University of Colorado at Boulder

Environmental, Population, and Organismic Biology

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May 10, 1993

Mark Gershman
City of Boulder
Open Space/Real Estate Department
P.O. 791
Boulder, CO 80306

Dear Mark,

I got your phone message, and enclosed is the final report from the study we did at the Sanitas Valley trail site. The results were very interesting. We found that although the abandoned alfalfa field had a greater number of insect species, the diversity of the Sanitas Valley site was significantly higher.

I have enclosed a final report, as well as a copy of the lab exercise.

Thank you for your support in this project.

Sincerely,

Deane Bowers

Deane Bowers

PROPOSAL TO:
Boulder Open Space Department

FOR:
"Laboratory Exercises in Entomology"

FROM:
Deane Bowers, Associate Professor (492-5530)
Environmental, Population, and Organismic Biology 548
University of Colorado
Boulder, Colorado 80309

I. Coordination

There are no other local, state or federal approvals necessary for the proposed study. As the faculty member teaching this course, I (Deane Bowers) will be responsible for the project. I have attached a copy of my resume at the end of this proposal.

II. Objectives

The proposed project will involve 2 field trips to Boulder Open Space in my course here at the University, EPOB 4660/5660, Insect Biology. The first trip took place with verbal permission on September 10, 1991. This was to collect insects in an area with several different habitats, and to introduce students different types of collecting techniques.

The second trip is scheduled for Tuesday, September 24. This trip is part of a laboratory exercise to compare insect diversity in an abandoned alfalfa field and a more natural old field habitat. The exercise is attached at the end of this proposal. This exercise will introduce the students to sampling techniques, insect identification, and methods of calculating diversity indices. It will also show them how agriculture can affect insect populations.

III. Background

Please see attached laboratory exercise.

IV. Methodology

We will run 5 50-meter transects in each habitat and use sweep nets to sample 0.5 meters on either side of those transects. We will keep all the insects we collect; bring them back to the lab to sort, identify, and count; and measure the length of each

insect. We will then use the Shannon-Weiner index of diversity to compare the diversity of these two habitats.

V. Products and Reports

I will provide the Boulder Open Space with the results of these two laboratory exercises. First, I will provide a list of the orders of insects, and the approximate number of species in each order that we found collecting at our first site (Mesa Trailhead). Second, I will provide the data we collect on comparing diversity of the abandoned alfalfa field and the natural old field habitat.

VI. Literature cited

Please see attached laboratory exercise.

VII. Educational Research.

Instructor: Deane Bowers, Associate Professor of Biology. phone: 492-5530 (work), 786-8627 (home)

The class is composed of 22 students. We will be setting up transects and sampling them only once, on September 24, 1991. If possible, in future years of teaching this course, I would like to continue to use Open Space land for this laboratory exercise. However, this year, there will only be one more field trip, on September 24.

LABORATORY 4

Insect diversity in an alfalfa field and a "natural" old field habitat

Introduction

One method of comparing communities is by a comparison of the plant or animal diversity of that community. Diversity can be defined as a measure of the number of species and their relative abundances (that is, the number of individuals of each species). There are several measures of diversity, and in this laboratory, we will compare the insect diversity of two habitats: an abandoned alfalfa field and a "natural" old field habitat, using two different methods of calculating diversity. We will sample both habitats by sweep-netting.

This week, we will separate into 2 groups, each of which will sample one of the habitats. We will then come back to the lab to count and sort the samples, and next week, we will combine all the data from each habitat, graph the data, and calculate the diversity indices.

Objectives

1) Compare the number of species and the diversity of species in an agricultural field and a natural field habitat.

2) Compare the size distribution of insects in these two habitats (if time).

3) Use of sampling techniques

4) Calculation and comparison of diversity indices for the two insect communities.

