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Analysis of Whistling Patterns in the Eastern Bob-White, Colinus v. virginianus L.

James B. Elder
Iowa State College

Analysis of Whistling Patterns in the Eastern Bob-White, *Colinus v. virginianus* L.[1]

By JAMES B. ELDER[2]

INTRODUCTION

The cheery whistle of the male bob-white, *Colinus v. virginianus* L., is a familiar and welcome sign of spring wherever this species occurs. Game biologists have made practical use of the bob-white's whistle by using roadside counts of whistling bob-whites as a means of estimating changes in relative abundance from year to year (Bennitt, 1951). As devised by Bennitt for use in Missouri, the roadside whistle counts required the services of a large number of observers. Each observer was assigned a predetermined "station" consisting of about thirty miles of all-weather road within a major soil type. Counts were made during the first hour after sunrise on any two calm, dry days between July 13-19. The first observation was made at the starting point at sunrise. The observer recorded the number of bob-whites heard whistling. Thereafter the observer stopped at one-mile intervals along his assigned route during the hour, counting the whistling birds at each stop. At the beginning and end of the hour he recorded air temperature, cloudiness, and wind velocity, and at each stop he recorded type of road, time, and mileage.

Each stop required usually from two to three minutes. In the course of the hour from eight to sixteen stops were made, averaging about thirteen. From the data obtained, call indices (Call Index = the average number of bob-whites heard whistling per stop) were computed for the zoogeographical regions of the state and for the state as a whole.

Although some mated cocks are known to whistle, the bulk of bob-white whistling activity is carried on by unmated cocks. (Stoddard, 1931). The call index, therefore, is an estimate of the proportion of surplus cocks in a population. In Missouri, regional call indices have been used to predict hunting success (average number of birds bagged per gun per hour).

In order to learn more about bob-white whistling behavior, intensive studies of whistling patterns were made during the summers of

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[2]Graduate assistant in Wildlife Research, Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

1954 and 1955 on a 7713-acre Quail Research Area in Decatur County in south-central Iowa (Sanders, 1943). Objective of the investigations was to record and interpret daily and seasonal variation in whistling patterns in relation to daily changes in weather, seasonal climatic changes, nesting phenology, and other environmental factors.

Methods

Whistle data were obtained at two listening stations from July 9 to August 7, 1954 and from June 1 to August 2, 1955. One station was located in the SW¼ of Section 11, the other in the NW¼ of Section 13, Woodland Township, Decatur County. As the two stations were approximately one and one-half miles apart, there was no overlap in the birds heard whistling at each station.

Weather	Start	Finish	
			Observer: J. B. E.
Temp.	66.5	68.5	Place: Section 13, Woodland
Wet Bulb D.	65.1	67	
Dew	0	....	Date: June 29, 1955
Wind	SE 4.0 mph	S 5.5 mph	
Clouds	10	10	Sunrise: 0448
			Time Start: do

Time	Individual whistlers 1	2	3	4	5	6	7	Total quail whistling	Other
0448-49	111							11 (2)	#1, 75 yd. NW NE
0449-50	111111	111						11 (2)	#2, SSE 100 yd. in elm, edge of drainage
0450-51	111	1111						1111 (4)	NE, NE[2]
0451-52	1111	111						11111 (5)	NE, SW, S
0452-53	11	111						111 (3)	NE

Figure 1. Sample field form indicating manner of recording bob-white whistling observations.

In 1954 daily counts were made simultaneously at the two stations by the writer and Mr. John Barrington, field assistant, from one-half hour before sunrise to two hours after sunrise. As the servises of a field assistant were not available in 1955, the writer alternated his daily observations between the two stations. Because of the great variability in whistling in 1954 during the half hour before sunrise, this interval was eliminated in the 1955 counts and has been eliminated from the 1954 analyses.

Weather measurements were made at the start and finish of each day's count. These included temperature and wet-bulb depression (for computing relative humidity, absolute humidity, and vapor pressure deficit) by means of a sling psychrometer, wind velocity by means of a Taylor hand anemometer, dewfall by means of a Duvdevani dew block, precipitation by means of two eight-inch non-recording gauges, and nebulosity, estimated as 0-10, clear to a completely overcast sky. Changes in any weather factor during the course of a count were noted on the field sheets at the time of occurrence. In 1954, weather observations were made at the writer's place of residence, located 0.5 and 1.75 miles from Stations 11 and 13, respectively. In 1955, weather observations were made at the stations.

