

A COMPARISON OF SAMPLING METHODS
USED IN FIELD PESTICIDE
SIDE EFFECTS STUDIES

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ABSTRACT

A COMPARISON OF SAMPLING METHODS USED IN FIELD PESTICIDE SIDE EFFECTS STUDIES

by Jon Roger Maki

Comparisons of the performance of the D-Vac vacuum sampler and a standard sweep net were carried out in an old field community in southern Michigan. Samples were collected at 5 different periods during the day to relate yield, method, and time of sampling. Analysis of the data was performed by Duncans Range Test.

Results show that the modified vacuum-sweep method yielded significantly larger numbers of most insect groups than did the standard sweep net method. The results of this study suggest that no single method is capable of adequately sampling the entire insect fauna of a similar area. It would also seem advisable to avoid very early or very late sampling if the data are to be used in studies comparing population densities in widely separated areas.

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By

Jon Roger Maki

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INTRODUCTION

The objective of this study was to evaluate the potentialities of the vacuum-sampling technique as a censusing tool in pesticide side-effects sampling programs. It was hoped, as a result, that recommendations could be made which would insure representative and reliable samples that would be superior to the widely used sweep net method of sampling.

The simplicity of sweep net design and use has contributed to its popularity among field biologists. Certain authors have, however, presented data indicating that yields of some species are affected by weather, sweep technique, and the inability of the net to reach lower parts of the vegetation.

The use of a vacuum sampler ostensibly has a unique advantage in that soil-surface arthropods are sampled in addition to inhabitants of plant surfaces. A further advantage is that, theoretically at least, insects will be sampled at all levels on the plant. Finally, once a uniform method of vacuum sampling is selected, yields should be independent of operator idiosyncracies.

The apparent need for an improved method of obtaining uniform, reproducible data prompted the comparison of a conventional sweep net and a commercially available vacuum device which will be described here.

LITERATURE REVIEW

DeLong (1932) was one of the first researchers to discuss the problems associated with use of sweep nets in sampling programs. Weather factors, as well as length and rapidity of stroke are mentioned as having some bearing on sample yield by this author. He concludes that the sweep net should be used only for qualitative approaches, since he doubts if the data resulting from sweeping are an accurate estimate of population structure and density.

Gray and Treloar (1933) carried out an extensive series of sweepings in an alfalfa field. Statistical analyses of their data indicated that the population was far from randomly dispersed, even in such a homogeneous area. Further analysis indicated that upwards of 26,000 sweeps would be necessary to obtain data with a 10% standard error in some taxonomic groups. As might be expected, these authors concluded that the sweep net was not practical in quantitative studies.

Romney (1945), and Hughes (1955), presented data indicating that weather can have a marked effect on sweep net yields of some species. Romney found that sweep net yields of the beet leafhopper increased 200% when the air temperature rose from 80 to 105 degrees F. He also found that yields of leafhoppers decreased with increasing wind velocity. Hughes found that yields of Meromyza variegata (Diptera, Chloropidae) decreased with increasing wind velocity. In the laboratory, he observed that individuals of M. variegata would cling more tightly

to the substrate under windy conditions. Such a behavioral characteristic would partially explain the decreased sweeping yields of this species under inclement weather conditions. Hughes also discussed points similar to those presented by DeLong (1932). DeLong and Hughes point out that sweep yields are influenced by the position of the insect on the plant surface, and therefore, conditions which result in a movement of insects to the lower portions of a plant would lead to decreased sweeping yields.

Various techniques have been developed in an attempt to overcome inherent deficiencies of the sweep net method. Beall (1935), Romney (1945), Cross (1956) and Menhenick (1963) developed methods to standardize their sweep sample yields. In each case, the total number of insects in a unit area was determined by enclosing a small plot in a cage or cylinder and removing all insects present. The number of sweeps needed to sample a standard area was then calculated. Results obtained by each author vary with the species in question. Beall found that for some species the yield of six to nine sweeps was equal to the population on a square meter. For adult Melanoplus sp. (Orthoptera, Acrididae), Cross found the yield of fifty sweeps to be equal to the population in a 2.7 square meter area. Employing a correlation analysis, Romney compared the yield of beet leafhoppers in fifty sweeps to the yield of one square yard of cylinder placements. Correlation coefficients ranged from 0.73 to 0.93 respectively for nymphs and adults of this species.

Research has been carried out in attempts to find satisfactory replacements or supplements for sweep net sampling. Romney (1945) tested a variation in technique which he termed "brisk sweeping".

This method yielded only slightly more beet leafhoppers than did standard sweeping methods. Fenton and Howell (1957) compared five methods of sampling in an alfalfa field. Sweeping was found to yield approximately ten percent of the aphids obtained from clipped plants. Their data showed that for arthropods other than aphids and thrips, from forty-four to seventy-seven percent of the total present were taken by sweeping.

Johnson et al. (1955) was apparently the first to utilize the "vacuum cleaner" principle in insect collecting. They concluded that the method seemed very promising. Dietrick et al. (1959) described a vacuum sampler being used in California. Dietrick et al. (1960) compared the vacuum sampler and a sweep net in alfalfa fields. In this study, the yield from five square feet of vacuum sampling was compared to the yield of five sweeps. Analysis of the data showed the mean vacuum yields to be larger than sweep net yields, for all insects except the spotted alfalfa aphid. Significant differences between methods were found in several other taxonomic groups. The authors suggest that the vacuum sampler could become a valuable tool in further sampling programs. Two problems associated with the use of this method were the large quantities of trash in the samples, which necessitated the use of a modified Berlese funnel to remove the insects from the samples, and the bulkiness of the sampling device. Dietrick (1961) discussed a modified sampler which could be operated by one man.

MATERIALS AND METHODS

This sampling program was carried out in a 16.5 acre old field community on the south campus of Michigan State University. The vegetation of the field consisted almost entirely of different species of grasses. No insecticides were used in or near the field throughout the summer.

The field was mapped and divided into 240 plots, each 30 feet by 30 feet. The plots were numbered consecutively to aid in choosing the specific sample locations.

The vacuum sampling devices mentioned in earlier works were quite bulky in comparison to the D-Vac model 12 sampler used in this study. The D-Vac, as shown in Figure 1, consists of a power source, a blower, and a housing for the sampling bag. A 1.26 cubic inch, three quarter horsepower, 2 cycle gasoline engine supplies the power. A fine mesh nylon net is fastened to the fiberglass housing, the open end of which measures 0.929 square feet. The sampler is three feet in length and weighs 15-1/2 pounds.

Samples were taken by placing the open end of the sampler over the plants and lowering it to the soil surface. The sampler was then raised approximately one half inch to insure good air flow throughout the duration of the sampling period, and held in this position for 30 - 40 seconds each time a sample was taken. Samples taken in the above manner were termed a "standard" vacuum sample. Figure 2 illustrates the taking of such a sample.



Fig. 1.--D-Vac Sampler



Fig. 2.--Taking a standard vacuum sample

During the last half of this sampling program, a modified vacuum method was also studied. For this type of sampling, the operator lowered the open end of the sampler until its lower edge was approximately 4 inches from the soil surface. With the long axis of the sampler inclined approximately 45 degrees, the operator moved rapidly along a straight line for a predetermined distance. This method was termed "vacuum sweeping" and is shown in Figure 3.

Sweep samples were taken with a standard sweep net. The handle length of the net used was 35-1/2 inches, while the hoop diameter was 12 inches. The hoop described an arc of approximately 6 feet during sampling. The lower edge of the hoop was from 4 to 6 inches above the soil surface, at the lowest point of the arc. All vacuum and sweep samples were taken by the author.

Areas to be sampled were chosen by drawing the plot numbers from a jar containing numbered tabs of paper. No plot was sampled more than once a day on the premise that the sampling program being carried out would disturb the area to such a degree that results of a second sampling series would not be representative.