Equipment

Bring with you:
- laboratory notebook
- sweep nets
- insect nets
- tape measure
- marker flags
- writing implements
- killing jars (be sure they are working)
- extra sample bottles
- label tape

For next week:
- calculator
- laboratory notebook

ruler (cm)

Methods

A. Field sampling

1. Divide up into pairs. Each pair of people will sample one transect. There will probably be one group of 3.

2. At each site, set up 5 transects of 20 meters in length, about 10 meters apart. Mark the ends of the transects with flags.

3. Using a sweep net, sample 1/2 meter on either side of the transect by walking down the middle of the transect and sweeping the net back and forth in front of you. Collect all the insects in your sweep net, and put into killing jar. Keep samples from different transects separate. You will probably have to stop occasionally as you walk the transect to put your samples into a killing jar, and then perhaps to transfer samples to other containers.

4. Sample each transect two times.

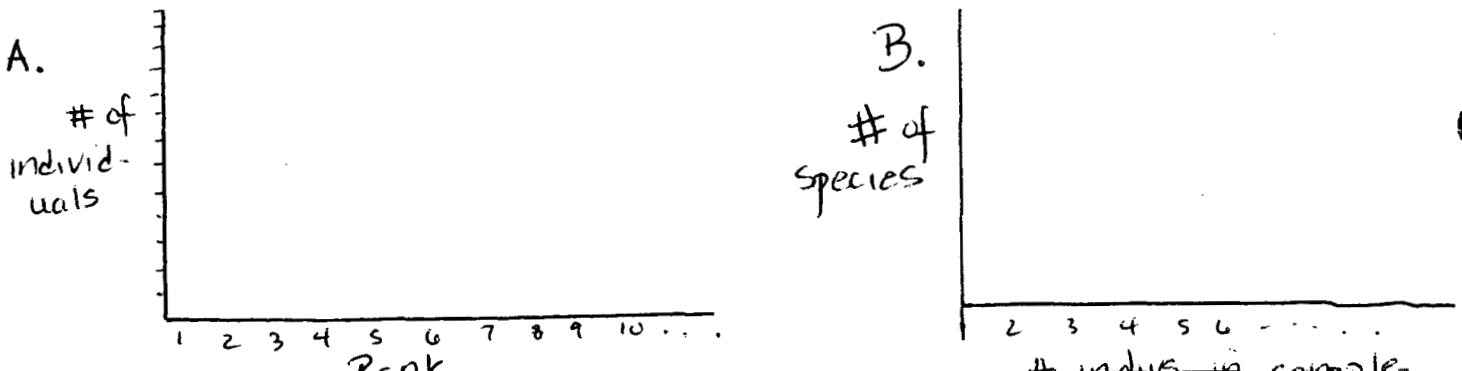
B. Back in the lab

5. Make sure your insects are dead. Pin up your insects.

6. As a group (all the people that sampled each habitat) sort your insects into "morphospecies". Morphospecies are groups of insects that look like they belong to the same species. Because we do not have time to key out all the insects, we will use this method of sorting. We will assume that each morphospecies is a species. It might be easier for each pair of people to sort their insects, and then to all get together to combine the samples.

7. Count the number of individuals that belong to each morphospecies.

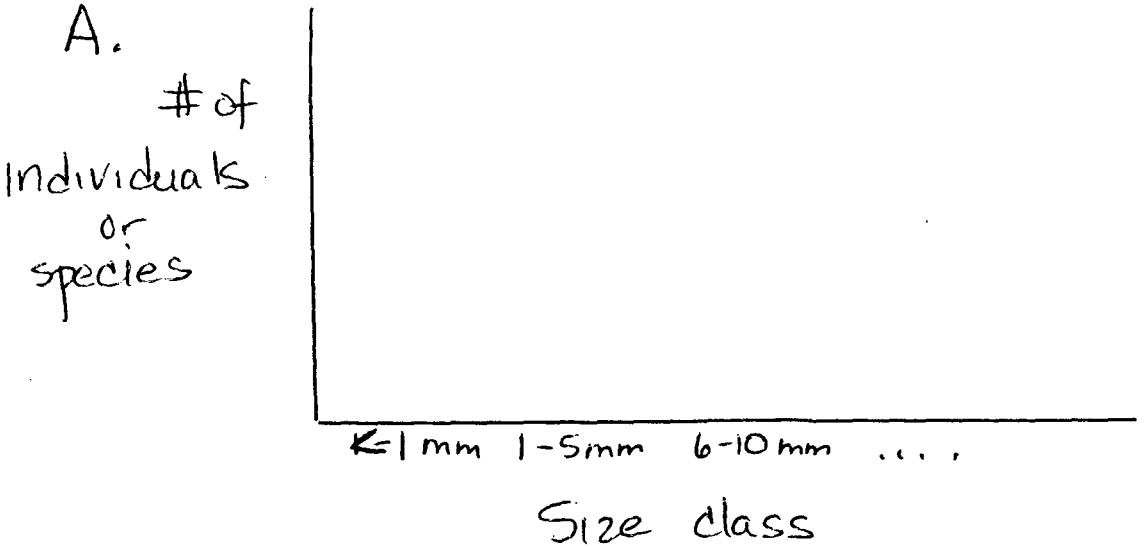
8. Graph the data as follows:



