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THE EFFECT OF DIEL PERIODICITY ON SAMPLING GRASSLAND INSECT POPULATIONS

By

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GRASSLAND BIOME

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ABSTRACT

This study was done to determine the best sampling schedule for grassland insects in relation to various abiotic factors. The study site was Pantex, near Amarillo, Texas. Temperature was found to be the most important factor in construction of a sampling schedule followed by wind velocity and relative humidity in that order. Determination of the "best" time(s) for sampling grassland insects during different months (June, July, August, October, November) are presented in this study.

INTRODUCTION

For many years man has made comparatively little effort towards understanding the balance of nature within the grassland ecosystem. It was not for lack of desire but rather because of limitations imposed by finances, manpower, and technology.

Through the planning and direction of Dr. George Van Dyne of Colorado State University, the Grassland Biome Project of the United States International Biological Program (US/IBP) was conceived.

The problems of manpower and financial support were soon overcome, but the inherent problems of new tasks and new technology had just begun.

Briefly, the US/IBP Grassland Biome headquarters was established at the Pawnee Site near Fort Collins, Colorado. This site was designated as an intensive study site and coordinating nucleus for six satellite study areas designated as Comprehensive Network Sites.

Obviously, the first step in the program was to develop an efficient method of trapping the various types of insects associated with a particular grassland site.

The problem of time then became a factor. It was suspected that some species of insects would be more plentiful in samples taken at a certain time of the day, which led to the initiation of this study.

This study was designed to provide data needed in the refinement of sampling methods at the Pantex Site.

It was anticipated that the data obtained and the methods of statistical analysis used would assist in the improvement of sampling methods used by workers at the five other Comprehensive Network Sites and at the Intensive (Pawnee) Site near Fort Collins, Colorado.

Purpose and Scope

Since the initiation of the US/IBP Grassland Biome study, much interest has focused on the structure and function of the insect populations within the grassland ecosystem.

This report is concerned with studies initiated and executed at the Pantex Site, near Amarillo, Texas, which is one of the six comprehensive study sites of the Grassland Biome.

As standardization of techniques was a critical point both within and among the Comprehensive Network Sites, this study was initiated to determine which hours of the day would be optimal for sampling to obtain the best estimate of grassland insect populations, based on both numbers of insects and numbers of species of insects trapped.

Obviously, the number of variables involved in a study such as this is tremendous, and therefore restrictions had to be placed on the factors analyzed in this study. Those considered to be of major significance were the following:

A. Numbers of insects

B. Numbers of insect species

C. Time of year

D. Time of day

E. Temperature

F. Wind velocity

G. Relative humidity

This experiment was designed specifically to test the following null hypotheses:

A. The time of day at which samples are taken will not affect the number of insects in the samples.

B. The time of day at which samples are taken will not affect the numbers of species of insects in the samples.

C. There is no interaction between the time of day and the time of year in the numbers of species of insects in the samples.

D. There is no interaction between the time of day and the time of year in the numbers of species of insects in the samples.

E. Changes in temperature, during a 24-hr period, do not affect the numbers of insects in the samples.

F. Changes in temperature, during a 24-hr period, do not affect the numbers of species of insects in the samples.

G. Changes in relative humidity, during a 24-hr period, do not affect the numbers of insects in the samples.

H. Changes in relative humidity, during a 24-hr period, do not affect the numbers of species of insects in the samples.

I. Changes in wind velocity, during a 24-hr period, do not affect the numbers of insects in the samples.

J. Changes in wind velocity, during a 24-hr period, do not affect the numbers of insect species in the samples.

K. Variation in the numbers of insects per sample at one sampling date or for all dates combined is due to random experimental error and is not explained by linear regression.

L. There are no changes in the species found at the various sampling dates.

M. Stepwise removal of the first, second, and third most numerous groups of insects will not affect the relationship of the numbers of insects found in a sample and the time of day at which the sample was taken.

Review of Previous Research

Increased efficiency as it pertains to productivity of grasslands has long been of interest to farmers, to ranchers, and to conservationists throughout the world.

Only recently, with the initiation of the US/IBP Grassland Biome Program, has there been an intensive study of all the various compartments within this system.

Insects are important components of many systems, especially those which involve agricultural practices; however, the basic structure of the overall insect populations within a grassland is usually assumed to be much more complex than that of a monocultural system and therefore presents problems which are unique.

Optimal times of day, based on activity of the organism, have been established for collecting certain groups of insects and other arthropods, using specific types of traps. This has been demonstrated many times, i.e., noctuids (Williams 1936); Hemiptera (Williams 1936); *Ptinus tectus* Boie. (Bentley et al. 1941); earwigs (Chant and McLeod 1952); tenebrionids (Cloudsley-Thompson 1953); Chloropidae (Hughes 1955); Heteroptera (Southwood 1960); various groups (Lewis and Taylor 1964); Neuroptera; spiders (Lowrie 1971).

Williams (1940) stated, "the number of insects caught at any particular time is mainly determined by two factors, that is, the activity of the insect and the total population available for sampling." However, one must consider the fact that light traps were the primary source of the data used to arrive at these conclusions and therefore biased the data in favor of insects physically attracted to light and insects which were flying at the time of sampling. It is doubtful that a sample procurred from a light trap, as compared to the quick-trap, would yield as complete an estimate of the total insect population present.

Southwood (1960), using both a light trap and a suction trap, demonstrated the selective abilities of each to capture certain types of insects.

In view of the fact that a method greatly different from the classical light trap and other traps using an attractant was used in this study, it would seem, at first glance, fruitless to compare the data. However, it seemed reasonable to assume a relationship between the number of insects captured, regardless of the method employed, and the various factors discussed in this study, i.e., time of day, time of year, temperature, relative humidity, and wind velocity.

Uvarov (1931) did an extensive study on weather, climate, and insects and decided that air temperature was the single most important factor determining insect activity, although wind could also be important. With obvious exceptions, such as nocturnal insects, Uvarov (1931) implies that, on an average, midday would provide the most optimal conditions for insect activity, resulting in higher catches. Again, it must be remembered that light traps, sweepnets, and direct observations were used to obtain these data.

Uvarov (1931) quoting Cook (1921) on the study of the influence of the main weather factors involved in moth flight stated that the relative humidity of the air is the main factor and that any increase in relative humidity up to about 54% resulted in an increase in the number of captured moths, but an increase beyond that resulted in a decrease in the number caught.

Uvarov (1931) stated that the results obtained could possibly be explained by the indirect influence of both wind velocity and temperature, since the activity of some insects increases with a decrease in wind velocity, and absolute humidity and the activity of many insects both increase with temperature.

Williams (1940) stated that the conclusions drawn from the study of any individual weather factor may be, and often are, deceiving due to the close correlation between many of the weather factors themselves; his results indicate that days with high temperatures and nights with low wind velocity produce the highest numbers of insects in the traps.

Williams and Singh (1951) discussed the relationship between insect activity and moonlight, finding that cloudy nights and/or nights with little moonlight produced more insects in the trap than clear nights with bright moonlight, but also discussed the possible effect of normally warmer temperatures associated with cloudy nights.

Chant and McLeod (1952) conducted a study on the effect of climatic factors on earwig abundance and claim no significant correlation between earwig abundance and relative humidity, although correlations with wind velocity and temperature were significant.

Southwood (1960) found, while collecting various Heteroptera with a suction-trap, that the maximum daily temperature had a much greater effect on the number of insects captured than did the minimum daily temperature, and also that light-traps cause an increase in the number of insects flying in a given area, and therefore results in overestimates of populations.

Lewis and Taylor (1964), while studying various groups of Diptera, reported that during the summer months light was the important factor in increased activity, but in early spring and fall temperature became the most important factor.

Turnbull and Nicholls (1966) were acutely aware of the inadequacy of the various methods employed to collect insect data for population studies and therefore developed a trap called a "quick-trap." Tests were conducted using other types of traps, and it was determined that, while no single type of trap captured every species in a community, the "quick-trap" captured 80% plus, which was considerably more efficient than any other method tested.

A detailed description of the "quick-trap" and its use is given in Turnbull and Nicholls (1966), and data are presented supporting the statement that the "quick-trap" captured as many individuals as any other single method of trapping, and in most cases many more.

Turnbull and Nicholls (1966) stated, "The 'quick trap' coupled with a vacuum collector is the best way to census the whole arthropod population of a grassy field," and "It works best on relatively short grass, preferably not more than 8 inches high."

Site Description

The following data was condensed from Huddleston (1970). The Pantex Site is located 15 miles east of Amarillo, Texas, on U.S. 60. Approximate ground elevation is 3,590 ft. The area within the Pantex Site is characterized as shortgrass prairie with blue grama grass predominating. Prickly pear cactus is both numerous and important throughout the study area. Vegetative composition and productivity appear to be uniform throughout the sampling area used in this study, as well as surrounding areas.

Rainfall varies widely from year to year, with 70 to 80% of the annual total occurring between May and October as short, intensive thunderstorms. The average annual rainfall is approximately 21 inches, with a range of 10 inches in 1956 to 40 inches in 1923.

The main annual maximum temperature is 72°F; the mean annual minimum temperature is 42°F.

Topographically the Pantex Site is nearly a level plain, most land having less than a 4% slope. According to Weather Bureau records, the average wind velocity on a yearlong basis is 7.1 mph.

Soil on the study site is Pullman silty clay loam, classified as a reddish chestnut soil with a brown, compact, clayey subsoil which restricts water percolation. The sub-strata are permanently dry, and the soil is seldom wet for extensive periods of time.

METHODS AND PROCEDURES

Experimental Methods

Samples were taken at 2-hr intervals over a 24-hr period in each of five months (June, July, August, October, and November), using a "quick-trap" (Turnbull and Nicholls 1966) and D-Vac (Dietrick et al. 1959). Essentially, the D-Vac is nothing more than a highly modified vacuum cleaner with a fine-mesh bag in the hose in which insects and litter are collected. Six sample plots were randomly selected for each 2-hr period, and a "quick-trap" was then hand-thrown onto each plot.

Once the "quick-trap" was thrown, the D-Vac hose was inserted into the trap, and the enclosed area was thoroughly vacuumed. The insects and litter collected from each of the six traps was then returned to the laboratory and placed in modified Berlese funnels for a 2½-hr period.

The efficiency of the modified Berlese funnels was determined by handsorting the litter after removal from the funnel. Hand-sorting was accomplished by carefully scanning the litter under a dissecting microscope and counting any insects found, which proved to be time-consuming but rewarding in that an extraction rate of 90% plus was determined. All of the samples taken in June, July, and August were hand-sorted in this way, as well as randomly selected samples taken in October and November.

Infra-red heat bulbs (250 W) were used in the modified Berlese funnels and were wired in such a way that the voltage could be reduced from 110 volts to 55 volts, giving an option of two temperature regimes.

Low temperatures were used for the first 2 hr, allowing the more sensitive insects to be extracted; a high temperature was subsequently used for 30 min, allowing the less heat-sensitive insects to be extracted.

Once the extraction into 70% alcohol was completed, the jars of insects were removed from the funnels and examined with the aid of a dissecting microscope. Insects were counted and separated according to obvious taxa; skill varied from order to species, depending on the abilities of the operator. Insects that could not be identified to species were given a code number which corresponded to a particular species in a set of coded voucher specimens. When positive identification of each species has been made, it will be simply a matter of substituting names for code numbers. Labels for each species contained the date of capture, time of day collected, the replicate from which it was collected, and the numbers of individuals.

All specimens collected during these studies were placed in 70% ethyl alcohol and stored for future reference.

Experimental Design and Analysis

Sampling plot design involved six blocks of 100 plots each. Each sampling plot was approximately 9' × 9' (Fig. 1). At each of the 2-hr intervals, one plot from each of the six blocks was chosen from a random numbers table.

In order to test the first and second hypotheses (A and B), a simple two-way analysis of variance was used in conjunction with the Duncan's Multiple Range Test for comparison between means.

Hypotheses C and D were tested by means of a factorial analysis, while hypotheses E, F, G, H, I, J, and K were tested by means of either linear or polynomial multiple regression using a computer.

Hypotheses L and M were tested by means of graphs and visual observations.

FINDINGS AND INTERPRETATIONS

For the sake of continuity, each of the proposed null hypotheses is discussed in the order of initial presentation in the introduction to this paper.

Hypothesis A

The time of day at which samples are taken will not affect the number of insects in the samples.

Based on Fig. 2, one would tend to reject the null hypothesis. Peaks of insect abundance, for the most part, occur between 11:00 AM and 3:00 PM and between 10:00 PM and midnight.

Analysis of variance (Table 1) indicated that indeed there were significant differences in the number of insects in samples taken among the various time periods involved.

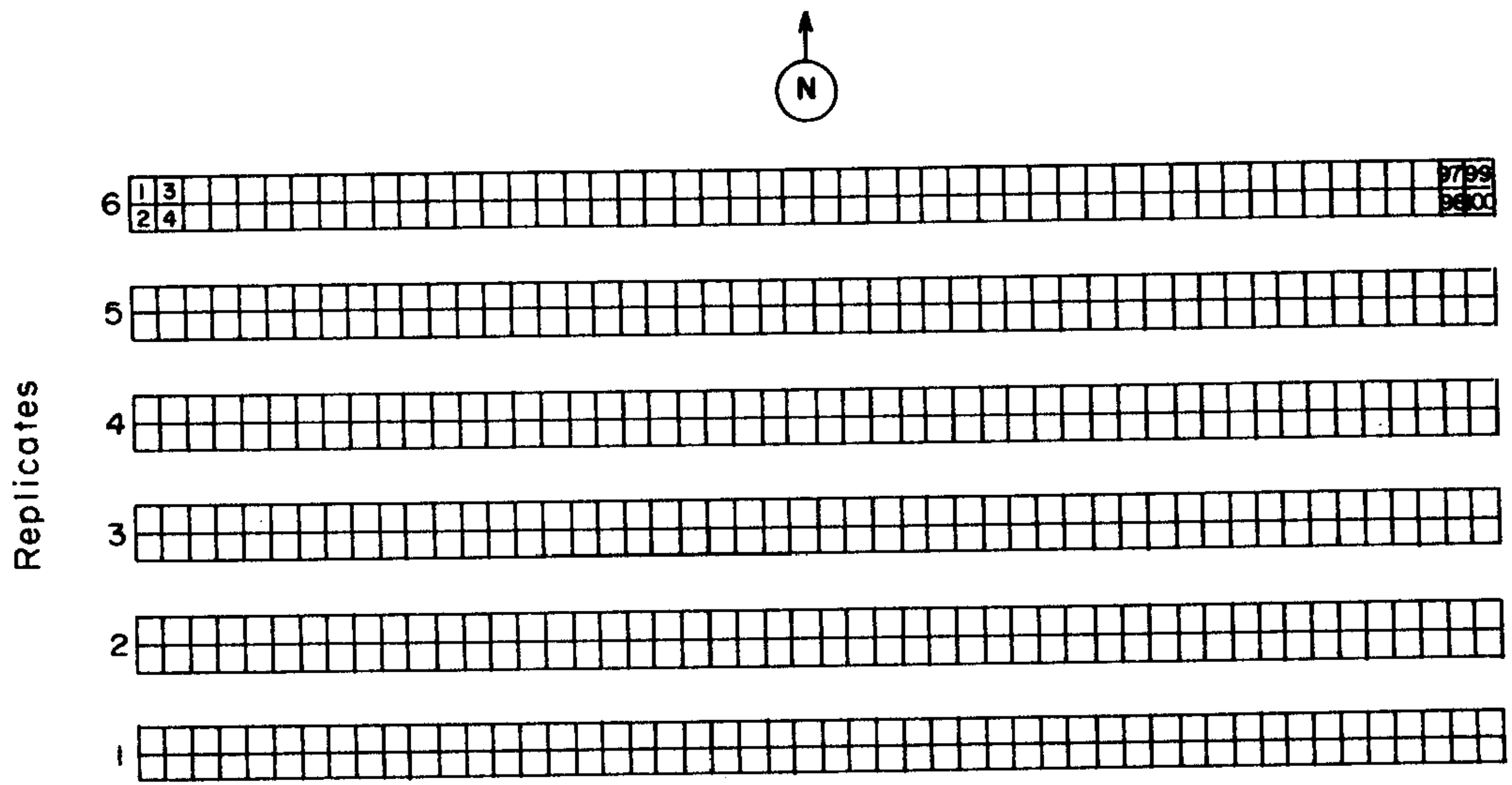

Fig. 1. Plot design, Pantex Site, 1971 (scale 1/8" = 9').