Samples were taken at five periods during the day: 6:30 AM; 9:30; 12:30; 3:30; and 6:30 PM E.S.T. Sampling was carried out at these times in order to determine the relationships between methods, time of sampling, and sample yield. Samples were taken at 6:30 AM to represent conditions at approximately 30 minutes after sunrise. The three hour intervals following this were arbitrarily chosen. The 6:30 PM sampling was carried out about 30 to 45 minutes prior to sunset.

At each of the above-mentioned times, seven replicated plots



Fig. 3.--Taking a vacuum sweep sample

were sampled. All three methods being compared were used within each plot. The samples taken in each plot were as follows: one standard vacuum sample; five six foot sweeps with a sweep net; and thirty linear feet of vacuum sweeping. The number of standard vacuum samples taken in each plot was chosen arbitrarily. The number of net sweeps and vacuum sweeps taken were chosen in such a way that the methods could be compared assuming equal, or almost equal, areas sampled.

During operation, a large volume of air is exhausted from the blower of the vacuum sampler. Care had to be exercised to prevent the passing of this exhaust air over an area in the plot which would be sampled by other methods. This was accomplished by sampling in a uniform pattern at all times. Samples were taken in the following order: first, the vacuum sweeping; second, the standard vacuum; and third, the net sweeps. All vacuum sweeps were taken along an imaginary north-south line. The specific direction travelled was chosen to prevent the passing of the blower exhaust over the sampling plot. Standard vacuum and sweep net samples were subsequently taken in an undisturbed portion of the plot.

Samples were transferred to pint jars of 70% ethyl alcohol, in the field. Separate jars were maintained for each method, at each sampling period. The total yield from seven replications, for each method and time, was kept in a single jar. Each jar was labelled with date, time of sampling and method used.

Samples collected in the field were brought into the lab for sorting and subsequent identification. The first problem encountered was to develop a method of separating the arthropods from the large amount of plant material that was often present in the samples. Hand

picking was attempted, but was found to be far too slow. A screening technique developed for concurrent pesticide side-effects studies, using the series of screens illustrated in Figure 4, was modified to suit the needs of this study.

Mesh openings of the five screens used ranged from 0.0117 to 0.525 inches. The mixture of arthropods and plant material was poured from the jar onto the uppermost of the series of screens. A hose with a small shower head was used to direct water over the sample. Washing was continued until all arthropods had been sorted according to size. This usually took from 1 to 4 minutes, depending on the sample. Each screen was then inverted, and the arthropods and plant material which didn't pass through were washed into separate white enamel pans. Sufficient water was added to insure flotation.

A small copper screen scoop was then used to pick the arthropods from the water's surface. Observations indicated that most of the arthropods floated for at least five minutes. The tendency to float, plus the fact that those arthropods in the pan were of uniform size made this method much more rapid than hand picking. Observations indicated that very few insects were lost due to breakage, and if care was exercised, close to 100% recovery of all arthropods in the upper four screens could be accomplished. Arthropods recovered from the upper four screens were kept in a separate vial.

The mixture of fine organic matter and small arthropods which collected on the 50 mesh screen was carefully collected and placed in a separate jar for further treatment. Microscopic examination of the water which passed through the screens indicated that very few arthropods were passing through the final screen.



Fig. 4.--Screens used in sample sorting

The final screening residue was later placed in a white enamel pan, and floated in a saturated sugar solution. Fine copper mesh scoops were used to pick the arthropods from the surface of the solution. Removing of arthropods from the solution was complicated by the presence of floating organic material.

The percentage of recovery attained by the sugar flotation method was not as high as that obtained from the upper screens. The small size of Collembola and mites made it exceedingly difficult to bring about total recovery. Also, some mites had a tendency to sink to the bottom of the pan. Consequently, figures on Collembola and mites were omitted from the statistical analyses of the data.

All identification of arthropods in the samples was done by the author. Most insects were identified to family level using the keys and terminology of Borror and DeLong (1954). Lepidoptera were designated only as adults and larvae. Chalcid wasps, Muscidae and Anthomyiidae were designated as Chalcidoidea and Muscoidea respectively. Arthropods other than insects were identified to order only.

A total count was made of all arthropods collected in the upper four screens. The arthropods collected by the final screening and floating techniques were placed in a Petri dish which had been divided into six wedges of equal area. Three wedges were chosen randomly before the sample was placed into the counting dish. Samples placed in the counting dish were stirred to produce as even a distribution as possible, and the arthropods in the three chosen wedges were identified and tallied. The figures resulting from this tally were then doubled, to give an estimate of total numbers in that portion of the entire sample. Data from both parts of the sample were combined

to give totals for each taxon present in each sample.

Analyses of the resulting data were carried out in hopes of providing at least partial answers to two basic questions. First of all, what is the effect of the time of day at which the sample is taken on sample yield? In some sampling programs, the areas to be sampled are widely separated or numerous enough to prevent completion of sampling in a relatively short period of time. If sampling yields at certain periods of the day are consistently greater or less than at other periods, adjustments should be made in sampling time to prevent drawing erroneous assumptions from the sampling data. The second major point of interest is the comparative efficiencies of the 3 methods used. Some inadequacies of the sweep net method of sampling have been pointed out in the literature review. Theoretically, at least, comparisons of the 2 vacuum sampling methods with the sweep net, would aid in designing future sampling programs which would yield data representative of population structure and density in the sampling areas. The results of these analyses are presented in ensuing portions.

RESULTS - TIME OF SAMPLING

Tables 1 to 9 of Appendix A list the taxa present in the samples. Totals are given on an hourly and daily basis, with each table representing the results of one days sampling.

Analysis of the effect of time of day was accomplished by the use of Duncans Multiple Range test (LeClerc et al., 1962). A randomized block analysis of variance was performed on each set of data. A Multiple Range test was performed only on those sets of data which exhibited significantly heterogeneous means. For the purpose of this analysis, the yields at each of the five sampling periods were utilized as treatments, while the days on which samples were taken were used as replications. Inspection of the data revealed that, numerically at least, a relatively small number of taxa made up the bulk of the sample. For the purposes of this analysis, these numerically dominant taxa were combined into five arbitrary "groups", which are as follows:

- (1) Acrididae; (2) Miridae and Nabidae; (3) Diptera and Chalcidoidea;
- (4) Coleoptera and Formicidae; and (5) Cercopidae and Cicadellidae.

Groups 1, 2, and 5 consist of one or two families, the representatives of which appear to be similar in relation to position on the sampling substrate and ease of capture. The taxa placed in group 3 (Diptera and Chalcidoidea) were chosen because most of the Diptera were acalypterate forms, and from the standpoint of sampling success, these two taxa seem to be similar. Group 4, consisting of Coleoptera and ants, was chosen because many of the Coleoptera in the samples were

small, ground dwelling forms. Here again, the apparent behavioral similarities of the taxa within group 4 would seem to make this grouping a logical one. The taxa not included in the above-mentioned groups were not analyzed in groups, or singly, but a Multiple Range analysis was also performed to compare total sample yield at different times of the day. The combination of methods and arthropod "groups" dictated that 18 separate analyses had to be performed.

As Table 1 indicates, only four series of significant differences were observed in these analyses. The yield of Acrididae (Group 1) in 6:30 AM sweep net samples was observed to be significantly greater than net yields at 12:30. Yields of Coleoptera and Ants (Group 4) at 6:30 AM were significantly larger than yields at other periods, using all three methods.

Figures 5 to 10 present a series of graphs of mean yields at different sampling periods. In Figure 5, mean total yield has been plotted against time of sampling. The following points of interest should be noted: (1) In terms of total number of arthropods in the samples, the general superiority of the vacuum-sweep method is evident; (2) The sweep net yields follow a distinct pattern of high yields at early and late hours of the day; and (3) Both the standard vacuum and vacuum-sweep yields show a tendency to be higher at the earliest sampling period, but show no evidences of increasing later in the day.

In Figure 6, the mean yields of Cercopidae and Cicadellidae have been plotted against sampling time. In this group of insects, the mean standard vacuum yields were quite uniform at all times. Mean sweep yields decrease until 3:30, and then begin to rise. Mean

vacuum-sweep yields decrease from 6:30 to 9:30 AM, but vary in an irregular manner after that.