9. What do you notice about these data? What patterns (or lack of pattern) are visible here?

10. Sort your insects into size classes (< 1mm, 1-5 mm, 6-10 mm, and so forth. And count the number of individuals and number of species in each size class. Graph those data.

A.



C. Calculation of diversity indices. We will use the Shannon-Wiener Index to provide an estimate of species diversity. This index is based on information theory, the primary goal of which is to provide a measure of the amount of order (or disorder) in a community. This measure is a function of the number of species and the number of individuals in each species.

Strictly speaking, the Shannon-Wiener index should be used only on random samples drawn from a large community in which the total number of species is known. That is not the case in our comparison: our samples are not randomly collected, and we do not know how many species exist in these two communities. However, for our purposes, this index will provide a basis for the comparison of our two communities.

The Shannon-Wiener index is calculated as follows:

$$\hat{H}' = -\sum \hat{p}_i (\ln \hat{p}_i)$$

where:

H' = Index of species diversity

s = number of species

p_i = proportion of total sample belonging to the ith species.

It can also be expressed in another way:

$$N_1 = e^{\hat{H}'}$$

where: $e = 2.71828$ (the base of the natural log)

$\hat{H}'$ = SHannon-Wiener function (calculated with base e logs

N_1 = number of equally common species that would produce the same diversity as H'.

On the next page is an example of the calculation of the Shannon-Weiner Index.

To calculate Shannon-Wiener diversity index — example.

Hough (1936) tallied the abundance of large trees in a virgin forest in Pennsylvania:

Tree species	No. of individuals, n_i	Proportional abundance, p_i
Hemlock	1940	0.521
Beech	1207	0.324
Yellow birch	171	0.046
Sugar maple	134	0.036
Black birch	97	0.026
Red maple	93	0.025
Black cherry	34	0.009
White ash	22	0.006
Basswood	15	0.004
Yellow poplar	7	0.002
Magnolia	4	0.001
Total	3724	1.000

Shannon-Wiener Function

From equation (10.29):

$$\hat{H}' = -\sum \hat{p}_i \log_2 \hat{p}_i$$

$$= (0.521)(\log_2 0.521) + (0.324)(\log_2 0.324)$$

$$+ (0.046)(\log_2 0.046) + \cdots$$

$$= 1.829 \text{ bits per individual}$$

From equation (10.30):

$$\hat{N}_1 = e^{\hat{H}'} \quad \text{(base } e \text{ logs)}$$

$$= 2^{\hat{H}'} \quad \text{(base 2 logs)}$$

$$= 2^{1.829}$$

$$= 3.55 \text{ species}$$

April, 1993

A Comparison of Insect Diversity in an Alfalfa Field and the Sanitas Valley Open Space Habitat

A Report Prepared by:
Deane Bowers and the students of E.P.O.B. 4160/5160 (Insect Biology)
E.P.O. Biology, University of Colorado

Objectives: To use sweep-net sampling methods to estimate and compare the insect diversity of an abandoned alfalfa field and the short-grass praire habitat of the Sanitas Valley Open Space.