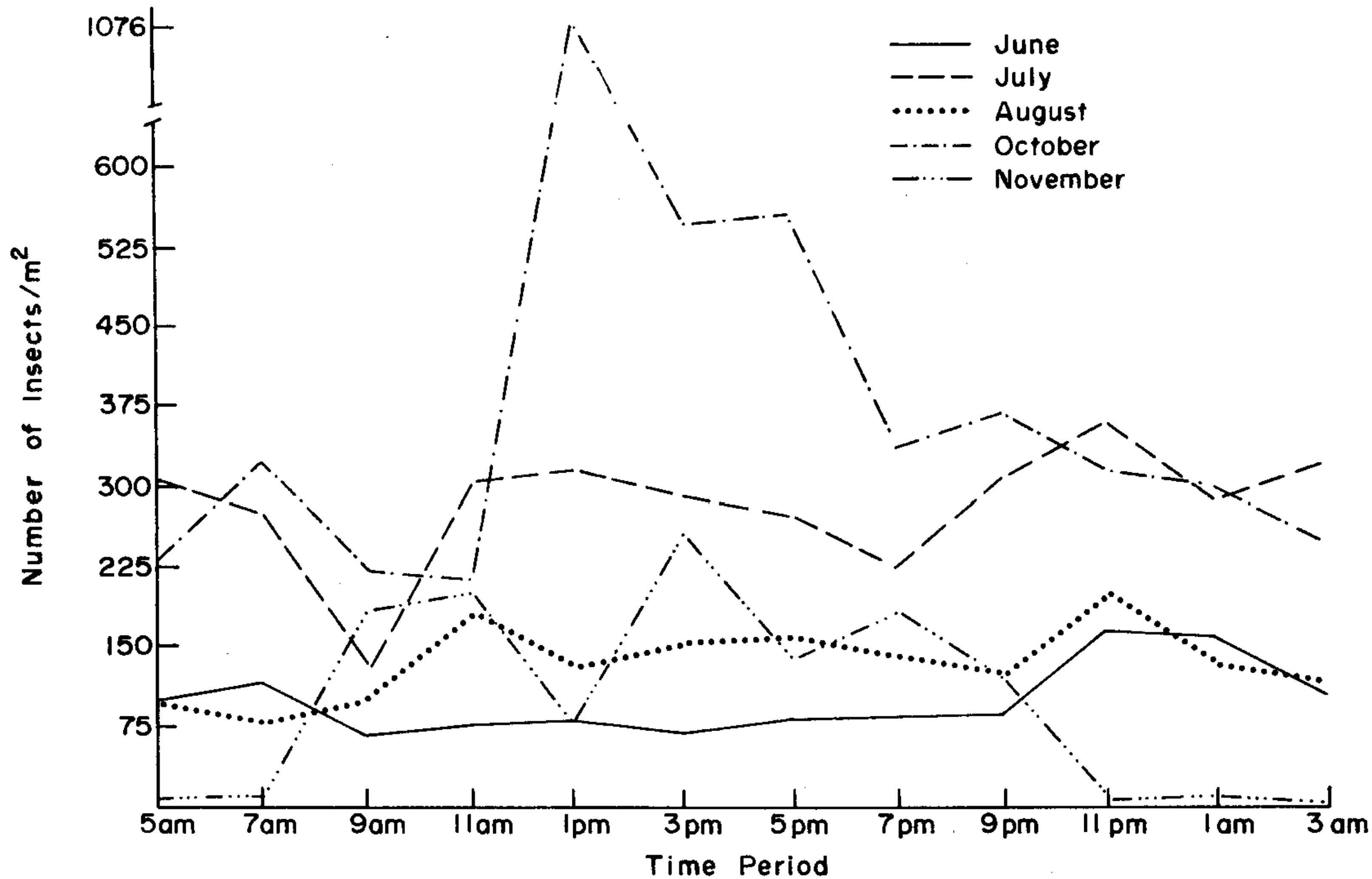

Fig. 2. Insect numbers/m^2 vs. time of day vs. time of year.

Table 1. Analysis of variance for variable insect numbers: Pantex Site, Amarillo, Texas, 1971.

Source of Variations	Analysis of Variance			
	Degrees of Freedom	Sums of Squares	Mean Squares	F values
Dates	4	1,227,711.2	306,927.8	123.0**
Time	11	255,110.6	23,191.9	9.3**
Date x Time (interaction)	44	981,232.8	22,300.7	8.9**
Error	300	748,544.2	2,495.1	

**Significant beyond the 1% level.

Comparisons of the various time periods, relative to insect numbers, was accomplished by means of Duncan's Multiple Range Test (Table 2), which indicated 1:00 PM as the time period yielding the most insects in the samples, and being significantly different from all other time periods. Table 2 also indicated that afternoon samples, in general, produced more insects than morning samples.

Based on these data, and ignoring all other variables, the null hypothesis was rejected. However, it was determined that times of day alone cannot be used as a guideline for sampling schedules. The reasons for this have been discussed in a preceding section.

Hypothesis B

The times of day at which samples are taken will not affect the number of species of insects in the samples.

As expected, correlation between insect numbers and number of species was high. Fig. 3 showed a daytime trend pertaining to the time(s) at which the highest number of insect species were trapped; this corresponded closely with values shown in Fig. 2.

Analysis of variance (Table 3) and Duncan's Multiple Range Test (Table 4) indicated that again there were significant differences among the various time periods. It was noted (Table 4) that the time periods between 11:00 AM and 9:00 PM contained the largest numbers of insect species.

Based on the data presented, the null hypothesis was rejected, and it was concluded that different time periods would indeed produce different numbers of insect species in the traps.

Table 2. Duncan's Multiple Range Test: Comparison of mean numbers of insects present at various time periods, Pantex Site, Amarillo, Texas, 1971.

Time Period	Mean Number of Insects Present*
1 PM	169.6
3 PM	134.0
5 PM	121.1
9 PM	111.2
11 PM	104.5
1 AM	103.0
7 PM	98.4
11 AM	97.3
7 AM	81.0
3 AM	79.3
9 AM	75.5
5 AM	73.6

*Means flanked by the same line are not significantly different at the 5% level (Duncan's Multiple Range Test).

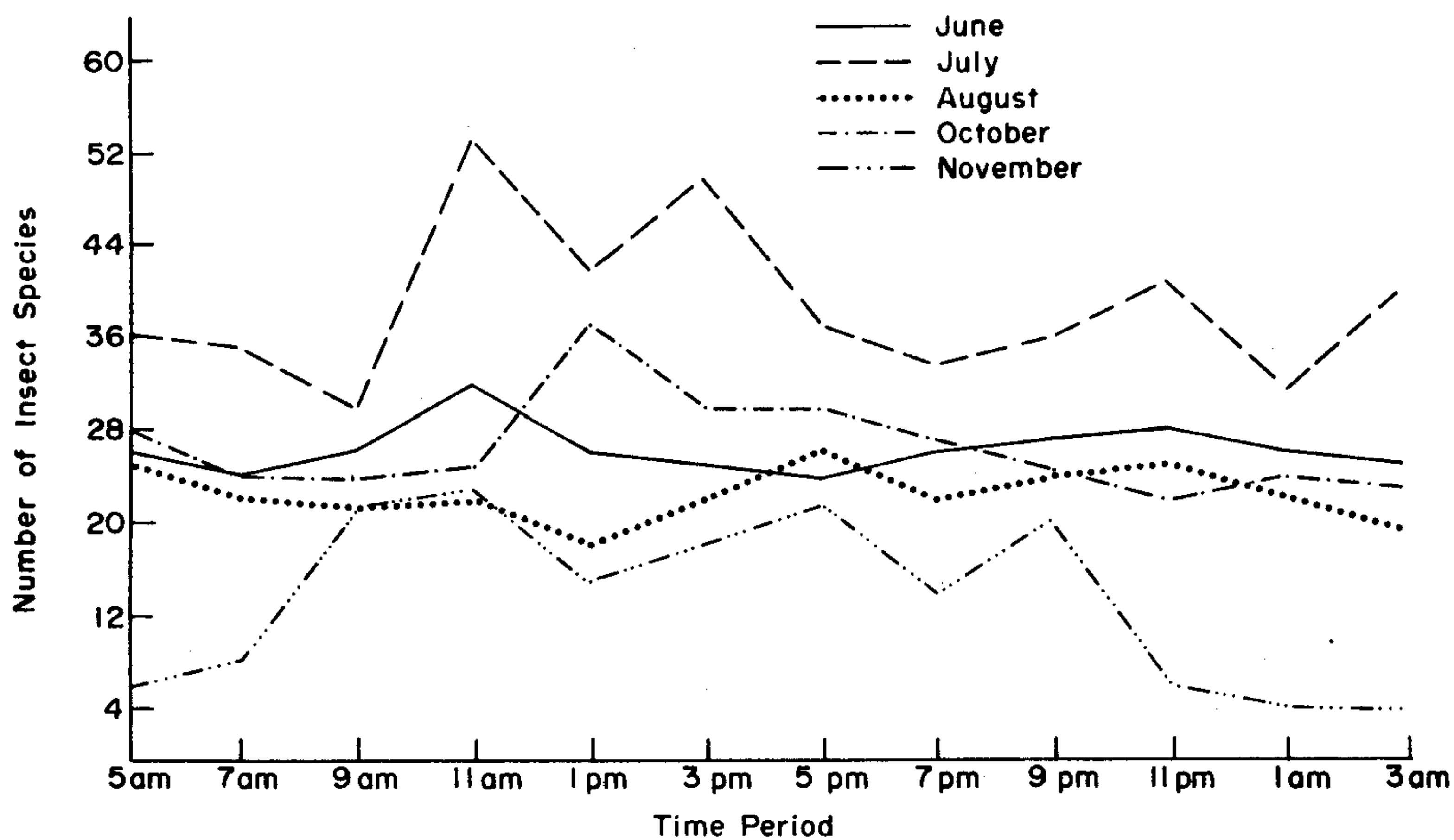

Fig. 3. Number of insect species vs. time of day vs. time of year.

Table 3. Analysis of variance for variable numbers of insect species, Pantex Site, Amarillo, Texas, 1971.

Source of Variations	Analysis of Variance			
	Degrees of Freedom	Sums of Squares	Mean Squares	F Values
Dates	4	6,659.7	1,664.9	235.3**
Time	11	738.3	67.1	9.5**
Date x Time (interaction)	44	1,569.4	35.7	5.0**
Error	300	2,122.5	7.1	

**Significant beyond the 1% level.

Table 4. Duncan's Multiple Range Test: Comparison of mean numbers of insect species present at various time periods, Pantex Site, Amarillo, Texas, 1971.

Time Period	Mean Number of Insect Species Present*
5 PM	13.8
3 PM	13.5
11 AM	13.5
1 PM	13.2
9 PM	12.8
7 PM	11.5
11 PM	11.1
9 AM	11.1
1 AM	10.6
3 AM	10.3
7 AM	10.0
5 AM	9.8

*Means flanked by the same line are not significantly different at the 5% level (Duncan's Multiple Range Test).

It was also determined that time of day alone should not be used as a guideline for sampling schedules, due to underlying abiotic factors which are to be discussed later in the text.

Hypothesis C

There is no interaction between the time of day and the time of year in the number of insects in the samples.

Analysis of variance (Table 1) indicated that there was indeed an interaction between the time of day and the time of year in the number of insects in the samples and, furthermore, that these differences were not of the same nature (Table 5). That is, the differences observed between the various time periods were dependent on the particular sampling data involved and would be variable with each date. Based on these data the null hypothesis was rejected.

Hypothesis D

There is no interaction between the time of day and the time of year in the number of species of insects in the samples.

Table 3 indicated, as expected due to correlation between insect number and number of species, that there was an interaction present. Table 6 indicated, as in Table 5 for insect numbers, that the differences observed between time periods were dependent on the date involved.

Based on these data, the null hypothesis was rejected, and it was concluded that the time of day which produces the largest number of species of insects in the samples is a function of the time of year at which samples are taken.

Table 5. Analysis of covariance: Comparison of insect numbers with time period, date, temperature, relative humidity, and wind velocity, Pantex Site, Amarillo, Texas, 1971.

Source of Variations	Analysis of Covariance			
	Degrees of Freedom	Sums of Squares	Mean Squares	F Values
Dates	4	180,111.31	45,027.83	13.57**
Time Period	11	19,856.39	1,805.13	0.54
Wind Velocity	1	6,159.24	6,159.24	1.86
Temperature	1	23,347.47	23,347.47	7.04*
Relative Humidity	1	1,190.44	1,190.44	0.36
Error	41	136,037.89	3,317.99	

**Significant beyond the 1% level.

*Significant beyond the 5% level.

Table 6. Analysis of covariance: Comparison of numbers of insect species with time period, date, temperature, relative humidity, and wind velocity, Pantex Site, Amarillo, Texas, 1971.

Source of Variations	Analysis of Covariance			
	Degrees of Freedom	Sums of Squares	Mean Squares	F Values
Dates	4	496.58	124.14	21.3**
Time Period	11	18.43	1.67	0.3
Wind Velocity	1	3.52	3.52	0.6
Temperature	1	9.32	9.32	1.6
Relative Humidity	1	9.00	9.00	1.5
Error	41	238.90	5.83	

**Significant beyond the 1% level.

Hypothesis E

Changes in temperature, during a 24-hr period, do not affect the numbers of insects in the samples.

Data concerning this hypothesis were analyzed by means of linear regression (Table 7) and least-squares analysis of covariance (Table 5).

Table 7 showed a positive correlation between insect numbers and temperature, although the calculated value (0.1018) is below the value required for significance (0.25).

However, Table 5 showed that there was a significant difference in the number of insects caught at various temperatures but did not show which temperatures were "important."

Therefore, the percent of the total number of insects trapped, for a given date, was calculated for various temperature ranges (Fig. 4, 5, 6, 7, 8). It was noted that the temperature range, which corresponded best with high numbers of insects in the samples, was 60° to 70°F.

The peaks of insect numbers occurring around midnight (Fig. 2) were, at first glance, assumed to be due to sampling at periods of low activity. However, further investigation revealed that, in general, these peaks occurred during periods when the temperature approached the 60° to 70°F range.

Based on these data, the null hypothesis was rejected, and it was concluded that changes in temperature are a major factor in selecting a sampling period, regardless of time of day or time of year.

Hypothesis F

Changes in temperature, over a 24-hr period, do not affect the numbers of species of insects in the samples.

Table 7. Linear regression: Correlation of independent variables (temperature, relative humidity, and wind) with each other and with the dependent variables (number of insects and number of species of insects), Pantex Site, Amarillo, Texas, 1971.

Variable	Variable	Correlation*
Number of Insects	Number of Species	0.68
Wind Velocity	Temperature	0.28
Wind Velocity	Relative Humidity	-0.38
Temperature	Relative Humidity	-0.21
Number of Insects	Wind Velocity	-0.08
Number of Insects	Temperature	0.10
Number of Insects	Relative Humidity	-0.05
Number of Species	Wind Velocity	-0.32
Number of Species	Temperature	0.28
Number of Species	Relative Humidity	0.24

*Requires 0.25 to be significant at the 5% level.

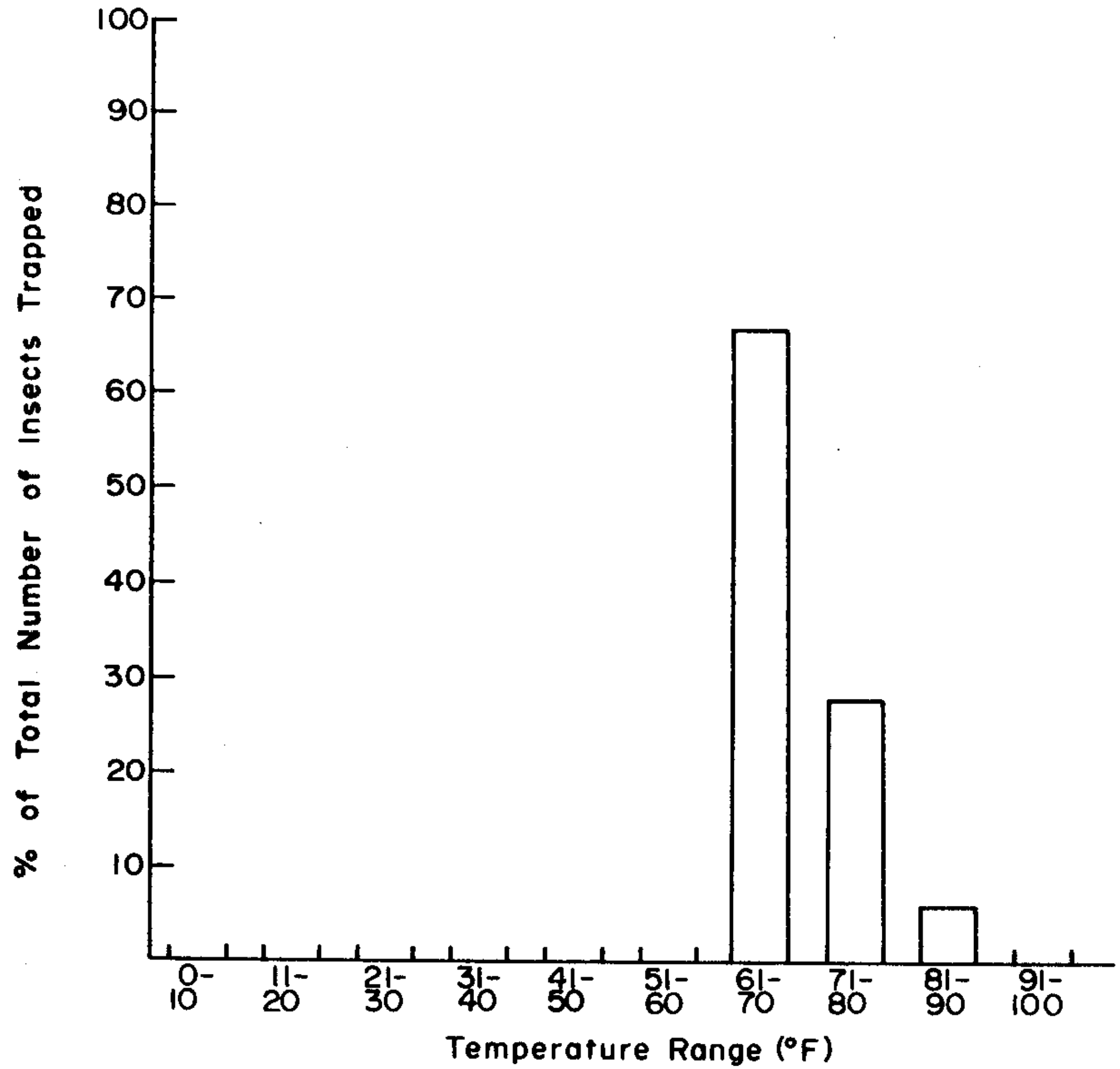

Fig. 4. Percent of total number of insects trapped vs. temperature, Pantex Site, June 1971.

