STRUCTURE AND DIVERSITY OF ARTHROPODS AT WAHILA RIDGE, HAWAII

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ABSTRACT

Arthropod populations and their structure in soil and litter at three elevations were studied at Wahila Ridge, Hawaii. Berlese funnel was used to extract the fauna from soil and litter samples. More species and higher population of arthropods were recovered in stream soil and litter than in soil and litter at middle and hill elevations. It was probable that during dry conditions, most of the arthropods died and/or aestivated and became active again as soon as vegetation and litter became abundant. During the second sampling, there was a greater number of species and population of arthropods than in the first and third samplings, the greatest number of arthropods occurring in stream soil and litter. The arthropod populations in stream soil and litter were more diverse, had lower index of dominance, but showed more evenness, similarity and richness compared to those on the hill and middle elevations. Species and populations of arthropods in soil and litter were affected by weather.

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INTRODUCTION

Population structure and diversity of arthropods of any given faunal community are used to describe particular functions and interrelations of species and individuals. They are also used to compare composition of communities at different times of the year and the effect of chemical treatment on them. Menhinick (1962) compared species diversity indices of several invertebrates. He found that taxonomic composition was less varied and there was less number of individuals and species of large organisms in the grassland pesticide

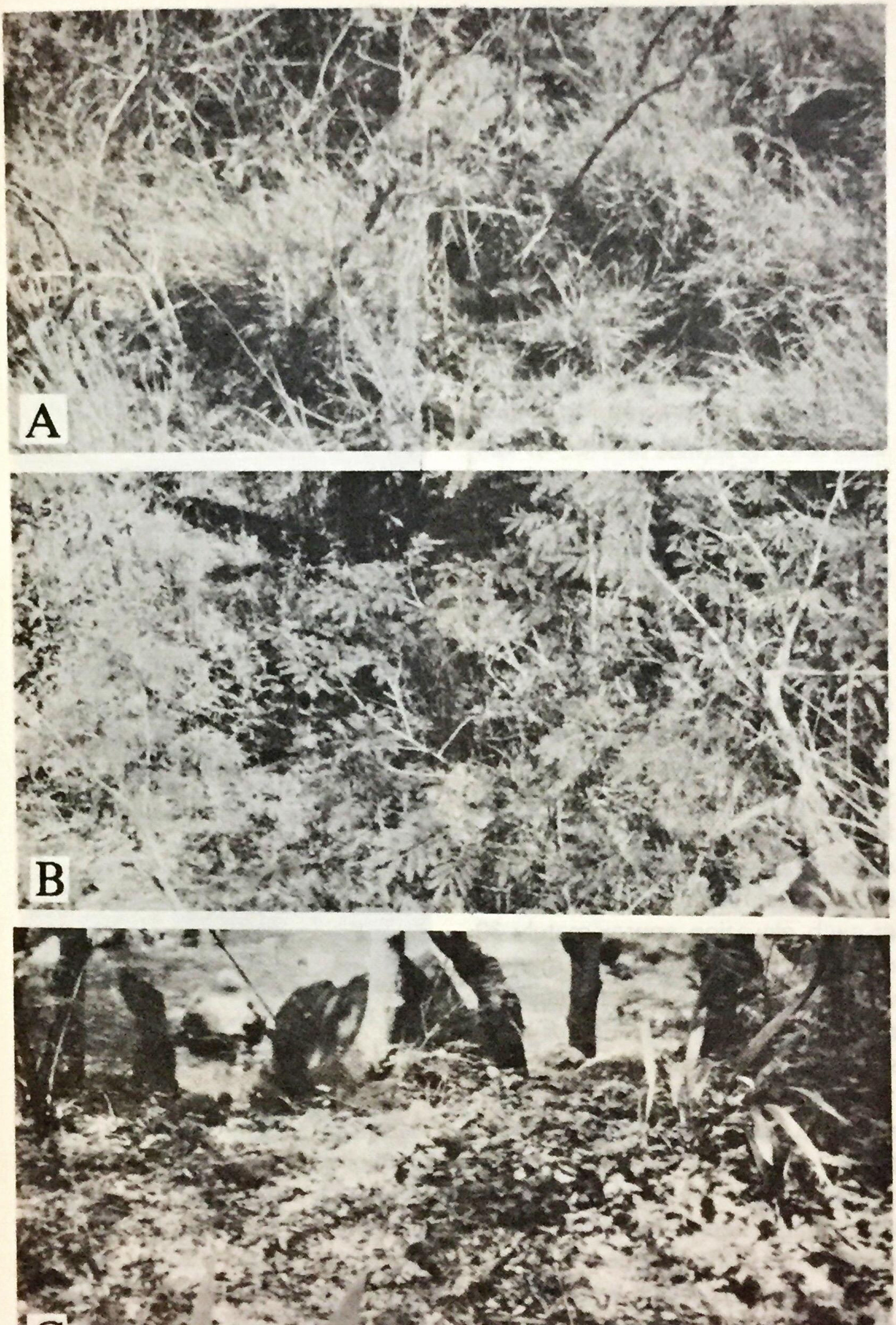

Fig. 1. Representative sampling stations at (A) hill elevation, (B) middle elevation and (C) stream elevation.

treated compared to the untreated areas. Uetz (1975) reported that a seasonal peak in species diversity and species richness of wandering spiders in forest litter occurred in mid-summer and was significantly correlated with prey abundance, but not with either temperature, humidity or rainfall.

A survey of arthropods in soil and litter during the months of February and March determined the distribution of arthropod populations between and within each of three elevations, the population changes with time, and the indices of population structures at different elevations and at different times.

MATERIALS AND METHODS

Wahila Ridge was divided into 3 elevations and samples were taken from stream, middle (100 m), and hill (200 m) elevations (Fig. 1). Samples were taken at three different sampling times which were spaced two weeks apart. Four sampling stations were established at each elevation approximately 30 m apart. Each station was marked with blue flagging tape to facilitate easy location of the site for subsequent samplings.

At each station, 100 g of litter and 200 g of soil samples were taken. Soil samples were taken directly below the spot where the litter had been removed. The samples were first placed in separate plastic bags which were tied to prevent the arthropods from escaping. The plastic bags were then brought to the laboratory for processing.

Berlese funnels were used to separate arthropods from the litter and soil samples. The funnels were equipped with fine wire mesh to hold the samples and 50 wattlight bulbs were placed above the funnels to drive out the arthropods into bottles containing 75% ethyl alcohol (Fig. 2).

