrected dpm × g^{-1}	Soil Activity Correction (-6,100 dpm/g)	Total dpm/sample
				Adults				
Rhyssemus n. sp.	1	4	.0011	.0044	5.7×10^4	6.6×10^4	6.0×10^4	260
	2	13	.0011	.0143	6.8×10^5	1.2×10^6	1.2×10^6	17,160
	3	11	.0011	.0121	2.0×10^5	4.9×10^5	4.8×10^5	5,800
	4	10	.0011	.011	6.5×10^4	1.8×10^5	1.7×10^5	20
				Larvae				
Rhyssemus n. sp.	1	5	.0005	.0025	4.0×10^3	4.6×10^3	0	0
Rhyssemus n. sp. (5) and *Phyllophaga* sp. (6)	2	11	.0005	.0055	7.3×10^3	1.3×10^4	7.1×10^3	40
Ctenicera sp. (2)	3	2	.0005	.001	3.5×10^4	8.5×10^4	7.9×10^4	80
Rhyssemus n. sp. (15) and Staphylinidae #14[a] (1)	4	8	.0005	.004	7.3×10^5 5.0×10^4	2.0×10^6 1.3×10^5	19.6×10^6 1.3×10^5	$\Sigma = 4,160$
				Nymphs				
Margarodes (without case)	1	20	.0016	.032	0	0	0	0
	2	8	.0016	.0128	8.6×10^3	1.5×10^4	$\bar{x} = 2.6 \times 10^3$	$\bar{x} = 70$
		9	.0016	.0144	1.0×10^3	1.9×10^3		
	3	5	.0016	.0080	1.8×10^3	4.5×10^3	0	0
	4	14	.0016	.0224	6.3×10^3	1.7×10^4	1.1×10^4	240
Margarodes (with case)	1	8	.0014	.0112	0.9×10^3	1.0×10^3	0	0
	2	40	.0014	.056	8.2×10^4	1.5×10^5	1.4×10^5	8,000
	3	16	.0014	.0224	7.2×10^4	1.8×10^5	1.7×10^5	3,800
	4	12	.0014	$\Sigma = .0294$	3.9×10^4	1.0×10^5	$\bar{x} = 7.5 \times 10^4$	2,200
		9	.0014		1.5×10^4	4.3×10^4		
				Pupae				
Diptera #45	1	9	.0015	.0135	2.2×10^3	2.5×10^3	0	0
Diptera	3	4	.0015	.006	1.6×10^3	3.9×10^3	0	0
				Egg Cases				
Orthoptera #01	2	7	.0015	.0105	3.8×10^4	6.8×10^4	6.2×10^4	650
Orthoptera #01	4	2	.0015	.003	3.0×10^5	8.1×10^5	8.0×10^5	2,400
								$\Sigma = 4,900$

[a] Numerical designations refer to unidentified specimens retained by J. E. Lloyd.

Absence of radioactivity from fly pupae (Diptera #45) indicated no soil-borne contamination. The grasshopper eggs (Orthoptera #01) were radioactive; however, oviposition may have occurred because a single adult female *Psoloessa delicatula* (Scud.) of the family Acrididae was placed in the cage after radioactive tagging of the plants.

If one examines the data in terms of net isotope ingested by the arthropods, a different picture emerges. Although activity densities reached very high levels, the total biomass per sample period was usually low (Table 2), seldom exceeding .02 g dry weight. There was a total activity over all groups of 44,900 dpm or 20.4 nCi. Since the starting amount was 2 mCi (2×10^6 nCi), only $\frac{20.4}{2 \times 10^6} = 1 \times 10^{-5}$ of the total amount of isotope was ingested.

If one only considers roots with an average standing crop of 900 g/m^2 and a mean activity of 5×10^5 dpm/g, the total activity available to the soil arthropods was $900 \times 5 \times 10^5 = 4.5 \times 10^8$ dpm, or 2.04×10^5 nCi. This was 10% of the total isotope applied; hence, 1×10^{-4} or 0.01% was actually ingested.

These ingestion rates, although low, may be minimal because the sample plots were extremely dry in the latter half of the study. Further investigations, proceeding over the entire range of temperature and moisture conditions of the growing season, should be carried out in the near future.

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