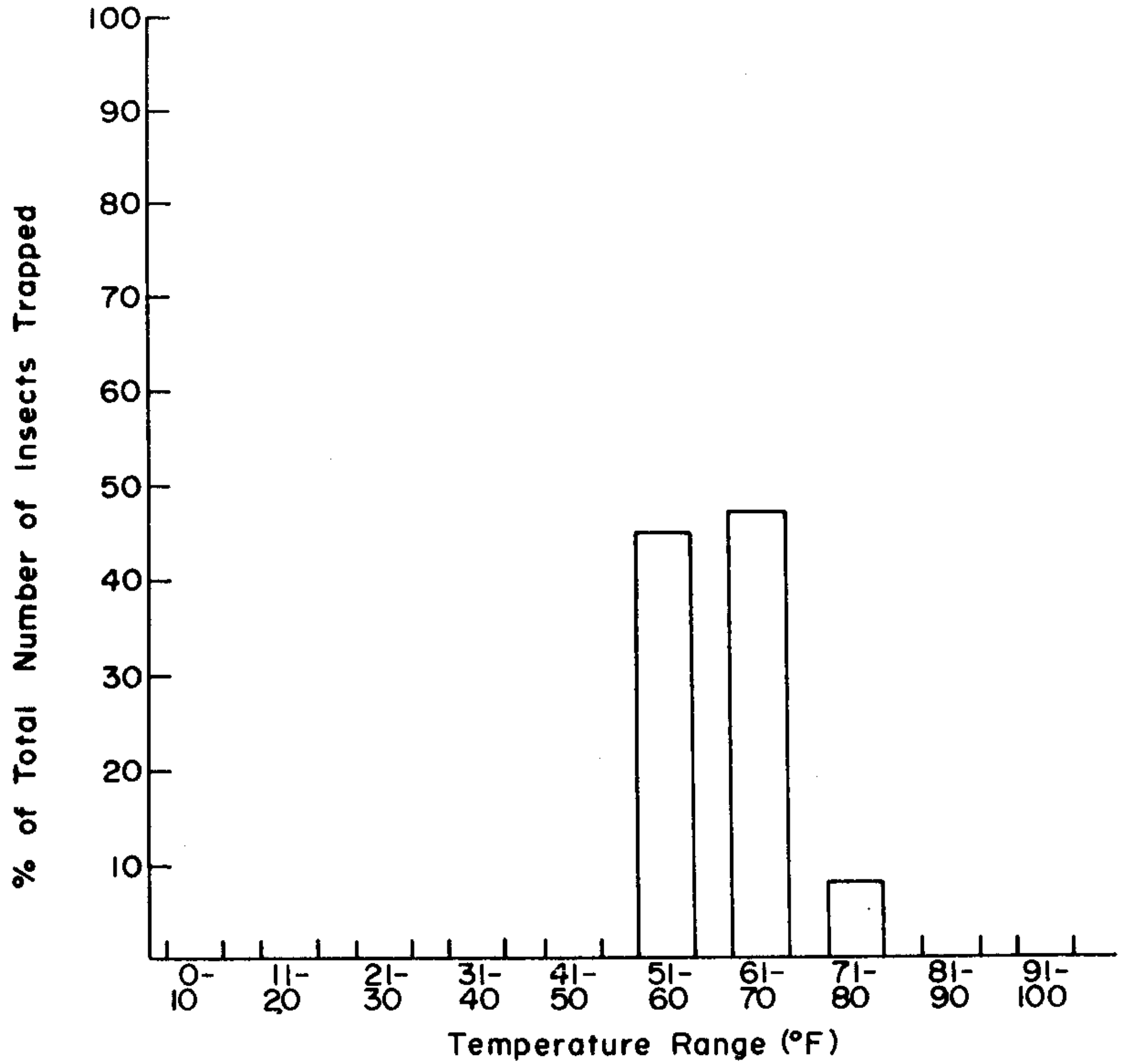

Fig. 5. Percent of total number of insects trapped vs. temperature, Pantex Site, July 1971.

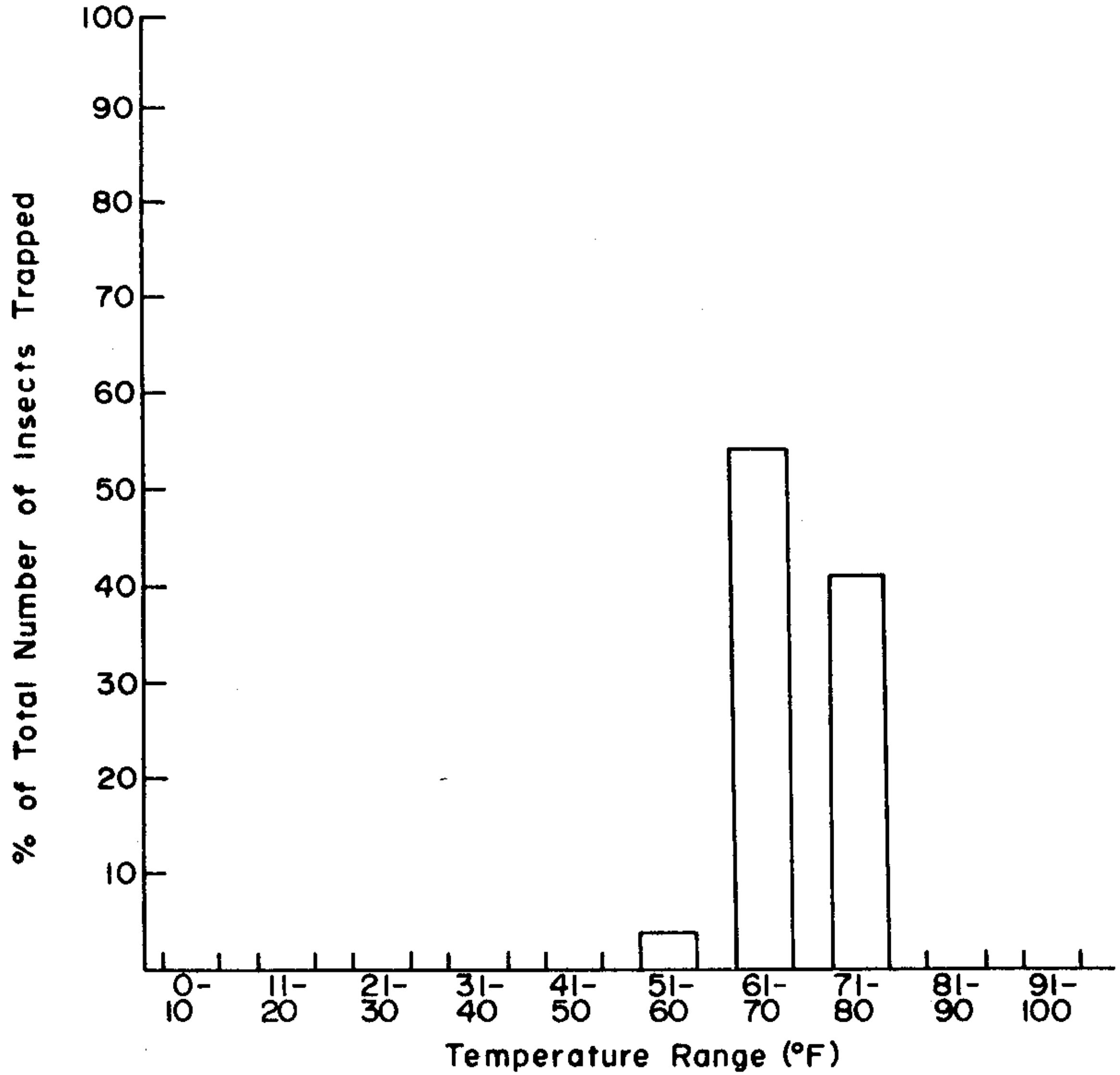

Fig. 6. Percent of total number of insects trapped vs. temperature, Pantex Site, August 1971.

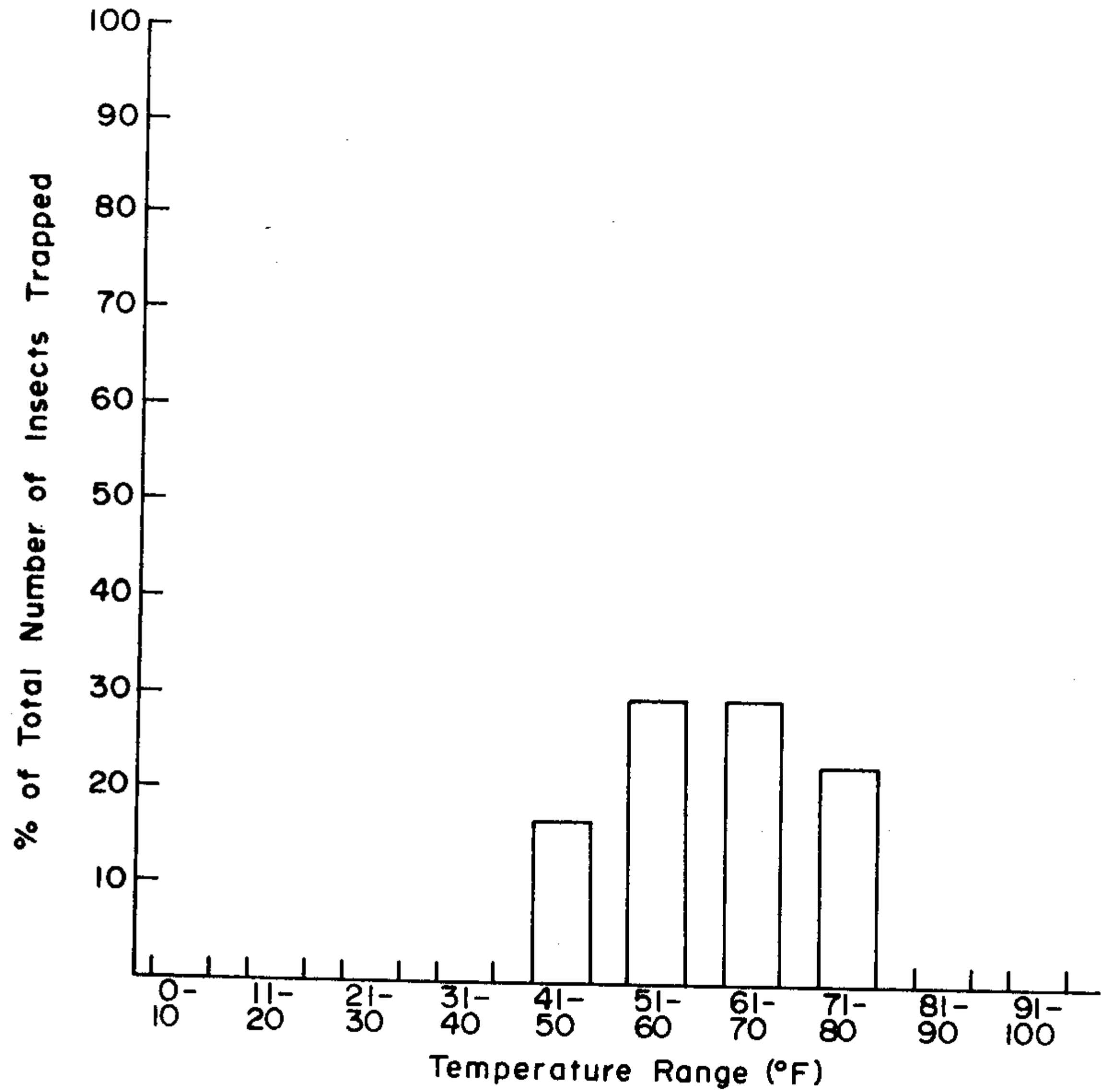

Fig. 7. Percent of total number of insects trapped vs. temperature, Pantex Site, October 1971.

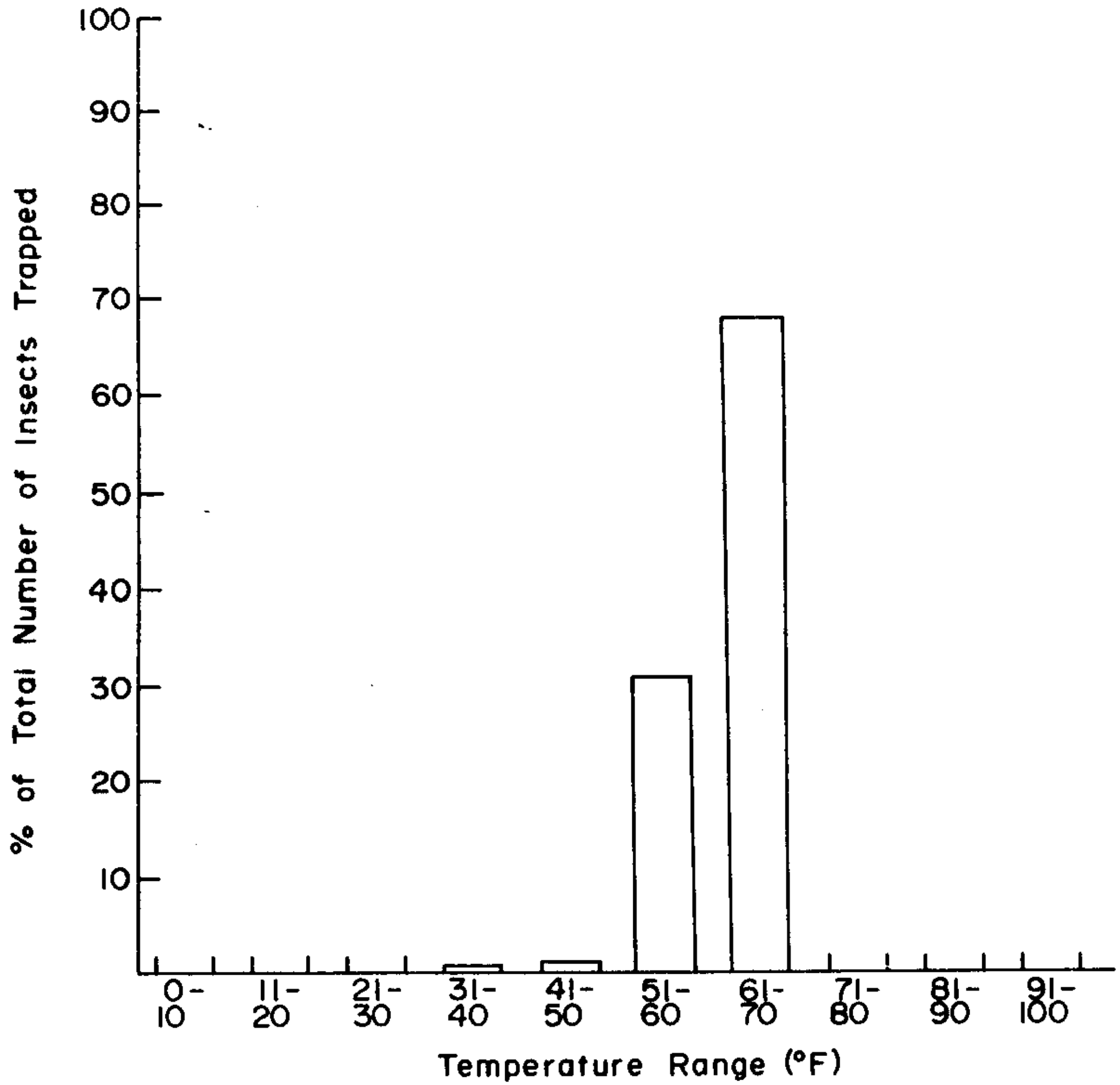

Fig. 8. Percent of total number of insects trapped vs. temperature, Pantex Site, November 1971.

Table 7 showed a high, positive correlation between the numbers of insects in the samples and the numbers of species of insects in the samples. It was then concluded that a reduction or an increase in the numbers of insects in the samples would result in a similar trend for numbers of species of insects in the samples.

This conclusion was further supported by the positive correlation between the numbers of insects in the samples and temperature (Table 7).

As the year progressed from warm to cool months the numbers of species found in the samples was reduced, and it is assumed that the faunalistic change was in favor of the more cold-tolerant species.

This assumption was based on the tremendous variation in the biology of the individual species within a given group, in general.

Based on these data, the null hypothesis was rejected, and it was concluded that changes in temperature, within an optimal range, do result in changes in the number of insect species in the samples.

Hypothesis G

Changes in relative humidity, during a 24-hr period, do not affect the numbers of insects in the samples.

Table 7 shows a negative correlation between temperature and relative humidity, therefore one would expect that as relative humidity increases, the numbers of insects found in the samples would decrease, resulting in a negative correlation between insect number and relative humidity, as indicated in Table 7.

Least squares analysis of covariance (Table 5) indicated no differences in the number of insects captured at the various levels of relative humidity. This may be misleading in that wind velocity and relative humidity are closely interacting factors and for practical purposes could not be considered separately.

It appeared (Fig. 9, 10, 11, 12, and 13) that during the mid-summer months (June and July), a relative humidity range of 70 to 80% produced the highest number of insects. As the season progressed, "optimal" relative humidity range was reduced to 60 to 70% in August, 30 to 40% in October, and 10 to 20% in November.

These data correspond nicely with the negative correlation between temperature and relative humidity.

Based on these data, the null hypothesis was rejected. It was concluded that changes in relative humidity during a 24-hr period do indirectly affect the number of insects in the samples.

Hypothesis H

Changes in relative humidity, during a 24-hr period, do not affect the number of species of insects in the samples.

Again, Table 7 indicates a strong positive correlation between the number of insects and the number of insect species in the sample. However, Table 7 also indicates a nonsignificant but positive correlation between the number of insect species and relative humidity, which may be due in part to the presence of inherent error in the experiment or behavioral patterns of certain species.