TABLE 1
COMPARISONS OF TIME OF SAMPLING FOR EACH METHOD AND GROUP

	Group 1			Group 4		
	Vacuum	Sweep	Vac-Sw	Vac-Sw	Sweep	Vacuum
1 6:30 AM	1.8	49.2* (3)	0.8	32.6* (2,3,4)	17.2* (2,3,4)	21.0* (2,3,4,5)
2 9:30	2.1	29.7	1.8	14.0	8.3	10.8
3 12:30	2.6	25.1	0.6	12.8	6.0	4.6
4 3:30	1.8	41.4	1.4	10.0	10.1	10.4
5 6:30 PM	1.8	47.9	1.0	24.8	12.4* (3)	11.8

1. No significant differences were found in Groups 2, 3, and 5.
2. The numbers in this table represent the mean of the replications at each time.
3. Asterisks adjacent to a number indicate that the mean is significantly larger than the mean of the sampling period indicated in the parenthesis.

Figure 7 presents mean yields of Acrididae at each sampling period. Sweep net yields exhibit a pattern similar, in form, to other groups. Mean yields using the vacuum sampling methods were consistently low. As stated earlier, sweep net yields of Acrididae at 6:30 AM were significantly larger than mean yields at 12:30.

Figure 8 presents mean yields of several Hemipteran taxa plotted against sampling time. In this group, no marked trends are

evident. Mean yields are relatively uniform for all three methods.

In Figure 9, the standard vacuum and sweep net yields of Diptera and Chalcidoidea exhibit a marked divergence from the other patterns. In this group, mean sweep net and standard vacuum yields are relatively constant. Vacuum-sweep yields, on the other hand, exhibit a constantly decreasing yield until 3:30 PM, after which mean yields increased.

Figure 10 indicates that yields of Coleoptera and ants varied similarly for all 3 methods. In each case, yields at 6:30 AM were significantly higher than yields at 9:30, 12:30 and 3:30. Sweep net yields at 6:30 PM were higher than yields at 12:30. Mean standard vacuum yields at 6:30 AM were significantly higher than mean yields at 6:30 PM.

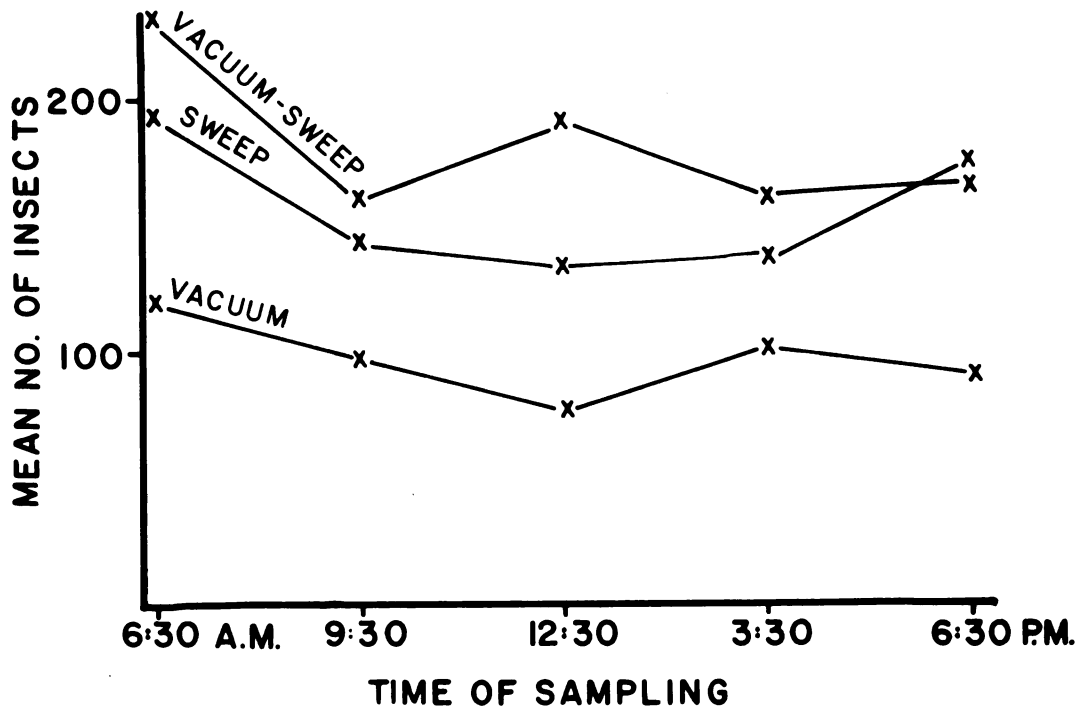


Fig. 5.--Mean total yield of insects at each sampling period.

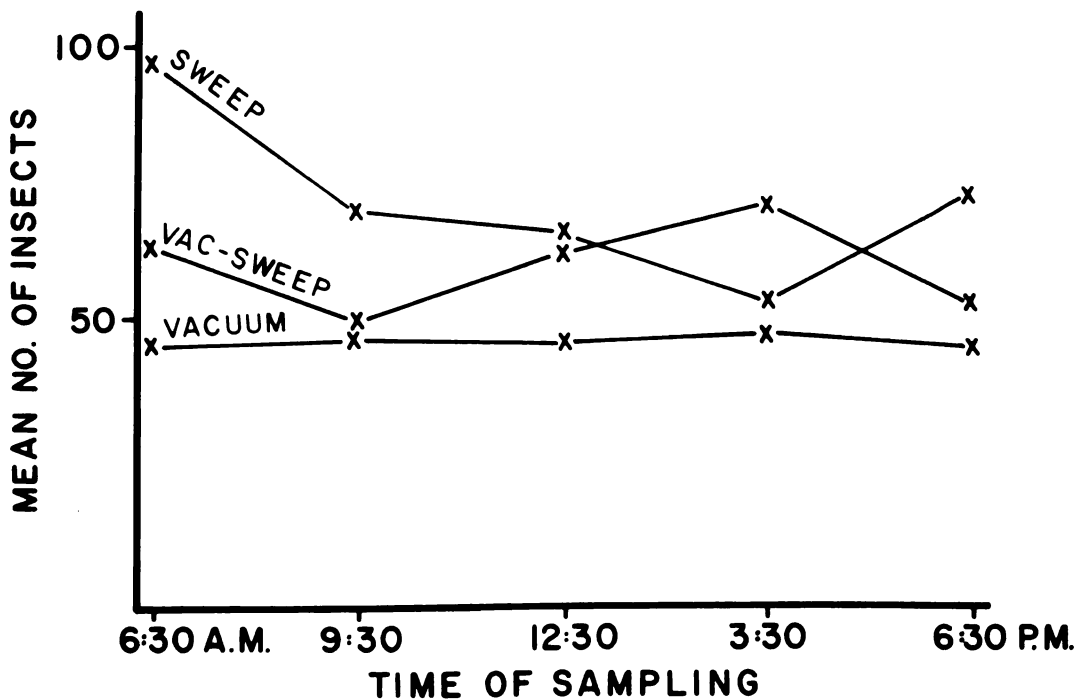


Fig. 6.--Mean yield of Cicadellidae and Cercopidae at each sampling period.