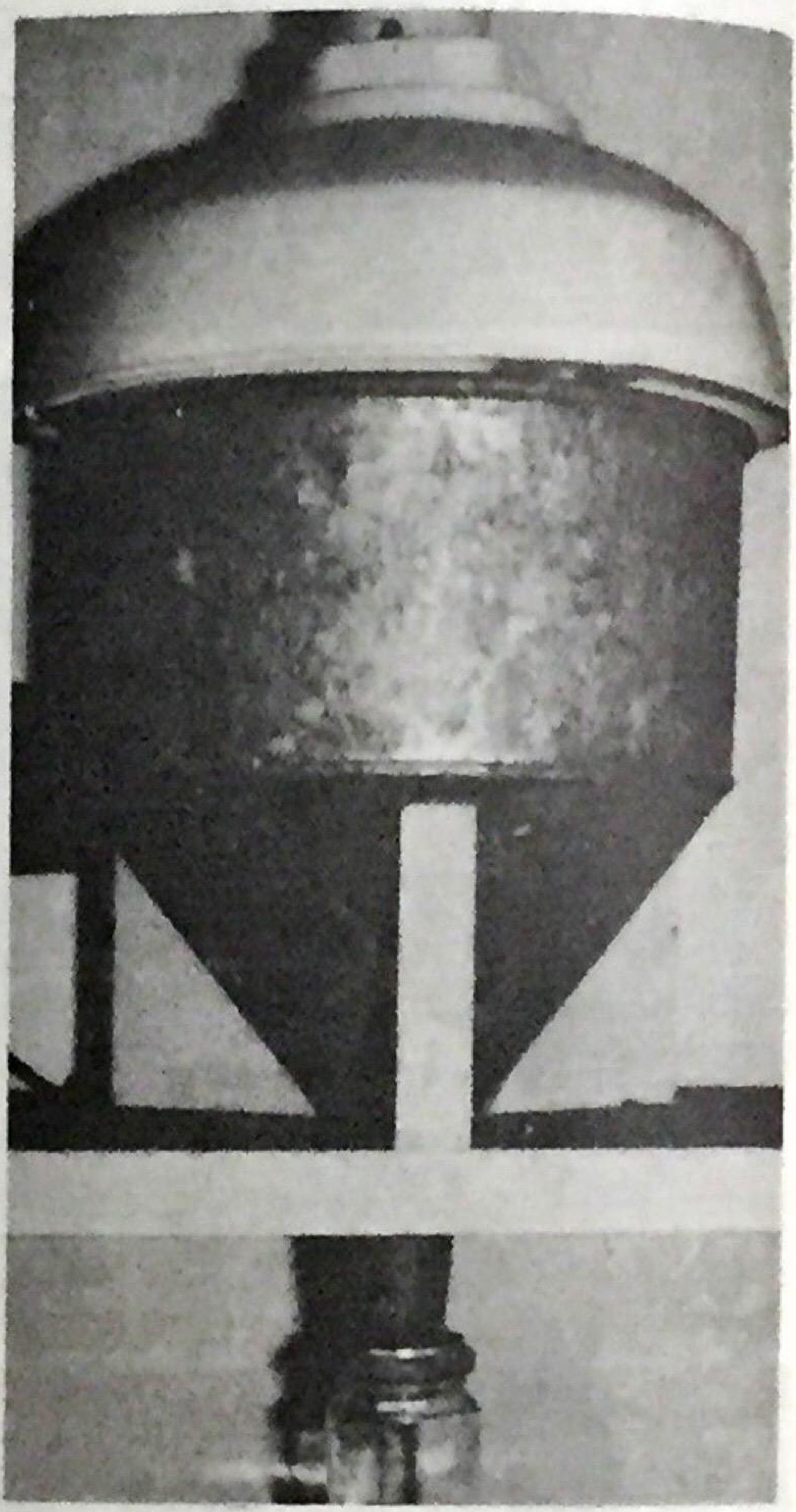

Fig. 2. Berlese funnel used for separating arthropods from soil and litter.

Before counting, the bottles containing alcohol and the killed arthropods were agitated to obtain an even 10 ml aliquot sample. The arthropods from these 10 ml samples were then counted under a stereomicroscope..

The data were used to calculate for indices of diversity, dominance, similarity between samples, richness and evenness of the fauna following the method used by Odum (1971).

RESULTS AND DISCUSSION

Distribution of Arthropods Within Each Elevation.

First Sampling. Table 1 shows the population of different species at 3 elevations and at 3 sampling times. On the hill, 5 species of arthropods (sowbugs, mites, collembola, psocids and ground beetles) were found in soil samples while in litter, only collembola and psocids were found. However, the populations of the different species were very low. At middle elevation, only 4 species (sowbugs, mites, collembola and ants) of arthropods were found in both the litter and soil samples. On the other hand, the stream soil samples revealed 7 different species (sowbugs, mites, collembola, ants, other hymenoptera, psocids and millipeds) and showed the highest population of arthropods with 4,017 individuals. The presence of fewer species and lower populations of these species at the hill and middle elevations could be attributed to very dry