Least squares analysis of covariance (Table 6) indicated no significant differences in numbers of insect species at various levels of relative humidity.

Based on these data, the null hypothesis was accepted but with reservations. It was concluded that changes in relative humidity do indirectly affect the number of species of insects in the samples.

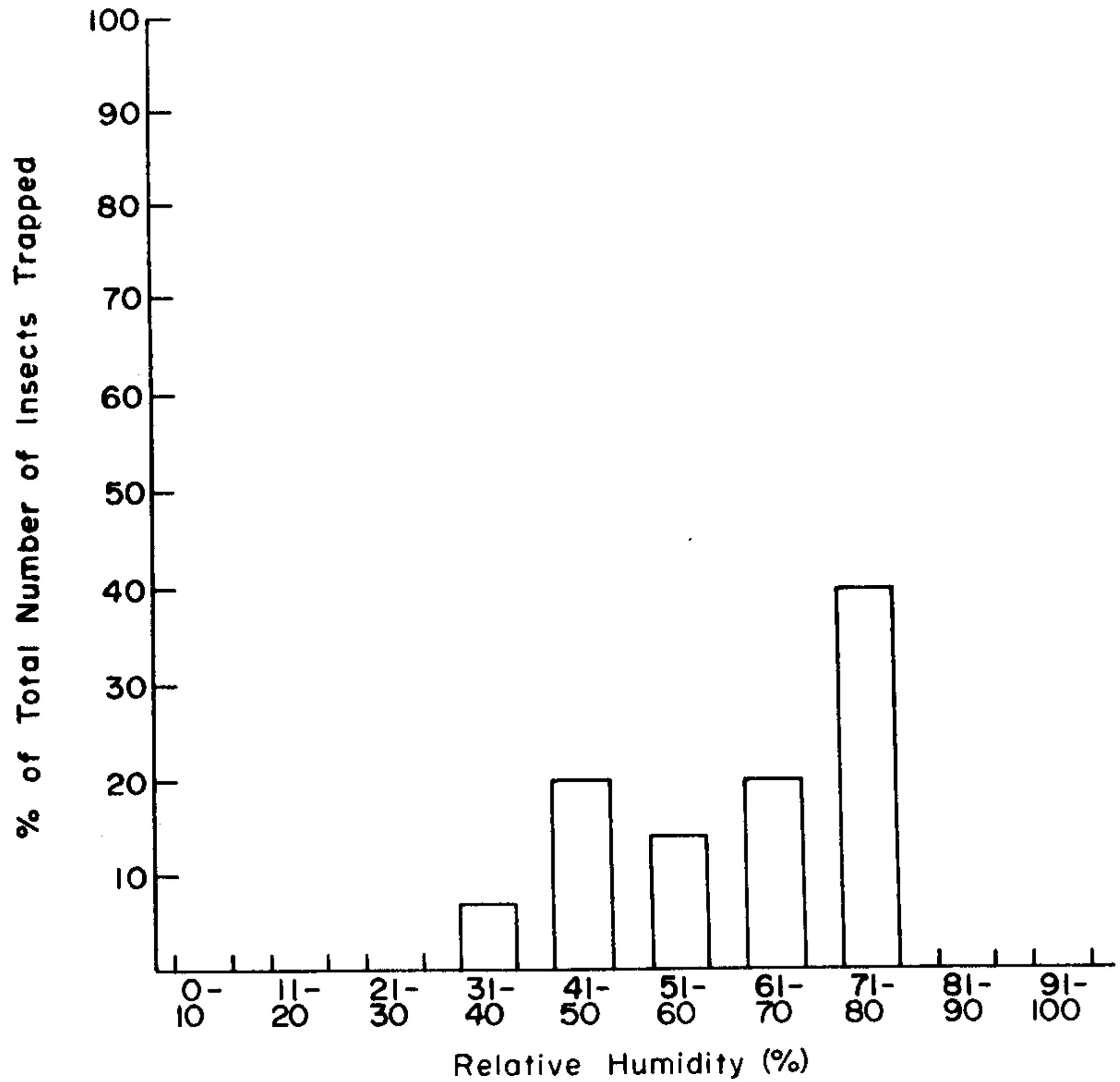

Fig. 9. Percent of total number of insects trapped vs. relative humidity, Pantex Site, June 1971.

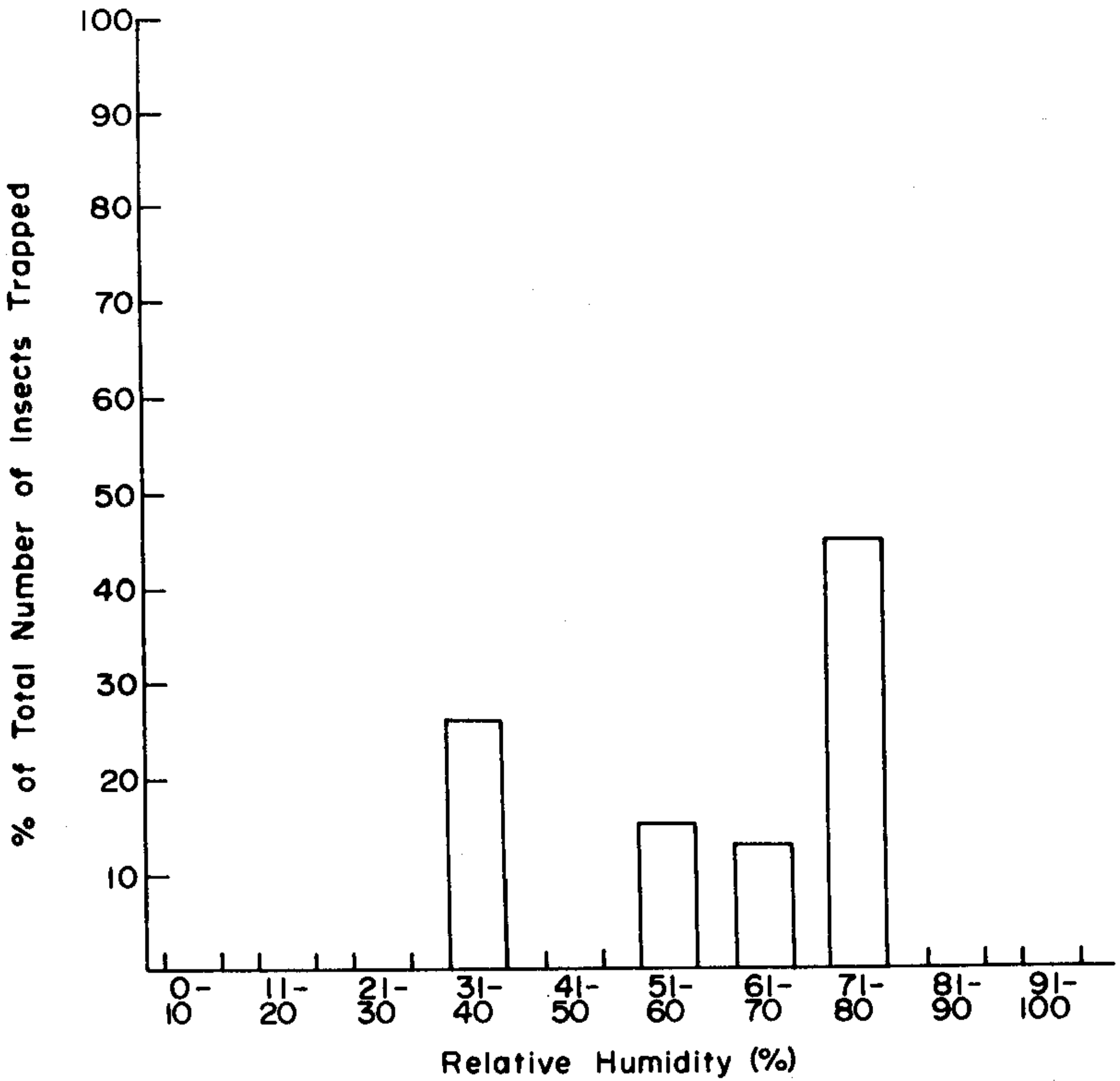

Fig. 10. Percent of total number of insects trapped vs. relative humidity, Pantex Site, July 1971.

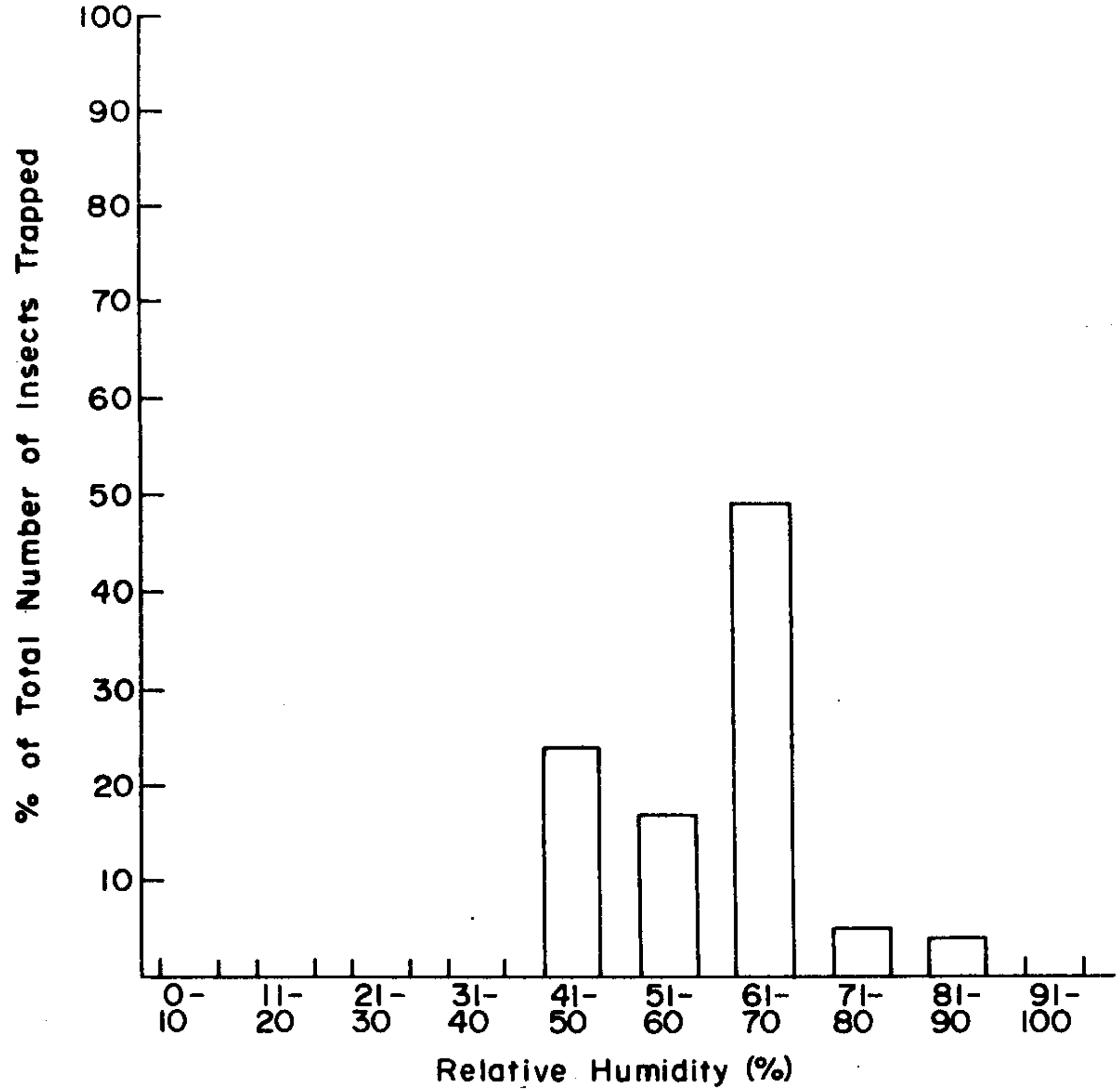

Fig. 11. Percent of total number of insects trapped vs. relative humidity, Pantex Site, August 1971.

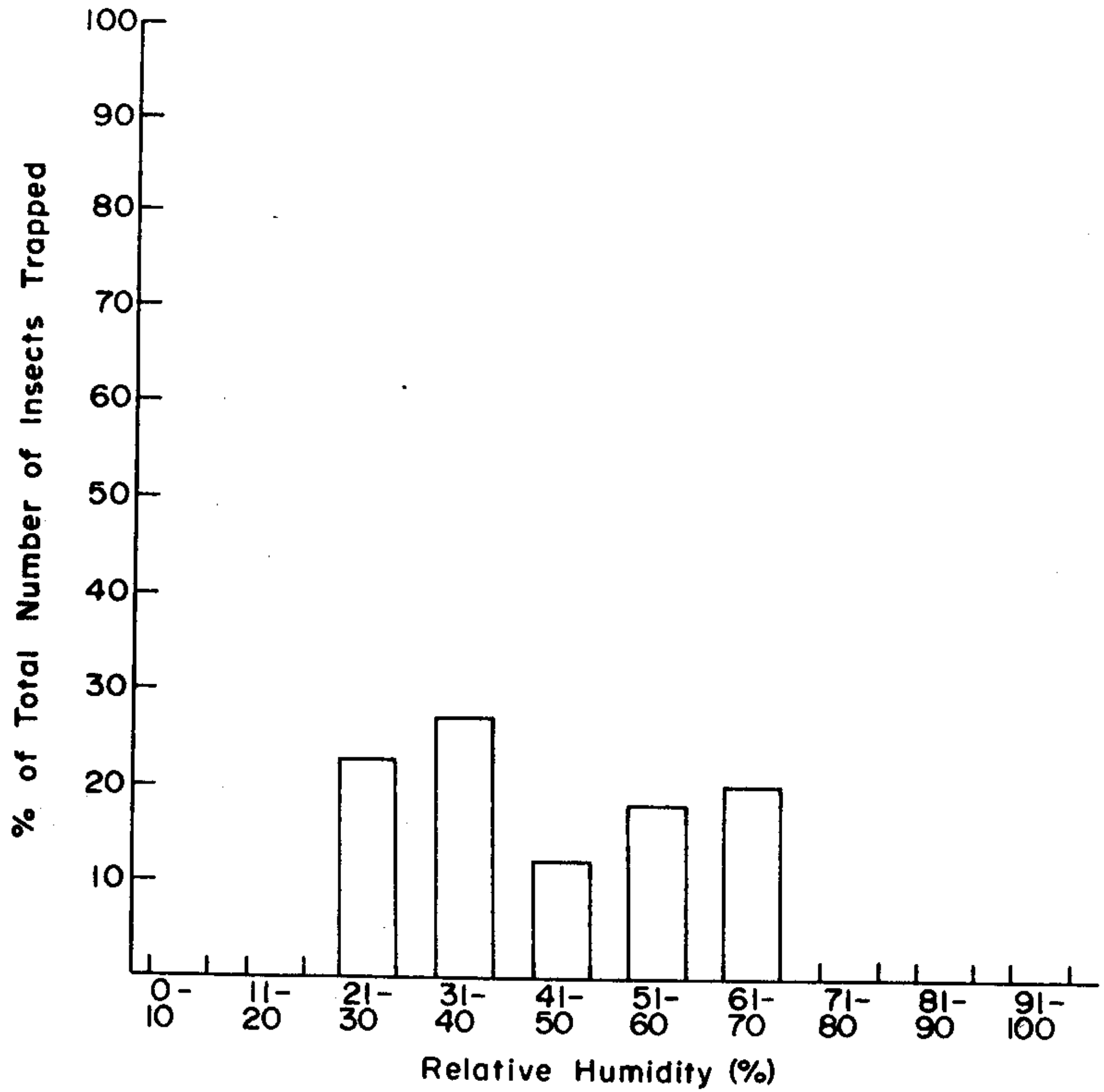

Fig. 12. Percent of total number of insects trapped vs. relative humidity, Pantex Site, October 1971.