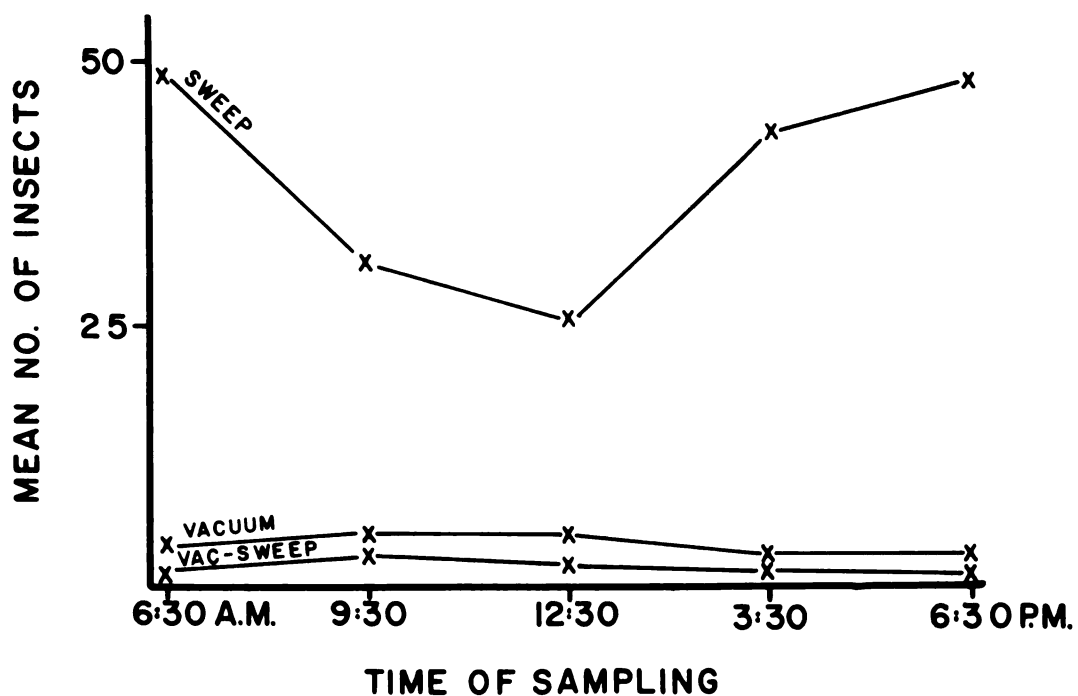


Fig. 7.--Mean yield of Acrididae at each sampling period.

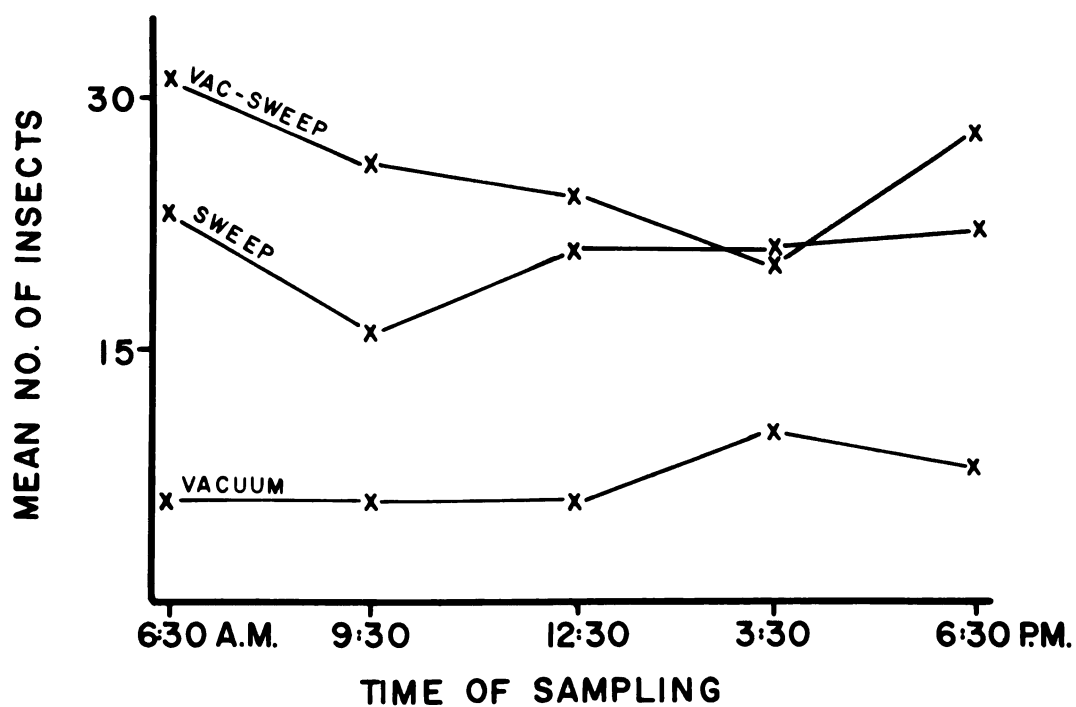


Fig. 8.--Mean yield of Miridae, Nabidae and Pentatomidae at each sampling period.

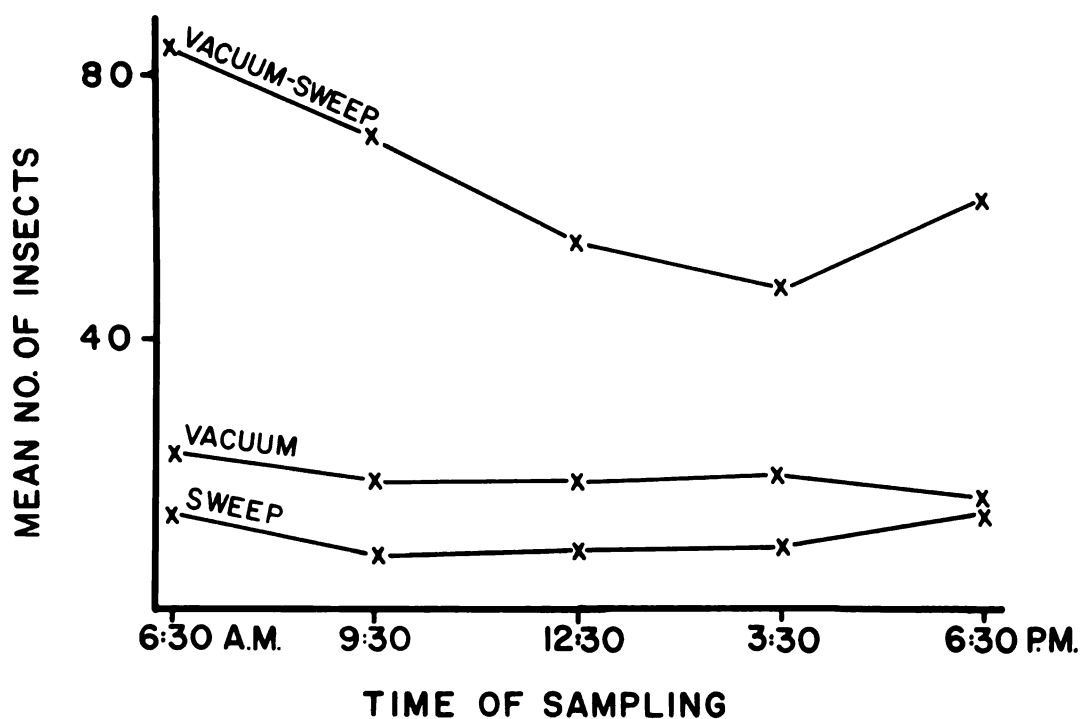


Fig. 9.--Mean yield of Diptera and Chalcidoidea at each sampling period.

