Seasonal and Spatial Variation of Species Diversity in Collections of Scarabaeidae, Elateridae, and Cerambycidae from West Central Indiana[1]

DAVID B. MACLEAN
Department of Biological Sciences
Youngstown State University, Youngstown, Ohio 44555

Introduction

The organization of biotic communities has received increasing attention in recent years from both plant and animal ecologists. Research on plant communities has emphasized the successional changes that occur with time. Approaches to the study of plant communities have often involved ordination procedures and an analysis of the relationships between plants and environmental gradients. Animal communities have usually been arbitrarily defined according to either the habitat or taxonomic group. Research on animal communities has been less extensive than plant studies and has emphasized species diversity as a basic characteristic. Poole (7) has stated that the degree of community organization may be related to the relative difference in the variabilities of seasonal species diversity and the populations of the most abundant members of the community. This paper presents the results of research on the seasonal and spatial variations of collections of three insect families and their representative species populations.

Methods

The 16 sites chosen for this study were all mixed hardwood stands of varying vegetational composition, soils, topography, and past management. The stands were representtive of woodland habitats found throughout Tippecanoe County, Indiana.

The trees, saplings, and seedlings were tallied in to one-half acre (one acre= 4048.3 M^2) plot near the center of each stand. The diameter of the trees (4.0 inches and over diameter breast height) (1.0 inch = 2.54 cm.) and saplings (1.0 to 3.9 inches diameter breast height) and the number of seedlings (less than 1.0 inches in diameter) were recorded for all woody species. Only seedlings over 12 inches high were recorded.

Insects were sampled by an omnidirectional light trap at the center of each site. The attractant source was two 2-watt argon glow lamps powered by three 45 volt batteries (5). The traps were operated from July to September of 1966 and from late May through August of 1967. collections were made at stand 16 only during 1966 and at stands 5 and 13 only during 1967. collections were made every two days except at the end of the sampling season when they were made twice a week.

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[1]Based in part on the Ph.D dissertation of the author, "Ordination of Forest Insect and Plant Communities in West Central Indiana" submitted to the faculty, Department of Entomology, Purdue University in partial fulfillment of the requirements for the Ph.D degree, January, 1969.

The insect families chosen for analysis were the Scarabaeidae, Elateridae, and Cerambycidae. Many additional families could have been included but for practical reasons the study was confined to these well known groups. All determinations were made by the author.

Results

Twenty five species of trees were assigned to four species-groups (9): (1) beech-maple species-group; (2) oak-hickory species-group; (3) upland mesophytic species-group; (4) lowland-depressional species-group. An additional designation was made for a black locust "species-group" because of the large numbers of this species at stand 13. Relative importance values were calculated for each tree species as the average of its relative density, frequency, and basal area (2). Based on the relative importance values of species-groups, each stand was designated as one of the five forest types of Schmelz and Lindsey (9). Eleven stands were designated as mixed woods, two as oak-hickory, two as lowland-depressional, and one as "early successional".

