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THE PHYSICAL-CHEMICAL PROPERTIES OF ALCOHOL-GASOLINE BLENDS

III. THE A. S. T. M. DISTILLATION CURVES AND REID VAPOR PRESSURE

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Within the last few years, the A. S. T. M. distillation data have become one of the most commonly used specifications for motor fuel. These temperature specifications are changed to meet seasonal conditions to give the higher test gasoline of winter and the less volatile gasoline of summer. Aside from the anti-knock qualities, the distillation characteristics are also the major differences between the premium, regular and competitive grades of fuels sold at any one season.

The correlation of motor performance with the A. S. T. M. distillation curve for the fuel has resulted from the research work of many individuals. A summary and bibliography of this is given in the recent paper by Blair and Alden (1). While the automotive engineer and petroleum technologist are not in complete agreement as to what these specifications should be for the fuel to give maximum motor performance the following general statement is frequently given.

1. The temperature of distillation of the first 10 per cent of the fuel is a relative measure of its starting qualities. This fraction will also be a relative measure of the loss of fuel by evaporation during storage.

2. The temperature of distillation of the first 30 per cent of a fuel is a relative measure of the acceleration qualities of a fuel. This fraction also determines the performance of a cold motor on choke.

3. The temperature of distillation of the first 60 per cent of a fuel is a relative measure of the performance of the hot motor under driving conditions.

4. The temperature of distillation of the last 10 per cent of a fuel is a relative measure of the amount which will condense on the cylinder walls and cause crankcase dilution.

The distillation range for gasoline has changed greatly in the last twenty years. The gasolines of twenty years ago had a relatively low initial temperature and final temperature (70°–250°F.) The increased demand for gasoline has caused more of the higher fractions to be sold as gasoline with resulting increase in both the initial and final temperatures. The introduction of the cracking process has created greater supplies of the low boiling fractions with a resulting lowering of the initial temperature of present grade gasolines. The regular fuels available in the midwest have an initial temperature of about 100°F. and a final temperature of about 400°F., these temperatures varying somewhat with the season and variety of the gasoline.

DISTILLATION DATA FOR ALCOHOL BLENDS

Alcohol forms azeotropic mixtures with various hydrocarbons. It can accordingly be predicted that a lowering of the distillation temperature will be caused by the addition of alcohol to gasoline. This prediction has been verified by Ross and Ormandy (2) for British gasolines, by Schweitzer (3) for French gasolines, by Spausta (4) for Austrian gasolines and by Bureau of Standards (5) for American gasolines.

Samples of twenty different brands of gasoline sold commercially in the midwest have been examined in this laboratory. The data reported in table 1 for varying concentrations of alcohol in gasoline are typical of the results found for all the gasolines investigated. The data of Ross and Ormandy (2) have been plotted in figure 1 and the data of table 1 if plotted in the same manner give similar distillation curves. The data of Brown (6) are the only published data which are not in complete agreement with the above, a higher initial temperature being reported by him for the alcohol-gasoline mixtures than for the original gasoline. In using the A. S. T. M. method, the initial boiling point recorded is a function of the proportion of the low boiling constituents as well as their boiling point. This may account for the higher initial point reported by Brown. This increase in the initial temperature of distillation of the alcohol blends might also be obtained by using gasolines very poor in low boiling constituents, but it certainly is not characteristic of the commercial grades of fuels in this or in the foreign countries from which data are available.

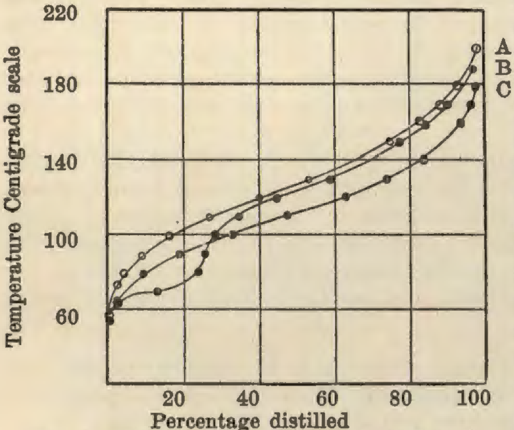

Fig. 1. Comparison of the A. S. T. M. distillation curves for a premium gasoline, (C) a lower grade of gasoline, (A) and a 10 per cent alcohol blend with the latter gasoline (B). Data taken from Ross and Ormandy.