Each minute of the 120-minute count was listed in the left hand column of the field sheets (Figure 1). These were grouped into five-minute intervals beginning with the first minute (sunrise). Whistling activity was recorded as follows: the total number of birds whistling during each one-minute interval was listed in the total column. Each bird whistling during the minute was tallied as soon as it was identified. An attempt was made daily to record individual whistling patterns and movements for a few close, loud, or otherwise distinctive whistlers. For these birds the actual whistles per minute per bird were tallied in the column assigned to the individual. Notes on their whistling locations and movements were entered in the right-hand column.

During each five-minute interval the total birds whistling were separated as individuals. The birds for which whistles per minute data were being recorded were already separated as individuals in their assigned columns. Others were differentiated by assigning symbols indicating the compass direction from which the birds were heard whistling (Figure 1, NE, SW, S). Two or more birds whistling from the same general direction during a five-minute interval were separated by numbering duplicate symbols (Figure 1, NE, NE^2). By means of this system of recording data it was possible to compute call indices for each of 120 one-minute intervals, sixty two-minute intervals, forty three-minute intervals, thirty four-minute intervals and twenty-four five-minute intervals.

Thus, in Figure 1, six birds whistled during the first five-minute interval. Two whistled during the first minute, two during the second, four during the third, five during the fourth, and three during the fifth. Three birds whistled during the first two-minute interval, six during the second, etc.

Since, the two-, three-, and four-minute intervals frequently were comprised of parts of two concurrent five-minute intervals, care was taken to retain individual identities from one five-minute interval to the next insofar as possible.

With the detailed separation of whistling individuals, it was possible to summarize each daily count into a large variety of component call indices for purposes of comparison and analysis both within and between daily counts. Each daily summary consisted first of tabulating the call indices for each of 120 one-minute intervals, sixty two-minute intervals, etc., as indicated above. These were then summed over various time combinations and averaged. The present paper deals with call indices computed for one-, two-, three-, four-, and five-minute intervals during the following time combinations: (1) Minutes 1-120-sunrise to two hours after sunrise, (2) Minutes 1-60-first hour after sunrise, and (3) Minutes 61-120-second hour after sunrise.

Table 1.

Bob-white whistling data for Sections 11 and 13 stations, 1954 and 1955, sunrise to 120 minutes after sunrise

Time interval	Mean number birds whistling daily per interval	Standard deviation	Coefficient of variation (percent)
A. Section 11 Station, July 9 to August 5, 1954			
1 minute	1.36	±1.044	76.8
2 minute	1.84	±1.288	66.4
3 minute	2.36	±1.423	60.3
4 minute	2.70	±1.427	52.9
5 minute	2.99	±1.594	53.3
B. Section 13 Station, July 9 to August 5, 1954			
1 minute	1.57	±1.023	65.2
2 minute	2.04	±1.133	55.5
3 minute	2.40	±1.188	49.5
4 minute	2.70	±1.258	46.6
5 minute	2.90	±1.304	44.9
C. Section 11 Station, June 4 to July 30, 1955			
1 minute	1.14	±0.6036	52.9
2 minute	1.43	±0.7106	49.5
3 minute	1.66	±0.8015	48.1
4 minute	1.87	±0.9054	48.4
5 minute	2.05	±0.9406	45.9
D. Section 13 Station, June 1 to August 2, 1955			
1 minute	1.59	±0.4064	40.1
2 minute	1.99	±0.5964	38.7
3 minute	2.32	±0.8013	38.6
4 minute	2.54	±0.9271	37.9
5 minute	2.74	±1.0538	37.4

Results

The mean number, standard deviation, and coefficient of variation of bob-whites heard whistling for each one- to five-minute interval starting at sunrise and stopping 120 minutes after sunrise were computed for Sections 11 and 13 stations for 1954 and 1955 (Table 1). With one exception, the coefficients of variations decreased as the length of the interval increased from one to five minutes. In the 1954 Section 11 data (Table 1A) the four-minute interval had the smallest coefficient of variation (52.9 percent), although it differed by only 0.4 percent from the five-minute interval (53.3 percent).