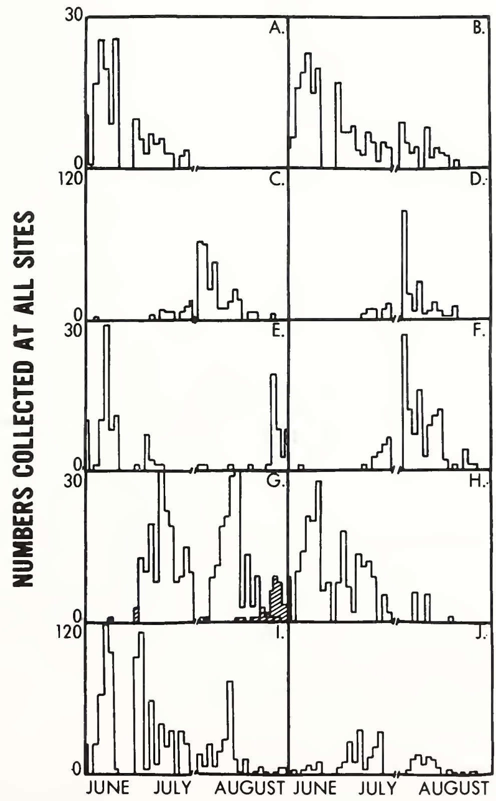

FIGURE 1. *Seasonal distribution of selected insect species.* A. *Serica campestris;* B. *S. sericea;* C. *Cyclocephala borealis;* D. *C. immaculata;* E. *Copris fricator fricator;* F. *Orthosoma brunneum;* G. *crossed hatched bars, Hemicrepedius bilobatus, clear bars H. memnonius;* H. *Melanotus sagittarius;* I. *M. similis;* J. *M. ignobilis.*

A total of 8179 specimens was identified from the light trap collections, consisting of 35 species of Scarabaeidae, 26 species of Elateridae, and 33 species of Cerambycidae. Twenty collections from May 30 to July 11, 1967 and twenty four from July 13 to August 30, 1966 were selected to represent the seasonal distribution of selected species. The period of peak adult flight was very short for some species, e.g. *Phyllophaga futilis, P. tristis, P. fusca,* and *P. inversa*. Others such as *Serica sericea, Hemicrepedius memnonius, Melanotus sagittarius, M. similis,* and *M. ignobilis* (Figure 1B, G, H, I, and J) were collected throughout most of the season. Two periods of adult activity were evident for *Copris fricator fricator*, the first from late May to June 29 and the second from mid-July to late August (Figure 1E). The most abundant cerambycid, *Orthosoma brunneum,* had a well-defined mid-seasonal period of abundance (Figure 1F).

Because light trap collections cannot be considered to be random samples, each collection was treated as a complete population (6). Species diversity values (H) based on Brillouin's formula:

$$H = \frac{C}{N} (\log_{10} N! - \log_{10} N!)$$

where c = 2.302585, and N was the number of specimens in each collection, were calculated for five periods from June through August (4).

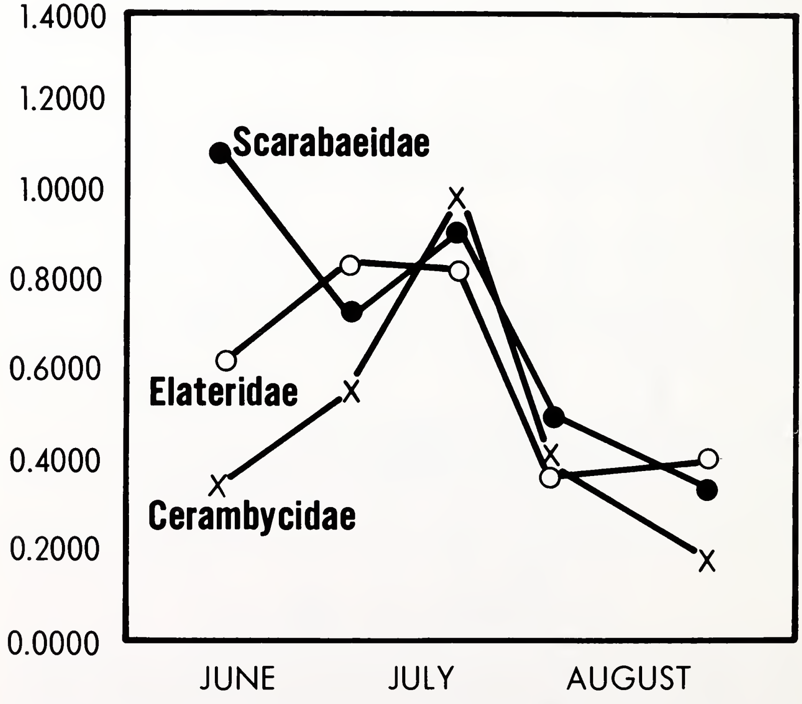

FIGURE 2. *Seasonal distribution of H for collections of Scarabaeidae (solid circles), Elateridae (open circles), and Cerambycidae (Xs) made during the summers of 1966 and 1967.*

The seasonal distribution of H averaged for all sites is shown in Figure 2 for the Scarabaeidae, Elateridae, and Cerambycidae. The average diversity of collections of Scarabaeidae, was highest during June, decreased in early July and reached a second maximum during mid-July. From late July to September, diversity decreased steadily. Collections made during the two periods of highest species diversity (June and mid-July) had an average of 264 and 46 specimens per site respectively. Collections made during early July and August had averages of 10, 12 and 8 specimens per site.