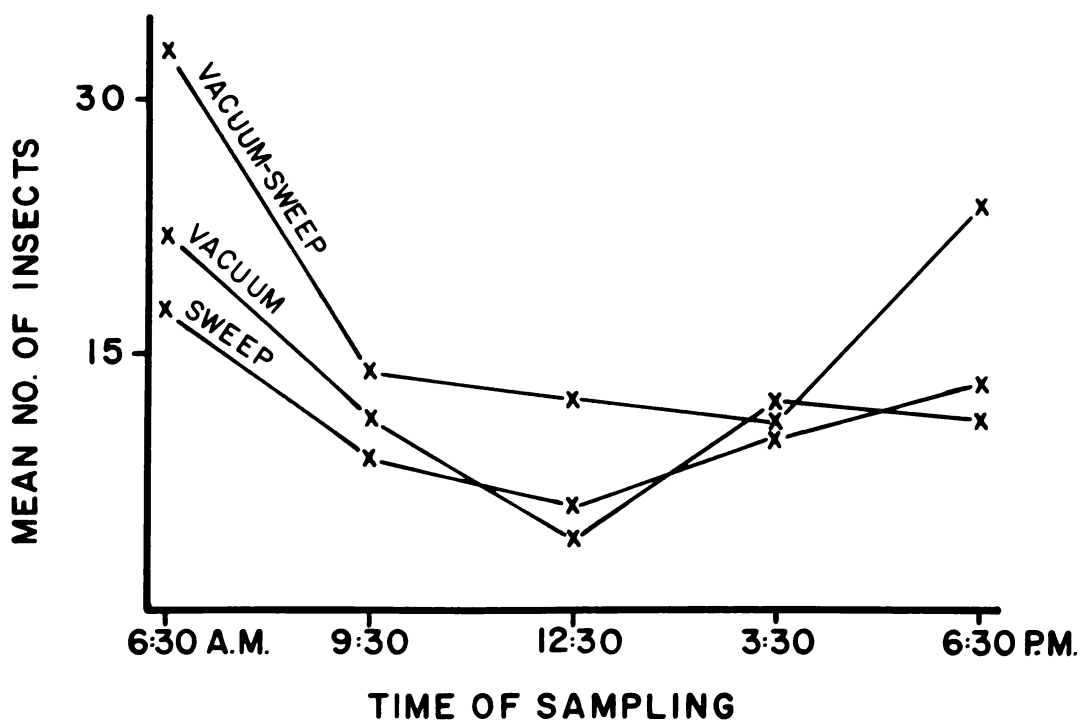


Fig. 10.--Mean yield of Coleoptera and Formicidae at each sampling period.

RESULTS - COMPARISON OF METHODS

The second major point of interest in this study was a comparison of the three sampling methods mentioned earlier. Of special interest was an attempt to assess the potential of the vacuum sampling techniques as a replacement for, or a supplement to, the sweep net method of sampling.

Methods of sampling were compared by the Multiple Range Test using the data from the five days in which all three methods were used. In this series of analyses, the methods of sampling were designated as treatments, and the 5 sampling days were designated as replications. To maintain continuity, the same "groups" of insects which were used in the analyses of time of sampling were again utilized. Thus six separate tests were run; one for each of the 5 groups, and one for total yield per day.

The results of these analyses are given in Table 2. The mean values in this Table 2 have been rounded off to the nearest whole number.

As Table 2 indicates, several significant differences were calculated from the data. Differences at the 1% level were found to exist in the following cases: (a) between sweep and standard vacuum in Group 1 (Acrididae) and Group 2 (Miridae etc.); (b) between vacuum-sweep and both sweep and standard vacuum in Group 3 (Diptera and Chalcidoidea) and Group 4 (Coleoptera and Formicidae); (c) between vacuum-sweep and standard vacuum in Group 5 (Cercopidae and

Cicadellidae); and (d) between vacuum-sweep and standard vacuum for total yield. All other significant differences observed were at the 5% level.

TABLE 2
COMPARISON OF METHODS BY A MULTIPLE RANGE TEST
AND COEFFICIENTS OF VARIATION

	Coeff. of Variation	Mean Yield			Coeff. of Variation	Mean Yield	
<u>Group 1</u>				<u>Group 4</u>			
Sweep	55.09	225	a	Sweep	74.94	30	b
Vac-Sw	152.88	5	b	Vac-Sw	55.31	95	a
Vacuum	58.68	3	b	Vacuum	28.88	50	b
<u>Group 2</u>				<u>Group 5</u>			
Sweep	11.28	134	a	Sweep	41.40	175	b
Vac-Sw	12.38	126	a	Vac-Sw	32.44	299	a
Vacuum	47.40	41	b	Vacuum	21.15	127	b
<u>Group 3</u>				<u>Total Yield</u>			
Sweep	15.07	9	b	Sweep	42.02	674	b
Vac-Sw	38.53	313	a	Vac-Sw	38.50	957	a
Vacuum	97.90	74	b	Vacuum	42.23	385	c

Mean yield values represent mean total yield per day.

Any two means with a common letter are not significantly different.

Group 1	Acrididae
Group 2	Miridae, Nabidae and Pentatomidae
Group 3	Diptera and Chalcidoidea
Group 4	Coleoptera and Formicidae
Group 5	Cercopidae and Cicadellidae

Variability of yields, using the above mentioned methods, was compared by the use of the coefficient of variation. The results of

these calculations are presented in Table 2. Simpson et al. (1960) state that correct interpretation of coefficients of variation is facilitated by experience in the area to which they are applied. For this reason, it would seem presumptuous to use the values of Table 2 in anything but a comparative sense.

DISCUSSION

Figures 5 to 10 indicate that certain marked trends in daily yield are evident. Mean total yields exhibit a pattern of higher yields at early and late sampling periods, and it appears that various weather factors are of major importance in determining these patterns. While no controlled experimental data are available, the author re-recorded observations of activity at different periods. These observations are contained in the following discussions.

Hughes (1955) and DeLong (1932) state that weather factors play an important role in determining sweep net yield. The weather factors affecting the daily mean yields in this study appear to be temperature and radiant energy. The role of radiant energy appears to be especially significant in the period immediately following sunrise, and just prior to sunset. In both of these periods, temperatures have not changed greatly from those in the preceeding hour. The appearance or disappearance of radiant energy, however, seems to have a marked effect on sample yields. Since insects are poikilothermic, one could expect them to be less active early in the morning, or late in the day. A decrease in activity seems to express itself in higher mean yields in sampling.

During the time at which samples were taken, observations of insect flight were made. The size and abundance of Acrididae made this group the easiest to observe. It appeared, throughout the summer, that the amount of insect flight was definitely reduced at 6:30 AM and

incidences of grasshopper flight were indeed rare. Furthermore, on certain occasions, numbers of grasshoppers and leafhoppers were observed near the top of the plant at 6:30 AM. The reduced activity of Acrididae resulted in little or no migration from the sampling plot while sampling was in progress. Also, reduced activity might well have prevented escape from the sampling devices. A combination of the above factors were probably of major importance in determining yields of Acrididae during the early morning hours.

Other factors might also be of importance. For example, Hughes (1955) mentions that humidity had some effect on the behavior of Chloropid flies. However, the scope of this study did not permit intensive observations on factors other than those already mentioned.

It is quite probable that different species within a genus or family, would react in a dissimilar manner to different combinations of weather factors. Some indications of differential response are seen in Figures 6, 7, and 8. In these cases, different families exhibit varying patterns of mean daily yield, although no definite conclusions can be drawn here because of the relatively gross taxa employed in these comparisons.

In light of the data presented above, it would seem advisable to avoid sampling at early or late hours, if the resulting data are to be used in a comparative study. On the other hand, if a faunistic study of an area is being contemplated, early morning sampling would provide a greater number of insects, and subsequently, a better representation of the taxa present.

On the basis of the Multiple Range analyses, it appears that the vacuum-sweep method is superior to the other methods used. Mean

yields of groups 3, 4, and 5, as well as total yield, are significantly larger than for either sweeping or standard vacuum sampling. This method is not the best for all insects, however, as the data from grasshoppers and Hemiptera indicates. Of particular interest is the data from grasshopper yields. In this group, the sweep yields are substantially larger than those using either of the vacuum techniques. Observations made in the field indicate that this may be due to the ability of grasshoppers to jump, or walk, out of the sampling bag, even when the engine is running. Another factor which could account for a portion of this difference in yield is the relative speed at which the sampling devices move through the vegetation. The sweep net, being the most rapid, would be more likely to capture the insects before they could escape from the path of the net. The engine noise from the vacuum sampler may also contribute to lower vacuum yields, but this is, at best, speculation.

No significant differences between sweep and vacuum-sweep yields were ascertained for group 2 (Miridae etc.). On several occasions, however, larger specimens of Pentatomidae and Coreidae were observed to walk out of the vacuum sampler. While this is not reflected in the yield comparisons in this group, it does provide further evidence to explain the lack of larger arthropods in vacuum samples.