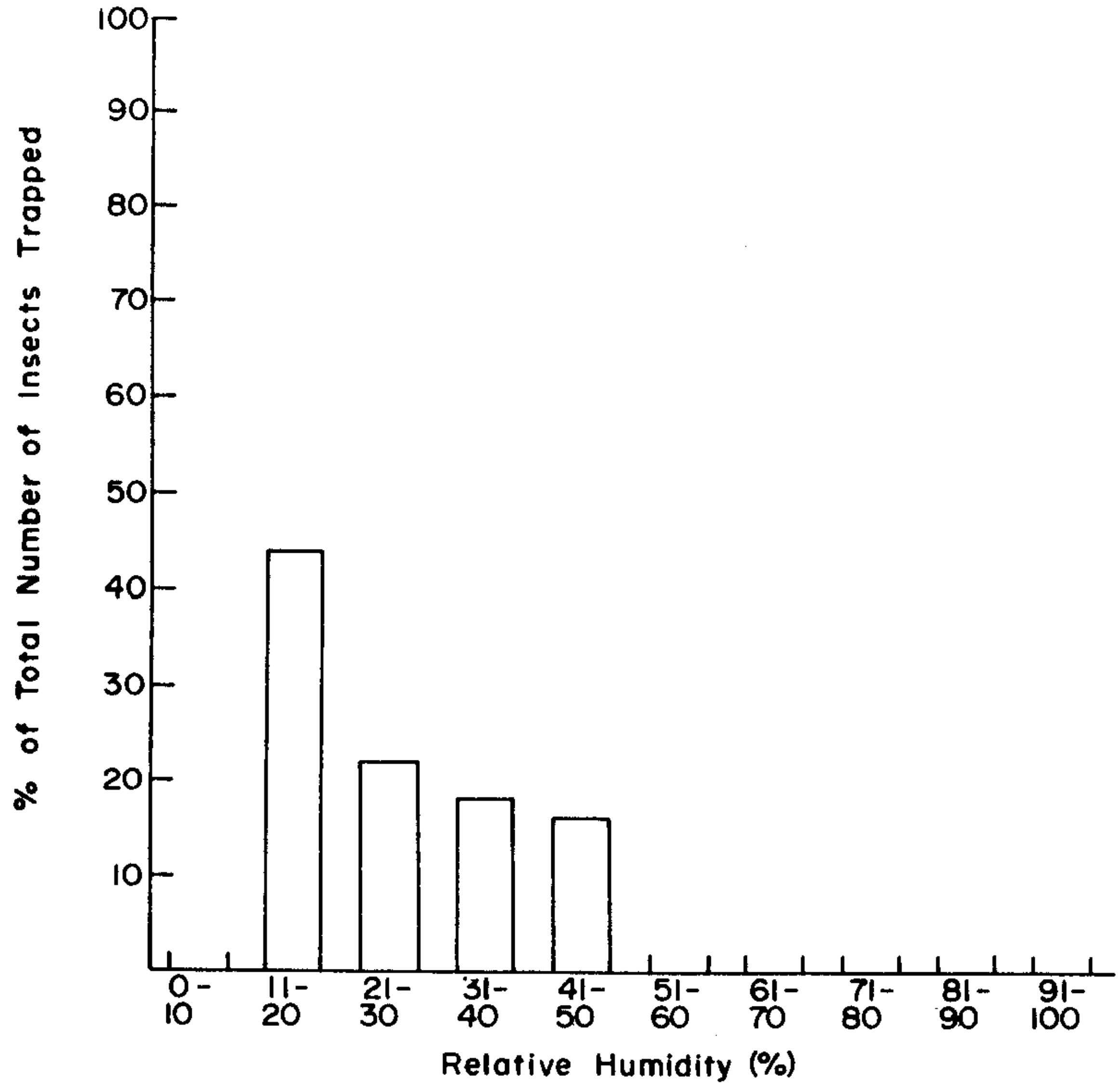

Fig. 13. Percent of total number of insects trapped vs. relative humidity, Pantex Site, November 1971.

Conclusions were based on the high positive correlation between the number of insects present in the sample and the number of insect species present in the samples (Table 7) and also on data in Fig. 9, 10, 11, 12, and 13.

Hypothesis I

Changes in wind velocity, during a 24-hr period, do not affect the number of insects in the sample.

Data indicated that there was a slight negative correlation between number of insects trapped and wind velocity (Table 7). However, least-squares analysis of covariance (Table 5) indicated no significant differences in the number of insects trapped at various wind velocities.

The apparent conflict of data was determined to be due to the interaction of the other abiotic factors considered, i.e., temperature, relative humidity, time of day, and time of year.

No obvious patterns could be detected from Fig. 14, 15, 16, 17, and 18.

Conclusions based solely on these data led to the acceptance of the null hypothesis but with reservations due to the unknown magnitude of dependency on the other related factors. It was assumed that wind velocity does affect the number of insects in the samples, but to what degree remains unknown.

Hypothesis J

Changes in wind velocity, during a 24-hr period, do not affect the number of insect species in the sample.

Data indicated a significant negative correlation between wind velocity and the number of species of insects in the samples (Table 7).

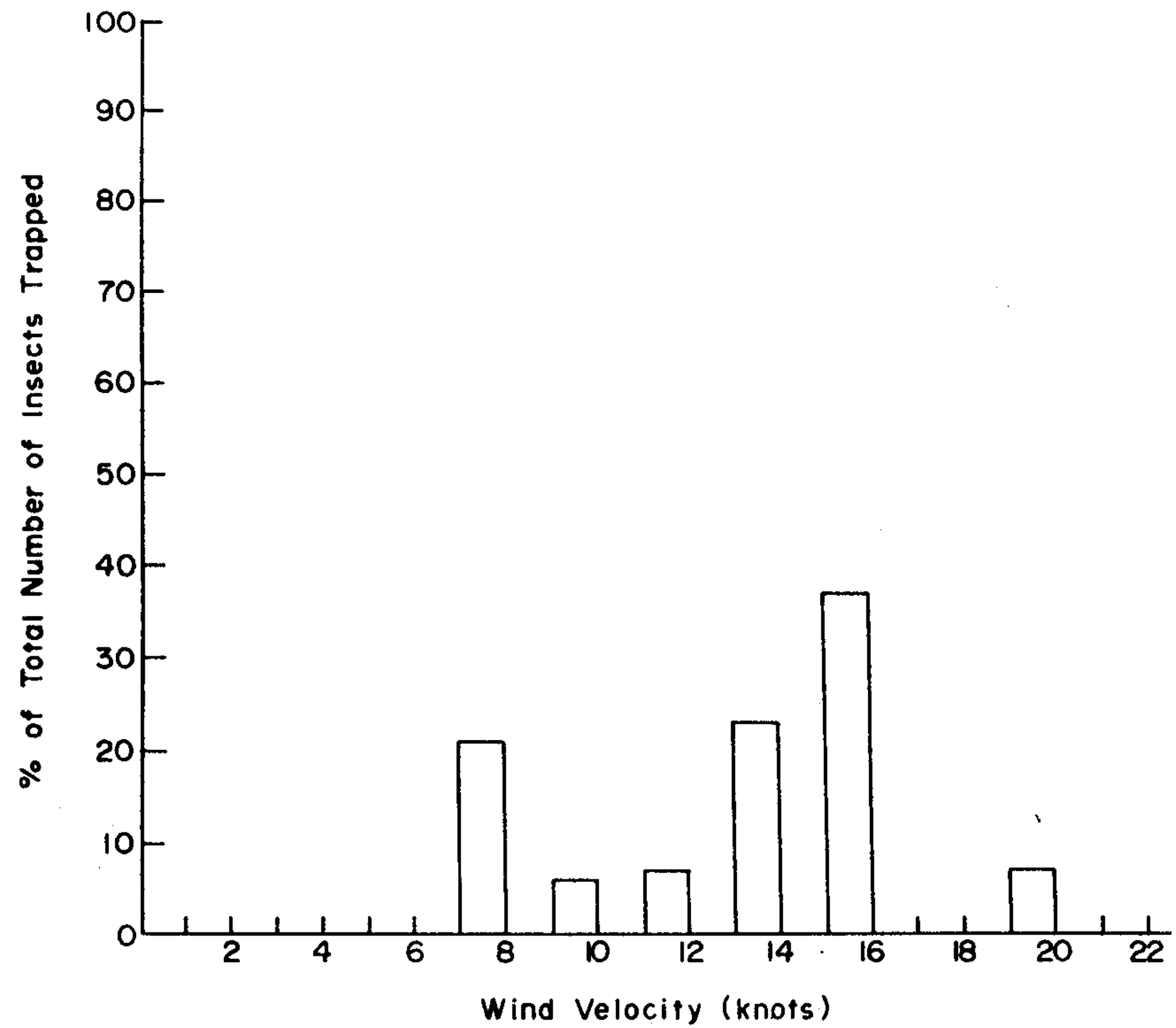

Fig. 14. Percent of total number of insects trapped vs. wind, Pantex Site, June 1971.

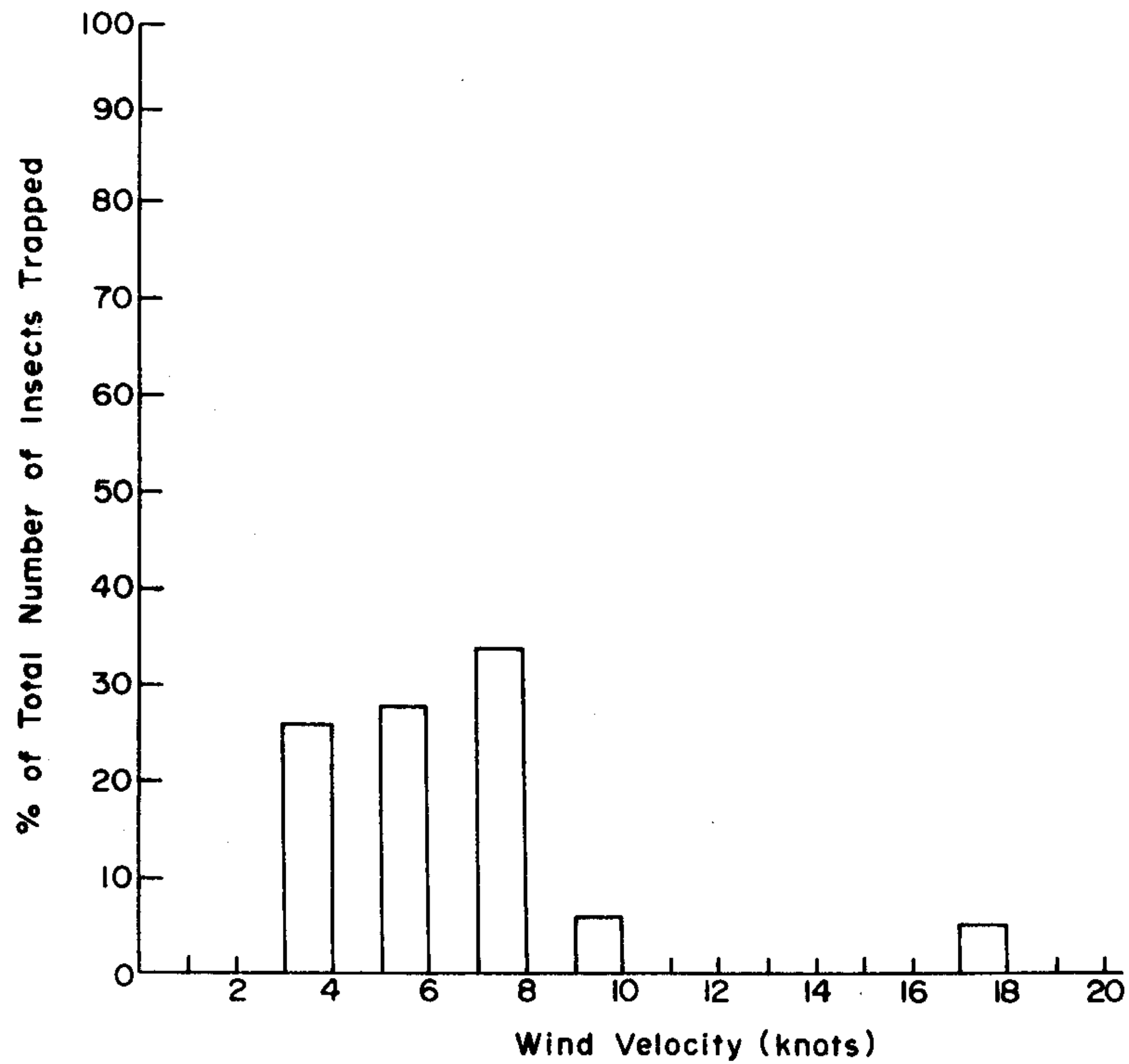

Fig. 15. Percent of total number of insects trapped vs. wind, Pantex Site, July 1971.

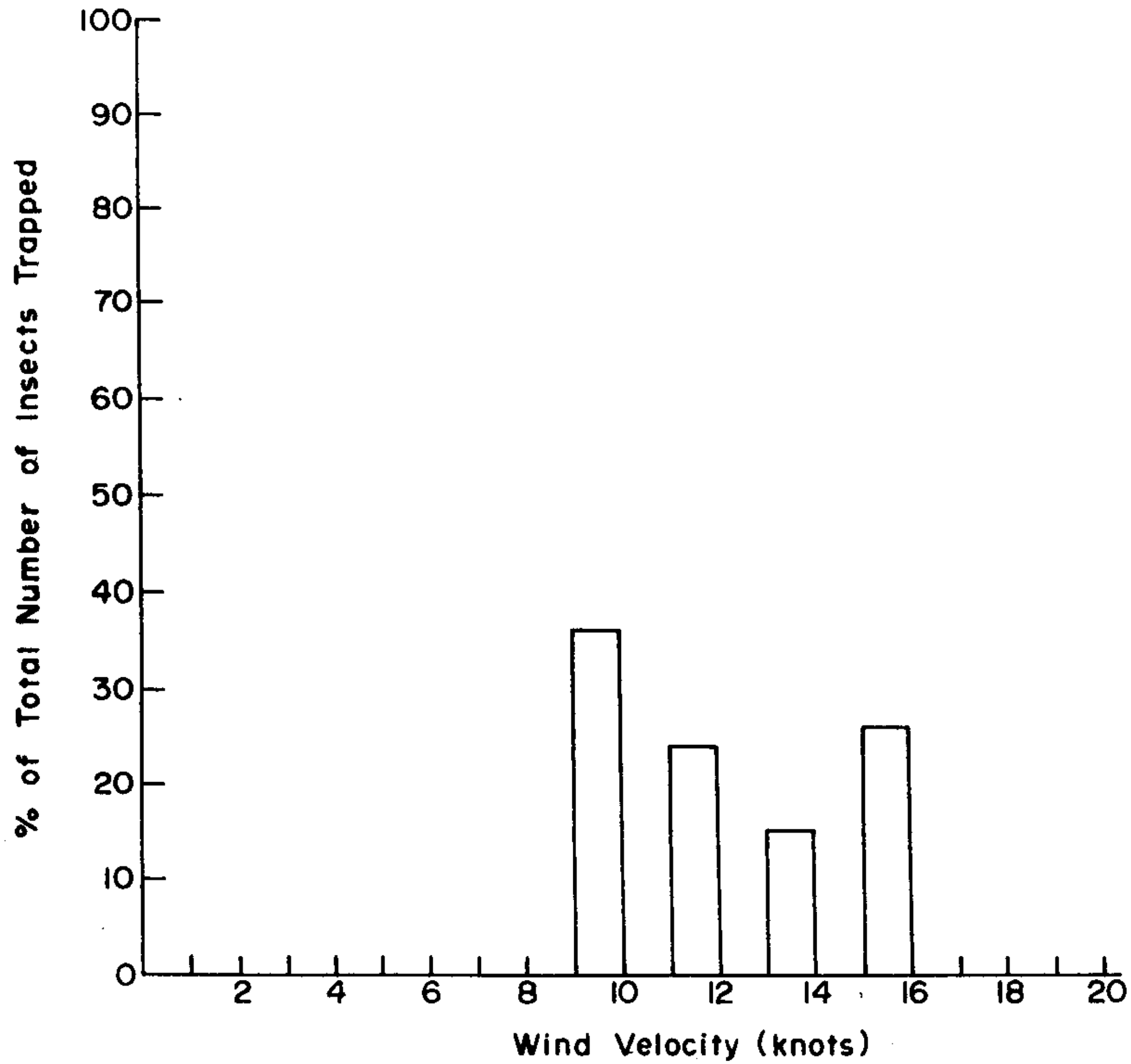

Fig. 16. Percent of total number of insects trapped vs. wind, Pantex Site, August 1971.

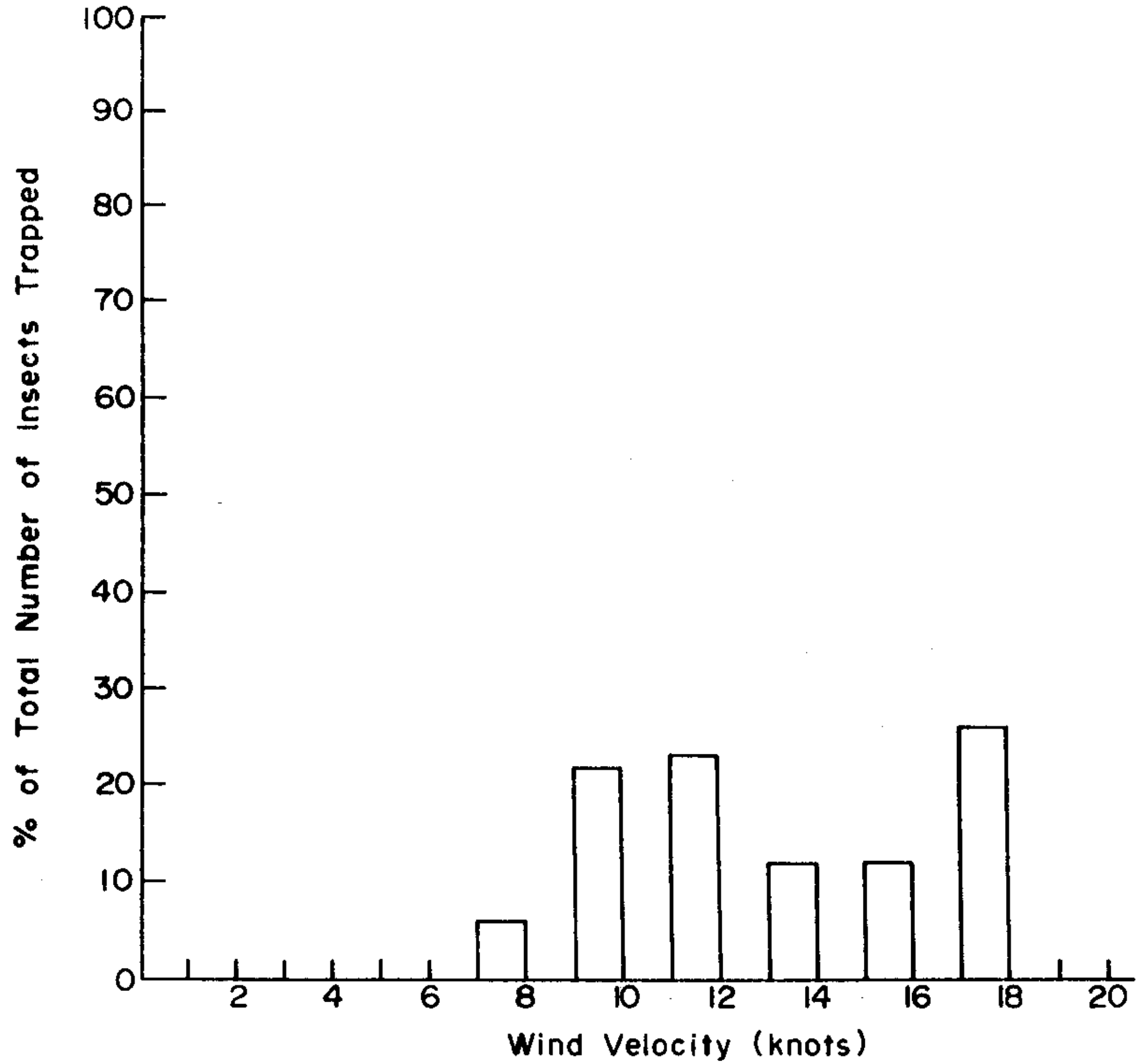

Fig. 17. Percent of total number of insects trapped vs. wind, Pantex Site, October 1971.