The distribution of H for collections of Elateridae reached a maximum in July and declined rapidly in early August and recovered slightly during late August.

The Cerambycidae showed a sharp increase in species diversity in late July and declined to a seasonal low in late August. Collections increased from an average of 3 individuals per site in June to a maximum of 20 in late July and declined to an average of only 2 cerambycids per site in late August.

A summary of the results of a model II analysis of variance of seasonal species diversity values (H) for collections of Scarabaeidae, Elateridae, and Cerambycidae is shown in Table 1. The two sources of variation were among dates (June, early July, early August, and late August) and within dates (among sites within collection periods). Variation in H among collection periods was highly significant for all three insect families. The added variance component for among dates accounted for 41, 22, and 32 percent of the total variation in species diversity for the Scarabaeidae, Elateridae, and Cerambycidae respectively. A

TABLE 1. *Summary of Analysis of Variance of H Values for Scarabaeidae, Elateridae, and Cerambycidae.*

Family	Source	d.f	F
Scarabaeidae	among dates	4	10.987***
	within dates	66	
Elateridae	among dates	4	4.985***
	within dates	67	
Cerambycidae	among dates	4	7.792***

***$P < 0.005$, 4 and 60 degrees of freedom.

TABLE 2. *Values of Coefficient of Variation based on H among and within dates and species of Scarabaeidae, Elateridae, and Cerambycidae.*

Family	Number Collected	C.V.[1] for H values		Range of population C.V. values[2]
		Among dates	Within dates	
Scarabaeidae	4960	0.4430	0.4342	0.8567-4.9888
Elateridae	2789	0.4958	0.6581	0.4198-2.1125
Cerambycidae	430	0.7052	0.8438	0.3354-1.3618

[1]Coefficient of Variation.

[2]Based on the ten most abundant species.

coefficient of variation was calculated from the antilog of the variance component for both among and within sites (Table 2). The scarabaeidae had the smallest coefficients of variation and the Cerambycidae the largest.

A coefficient of variation was also calculated for the ten most abundant species of each family based on the number of each species as a percentage of the total population during a collection period (7). The range of values is given for each family in Table 2. Poole (7) states that smaller values of coefficients of variation based on H than ones based on species populations indicate a degree of community organization. Values for all ten species of Scarabaeidae were much larger than those based on the among and within collection periods. However, the coefficients of variation of two species were smaller than that for among dates (*M. similis*) and within dates (*M. similis* and *M. ignobilis*). These species showed less variability in their seasonal population size than was present in the seasonal species diversity for the entire elaterid community.

Coefficients of variation for six of the ten most abundant Cerambycidae were less than the coefficient of variation for among dates. The range of coefficients for these species was quite small (0.3354-0.6942). Fewer than seventeen specimens were collected for each of the four species that had coefficients larger than the coefficient of variation for among dates. The fact that these species were infrequently collected could account for their high seasonal variability.

An inverse relationship was noted for numbers collected and the variability of the community both among and within dates (Table 2). The species diversity of communities composed of relatively small populations was more variable than that of communities made up of larger species populations. The seasonal variability of species populations was highest in numerically large communities and lowest in small communities.

Species diversity values (H) were calculated for all stands based on the species of trees recorded within each one-half acre plot. Correlation coefficients calculated for H (trees) and H (insects) were all nonsignificant.