In general, there was considerable difference between the coefficients of variation of the one- or two-minute intervals and the coefficients of the three-, four-, and five-minute intervals. These differences ranged from 23.9 percent between the one- and four-minute intervals in the 1954 Section 11 data (Table 1A) to 2.7 percent between the one- and five-minute intervals in the 1955 Section 13 data (Table 1D). In contrast, the coefficients of variation of the three-, four-, and five-minute intervals varied only from 7.4 percent in the 1954 Section 13 data (Table 1B) to 1.2 percent in the 1955 Section 13 data(Table 1D). It was apparent that there were only minor differences in the value of data in the three-, four-, and five-minute intervals. Considered in conjunction with the roadside whistle count, these results indicate that three-, four-, or five-minute stops furnish more reliable information than do one- or two-minute stops. In addition, the minor differences between the three-, four-, and five-minute interval data indicate that there is little to be gained in extending the stops from three to four or five minutes. In fact, the gain in information per stop probably would not compensate for the loss in data resulting from fewer stops in a given period of time.

Analyses of variance were computed for the 1954 Sections 11 and 13 data (Tables 2 and 3, Elder, 1956). The data analyzed were the bob-whites heard whistling during each one-, to five-minute interval for twenty-seven days between July 9 and August 5. The twenty-seven days were divided into three nine-day periods. In the analyses, days were those within any one of the three periods, and hours are the first versus the second hour on any given day. The purpose of the analyses was to analyze the sources of variation as related to periods, days, and hours. Since no consistent relationship could be found between daily call indices and concomitant weather data from graphic inspection of these data, the call indices were not corrected for possible weather variations. The variation between minutes within days and hours was used as an estimate of error.

Periods furnished a significant component of variation in each of the ten analyses, reflecting normal seasonal diminishing of whistling activity as the nesting season progressed. Days within periods were also significant indicating considerable day to day variation in whistling activity within each period. Ths was probably due in part to daily variation in weather.

In Missouri Bennitt (op. cit.) found that whistling activity was greater during the first hour after sunrise than during the second hour. From examination of call indices of the one-, to five-minute intervals over the first and second hours for both the Section 11 and Section 13 data, it was found that in general the call indices for the first hour were greater than those for the second hour. There were,

Table 2

Model analysis of variance of three-minute intervals, quail whistling data, July 9 to August 5, 1954, Section 11 Station, sunrise to 120 minutes after sunrise

Source of variation	D. F.	S. S.	M. S.	M. S.÷3	"F"
Periods	2	1417.9686	708.9843	236.3281	350.324**
Days/periods	24	462.3444	19.2644	6.4215	9.518**
Hours	1	1.4815	1.4815	.4938	.7319
Periods X hours	2	4.9685	2.4842	.8281	1.227
Hours X days/periods	24	143.0000	5.9583	1.9861	2.944**
Minutes/days/hours	1026	2076.5000	2.0239	.6746[a]	
Total	1079	4106.2630			

[a]Estimate of error for testing significance
**Significant at .01 level

Table 3

Model analysis of variance of three-minute intervals, quail whistling data, July 9 to August 5, 1954, Section 13 Station, sunrise to 120 minutes after sunrise

Source of variation	D. F.	S. S.	M. S.	M. S.÷3	"F"
Periods	2	346.5389	173.2694	57.7564	122.755**
Days/periods	24	1290.8279	53.7845	17.9282	38.105**
Hours	1	38.1565	38.1565	12.7188	27.032**
Periods X hours	2	4.8574	2.4287	.8095	1.720
Hours X days/periods	24	218.0611	9.0859	3.0286	6.436**
Minutes/days/hours	1026	1448.1500	1.4115	.4705[a]	
Total	1079	3346.5917			

[a]Estimate of error for testing significance.
**Significant at .01 level

however, frequent exceptions to this pattern. For example, on a given day, all of the first hour call indices might be smaller than those for the second hour, or, only the one-, and two-minute interval indices of the first hour might be smaller. Further, the differences between the call indices for the first and second hours in the Section 13 data were generally greater than those in the Section 11 data.