Introduction

The effort to understand the structure of biological communities has led to several hypotheses about the factors that control the diversity and abundance of plant and animal species. One hypothesis states that species diversity is correlated with habitat diversity. To test this hypothesis, to get some idea of the species composition of local insect communities and to introduce students to methods of insect sampling and calculations of diversity, we used sweep-net sampling along transects to calculate and compare insect diversity in an abandoned alfalfa field (relatively low habitat diversity) and in a short-grass prairie habitat. We defined diversity as the measure of the number of species and their relative abundances (the number of individuals of each species). Thus, this is a different measure than species richness, which is simply the number of species.

Methods

The two sites sampled were 1) an abandoned alfalfa field located behind St. Andrews Church on Baseline and 39th, in south Boulder; 2) the short-grass prairie located on the western slope of the Sanitas Valley trail, off of Mapleton, in west Boulder. Both sites were sampled in the same manner. At each site, 5 transects of 20 meters length were set up. Using a sweep net, a 0.5 meter strip on either side of each transect was sampled by sweep-netting. Each transect was swept twice. All samples were collected and taken back to the lab for sorting into morphospecies and counting.

The numbers of individuals of each species were determined. Using these data, a Shannon-Wiener species diversity index was calculated based on the samples from each transect at the two sites. We then compared the diversity of these samples using Analysis of Variance.

Results

Comparing the number of insect orders found at the two sites showed no differences. Species in 10 orders were collected from the two sites (Table 1). The number of species per transect varied from 39 to 110 in the alfalfa field samples and from33 to 54 in the Sanitas Valley samples. A graph of the morphospecies rankings based on the number of individuals collected from one of the five alfalfa field transects shows that most species were extremely rare in the sample, whereas very few species were very abundant (Fig. 1). For example, in one transect at the alfalfa field site (Fig. 1), 831 individuals of 55 morphospecies were collected. However, over 50% of those individuals were of a single species and over 90% were of only 10 species. Although more individual insects, as well as a greater number of species were found at the alfalfa field site (Table 2), the diversity was significantly higher at the Sanitas Valley site (Fig. 2) (one-way ANOVA, $F = 8.49$, $df = 1,8$, $P < 0.05$).

Discussion and Conclusions

Although there were more species found at the alfalfa field site, the insect diversity was higher at the Sanitas Valley trail site. Although we did not directly measure plant diversity at either site, visual comparisons suggest that the plant community is richer and more diverse at the prairie site of the Sanitas Valley trail. We would need to quantify characteristics of the plant community such as species diversity, percent cover and plant structural diversity in order to determine the importance of the plant community in contributing to the difference in insect diversity at these two sites. Nonetheless, our data show that the prairie site has a more diverse insect fauna than the abandoned alfalfa field.

Table 1. Insect orders collected at the two sampling sites: an abandoned alfalfa field and a shortgrass prairie.

Orders
Odonata
Orthoptera
Hemiptera
Homoptera
Ephemeroptera
Lepidoptera
Diptera
Hymenoptera
Coleoptera
Mantodea
Dermaptera

Table 2. Number of insect species, number of individuals, and calculation of diversity (H') for sweep sampling from each of 5 transects from the two sampling sites (abandoned alfalfa field and Sanitas Valley prairie).

Alfalfa Field				Sanitas Valley			
Transect No.	# of Species	# of Indivs.	H'	Transect No.	# of Species	# of Indivs.	H'
1	110	1257	2.55	1	54	522	3.07
2	39	802	1.70	2	41	185	2.73
3	39	507	2.29	3	46	528	2.84
4	42	530	2.46	4	38	575	2.68
5	55	831	2.04	5	33	342	2.43
MEAN	57	785.4	2.21	MEAN	42.4	430.4	2.75
S.D.	30.4	303.1	0.34	S.D.	8.0	163.4	0.23