The vacuum sampler, perhaps unfortunately, does not appear to provide as complete data on the total arthropod fauna as was hoped. As mentioned above, certain groups are poorly represented in the samples. For many taxa, however, vacuum-sweeping seems to be a superior method. Cercopidae, Cicadellidae, and acalypterate Diptera for example, were found to be especially amenable to this type of

sampling. If a sampling program for any of these taxa was contemplated, vacuum-sweeping would seem to be a worthwhile method. However, if one is interested in a program of sampling the entire arthropod fauna of an area, certain adjustments seem desirable. For example, both vacuum-sweeping and a sweep net could be used. Theoretically, the use of both methods would provide a more representative sample, than either would if used alone.

The analyses discussed previously indicate that the standard vacuum yields are significantly lower than the other 2 methods. One should not conclude, however, that this method is inherently inferior. The number of standard vacuum samples was arbitrarily chosen at one per plot. Therefore, the consistently lower yields may well be due to sampling of a smaller area, rather than to deficiencies in the method.

As Figures 5 to 10 indicate, mean standard vacuum yields are not as subject to daily variations as the other 2 methods appear to be. This is apparently due to the ability of the sampler to capture arthropods with little regard to their vertical stratification on the plant surfaces. As with the vacuum-sweep, however, few of the larger forms are represented in samples. This would seem to negate the use of only the standard vacuum in a program designed to sample the entire arthropod fauna of an area.

The time at which samples are to be taken is of importance. According to the results of the Multiple Range tests, time of sampling has a significant relationship in only two groups. However, as Figures 5 to 10 indicate, some distinct trends of daily yields appear evident. It would seem to be a mistake to ignore these trends. Generally speaking, however, if very early or very late sampling times

are avoided, the effect of time of sampling would be reduced. Perhaps the ideal solution would be to sample only at one specific time of the day, something that would not be feasible in a large scale program.

The results of method comparisons by the Multiple Range analyses, as well as the coefficients of variation, are presented in Table 2. These results could be used in conjunction, when selecting a sampling method for a similar area. While greater mean yields may be of primary importance, the variability inherent in the use of a method should also be considered.

SUMMARY

The primary objective of this study was to evaluate the potentialities of a vacuum sampling device in future arthropod sampling programs. The effect of time of sampling on sample yield was also investigated.

To accomplish the above objectives, 2 vacuum sampling methods and conventional sweep net sampling were tested in an old field situation.

Analysis of the sampling data indicates that the mean yields of samples taken at different times of the day are significantly different in relatively few cases. Figures 5 to 10 indicate that certain, statistically non-significant trends in mean yields are also evident. It would hardly be wise to ignore these trends, however, even if no significant differences were calculated. Samples taken at sunrise and noon would undoubtedly yield differences in numbers present, as well as in species composition. Data from such samples could lead to erroneous assumptions, especially if these data were to be used in a comparative study.

On the basis of these findings, it would seem desirable to avoid sampling at early or late hours. Sampling should not commence any earlier than 1-1/2 to 2 hours after sunrise, and should cease approximately 1-1/2 to 2 hours prior to sunset.

Results from the comparison of the 3 methods used indicate that no single method was capable of sampling the entire arthropod fauna of

the area. In Table 2 a series of significant differences between mean yields for each method are presented. The data presented in this figure could be used to select sampling methods for a specific group. If a sampling program is contemplated which includes the entire arthropod fauna, however, it seems advisable to select 2 methods. Theoretically, at least, this would provide a more representative.

The significant differences between methods can be partially explained. Some differences may be due to the fact that certain larger specimens were observed to be able to walk, or jump, out of the sampler. It is also likely that some of the differences between standard vacuuming, and the other 2 methods, may be due to the arbitrarily low number of samples taken per plot.

These data seem to confirm the theory that standard vacuum yields are at least partially independent of the stratification of the arthropods on the plant surface. This is reflected in the comparative lack of variation between yields at different sampling periods, using the standard vacuum method.

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APPENDIX I

SUMMARY OF ARTHROPODS COLLECTED

The total numbers and taxa of arthropods collected during the summer of 1963 are presented in this appendix. The lists are subdivided according to date, time and method of sampling.

7/2/63

	6:30 AM		9:30		12:30		3:30		6:30 PM		Total	
	V	S	V	S	V	S	V	S	V	S	V	S
Acarina	22	2	-	-	-	-	2	2	4	2	28	6
Araneida	7	-	4	8	6	5	9	2	5	-	31	15
Isopoda	9	-	-	-	-	-	-	-	-	-	9	-
Phalangida	-	-	-	1	-	1	1	-	-	-	1	2
Coleoptera	-	-	-	-	-	-	-	-	-	-	-	-
Chrysomelidae	-	4	1	2	-	-	-	-	-	1	1	7
Curculionidae	2	5	2	-	-	-	-	2	4	2	8	9
Lathridiidae	2	-	-	-	2	2	-	4	-	1	4	7
Mordellidae	2	-	2	-	-	-	-	-	-	-	4	-
Phalacridae	2	-	2	-	-	-	-	-	-	-	4	-
Collembola	-	-	-	-	-	-	-	-	-	-	4	-
Entomobryidae	18	-	-	-	-	-	6	-	14	-	38	-
Poduridae	4	-	-	-	-	-	2	-	14	-	20	-
Diptera	-	-	-	-	-	-	-	-	-	-	-	-
Cecidomyiidae	-	-	4	2	2	2	-	-	-	-	6	4
Chloropidae	14	4	8	2	2	2	-	4	4	-	28	12
Lauxaniidae	-	-	-	2	-	-	-	2	2	-	2	4
Lonchopteridae	-	2	-	-	-	-	-	-	-	-	-	2
Muscoidea	-	1	-	1	-	-	-	-	-	3	-	5
Mycetophilidae	-	-	-	-	-	-	-	-	4	-	4	-
Ochthiphilidae	2	-	2	-	2	-	-	-	-	-	6	-
Syrphidae	-	1	-	1	-	-	1	-	1	1	2	3
Hemiptera	-	-	-	-	-	-	-	-	-	-	-	-
Miridae	-	4	5	6	-	7	4	5	1	2	10	24
Nabidae	-	4	3	9	1	6	-	2	2	2	6	23
Pentatomidae	-	-	-	2	1	3	-	2	-	1	1	8
Reduviidae	-	1	-	-	-	-	-	1	-	1	-	3

7/3/63

	6:30 AM		9:30		12:30		3:30		6:30 PM		Total	
	V	S	V	S	V	S	V	S	V	S	V	S
Acarina	2	-	4	-	-	-	2	-	1	-	9	-
Araneida	2	2	4	2	-	6	-	-	5	-	11	14
Phalangida	-	-	3	1	-	-	1	-	-	-	4	1
Coleoptera												
Chrysomelidae	2	1	-	1	-	1	-	-	-	3	2	6
Curculionidae	2	-	4	-	2	-	-	-	-	-	8	2
Coccinellidae	-	-	-	-	-	-	-	-	-	-	-	2
Collembola												
Entomobryidae	-	-	-	-	-	-	-	-	8	-	8	-
Poduridae	4	-	-	-	-	-	-	-	2	-	6	-
Diptera												
Chloropidae	6	2	-	2	2	2	2	-	-	2	10	8
Muscoidea	1	2	2	-	-	-	-	-	1	-	4	2
Ochthiphilidae	-	-	-	2	-	-	-	3	-	4	-	9
Sciomyzidae	-	-	1	-	-	-	-	-	-	-	1	-
Syrphidae	-	6	-	5	-	-	1	3	-	6	1	20
Hemiptera												
Anthocoridae	-	-	-	-	-	-	-	2	-	-	-	2
Coreidae	-	-	-	-	-	-	-	1	-	-	-	1
Miridae	1	5	2	10	6	6	2	9	2	9	13	39
Nabidae	4	6	2	-	-	-	-	2	3	4	9	12
Pentatomidae	-	3	-	1	-	-	-	-	-	2	-	6
Reduviidae	-	1	-	-	-	-	1	-	-	1	1	2
Homoptera												
Aphididae	-	6	-	-	-	-	-	-	-	-	-	6
Cercopidae	6	26	8	14	11	17	-	10	1	26	26	93
Cicadellidae	84	89	100	78	60	59	87	30	61	109	492	365