In the analyses of variance, hours were significant in each of the analyses for Section 13, whereas hours were significant for only the one-minute interval analysis for Section 11. It is possible that the significant hours component of variation for the one-minute interval for Section 11 may be due to a differences in the whistling patterns of bob-whites at the two stations.

The interaction periods times hours was significant for the one-minute analysis for Section 11 and for the one-, and two-minute analyses for Section 13.

The significant interaction of hours times days within periods in each of the analyses reveals that whistling activity of bob-whites was greater during the first hour than during the second, and vice versa for different days within a given period and between the three periods.

The analyses thus demonstrated that there was considerable daily and seasonal variation from the pattern of greater whistling activity during the first hour after sunrise than during the second hour. Changes in weather factors during the course of a two-hour count, for example, a brief rainstorm or a period of high wind, were responsible for part of the variation, but the data obtained are not sufficient to permit quantitative evaluation.

Much remains to be studied in this investigation. With the tentative conclusion that the three-minute interval is the most logical listening period per stop for a roadside whistle count, we find certain components of variation as determined by the two stations on Sections 11 and 13 that are of significance within the three-minute interval (Tables 2 and 3). The component of variation due to periods may be assumed to be the normal seasonal decline in whistling behavior of the bob-white. The components of variation due to days within periods, hours on the Section 13 station, and hours times days within periods are at persent subject to biological speculation. Weather factors may be important and increased emphasis was given this phase of the study in 1955. Another factor may be physiological stimulation of one whistling bob-white on another. Also, the importance of differences in sex and age ratio and seasonal movements of quail in the vicinity of the two stations is unknown and may be helpful in providing a biological explanation for these important components of variation.

It was postulated that daily variation in call indices (number of birds heard whistling per three-minute interval) may have resulted from concurrent daily variation in weather. From graphic inspection of call indices and averages of weather measurements made at the start and finish of each daily count for both 1954 and 1955, three weather variables that appeared to be most consistently related to whistling activity were selected for statistical analysis. These were temperature, wind velocity, and vapor pressure deficit. Simple correlation coefficients were computed for the three-minute call indices over each daily two-hour count and each of these weather variables (Table 4).

The correlation coefficients for the 1954 data were negative for wind and positive for temperature and vapor pressure deficit. Wind was statistically significant for the Section 13 data while temperature and vapor pressure deficit were significant for the Section 11 data. Each of the coefficients was negative for the 1955 data and

Table 4

Correlation coefficients between three-minute call indices and weather factors, 1954 and 1955, Stations 11 and 13

Year and station	Wind	Temperature	Vapor pressure deficit
1954, 11	–.0789	.5026**	.6539**
1954, 13	–.4616*	.2002	.1752
1955, 11	–.334	–.139	–.1899
1955, 13	–.202	–.574**	–.272

*Significant at 1 percent level
**Significant at 5 percent level

only temperature for the Section 13 data was significant. In view of the fact that weather measurements in 1954 were made at 0.5 and 1.75 miles from Sections 11 and 13 stations, respectively, it is possible that the weather data used in the correlation analyses were not representative of actual conditions at the stations. This may account in part for the variation between correlation coefficients for the two stations. The 1955 weather data are presumed to be more representative of weather conditions inasmuch as measurements were made at the station sites.

Since it was possible that two or more weather variables interacted to produce an effect on bob-white whistling patterns, the method of multiple linear regression was used to examine the influence of wind, temperature, and vapor pressure deficit as independent and multiple factors for the 1955 Sections 11 and 13 data (Tables 5 and 6). The equation, $Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3$, was used. In this equation, Y = mean number of bob-whites heard whistling per three-minute interval during the first two hours after sunrise, X_1 = wind velocity, X_2 = temperature, and X_3 = vapor pressure deficit.

One basic assumption implicit in the multiple regression analysis technique is that the independent variables (X) are fixed or are measured without error. The measurements obtained for wind (X_1) did not account for high gusts. In the writer's observations it was found that whistling activity diminished and frequently ceased entirely during periods characterized by gusty winds.

For the Section 13 data the equation derived for the three variables was:

$$\hat{Y} = 6.633717 + (-.054066)\ X_1 + (-.061245)\ X_2 + (.08135)\ X_3.$$

The coefficient of multiple correlation, R, which measures the degree of linear association among dependent (Y) and independent (X_1, X_2, X_3) variables, was significant at the five percent level ($R = .595$; $R_{.05} = .523$, 24 D. F.). R^2, or the proportion of the

Table 5.