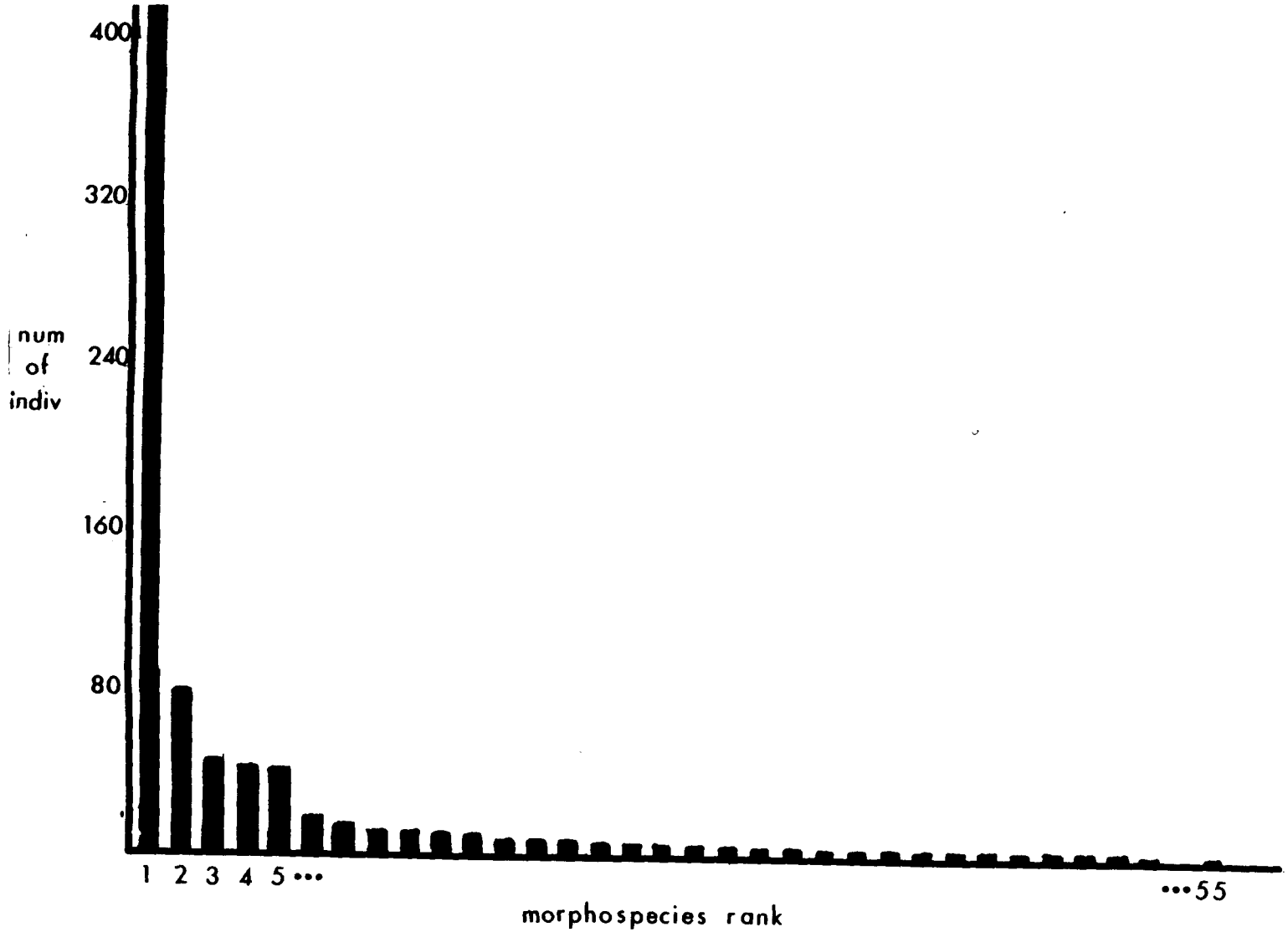


Figure 1. Number of individuals of each morphospecies for one of the alfalfa field transects.