The collections of Scarabaeidae and Elateridae were next subjected to a cluster analysis based on the unweighted pair-group method (10). The results, which are summarized in Table 3, show that the collections were clustered more by month than by site. At the 0.20 level of similarity, sixteen clusters of scarab

TABLE 3. *Summary of Cluster Analysis of Collections of Scarabaeidae and Elateridae.*

Family	Similarity level	No. of clusters
Scarabaeidae	0.80	53
	0.50	31
	0.20	16
	0.10	10
Elateridae	0.80	47
	0.50	28
	0.20	14
	0.10	11

collections were evident (Table 3). If several distinct insect communities existed, one would expect that most collections would be restricted to only one or two clusters. However, collections from three sites were included in five different clusters and nine sites in four different clusters. Thirteen of these clusters had collections from more than one site. The most distinctive collections came from sites 14 (heavily grazed white oak woodlot) and 15 (Wabash River floodplain) which occurred in three and two different clusters respectively. No cluster had more than two collections from the same site. However, based on seasonal periods, the clusters consisted of collections from no more than two consecutive months. Seven clusters included collections from the same month and nine from two months.

Cluster analysis of collections of 26 species of Elateridae produced 14 clusters united at the 0.20 level of similarity (Table 3). Twelve of these clusters had collections from more than one site. Collections from two sites were included in five different clusters, from five sites in three different clusters, and from one site in two different clusters. One cluster consisted of collections from three months and four from two months and eight from the same month. Like the Scarabaeidae, the collections of Elateridae were clustered more by month than by site.

Discussion

Based on values of H among and within collection periods, the Scarabaeidae made up the most stable, i.e. organized, insect community. A number of well recognized ecological groups are included within this family (8). Larvae of the genera *Phyllophaga, Cyclocephala, Macrodactylus,* and *Osmoderma* as well as many others feed on the roots of plants. Adults of most of these species feed on the foliage of forest trees and shrubs. Many of these species had highly variable populations, i.e. they were present for short periods of time but often in large numbers. However, they were replaced by other species throughout the season which tended to maintain a large number of species at most sites and thereby minimized the variability of the species diversity. Most plant feeding woodland species such as *Serica sericea* and *Diplotaxis harperi* showed less variability in their seasonal populations than did most species of *Phyllophaga.* Populations of dung feeding species (e.g. *Ateuchus histeroides punctatus* and *Copris fricator fricator*) were less variable than populations of grass feeding species (*Phyllophaga* and *Cyclocephala*) but more variable than the woodland species. *Pelidonata punctata,* a species that develops in decaying wood was one of the least variable scarabs throughout the season.

Values of H among and within sites for the Cerambycidae showed the least evidence of community organization. Many species of Cerambycidae appear to be opportunistic since their presence at a site depends on specific requirements for larval development (3). Populations of cerambycids were the least variable of any which indicates that the species present at a site are able to utilize food sources that are available on a nonseasonal basis.

Most species of woodland Elateridae are phytophagous (e.g. *Melanotus* spp.) while some are carnivorous (e.g. *Conoderus* spp. and *Hemicrepedius bilobatus*) (1). Plant feeding species are found in soil or in decayed tree trunks and plant remains. Populations that exhibited the most seasonal variation included both phytophagous species (*Limonius grisseus, Agriotes oblongicollis, M. sagittarius, M. corticinus*) and carnivorous species (*H. bilobatus*). Populations that showed the least seasonal variability also included both phytophagous (*H. memnonius, M. similis, M. ignobilis*) and carnivorous species (larvae of *Athous cuculatus* are carnivorous).

The results of this study provided indirect evidence of varying amounts of community organization for the Scarabaeidae, Elateridae, and Cerambycidae. Analysis of variance and cluster analysis of insect collections indicated that such community organization may involve successive species populations throughout the season more than differences between community types. The seasonal variability of species population may, in addition to many other factors, be related to the availability of its host food (e.g. plant stems, roots, wood, dung, etc.) and the ability of the insect to exploit it. If the food source is highly predictable in its seasonal availability (e.g. foliage and decayed wood for forest trees) the population may be less variable than that of a species that feeds on either seasonally abundant hosts or on less predictable food sources (e.g. prey of carnivorous species).

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