Three-minute bob-white call indices and corresponding wind velocities, temperatures and vapor pressure deficits for Section 11 station, 1955

Date	Call index	Wind velocity (M. P. H.)	Temperature (Degrees F.)	Vapor pressure deficit
June				
2	-	-	-	-
4	1.60	2.88	61.00	.0540
6	1.70	1.25	57.75	.0590
8	-	-	-	-
10	0.80	2.33	51.50	.0345
12	1.65	8.50	53.50	.0750
14	1.90	1.50	51.75	.0765
16	2.80	0 00	58.50	.1055
18	1.60	2.88	68.50	.1780
20	2.10	0.50	64.25	.0730
22	2.93	0.00	61.75	.1050
24	-	-	-	-
26	2.40	0.00	62.50	.0755
28	0.55	6.10	64.50	.1680
30	0.08	6.25	73.75	.1310
July				
2	1.00	4.75	74.75	.1360
4	2.45	2.13	73.00	.1070
6	2.20	3.75	69.50	.0365
8	3.18	4.83	76.50	.1965
10	-	-	-	-
12	0.75	1.30	70.50	.1620
14	1.33	0.00	69.00	.0960
16	1.40	2.33	67.50	.0785
18	2.40	1.00	69.50	.1075
20	1.43	0.00	73.50	.0970
22	2.05	1.25	78.00	.2160
24	-	-	-	-
26	1.80	3.00	77.75	.2290
28	1.13	0.38	79.25	.2675

sum of squares of the dependent variable which is explained by the multiple regression equation, was .3542, or 35.42 percent. In other words, 35.42 percent of the daily variation in call indices was attributable to the effect of the three weather factors at Section 13 station.

From t-tests of significance of the calculated b values, it was found that b_2 (temperature) was significant at the one percent level ($t = 3.06$, $t_{.01} = 2.79$, 24 D. F.) while b_1 and b_3 were not significant. From this it was apparent that of the three variables, temperature was most important.

The calculated multiple regression equation for the data from Section 11 was:

$$\hat{Y} = 2.382066 + (-.109683)X_1 + (-.003387)X_2 + (-1.843689)X_3.$$

The coefficient of multiple correlation, R, was not statistically

Table 6.

Three-minute bob-white call indices and corresponding wind velocities, temperatures and vapor pressure deficits for Section 13 station, 1955

Date	Call index	Wind velocity (M. P. H.)	Temperature (Degrees F.)	Vapor pressure deficit
June				
1	1.43	10.63	64.00	.1390
3	3.70	5.85	67.50	.0675
5	2.35	6.25	61.25	.0650
7	3.13	4.75	52.25	.0735
9	3.95	0.75	51.25	.1150
11	-	-	-	-
13	3.03	1.50	49.25	.0325
15	3.80	0.00	56.00	.0870
17	4.48	5.13	64.00	.1500
19	3.15	0.50	65.75	.0755
21	1.13	7.20	67.50	.1635
23	2.18	3.13	58.00	.1560
25	-	-	-	-
27	2.10	4.13	64.50	.1275
29	2.59	5.08	67.50	.0570
July				
1	1.76	0.75	68.25	.1275
3	-	-	-	-
5	1.23	2.08	71.25	.1025
7	1.98	5.00	72.00	.0895
9	-	-	-	-
11	1.53	3.75	76.25	.1270
13	2.38	1.25	69.50	.2065
15	1.95	4.50	68.50	.1325
17	1.98	2.50	68.25	.0695
19	1.30	1.75	72.00	.1025
21	2.65	2.17	76.00	.1420
23	2.35	0.00	75.25	.0845
25	2.10	6.25	71.50	.0515
27	2.35	6.25	78.00	.2625
29	1.45	3.44	78.25	.2215
31	1.53	4.50	79.00	.1620
Aug.				
2	1.35	1.88	75.50	.1390

significant ($R=.362$, $R_{.05}=.552$, 21 D. F.) R^2 was found to be .1313; thus, only 13.13 percent of the variation in daily whistling at Section 11 station could be attributed to the three weather variables. T-tests of the b values were all non-significant.