[illegible]

7/5/63

	6:30 AM		9:30		12:30		3:30		6:30 PM		Total	
	V	S	V	S	V	S	V	S	V	S	V	S
Acarina	4	10	10	-	4	4	2	4	2	-	22	18
Araneida	8	12	8	1	7	6	2	2	-	-	25	21
Phalangida	-	-	-	-	1	2	-	-	-	-	1	2
Coleoptera	-	1	-	-	-	3	-	-	-	-	-	4
Chrysomelidae	2	8	-	2	-	-	-	-	-	-	2	10
Curculionidae	2	-	-	-	4	-	-	-	-	-	6	-
Lathridiidae	-	-	-	-	-	-	-	2	-	-	-	2
Nitidulidae	-	-	-	-	-	-	2	-	-	-	2	-
Phalacridae	-	-	-	-	-	-	-	-	-	-	2	-
Collembola	-	-	-	-	-	-	-	-	-	-	-	-
Entomobryidae	14	-	8	-	6	-	10	-	-	-	38	-
Poduridae	14	-	8	-	-	-	14	-	-	-	36	-
Diptera	-	-	-	-	-	-	-	-	-	-	-	-
Chloropidae	6	2	8	-	-	2	6	2	8	-	28	6
Lonchopteridae	-	-	-	-	-	-	-	2	-	2	-	4
Muscoidea	1	4	-	-	-	-	-	1	-	-	1	5
Mycetophilidae	-	2	-	-	-	2	-	-	-	2	-	6
Ochthiphilidae	4	1	4	-	8	-	2	2	-	4	18	7
Phoridae	-	-	-	-	4	-	-	-	-	4	4	4
Syrphidae	-	5	-	2	-	-	-	4	-	2	-	13
Trypetidae	-	2	-	-	-	-	-	-	-	2	-	4
Hemiptera	-	-	-	-	-	-	-	-	-	-	-	-
Anthocoridae	-	-	-	-	-	-	-	-	-	2	-	2
Miridae	1	2	-	5	2	6	-	5	2	5	5	23
Nabidae	1	4	1	3	2	-	2	4	1	4	7	15
Pentatomidae	-	3	-	2	-	2	-	3	-	-	-	10
Reduviidae	-	-	-	-	1	2	1	-	-	-	2	2
Scutellaridae	-	-	-	1	-	-	-	-	-	-	-	1

7/16/63

	6:30 AM			9:30			12:30			3:30			6:30 PM			Total		
	V	S		V	S		V	S		V	S		V	S		V	S	
Acarina	12	-		-	-		2				4		-			12		6
Araneida	2	6		8	2		4				4		4			10		20
Isopoda	3	-		-	-		-				-		-			3		-
Coleoptera	-	-		-	-		-				-		-			-		-
Chrysomelidae	-	-		-	-		-				-		1			-		1
Curculionidae	2	10		2	4		-				3		2			4		19
Mordellidae	-	-		-	2		-				-		-			-		2
Nitidulidae	-	-		-	2		2				4		-			-		8
Phalacridae	-	6		2	6		-				4		4			2		20
Staphylinidae	2	-		6	-		-				-		-			8		-
Collembola																		
Entomobryidae	6	-		16	-		-				10		-			22		10
Poduridae	20	-		58	-		-				-		-			78		-
Diptera																		
Cecidomyiidae	-	-		4	-		-				-		-			4		-
Chloropidae	2	4		4	4		-				-		4			6		12
Mycetophilidae	-	-		2	-		-				2		-			2		2
Ochthiphilidae	8	1		3	1		2				-		4			11		8
Phoridae	-	-		2	-		-				4		-			2		4
Syrphidae	1	1		-	2		2				-		-			1		5
Trypetidae	-	-		-	2		-				-		-			-		2
Hemiptera																		
Anthocoridae	-	6		2	2		4				-		-			2		12
Coreidae	-	-		-	1		4				2		-			-		7
Miridae	6	1		-	2		12				3		10			6		28
Nabidae	3	12		-	6		4				3		6			3		31
Pentatomidae	-	1		-	-		4				2		-			-		7
Reduviidae	-	-		-	2		-				-		1			-		3

[illegible]

Note: Due to a mechanical failure, no vacuum samples were taken at 12:30, 3:30 and 6:30 PM.

7/21/63

	6:30 AM		9:30		12:30		3:30		6:30 PM		Total	
	V	S	V	S	V	S	V	S	V	S	V	S
Acarina	36	-	30	-	-	-	4	-	18	2	118	2
Araneida	17	6	4	8	1	2	10	9	12	-	44	25
Isopoda	6	2	8	-	-	1	4	-	2	-		
Coleoptera												
Chrysomelidae	1	-	-	-	-	-	-	2	-	-	1	2
Curculionidae	-	4	2	12	2	1	-	4	-	2	4	23
Lathridiidae	-	2	4	-	-	-	-	4	-	2	4	8
Mordellidae	-	4	-	2	-	-	2	-	-	2	2	8
Nitidulidae	-	-	-	-	-	-	2	2	-	-	2	2
Phalacridae	8	-	-	-	-	-	2	-	8	-	18	-
Staphylinidae	4	-	2	-	-	-	-	-	6	2	12	2
Collembola												
Entomobryidae	70	-	20	-	-	-	16	-	90	-	196	-
Poduridae	90	-	58	-	-	-	66	-	138	-	352	-
Diptera												
Agromyzidae	-	-	-	-	-	-	-	-	-	3	-	3
Calliphoridae	1	-	-	-	-	-	-	-	-	-	1	-
Cecidomyiidae	2	-	4	-	2	-	4	-	10	2	22	2
Chloropidae	6	2	6	-	-	-	6	4	10	-	28	6
Muscoidea	-	-	-	-	2	-	-	1	-	-	2	1
Mycetophilidae	2	-	4	-	2	-	2	-	-	-	10	-
Ochthipphilidae	2	-	-	-	2	2	2	2	8	3	14	7
Phoridae	2	-	-	-	-	-	-	2	-	2	2	4
Sciomyzidae	2	1	-	-	-	1	-	-	-	-	2	2
Syrphidae	-	-	-	-	-	-	-	1	-	1	-	2
Trypetidae	-	-	-	-	-	-	2	-	-	-	2	-
Hemiptera												
Anthocoridae	-	-	4	-	-	-	2	2	-	-	6	2
Coreidae	-	1	-	-	-	3	-	-	-	-	-	4

Miridae	5	9	13	11	2	11	17	23	6	9	43	63
Nabidae	1	2	6	5	2	5	5	4	6	5	20	21
Pentatomidae	-	2	-	3	1	1	-	-	-	1	1	7
Reduviidae	2	-	1	1	1	1	-	-	1	-	5	2
Scutellaridae	-	-	-	-	-	-	-	-	-	1	-	1
Homoptera												
Aphididae	-	2	-	-	-	-	-	6	4	-	4	8
Cercopidae	3	29	7	10	7	7	3	27	8	27	28	81
Cicadellidae	42	229	37	84	35	24	45	136	51	92	210	565
Fulgoridae	-	1	-	-	-	-	-	-	-	-	-	1
Hymenoptera												
Braconidae	4	1	-	-	-	-	2	-	2	-	8	1
Chalcidoidea	-	2	13	-	-	-	8	-	4	-	25	2
Formicidae	15	20	16	4	-	2	6	5	10	22	47	53
Halictidae	-	-	-	2	-	1	-	1	-	-	-	4
Lepidoptera												
Adults	-	-	-	-	-	-	-	2	-	-	-	2
Immatures	-	7	2	2	-	-	2	3	-	6	4	18
Odonata												4
Lestidae	-	-	-	-	-	-	-	-	-	1	-	1
Orthoptera												
Acrididae	2	72	2	24	-	25	-	119	2	46	6	286
Gryllidae	2	-	1	1	2	-	3	1	6	3	14	5
Tettigonidae	-	-	-	-	-	-	-	-	-	1	-	1
Thysanoptera												
Phloeothripidae	6	-	4	-	2	-	-	4	2	-	14	4
Thripidae	-	-	4	-	-	2	4	-	4	-	12	2
Totals	314	301	252	168	62	91	219	367	408	238		