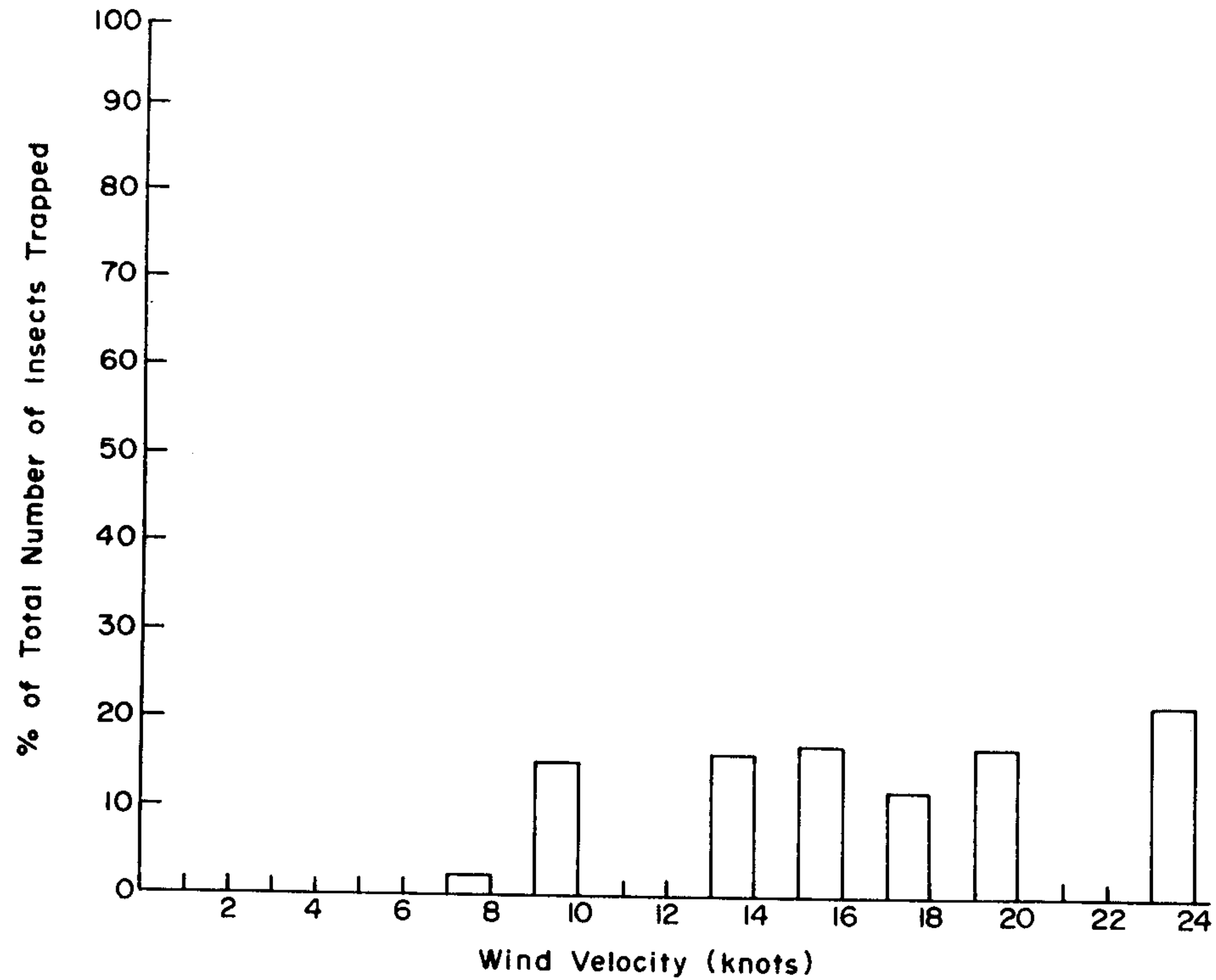

Fig. 18. Percent of total number of insects trapped vs. wind, Pantex Site, November 1971.

These data were not in accord with the findings on insect numbers versus wind velocity, but could be explained by the fact that as wind velocity increased, insects disturbed by the sampling technique were simply blown away from the sample area. Another possibility considered was that insects utilizing wind as a dispersing agent would be moving about as the sample trap was thrown, thereby reducing the chances that they would be trapped.

It was established (unpublished data) that the quick-trap was not as efficient with flying insects as corresponding nonflying insects. This, again, would depend on specific behavior which was beyond the scope of this study.

Therefore, the null hypothesis was accepted although the exact causative agents were not determined and it was suspected that an increase in wind velocity would result in a lower number of species in the samples.

Hypothesis K

Variation in the number of insects per sample at one sampling date or for all dates combined is due to random experimental error and is not explained by linear or polynomial multiple regression.

This hypothesis was tested by means of a simple analysis of variance (Table 1) and Duncan's Multiple Range test. Table 8 shows the results of these analyses and indicates that the variation in hypothesis K is significant between all sampling dates with the exception of June and November. Possibilities considered for this occurrence were (a) both June and November produced low numbers of insects, thereby increasing experimental error, and (b) dry conditions preceding June samples, cold and dry conditions during November samples.

Table 8. Duncan's Multiple Range Test: Comparison of mean insect numbers over dates, Pantex Site, Amarillo, Texas, 1971.

Date	Mean Number of Insects*
October	198.4
July	144.3
August	77.2
June	50.4
November	49.9

*Means flanked by the same line are not significantly different at the 5% level (Duncan's Multiple Range Test).

Based on these data the null hypothesis was rejected, and it was concluded that variations in sect numbers were real, not due to random experimental error, and could possibly be explained by positive correlation between precipitation before sampling and insect numbers.

Hypothesis L

There is no change in the species found at the various sampling dates.

Faunalistic changes did occur over the five dates included in this study.

Hypothesis M

Stepwise removal of the first, second, and third most numerous groups of insects will not affect the relationship of the number of insects found in a sample and the time of day at which the sample was taken.

Data indicated that the relationship of the number of insects vs. time of day taken was not influenced by stepwise removal of the first, second, and third most numerous groups (Fig. 19, 20, 21, 22, and 23).

On this basis, the null hypothesis was accepted. The original intent of this procedure was to see if numbers curves would be flattened as expected by removal of the most numerous groups. Obviously, this was not the case. Available data were not sufficient to hypothesize on this phenomena.

SUMMARY AND CONCLUSIONS

It appeared from the data collected that when all of the variables involved were held at a favorable constant value, the time of day at

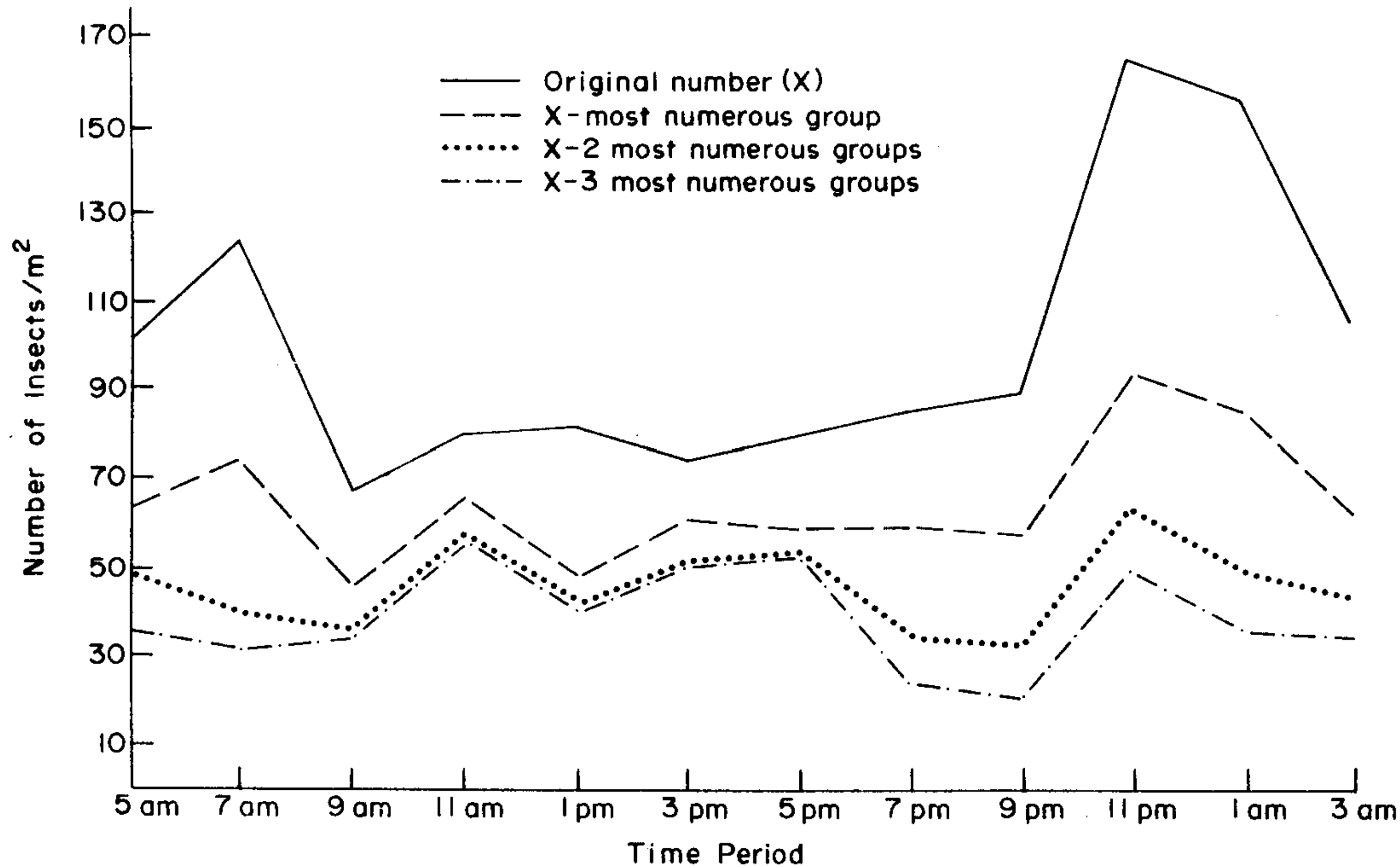

Fig. 19. Effect of stepwise removal of the three most numerous groups, June 1971.

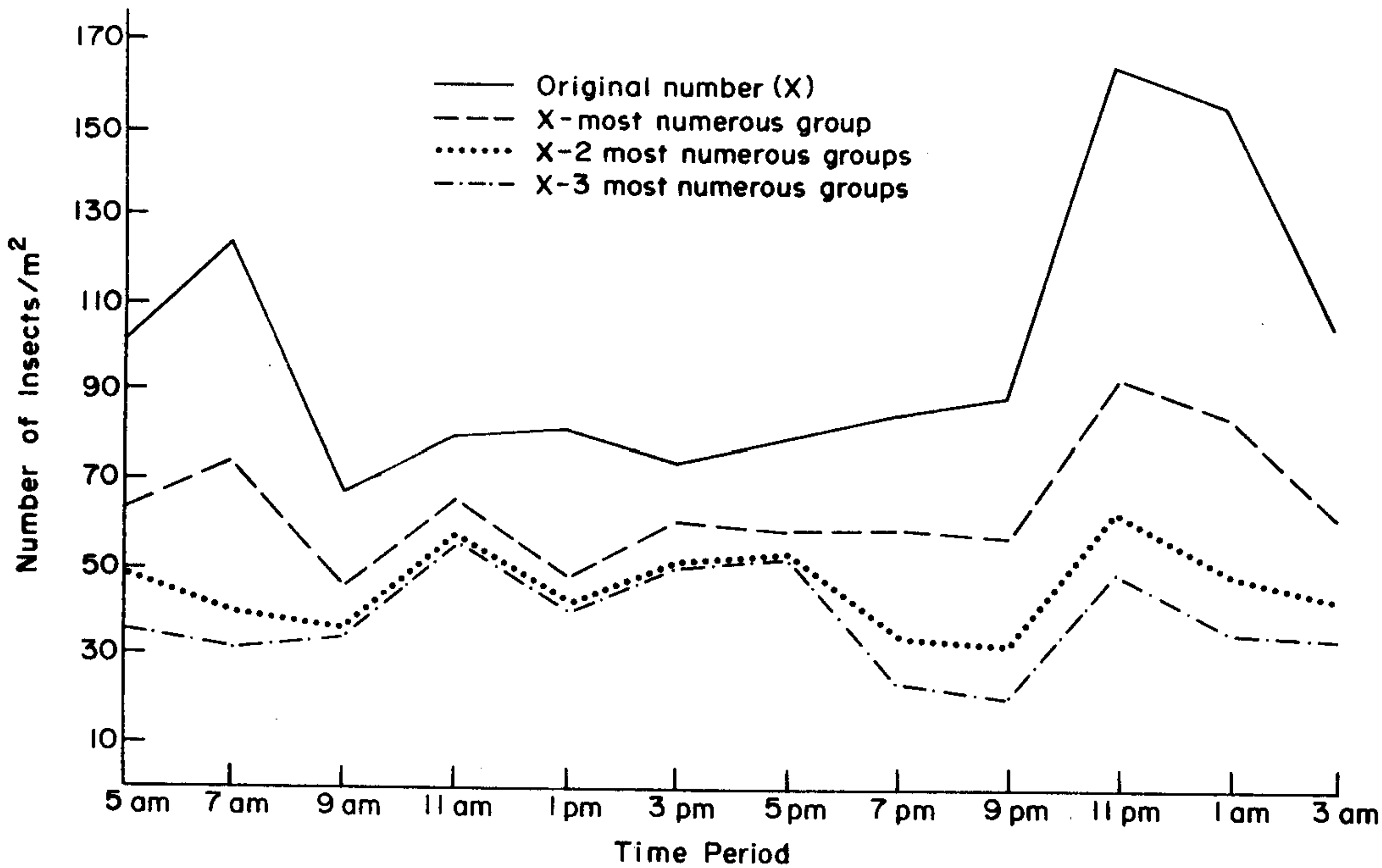

Fig. 19. Effect of stepwise removal of the three most numerous groups, June 1971.

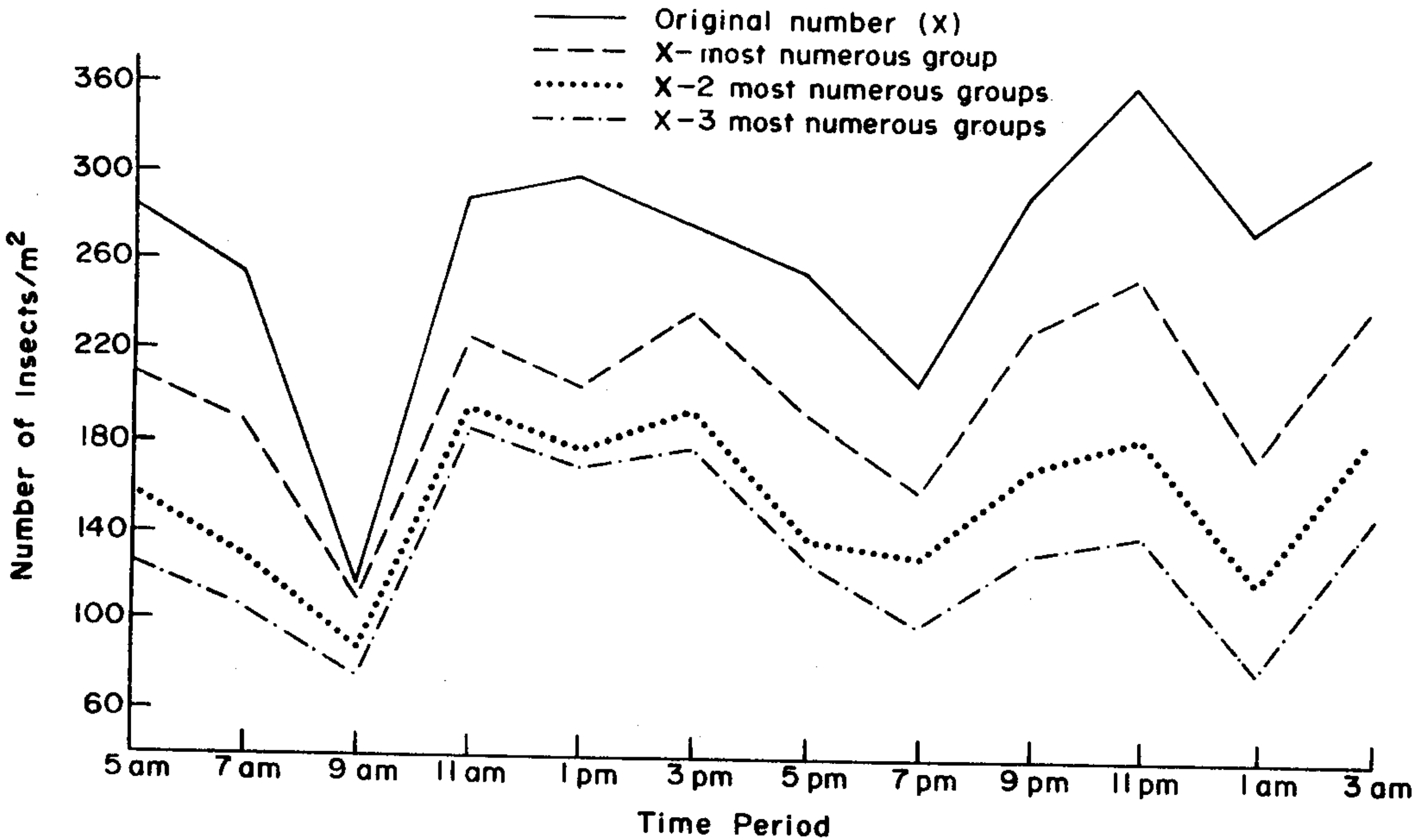

Fig. 20. Effect of stepwise removal of the three most numerous groups, July 1971.