conditions that existed in the area prior to the first sampling. Leaf litter was sparse and the soil was very dry on these elevations. On the contrary, areas surrounding the stream have dense vegetation. Leaf litter was abundant and moist and arthropods could be observed while collecting the samples near the

Table 1. Total arthropod population in soil and litter collected from three elevations at Wahila Ridge, Hawaii.

	Sowbugs	Mites	Collembola	Ants	Other hymenoptera	Psocids	Ground beetles	Millipeds	Fly	Other Beetles	Total
First sample											
Hill Litter	—	—	16	—	—	354	—	—	—	—	370
Middle Litter	261	1295	11	30	—	—	—	—	—	—	1597
Stream Litter	586	688	52	26	38	102	—	78	—	—	1570
Hill Soil	67	640	93	—	—	12	12	—	—	—	824
Middle Soil	115	1438	97	33	—	—	—	—	—	—	1683
Stream Soil	2454	1088	320	77	31	47	—	—	—	—	4017
Second sample											
Hill Litter	616	18867	253	20	27	13	—	7	—	—	19803
Middle Litter	140	2900	433	33	33	7	119	—	—	13	3678
Stream Litter	120	3987	1607	120	20	80	—	60	13	13	6020
Hill Soil	7	2587	300	13	7	7	—	7	—	—	2928
Middle Soil	73	2486	107	13	—	7	—	—	—	—	2686
Stream Soil	620	1733	73	20	27	7	—	—	—	—	2480
Third sample											
Hill Litter	—	1139	—	—	7	—	—	—	—	7	1153
Middle Litter	87	2293	100	20	13	—	—	—	—	47	2540
Stream Litter	—	2048	418	53	—	—	—	40	12	—	2571
Hill Soil	40	2331	7	53	—	—	—	—	—	—	2431
Middle Soil	127	1013	7	13	7	—	—	—	—	—	1167
Stream Soil	166	1634	126	43	33	32	—	188	12	6	2240