8/2/63

	6:30 AM						9:30						12:30						3:30						6:30 PM						Total											
	V			VS			V			VS			V			VS			V			VS			V			VS			V			VS			V			VS		
	S			S			S			S			S			S			S			S			S			S			S			S								
Acarina	104	-	8	-	-	16	-	-	-	-	-	-	-	2	-	2	18	-	8	130	-	18	-	8	130	-	18	-	-	-	-	-	-	-	-	-	-					
Araneida	14	9	24	7	5	7	-	-	-	-	-	9	6	25	3	9	9	6	25	64	29	64	-	6	25	64	29	64	-	-	-	-	-	-	-	-	-					
Isopoda	7	-	2	3	-	3	-	-	-	-	-	2	-	5	-	-	5	-	-	22	-	2	-	-	22	-	2	-	-	-	-	-	-	-	-	-	-					
Phalangida	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	3	-	1	5	1	1	-	-	1	5	1	1	-	-	-	-	-	-	-	-	-					
Coleoptera	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Chrysomelidae	4	-	-	1	2	4	-	-	-	-	-	-	-	2	2	-	-	-	-	7	5	-	-	-	-	7	5	-	-	-	-	-	-	-	-	-	-					
Curculionidae	-	-	14	4	-	4	-	4	-	6	-	6	2	-	-	6	2	-	14	12	-	44	-	-	14	12	-	44	-	-	-	-	-	-	-	-	-					
Lathridiidae	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Meloidae	-	-	-	-	-	-	-	-	-	6	-	6	-	-	4	2	2	-	4	2	4	12	-	-	4	2	4	12	-	-	-	-	-	-	-	-	-					
Mordellidae	-	-	-	-	-	-	-	-	-	2	-	2	-	4	-	-	-	-	-	4	-	2	-	-	-	4	-	2	-	-	-	-	-	-	-	-	-					
Phalacridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Staphylinidae	4	-	-	-	-	-	-	-	-	-	-	2	-	4	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Collembola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Entomobryidae	52	-	114	36	-	10	-	10	10	-	-	-	10	36	-	32	12	-	16	146	-	172	-	-	16	146	-	172	-	-	-	-	-	-	-	-	-					
Poduridae	86	-	772	60	-	60	-	2	4	-	-	-	4	68	-	36	28	-	80	246	-	890	-	-	80	246	-	890	-	-	-	-	-	-	-	-	-	-				
Diptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Cecidomyiidae	8	3	32	18	-	24	-	24	12	-	20	-	12	-	-	2	38	4	-	24	42	5	138	-	-	24	42	5	138	-	-	-	-	-	-	-	-					
Chloropidae	4	2	14	6	-	6	-	12	10	-	16	-	10	14	-	-	30	8	-	22	42	2	94	-	-	22	42	2	94	-	-	-	-	-	-	-	-					
Dolichopodidae	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Lonchopteridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Mycetophilidae	-	-	2	-	-	4	-	4	-	2	2	-	-	-	-	-	4	4	-	4	4	-	16	-	-	4	4	-	16	-	-	-	-	-	-	-	-					
Muscoidea	-	-	4	1	1	1	-	2	-	2	2	-	-	-	-	3	-	-	1	8	4	6	-	-	-	-	1	8	4	6	-	-	-	-	-	-	-					
Ochthiphilidae	4	4	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2	4	-	-	8	4	6	-	-	-	-	8	4	6	-	-	-	-	-	-	-					
Phoridae	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Syrphidae	-	2	-	-	3	2	-	2	-	2	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Tachinidae	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	2	-	1	1	1	3	-	-	-	1	1	1	3	-	-	-	-	-	-	-	-					
Tipulidae	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					

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	V	S	VS	V	S	VS	V	S	VS	V	S	VS	V	S	VS	V	S	VS
Acarina	2	-	88	2	-	2	-	-	-	-	-	8	2	-	4	6	-	102
Araneida	10	8	6	14	6	5	4	5	6	4	1	2	3	6	13	35	26	32
Isopoda	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	1	-
Coleoptera	-	1	2	-	1	-	-	2	-	-	-	-	-	2	-	-	6	2
Chrysomelidae	2	4	-	-	2	8	-	-	-	-	-	-	-	-	-	2	6	8
Curculionidae	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Coccinellidae	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-
Cantharidae	-	-	-	-	-	-	-	2	-	4	-	6	-	-	26	10	-	62
Carabidae	-	-	22	4	-	8	2	-	10	-	-	-	-	-	-	2	-	16
Lathridiidae	2	-	-	-	2	6	-	-	-	-	-	-	-	2	-	-	4	-
Mordellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitidulidae	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	4	-	6
Phalacridae	-	-	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Collembola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Entomobryidae	36	-	96	-	-	-	-	-	-	-	-	-	-	-	24	36	-	120
Poduridae	12	-	370	-	-	-	-	-	-	-	-	-	-	-	102	12	-	472
Diptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cecidomyiidae	4	-	32	2	-	26	4	-	10	4	-	4	2	-	30	16	-	102
Chloropidae	6	4	36	2	1	12	2	-	12	10	-	12	2	-	10	22	5	82
Mycetophilidae	8	-	-	-	-	2	-	-	-	-	-	4	-	-	-	8	-	6
Muscoidea	-	5	1	-	-	-	-	1	-	-	1	-	-	3	-	-	10	1
Ochthiphilidae	2	-	-	-	-	2	1	-	-	-	1	4	-	2	-	3	3	6
Otitidae	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Phoridae	-	-	-	-	-	14	-	-	-	-	-	2	-	-	4	-	-	20
Pipunculidae	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	-
Syrphidae	-	2	-	-	-	-	-	-	-	-	-	1	-	1	-	-	3	1
Tachinidae	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

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	V	S	VS	V	S	VS	V	S	VS	V	S	VS	V	S	VS	V	S	VS
Acarina	14	-	33	42	-	12	-	-	-	10	-	-	14	-	-	80	-	45
Araneida	6	7	12	13	3	3	7	5	4	17	5	4	13	8	3	56	28	26
Isopoda	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Phalangida	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Coleoptera	-	-	12	2	2	-	6	-	5	2	1	-	4	-	-	14	3	17
Chrysomelidae	-	-	6	4	2	-	-	-	-	-	-	-	-	-	1	4	2	7
Curculionidae	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
Carabidae	4	-	4	-	-	-	-	-	-	-	-	-	-	-	-	4	-	4
Lathridiidae	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Meloidae	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	4	-	2
Nitidulidae	4	2	6	-	-	-	-	-	-	2	-	-	-	2	-	6	4	6
Staphylinidae	24	-	52	6	2	-	8	6	-	22	-	-	24	-	2	84	8	54
Collembola	64	-	66	14	6	-	32	8	-	6	-	70	132	-	850	248	14	986
Entomobryidae	-	-	32	6	-	6	4	2	10	6	-	2	-	-	-	16	2	50
Poduridae	-	-	10	-	2	-	-	-	-	4	-	8	-	-	4	6	4	22
Diptera	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-
Cecidomyiidae	2	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Chloropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichopodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lonchopteridae	-	-	6	-	-	4	2	-	8	2	2	6	-	-	2	4	2	26
Mycetophilidae	1	2	8	1	-	-	-	1	-	-	2	1	-	3	-	2	8	9
Muscoidea	4	-	6	-	-	6	-	3	16	-	-	-	-	-	2	4	3	30
Ochthipphilidae	-	-	-	-	-	-	2	2	6	-	-	-	-	-	2	2	2	8
Phoridae	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Pipunculidae	-	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	4
Scatopsidae	-	-	4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	7
Syrphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Trypetidae	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
Tachinidae	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

MICHIGAN STATE UNIVERSITY LIBRARIES



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