As pointed out above, the A. S. T. M. distillation data for a fuel can be used as a qualitative measure of the performance of the fuel in a motor. The data of table 1 have been plotted in figure 2 in such a manner as to emphasize the influence of the alcohol content of the fuel on the temperature of volatilization of the successive fractions. The temperature of volatilization of the 10 per cent, 30 per cent, 60 per cent and 90 per cent fractions are of particular interest; referring to these fractions as plotted in figure 2 it is seen:

1. That the initial temperature of distillation and the temperature of the first 10 per cent distilling are not appreciably changed until alcohol concentrations of 40 per cent or more are reached. So far as volatility of fuel is concerned there should be no appreciable difference in starting qualities of the blends containing 10 per cent or 20 per cent alcohol and that of the original gasoline. The easier starting qualities reported for the alcohol blends particularly in winter weather are probably due to the fact that alcohol forms explosive mixtures with air over a wider range of

proportions than does gasoline. It would also be concluded that the alcohol blends would show no greater loss in storage than would the original gasoline.

TABLE 1. *Influence of absolute alcohol concentration upon the A. S. T. M. distillation range of alcohol gasoline*
Gasoline dried over $CaCl_2$. Absolute alcohol dehydrated with CaO

Percentage distilled	Alcohol content of blend percentage by volume								
	Nil.	0.5	1.0	2.0	4.0	6.0	8.0	10.0	15.0
	°F	°F	°F	°F	°F	°F	°F	°F	°F
Initial	101	100	100	101	100	100	102	104	101
5	125	119	119	118	119	121	121	122	123
10	137	133	138	136	134	129	130	131	132
20	165	169	169	161	169	142	142	144	144
30	193	191	196	190	188	163	151	152	152
40	218	214	220	215	214	208	195	182	158
50	241	242	242	240	238	236	232	230	215
60	266	268	272	268	268	260	260	258	247
70	295	294	293	293	293	291	290	286	282
80	326	327	328	327	327	322	321	318	316
90	368	371	371	371	374	375	370	368	341
Final	400	401	398	398	400	398	400	401	394
Residue %	2.0	2.0	1.5	2.0	2.0	2.0	2.0	2.0	2.0
Recovery %	95	95	94	95	94	95	95	95	90
Bar. mm. Hg.	730	730	730	730	730	730	730	730	720
Room t. F.°	73	73	73	73	73	73	73	73	73

Table 1. continued

Percentage distilled	Alcohol content of blend percentage by volume								
	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100
	°F	°F	°F	°F	°F	°F	°F	°F	°F
Initial	103	100	104	106	108	138	145	150	173
5	123	125	130	138	140	148	154	169	174
10	133	134	138	140	154	162	168	171	174
20	145	150	160	165	165	167	171	172	174
30	154	163	165	167	169	170	172	173	174
40	159	167	167	169	171	171	173	174	174
50	163	169	169	171	172	172	173	174	174
60	233	180	171	172	173	173	173	174	174
70	271	266	239	173	174	174	174	174	174
80	306	300	295	284	176	175	174	174	174
90	330	338	342	325	336	176	175	174	174
Final	391	390	388	383	379	376	358	358	174
Residue %	2.0	1.0	1.0	0.8	0.8	0.5	0.5	0.2	0
Recovery %	97	97	98	98	97	98	98	98	98
Bar. mm. Hg.	720	733	736	733	736	736	736	730	730
Room t. F.°	73	73	90	73	90	90	90	90	90

2. That the temperature of volatilization of the first 30 per cent of the fuel is much lower for the alcohol blends than for the original gasoline. The greater volatility of this fraction undoubtedly accounts for the better acceleration of the alcohol blends particularly noticeable in cold weather. The data of Ross and Ormandy, figure 1, offer a direct comparison in this respect of a third grade gasoline, a 10 per cent alcohol blend with the same third grade gasoline and a premium fuel.

3. That the temperature of volatilization of the first 60 per cent of the fuel is very slightly affected by 10 per cent alcohol and depressed approximately 30°F. by 20 per cent alcohol. In harmony with this fact, very little difference can be observed in the power output of the hot motor under road conditions when operating on the 10 per cent blend or the original gasoline. The general observation has been that motor operation is smoother on the blend than on the original gasoline.