stream. Probably, during the dry conditions that existed prior to the first sampling, most of the arthropods from the hill and middle elevations died due to heat and/or were forced to aestivate in safer areas and became active again as soon as soil became moist and litter and vegetation became abundant.

Second Sampling. In general, there was a sharp increase in the population of arthropods in both soil and leaf litter and in the three elevations. The greatest increase was recorded in the stream litter with a total of 6,020 arthropods compared to only 1,570 during the first sampling. However, there was a reduction in arthropod population only in the stream soil. It was also noted that during wet conditions, arthropods had a tendency to stay more on leaf litter than in the soil. There were 9 species of arthropods in the stream litter followed by 8 species in the middle elevation litter and 7 species in both hill litter and soil. These numbers were higher than those recorded in the previous sampling.

Third Sampling. A few days before the third sampling, the hill became dry again because of lack of rain. As a consequence, the arthropods moved from the litter into the soil. This was shown by 4 species found in soil samples in comparison to 3 in the litter and their populations were much higher in the soil. Similar trend in species diversity and population of arthropods was observed in the other two elevations. The highest number of species (9) was recovered in the stream soil.

Species Structure.

Dominance of Arthropods. The index of dominance of arthropods at Wahila Ridge was highest in hill litter (over 0.90) which remained high in all three sampling dates (Table 2). The lowest index of dominance was recorded in stream litter (0.34).

Clearly, hill litter and soil which inhabit fewer species of arthropods but were higher in number were the dominant groups which largely controlled the energy flow and strongly affected the environment of all other species in the area.

Table 2. Index of dominance [1] of arthropods in soil and litter in three elevations at Wahila Ridge, Hawaii.

Sampling Period	Hill Litter	Hill Soil	Middle Litter	Middle Soil	Stream Litter	Stream Soil
1	0.92	0.62	0.69	0.74	0.34	0.45
2	0.97	0.62	0.66	0.85	0.51	0.54
3	0.97	0.92	0.80	0.76	0.64	0.55

[1] Index of dominance, $c = \Sigma (ni/N)^2$.

Table 3. Index of diversity[1] of arthropods in soil and litter in three elevations at Wahila Ridge, Hawaii.

Sampling Period	Hill Litter	Hill Soil	Middle Litter	Middle Soil	Stream Litter	Stream Soil
1	0.218	0.472	0.526	0.587	0.818	0.763
2	0.787	0.746	0.897	0.639	0.935	0.750
3	0.377	0.554	0.725	0.574	0.745	0.925

[1] Index of diversity is $\bar{H} = -\Sigma\left(\frac{ni}{N} \log \frac{ni}{N}\right)$

Diversity and Evenness of Species. Tables 3 and 4 show the indices of diversity ($\bar{H}$) and evenness (e) of species. It was observed that their populations were more diverse in litter and soils near the stream than in the hill and middle elevations during the sampling period. The lowest values were obtained from hill litter and soil during the first and third sampling. Thus, arthropods seemed to have been greatly affected by long drought that persisted before the first sampling was made.

The results agreed fully with the theory that index of dominance is inversely related to species diversity and evenness. As the number of species of arthropods increased, as shown in the soil and litter near the stream, species diversity and evenness also increased (Fig. 3). Species diversity was higher during the second sampling when the rains favored growth of vegetation and the accumulation of leaf litter.

One of the measurable characteristics of any collection of organisms is its diversity. Thus, a collection in which all individuals belong to one species has no diversity, while one in which individuals belong to different species has the maximum possible diversity. The population of arthropods on the hill were less varied in comparison with the more diverse arthropod populations inhabiting the litter and soil near the stream. The results of this study show that diversity and population structure of arthropods change with changing weather con-

Table 4. Pooled indices of diversity[1] and evenness[2] of arthropods in soil and litter in three elevations at Wahila Ridge, Hawaii.