In order to further examine the possible effects of the three weather variables on whistling, the data from Sections 11 and 13 were pooled and subjected to multiple regression analysis. The equation derived for the pooled within station data was:

$$\hat{Y} = 4.856904 + (-.084121)X_1 + (-.039038)X_2 + (.338507)X_3$$

The multiple R was significant ($R=.446$, $R_{.05}=.379$, 49 D.F.). R^2 was .1986 so that only 19.86 percent of the variation in whistling was due to weather. Only the b_2 (temperature) value was significant ($t=2.38$, $t_{.05}=2.00$, 49 D.F.). Results of the pooled analysis, therefore, are similar to those from the Section 13 analysis and reflect the significant negative correlation between temperature and call indices found in the Section 13 data.

Wind velocities in excess of eight miles per hour are considered to be critical in crowing counts of ring-necked pheasants (Kimball, 1949). Assuming the same to be true in call indices of bob-whites, only two mornings out of the 53 recorded had wind velocities in excess of eight miles per hour. Undoubtedly, if higher wind velocities had been encountered in 1955 a significant correlation would have been found between this weather factor and bob-white call indices.

From a graphic inspection of three-minute call indices and corresponding temperature observations there are indications that daily variation in call indices may be confounded with seasonal trends in temperature and with seasonal decline in whistling behavior and/or with a movement of whistling quail away from the station. The latter hypothesis is supported by two apparent levels of call indices in the Section 13 data. The Section 11 data do not indicate any noticeable decline in bob-white whistling behavior and have a weak negative correlation with temperature. Therefore, the significant correlation between temperature and call indices for the Section 13 data may be spurious.

Vapor pressure deficit was strongly correlated to air temperature in the two sets of data. Hence, little reduction in variation of daily call indices was made by including this factor.

In summary we might assume all of these weather relationships to be of importance in the variation of bob-white call indices and examine the pooled within multiple regression for the two stations. We find that less than 20 percent of the variation in daily call indices is accounted for by measurements on wind, temperature, and vapor pressure deficit. Certainly additional field studies are in order before positive conclusions may be made concerning the effects of weather on bob-white whistling behavior.

Summary

1. An investigation of bob-white whistling patterns as related to temperature, wind velocity, vapor pressure deficit, dewfall, precipitation, and nebulosity measured at the start and finish of each daily count was conducted in Decatur County, Iowa between July 9 and August 7, 1954 and between June 1 and August 2, 1955.

2. Counts of whistling bob-whites were made daily at two listening stations (Sections 11 and 13) from sunrise to two hours after sunrise in 1954 and were alternated between the two stations in 1955.

3. Mean number, standard deviation, and coefficient of variation of birds heard whistling were computed for each one- to five-minute

interval over the first and second hour after sunrise for the Sections 11 and 13 data for 1954 and 1955.

4. The minor differences between the coefficients of variation of the three-, four-, and five-minute intervals indicated that the three-minute interval would provide the most information in a roadside whistle count.

5. The one-, to five-minute call indices for twenty-seven days, separated into three nine-day periods, for the 1954 data were subjected to analyses of variance. The components of variation examined were periods, days within periods, hours (first vs. the second after sunrise), and the interactions periods times hours, and hours times days within periods. Periods were statistically significant in each analysis and was ascribed to seasonal decline in whistling activity. Days within periods was also significant indicating considerable day to day variation in whistling. Hours times days within periods was significant in each of the analyses. Hours were significant for all intervals in the Section 13 data but only for the one-minute indices in the Section 11 data. Periods times hours was significant only for the one- and two-minute call indices.

6. The independent and combined effects of wind, temperature, and vapor pressure deficit on daily call indices was examined by the method of multiple linear regression for the 1955 data for the two stations.

7. Only 35.42 percent of the daily variation in whistling at the Section 13 station could be attributed to the effects of the three weather variables. A highly significant value for temperature accounted for most of the variation. Of the variation at Section 11 station 13.13 percent was due to weather. None of the individual weather variables was significant.

8. From multiple regression analysis of the pooled 11 and 13 data only twenty percent of the variation in whistling was due to weather. Other possible explanations for the variation in whistling were discussed and additional future lines of investigation were suggested.

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Department of Zoology and Entomology
Iowa State College
Ames, Iowa