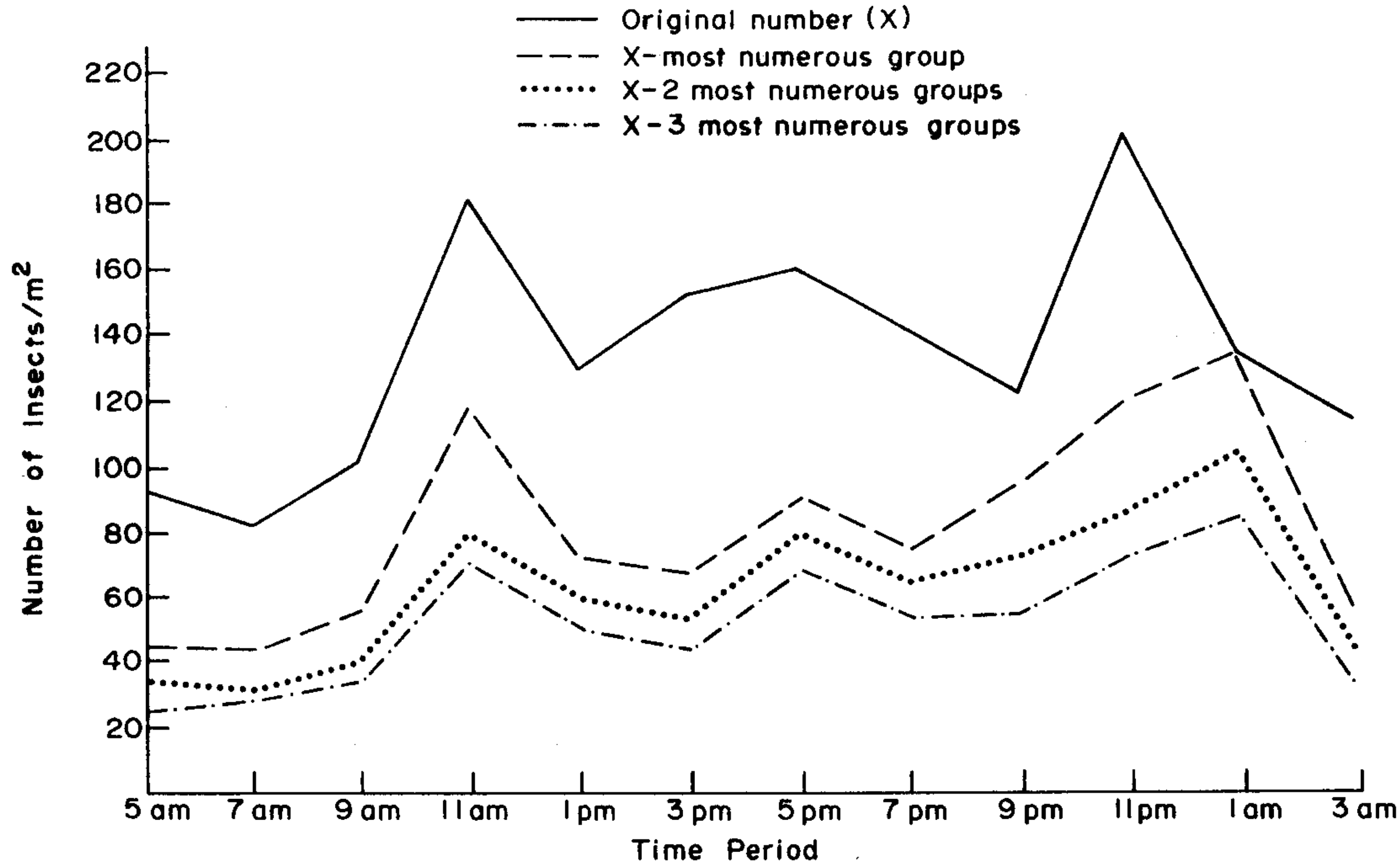

Fig. 21. Effect of stepwise removal of the three most numerous groups, August 1971.

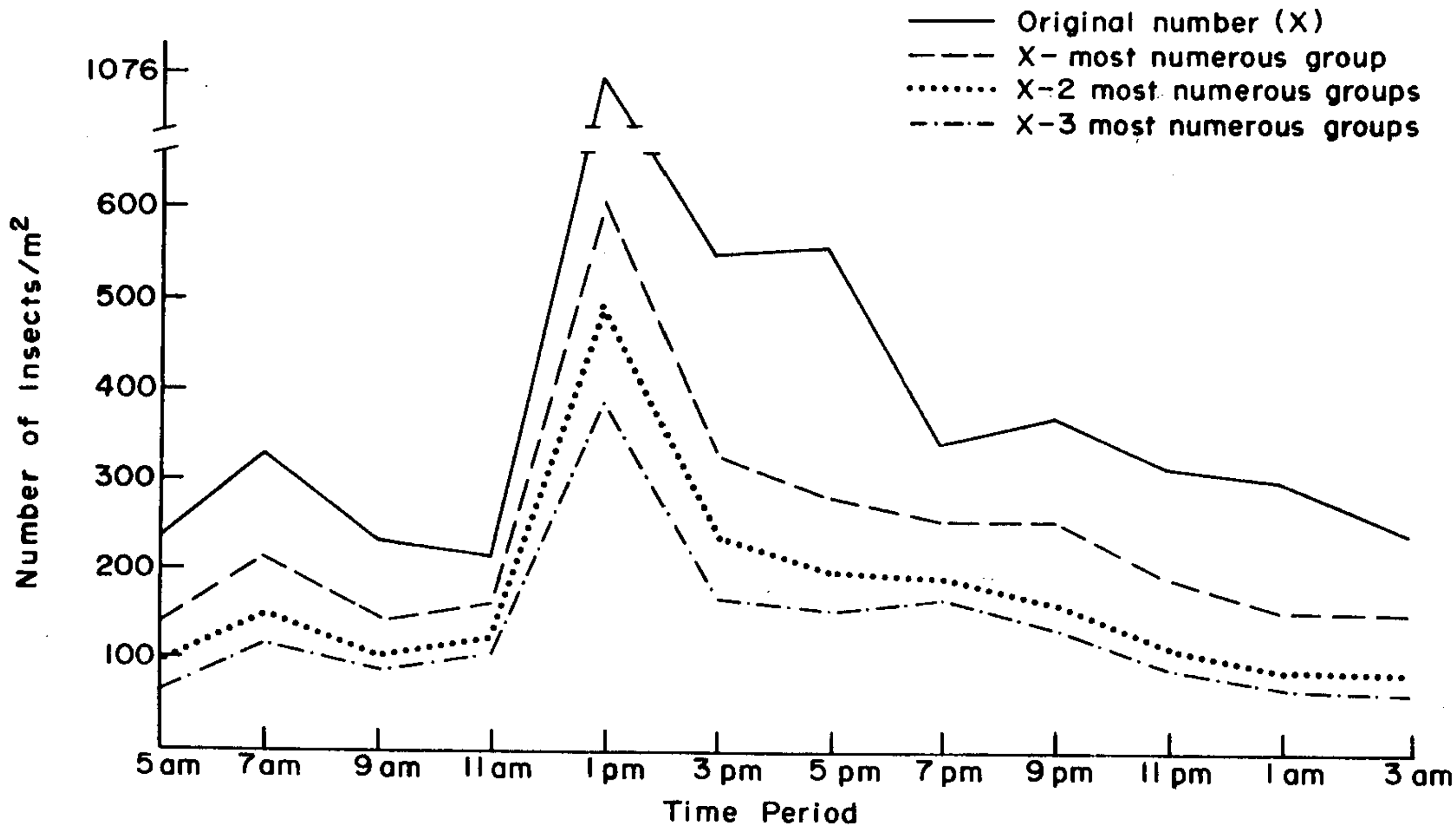

Fig. 22. Effect of stepwise removal of the three most numerous groups, October 1971.

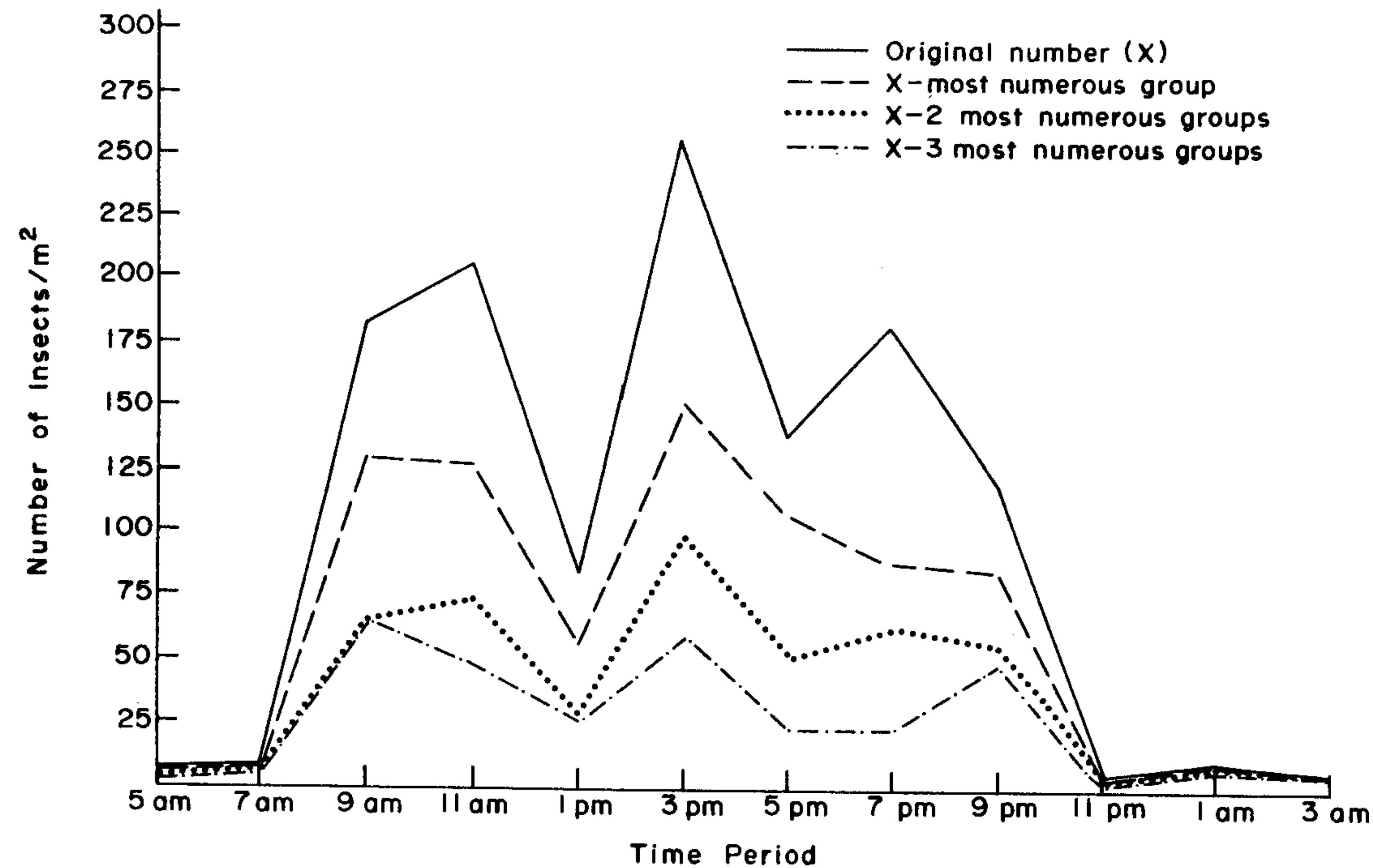

Fig. 23. Effect of stepwise removal of the three most numerous groups, November 1971.

which samples were taken made no difference in either the number of insects found in the samples or the number of insect species found in the samples.

Temperature seemed to be the major contributing factor involved in this study, with wind velocity and relative humidity, in that order, ranking next.

Therefore, it was concluded that temperature, at the time of sampling, should be the governing factor in construction of a sampling schedule. It appeared that a temperature range of 60° to 70°F was, in general, the most productive.

Obvious interactions among the various dates involved in this study (June, July, August, October, and November) and the closely interacting factors of temperature, wind velocity, and relative humidity made it impossible to determine an all-around best time to sample insect numbers and/or number of insect species on an annual basis. It was concluded that construction of sampling schedules should be done in such a way as to allow flexibility depending on weather conditions at various times of the year. Determinations of the "best" time(s) to sample grassland insects based on the data compiled in this study are as follows:

June - Temperature should range between 60° to 70°F; wind velocity should range between 13 to 16 knots/hr; relative humidity should range between 60 to 80%.

July - Temperature should range between 50° to 70°F; wind velocity should range between 3 to 8 knots/hr; relative humidity should range between 60 to 80%.

August - Temperature should range between 60° to 80°F; wind velocity should range between 9 to 12 knots/hr; relative humidity should range between 60 to 70%.

October - Temperature should range between 50° to 70°F; wind velocity should range between 9 to 18 knots/hr; relative humidity should range between 25 to 45%.

November - Temperature should range between 60° to 70°F; wind velocity should range between 9 to 24 knots/hr; relative humidity should range between 11 to 30%.

The above values and recommendations were based on results obtained in this study and are not meant to fit every situation. However, it was presented with the intention that it be used as a guideline for future studies of this nature.

It was also obvious from the data collected that there was indeed a faunalistic change as the year progressed from warm to cool months. Based on these data it was determined that, for example, when samples taken in June produced 30 species of insects and samples taken in October also produced 30 species of insects, these species often were not the same and would therefore require a modified method of sampling, depending on the species involved, for efficient population studies on a specific level.

The data concerned with the effect of stepwise removal of the three most numerous groups was more complex than initially anticipated. It was the belief of the investigator that this procedure would eliminate or at least reduce the peaks observed at various time periods. However, this did not occur. What this means, in terms of community structure, was not determined and will require a much more detailed investigation than was within the scope of this study.