Elevation	$\bar{H}$	e
Hill litter	0.072	0.240
Hill soil	0.319	0.456
Middle litter	0.255	0.424
Middle soil	0.250	0.415
Stream litter	0.556	0.658
Stream soil	0.449	0.531

[1] Index of diversity is $\bar{H} = -\Sigma\left(\frac{ni}{N} \log \frac{ni}{N}\right)$

[2] Index of evenness is $e = \frac{\bar{H}}{\log S}$

ni = importance value for each species
N = total of importance values
$\bar{H}$ = Shannon index

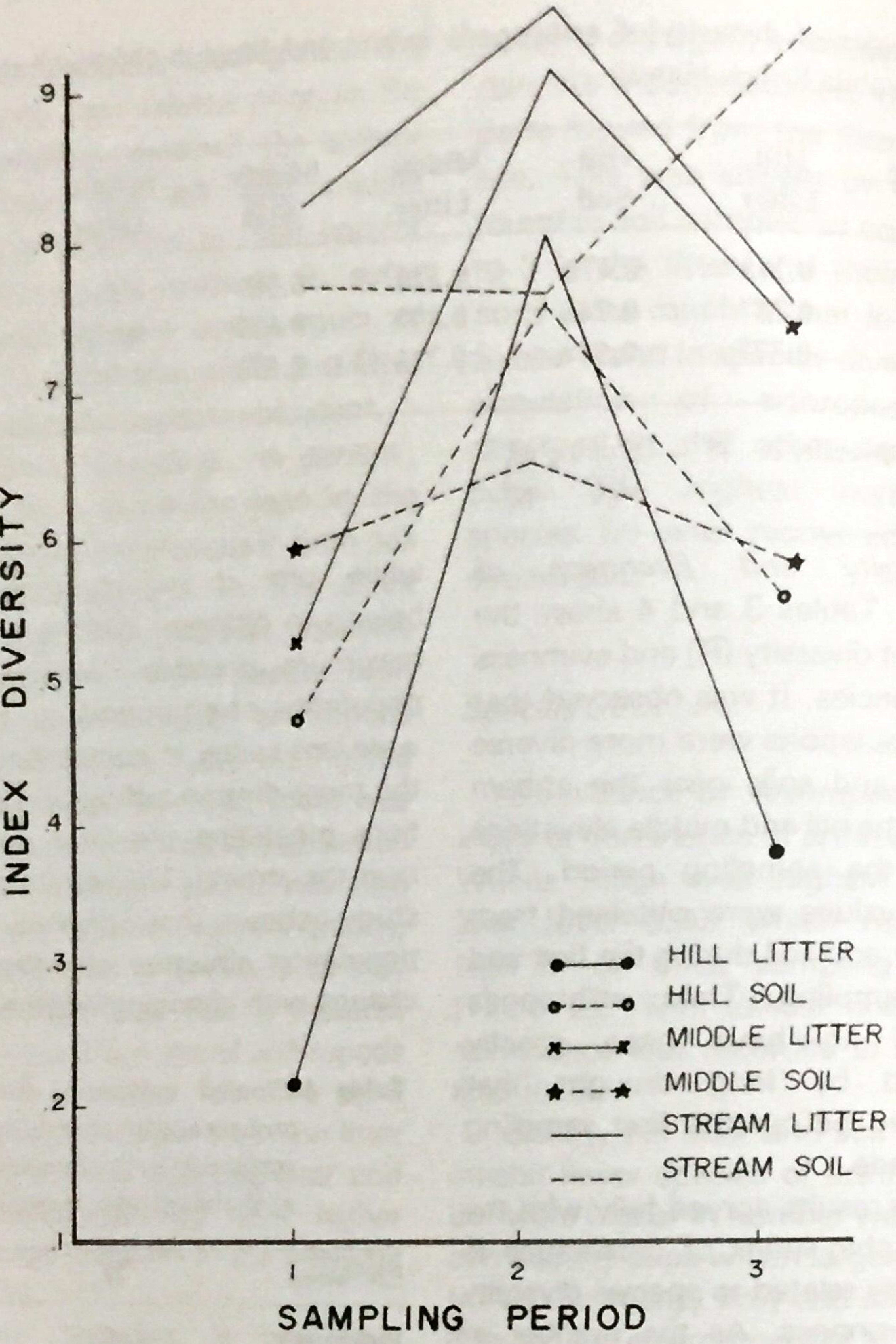

Fig. 3. Species diversity of arthropods in soil and litter from 3 elevations.