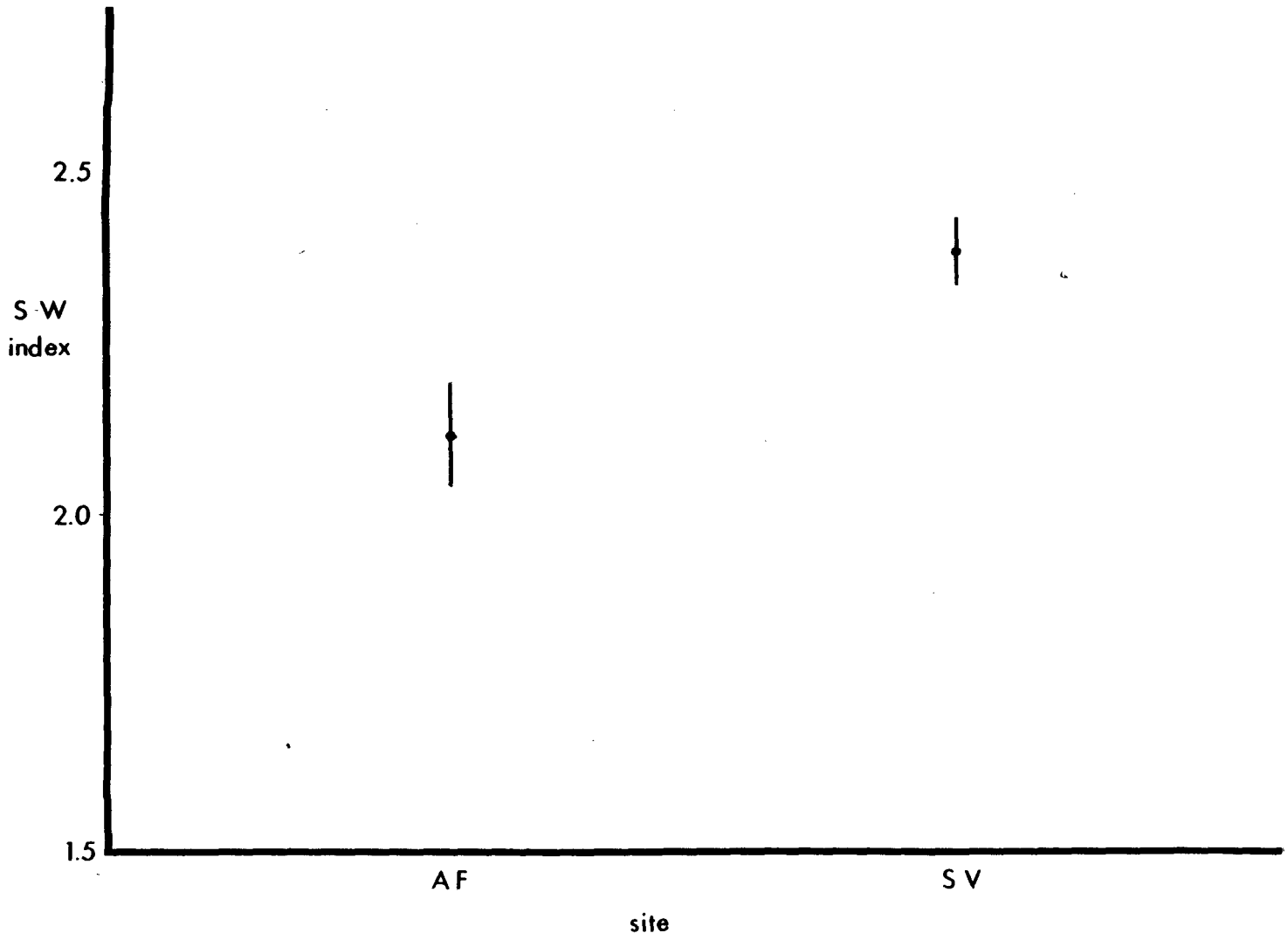


Figure 2. Shannon-Wiener diversity indices for the alfalfa field site (AF) and the Sanitas Valley site (SV). Means with standard deviations are shown.