ACKNOWLEDGMENTS

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APPENDIX A. LIST OF INSECTS, NUMBERS, AND TIME OF CAPTURE

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
						June 12-13, 1971						
Ento. 01	21	1	16	4	4	18	0	1	0	2	3	2
Podu. 01	8	5	2	1	0	4	0	0	0	11	0	66
Locust. 01	0	0	0	0	0	0	0	1	0	0	1	0
Locust. nym.	3	4	2	4	0	0	3	6	3	3	5	6
Pseu. 01	2	0	1	1	0	3	1	0	2	2	0	1
Nabi. 01	0	0	0	0	0	0	1	0	0	0	0	0
Miri. 01	0	1	0	0	0	0	0	0	0	1	0	0
Lyga. Geo.	3	3	3	2	4	0	2	0	1	0	3	4
Lyga. Geo. nym.	0	0	0	0	0	0	1	1	1	0	1	0
Hemi. nym,	0	0	0	0	0	1	0	0	0	0	0	0
Hemi. 05	1	0	0	0	0	0	0	0	5	0	0	1
Phlo.	12	2	6	4	4	19	30	22	23	3	3	4
Brown thrips	0	0	0	0	0	0	0	0	0	1	0	0
Cole. Chry. 01	3	16	20	3	1	4	0	0	0	20	4	4
Cole. Chry. 03	0	0	0	0	1	1	0	2	0	0	0	3
Cole. Chry. 05	1	1	0	1	0	0	0	0	0	1	0	1
Cole. Elat. 01	116	53	50	148	62	43	99	39	59	76	74	37
Cole. Cara. 04	12	16	5	2	5	7	11	7	0	2	13	7
Cole. Cara. 02	1	1	1	2	1	0	0	0	0	1	0	0
Cole. Cara. 08	0	0	0	0	0	0	0	0	0	0	1	0
Cole. Cocc. 04	2	0	0	0	0	0	2	0	0	0	0	0
Cole. Anth. 01	1	3	0	0	4	0	6	2	1	1	0	0
Cole. Anth. 02	0	0	0	0	0	0	0	0	0	0	0	0
Cole. Anth. 03	0	1	0	2	1	0	1	1	1	0	1	0

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Dipt.	7	4	1	4	2	0	0	0	1	0	0	7
Micro. Hyme.	0	6	3	4	1	4	5	8	5	0	0	1
Hyme. 15	0	0	0	0	0	1	0	0	0	0	0	0
Hyme. Dry. 01	0	0	0	0	0	1	0	0	0	0	0	0
Hyme. Form. Cre. 01	7	17	25	51	56	51	28	0	61	10	7	17
Hyme. Form. 02	0	0	3	0	3	10	15	16	20	1	1	0
Hyme. Form. 06	211	125	111	105	3	9	0	3	2	79	94	220
Hyme. Form. 01	0	0	0	0	0	0	2	2	0	0	0	0
Hyme. Form. Pog.	0	0	0	0	3	1	2	2	10	0	0	0
Hyme. Form. 03	0	0	0	0	0	7	0	0	0	0	0	0
Lepi. ad.	0	0	0	0	1	1	0	0	0	1	1	2
Lepi. lar.	0	0	0	0	0	0	0	0	0	0	0	0
Spiders	7	4	3	4	2	9	7	10	12	2	2	6
Cole. Tene. 02	3	7	5	2	1	2	5	9	5	1	3	6
Hemi. Ting. 01	1	0	2	1	1	0	0	0	0	0	1	4
Homo. nym. (Cica.)	36	28	35	20	29	25	21	27	17	32	39	41
Homo. Cica. 06	0	0	0	0	2	0	0	2	0	1	1	0
Homo. Cica. 08	0	0	0	0	1	0	0	0	0	0	0	0
Homo. Cica. 02	0	0	0	0	0	1	0	0	0	0	0	0
Cica. 03	5	1	0	0	0	0	1	3	4	1	1	1
Cica. 01	0	0	0	0	0	0	0	0	0	0	0	1
Cica. 05	0	0	1	0	0	0	0	0	0	0	0	0
Core. 01 nym.	2	6	0	0	0	6	1	4	0	0	0	0
Staph. 01	0	0	0	0	2	0	0	0	0	1	0	1
Tene. 01	0	0	0	0	0	1	0	1	0	0	1	1

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Psocoptera	0	0	0	0	0	1	0	0	0	0	0	1
Curc.	0	0	0	0	0	0	0	0	0	1	0	0
Scap.	1	0	0	0	0	0	1	0	1	0	0	0
Curc. Ger.	0	0	0	0	0	0	1	0	0	0	0	0
Antho.	0	0	0	0	0	0	1	0	0	0	0	0
Elat. 03	0	0	0	0	0	0	0	1	0	0	0	0
Hist. 01	0	0	1	0	0	0	0	3	2	0	1	0
Strepsiptera	0	0	2	0	0	0	0	0	1	0	0	0
Curc. Tych.	0	0	0	0	0	0	0	0	0	0	1	0
Mala. 01	2	0	0	0	0	0	0	0	0	0	0	1
Coriz. 01	0	0	1	0	0	0	0	0	0	0	0	0
Psyllidae	0	0	1	0	0	0	0	0	0	0	0	0
Elat. 02	0	0	0	0	0	0	1	0	0	0	0	0
						July 30-31, 1971						
Pod. 01	0	73	13	2	8	28	6	0	3	0	0	0
Smin. 01	11	38	36	18	10	7	32	3	7	11	7	9
Ento. 01	11	19	20	4	1	9	5	1	8	6	0	11
Locust. 01	1	0	1	1	0	4	3	2	1	1	1	1
Locust. 01 nym.	2	5	3	2	7	2	5	5	5	8	2	1
Aphid. 01	0	1	4	4	0	5	0	0	1	3	0	2
Pseu. 01	19	1	1	5	3	18	42	18	10	22	27	0
Pent. 01	0	0	0	0	0	0	0	0	0	0	0	0
Pent. 02	0	0	0	0	0	1	0	0	0	0	0	0
Pent. nym.	0	0	0	3	0	1	0	0	0	0	0	2

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Core. 01	0	0	0	0	0	1	0	4	0	0	0	0
Core. 01 nym.	1	2	0	1	1	0	2	2	0	1	1	1
Hemi. 08	1	0	0	0	0	2	4	2	4	0	6	2
Hemi. Pies. 01	0	0	0	0	0	1	0	0	0	0	0	0
Strepsiptera	0	0	0	0	0	2	1	3	4	0	0	2
Geo. 01	12	15	14	14	9	12	12	17	10	14	10	14
Geo. 01 nym.	0	0	8	4	0	0	7	0	3	0	2	9
Form. Pog.	0	0	0	0	0	3	5	2	3	1	0	2
Form. Cre.	3	2	10	0	2	47	43	35	21	19	37	26
Form. 02	0	0	0	0	0	1	0	0	0	0	0	0
Form. 06	120	158	172	176	38	31	12	44	28	99	180	254
Hemi. nym.	2	2	0	2	0	4	3	7	2	0	0	0
Cole. Tene. 02	1	3	1	0	0	0	0	1	0	0	1	0
Cole. Tene. 01	0	0	0	0	0	0	0	1	0	0	0	0
Chry. 01	0	0	0	0	0	4	1	0	0	0	0	0
Chry. 04	0	0	0	0	0	1	1	0	0	0	0	0
Cici. 01	0	0	0	0	0	1	0	0	0	0	0	0
Cocc. 04	0	3	0	1	2	4	2	1	1	5	3	2
Scap.	0	0	0	0	0	2	0	1	0	0	0	0
Cara. 04	0	5	3	2	0	0	0	0	0	0	0	0
Cara. 05	0	0	0	0	0	4	2	1	1	1	0	1
Elat. 01	289	114	97	72	75	97	97	124	186	91	118	133
Anth. 01	6	6	11	7	2	18	25	22	22	12	16	16
Anth. 03	0	0	2	0	0	11	8	9	8	4	4	1
Phlo. Ged.	51	60	49	37	30	149	193	250	149	82	98	50

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Thrips (brown)	0	2	2	3	1	6	2	5	0	8	0	0
Form. 03	1	13	3	3	7	0	0	0	0	0	40	17
Curc.	4	3	2	0	0	4	2	2	2	0	1	1
Redu. 01	0	1	1	1	0	1	0	0	0	0	0	0
Redu. 02	0	0	0	0	0	0	0	0	0	0	0	0
Spiders	5	12	4	12	4	12	13	9	12	9	11	10
Lepi. ad.	1	7	3	0	0	1	3	3	0	1	1	1
Lepi. lar.	0	8	1	2	1	2	2	1	2	0	0	2
Neur. ad.	2	0	0	1	2	0	0	0	0	0	0	0
Neur. lar.	0	0	0	0	0	0	0	0	0	0	1	0
Micro. Hyme.	4	11	6	14	8	9	8	15	11	10	10	9
Cole. Chry. 03	3	1	5	7	2	0	1	3	2	3	0	7
Cica. nym.	181	208	201	205	138	33	275	125	175	137	175	214
Cica. 01	1	0	0	0	0	7	6	3	5	3	2	1
Cica. 02	26	23	30	38	21	11	36	38	33	14	20	45
Cica. 03	9	9	14	17	7	39	6	4	7	0	6	5
Cica. 04	0	0	0	0	0	0	0	0	0	0	0	0
Cica. 05	0	0	0	0	0	2	0	0	0	0	0	0
Cica. 06	0	0	0	0	0	0	0	0	0	0	0	0
Cica. 07	96	132	164	132	127	42	59	66	77	70	83	200
Dipt.	21	34	20	25	18	13	0	11	7	9	11	19
Dipt. Asil. 01	0	0	0	0	0	0	1	0	0	0	0	0
Chry. 05	0	0	0	0	0	0	1	0	0	0	0	0
Melo. 01	0	2	0	0	0	0	3	0	0	0	0	2
Dipt. Asil. 02	1	0	0	0	0	0	0	1	0	0	0	0

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Bery. 01	0	3	1	3	0	0	0	1	1	0	4	0
Gryl. 01	0	1	1	0	1	0	0	0	0	0	0	0
Gryl. nym.	0	0	0	0	0	0	0	2	0	1	1	2
Hyme. 15	0	0	0	0	0	0	0	2	0	0	0	1
Mala. 01	0	1	0	0	0	0	0	1	1	1	1	1
Pent. 03	0	0	0	0	0	0	0	1	0	0	0	0
Hemi. Corimel.	0	0	0	0	0	0	0	0	0	0	1	0
Form. 03	0	0	0	0	0	33	21	35	15	30	0	0
Cole. lar.	2	4	5	4	1	10	3	0	0	1	1	4
Cica. 08	0	0	0	0	–	17	0	0	0	0	0	0
Anth. 02	0	0	0	0	0	0	0	1	0	0	0	0
Lyga. Bli. 01	1	0	0	0	1	0	0	0	1	2	3	0
Hemi. Miri. 01	0	0	0	0	0	0	0	0	0	0	0	1
Elat. 03	1	0	0	0	0	0	0	0	0	0	0	1
Hemi. Phas.	0	0	1	0	0	0	0	0	0	0	0	1
Staph. 01	1	0	0	0	0	0	0	0	0	0	0	0
Lyga. 02	0	0	0	1	0	0	0	0	0	0	0	0
Cara. 02	0	0	0	0	1	0	0	0	0	0	0	0

August 19-20, 1971

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
	–	–	–	18	–	–	–	–	–	–	–	–
Smin. 01	–	–	–	–	3	–	–	3	2	–	3	–
Locust. 01	1	–	–	2	–	1	–	–	1	2	2	–

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Locust. nym.	5	3	1	5	24	4	2	—	5	4	4	1
Pseu. 01	8	7	4	4	8	9	9	3	6	7	7	25
Lyga. nym.	—	—	—	—	—	—	—	3	—	—	—	—
Geo.	—	1	2	3	—	2	—	—	—	—	3	3
Hemi. Core. 01	—	—	7	—	1	—	—	3	—	—	1	—
Phlo.	18	8	—	3	—	76	58	—	64	33	6	17
Brown thrips	—	—	—	—	—	—	—	—	—	—	—	—
Dipt.	8	2	3	7	2	—	—	3	3	2	14	10
Mala. 01	—	1	—	—	—	—	—	—	—	3	1	2
Cole. lar.	—	1	—	—	—	2	—	—	2	—	—	2
Elat. 01	93	29	29	9	19	112	40	24	33	38	57	100
Cara. 04	—	15	9	3	3	6	11	14	18	12	26	18
Anth. 01	13	10	4	1	10	15	—	4	10	16	25	3
Anth. 03	6	5	1	2	3	19	11	2	1	2	4	1
Tene. 02	1	—	1	—	1	1	3	1	2	1	—	2
Form. Pog.	9	—	—	—	—	—	4	8	2	3	1	—
Form. Cre.	—	—	1	3	2	10	17	9	51	39	5	9
Form. 06	39	12	4	10	4	3	—	—	—	—	104	30
Chry. 01	—	1	2	2	—	3	35	14	8	1	3	1
Cocc. 04	2	—	—	—	1	—	—	—	1	—	—	—
Scar. 01	—	—	1	—	—	—	—	—	—	—	—	—
Lepi.	—	—	—	1	—	—	—	—	1	—	—	—
Lepi. lar.	11	8	1	—	4	3	6	7	4	1	2	6
Spiders	14	—	3	8	3	7	5	3	1	6	6	3

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Cica. nym.	403	192	143	118	143	197	171	250	207	198	83	245
Cica. 02	60	38	32	34	43	29	26	48	36	32	67	43
Cica. 03	12	4	3	–	9	26	9	15	–	2	–	21
Cica. 07	6	–	–	–	–	5	4	–	–	–	–	2
Bery. 01	–	–	1	–	–	–	–	–	–	–	–	–
Curc.	–	–	–	–	–	1	–	–	2	–	–	–
Hemi. nym.	9	2	2	4	12	–	5	6	7	9	9	12
Ting. 01	–	–	–	–	–	–	–	1	–	–	–	–
Micro. Hyme	28	–	12	4	5	14	–	5	5	4	7	39
Tene. 01	–	–	–	–	–	–	1	–	–	–	1	–
Melo. 01	–	–	1	–	1	–	–	–	2	–	–	1
Pent. 01	–	–	–	–	–	–	–	1	–	–	–	–
Cica. 06	25	4	–	–	–	–	–	–	7	3	16	6
Cica. 04	36	–	–	–	–	–	–	–	–	–	–	–
Core. 01 nym.	–	–	5	–	–	–	–	–	–	–	–	–
Lyga. 02	–	–	–	1	–	–	–	–	–	–	–	–
						October 2-3, 1971						
Elat. 01	23	32	17	12	7	29	60	55	51	70	48	24
Stap. 02	–	–	–	–	–	–	3	–	–	–	–	–
Anth. 01	–	–	–	–	–	–	–	–	–	–	–	–
Anth. 02	–	–	–	–	–	–	–	–	–	–	–	–
Bery. 01	2	–	1	3	2	9	4	3	–	1	1	2
Cole. Mala. 01	–	–	–	–	–	–	–	2	–	–	–	–
Anth. 03	6	10	2	3	10	17	23	40	26	21	5	8
Form. 06	20	18	17	15	3	10	14	16	12	106	83	31

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Geo. 01 nym.	–	–	–	–	9	–	3	–	–	–	–	–
Hemi. nym.	6	6	9	41	9	15	29	6	5	6	9	5
Phlo.	57	33	82	57	46	48	277	173	135	111	89	69
Brown Thrips	–	–	33	99	44	54	284	141	108	48	–	–
Chry. 01	6	10	2	–	6	9	12	20	5	2	3	7
Ting. 01	3	–	1	–	–	–	–	–	15	1	–	–
Cara. 04	–	–	1	–	–	–	1	1	–	–	–	–
Curc.	1	–	–	–	–	1	1	–	3	–	–	–
Melo. 01	–	–	–	–	–	–	10	–	–	–	–	–
Cole. lar.	1	1	2	4	–	2	4	4	11	1	5	–
Cica. nym.	209	215	136	179	134	165	362	311	244	241	287	232
Cica. 01	–	–	–	–	–	–	3	–	–	–	–	–
Cica. 02	55	66	55	71	47	55	120	49	45	76	72	56
Cica. 03	–	5	8	14	18	16	–	27	–	29	25	9
Cica. 06	13	–	–	9	5	–	–	5	16	–	15	–
Cica. 07	–	–	–	1	–	–	8	–	–	12	–	–
Cica. 08	–	–	–	–	–	–	–	–	–	–	11	–
Redu. 02	6	5	2	–	–	–	6	–	3	4	4	2
Gryl. 01	–	–	1	–	–	–	–	–	–	–	–	–
					November 13-14, 1971							
Ento. 01	1	1	5	2	1	79	12	113	–	120	20	1
Podu. 01	–	–	–	–	–	–	–	–	–	–	–	–
Smin. 01	–	–	–	–	164	233	80	325	97	287	109	–
Locust. 01	–	–	–	–	2	–	–	–	–	–	–	–
Locust. nym.	–	–	–	–	–	2	–	–	4	–	1	–

APPENDIX A. Continued

Insect	1 AM	3 AM	5 AM	7 AM	9 AM	11 AM	1 PM	3 PM	5 PM	7 PM	9 PM	11 PM
Pseu. 01	—	—	—	—	2	1	—	—	—	2	—	—
Thrips	—	—	1	—	32	19	1	13	2	—	28	1
Cole. lar.	—	—	3	3	—	1	1	—	2	—	—	—
Cica. 02	—	—	3	—	13	4	11	17	24	10	21	—
Phlo.	—	—	—	3	58	47	30	48	33	12	24	—
Chry. 01	—	—	—	1	2	—	2	2	8	2	4	—
Tene. 02	—	—	—	1	—	—	—	1	—	—	—	—
Anth. 03	—	—	—	1	8	5	1	3	5	3	3	—
Dipt.	2	1	2	1	4	3	1	3	9	—	14	1
Form. Cre.	16	8	—	4	3	—	2	—	—	—	6	—
Form. 06	2	1	1	—	—	3	—	—	3	—	—	1
Geo.	—	—	—	—	3	—	—	1	1	—	2	—
Hemi. nym.	—	—	—	—	12	3	2	9	14	14	15	—
Elat. 01	—	—	—	—	8	10	9	—	4	3	2	—
Bery. 01	—	—	—	—	1	2	—	—	—	—	2	—
Core. nym.	—	—	—	—	10	1	—	45	—	—	—	—
Lepi. ad.	—	—	—	—	2	—	—	—	—	—	—	—
Lepi. lar.	—	—	—	—	5	9	1	2	3	—	—	—
Spiders	—	—	—	—	14	5	5	12	12	12	8	—
Cica. nym.	—	—	—	—	192	171	85	161	171	80	92	1
Micro. Hyme.	—	—	—	—	13	11	6	3	10	3	7	1
Pent. 01	—	—	—	—	1	—	—	—	1	—	—	—
Pent. 01 nym.	—	—	—	—	1	—	—	—	2	—	—	—
Curc.	—	—	—	—	—	1	—	—	—	—	—	—
Core. 02	—	—	—	—	—	—	—	12	6	—	5	—
Redu. 02	—	—	—	—	—	—	—	4	1	—	1	—
Cica. 03	—	—	—	—	—	—	—	—	8	—	—	—
Cica. 06	—	—	—	—	—	—	—	—	1	2	—	—

APPENDIX B. Continued

NYM. = NYMPH	REDU. = REDUVIIDAE
PENT = PENTATOMIDAE	SCAP. = SCAPHIDIIDAE
PHAS. = PHASMIDAE	SCAR. = SCARABAEIDAE
PHLO. = PHLOEOTHRIPIDAE	SMIN. = SMINTHURIDAE
PHLO. GED. = PHLOEOTHRIPIDAE	STAPH. = STAPHYLINIDAE
PIES. = PIESMIDAE	TENE. = TENEBRIONIDAE
PODU. = PODURIDAE	TING. = TINGIDAE
POG. = POGONOMYRMEX	TYCH. = TYCHIUS
PSEU. = PSEUDOCOCCIDAE	