ditions. The following changes were observed: (1) during periods of very dry weather when vegetation and leaf litter were scarce, there was a decrease in the number and population of each species, notably on the hill and middle elevations; (2) on the hill, the arthropod population in the litter was found to move to the soil during drier periods; and (3) the number of species and their population were affected by weather and temperature. The species and population of arthropods were more diverse especially when there was continuous rain for a few days. On the other hand, Uetz (1975), in his study of the species diversity of wandering spiders, did not observe a significant correlation between diversity and seasonal weather factors.

Richness of Arthropod Fauna. Indices of richness shown (Table 5) were also higher in soil and leaf litter along the stream in the second count, followed by samples taken from the middle elevation. Hill litter and soil had a high diversity value in the second count only. This showed that many species became attracted to inhabit the hill when conditions were moist and shady and vegetation had started to grow.

Similarity of Species. Species of arthropods tended to become similar (Table 6) in stream soil and litter during the first and second sampling periods followed by species occurring in middle soil. Within each elevation, similar species of arthropods appeared in stream litter and soil and in middle elevation litter and soil during the first sampling. In the second count, species of arthropod populations were almost identical between hill litter and stream soil and between hill soil and stream soil. On the third count, species were found to be nearly identical when comparing the middle elevation litter and soil.

Table 5. Indices[1] of richness or variety of arthropods in litter and soil in three elevations at Wahila Ridge, Hawaii.

Sampling Period	Hill Litter	Hill Soil	Middle Litter	Middle Soil	Stream Litter	Stream Soil
1	0.779	1.249	0.937	0.937	1.873	1.561
2	1.401	1.731	2.242	1.167	1.381	1.471
3	0.653	0.886	1.467	1.304	1.467	2.388

[1] $d_1 = \frac{S-1}{\log N}$

S = number of species

N = number of individuals

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Table 6. Index of similarity[1] of species of arthropods in litter and soil in three elevations at Wahila Ridge, Hawaii.

	Stream Soil	Middle Soil	Hill Soil	Stream Soil	Middle Soil	Hill Soil
First sample						
Hill litter	0.50	0.25	0.40	0.44	0.67	—
Middle litter	0.80	1.00	0.67	0.73	—	—
Stream litter	0.92	0.73	0.67	—	—	—
Hill Soil	0.73	0.67	—	—	—	—
Middle Soil	0.80	—	—	—	—	—
Second sample						
Hill litter	0.92	0.77	1.00	0.82	0.75	—
Middle litter	0.80	0.67	0.75	0.74	—	—
Stream litter	0.75	0.63	0.82	—	—	—
Hill Soil	0.92	0.77	—	—	—	—
Middle Soil	0.83	—	—	—	—	—
Third sample						
Hill Litter	0.50	0.50	0.29	0.22	0.67	—
Middle Litter	0.80	0.91	0.80	0.50	—	—
Stream Litter	0.80	0.55	0.60	—	—	—
Hill Soil	0.62	0.89	—	—	—	—
Middle Soil	0.71	—	—	—	—	—

(between samples)

	HL3	HL2	HL1		HS3	HS2	HS1
HL1		0.44	—	HS1	0.67	0.67	—
HL2	0.40	—	—	HS2	0.73	—	—
	ML3	**ML2**	**ML1**		**MS3**	**MS2**	**MS1**
ML1	0.80	0.62	—	MS1	0.67	0.89	—
ML2	0.80	—	—	MS2	0.80	—	—
	SL3	**SL2**	**SL1**		**SS3**	**SS2**	**SS1**
SL1	0.62	0.82	—	SS1	0.80	1.00	—
SL2	0.25	—	—	SS2	0.80	—	—

HL = hill litter HS = hill soil
ML = middle litter MS = middle soil
SL = stream litter SS = stream soil

[1] Index of similarity is $S = \frac{2C}{A + B}$

A = number of species in sample A
B = number of species in sample B
C = number of species common to both samples