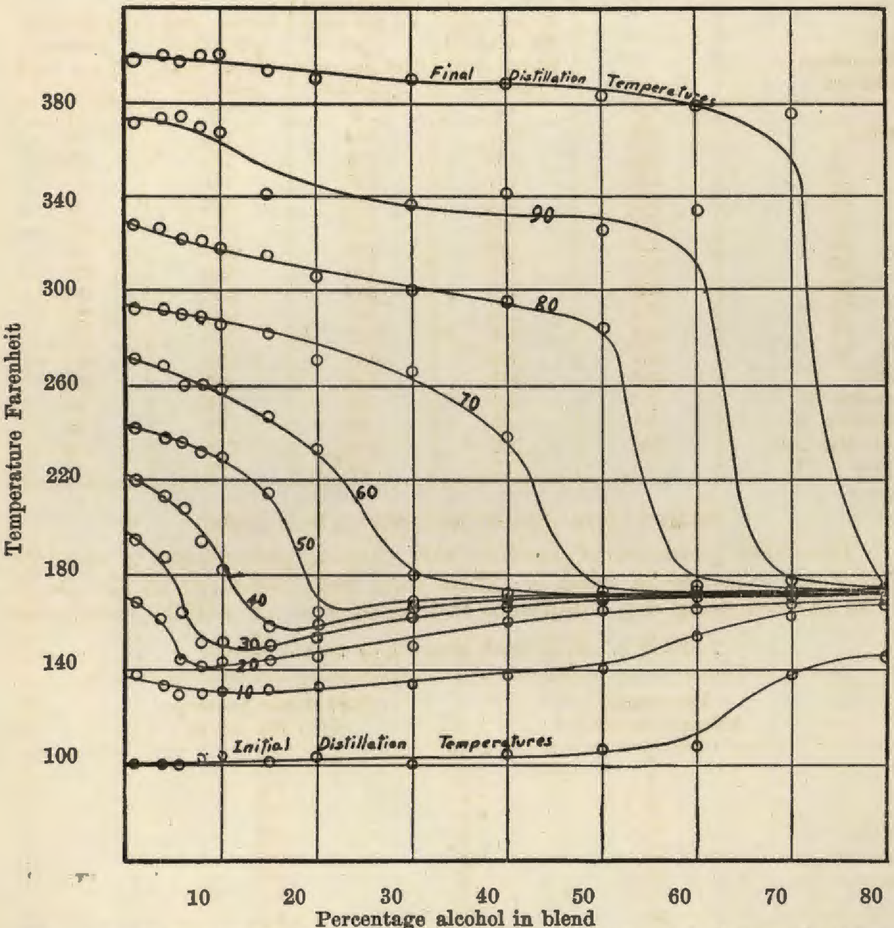

Fig. 2. The temperature of distillation of various fractions of alcohol-gasoline blends as a function of the alcohol concentration in the blend.

4. That the temperature of volatilization of the last 10 per cent of the fuel is not affected by 10 per cent alcohol but is lowered by addition of the 20 per cent or more of alcohol. The decrease in oil dilution reported for the alcohol blends is probably due to better combustion and lower flame temperatures rather than to greater volatility of this fraction of the fuel.

The slight effect of water on the A. S. T. M. distillation data for 10 per cent alcohol–90 per cent gasoline fuel is shown in table 2. The A. S. T. M. distillation data for a 10 per cent butanol—90 per cent gasoline blend and for a 10 per cent acetone–90 per cent gasoline blend are also shown in table 2, as examples of blends not containing constant boiling mixtures.

TABLE 2. *Influence of absolute ethanol, aqueous ethanol, n-butanol and acetone upon distillation range*

Percentage distilled	Gasoline	10 per cent abs. ethanol 90 per cent gasoline	10 per cent abs. ethanol 0.4 per cent H_2O 89.6 per cent gasoline	10 per cent n-Butanol 90 per cent gasoline	10 per cent acetone 90 per cent gasoline
	°F	°F	°F	°F	°F
Initial	101	104	100	102	96
5	125	122	121	121	106
10	137	131	130	143	114
20	165	144	142	170	132
30	193	152	153	190	158
40	218	182	163	207	195
50	241	230	230	230	227
60	266	258	254	237	257
70	295	286	283	281	281
80	326	318	317	315	311
90	368	368	368	371	370
Final	400	401	397	393	396
Residue %	2.0	2.0	1.5	1.5	1.5
Recovery %	95	95	96	97	98
Bar. Hg. mm.	730	730	738	736	738
Room t. °F.	73	73	73	73	73

REID VAPOR PRESSURE AND VAPOR LOCK

The vapor pressures of gasoline with varying percentages of absolute alcohol are recorded in table 3. These have been measured by the A. S. T. M. method using dry equipment instead of wet. It will be noted that

TABLE 3. *Reid vapor pressure of alcohol blends*

Percentage Ethanol in blend	Reid vapor pressure (dry) lbs. sq. in.
0	7.5
4	7.5
8	7.8
10	8.4
15	8.7
20	8.6
30	8.7
50	6.9
100	Too small to measure

the addition of 10 per cent or 20 per cent alcohol to gasoline causes an increase in the vapor pressure of approximately one pound per square inch. This has been used (6) as an argument that the alcohol blends will show a greater tendency toward vapor lock than the original gasoline.

Vapor lock has been troublesome only in the last few years as a result of the tendency to market gasolines with larger quantities of low boiling constituents. While it is encountered in the more volatile gasolines it cannot be directly correlated with the vapor pressure of the gasoline. The recent work of Blair and Alden (1) would indicate that vapor lock is due almost entirely to the presence of small amounts of very low boiling constituents in the gasoline. They have presented evidence to show that vapor lock in a particular motor could be correlated with the vapor equivalent of seventy-seven different gasolines of variable composition where the vapor equivalent was expressed as:

The estimated butane content of the fuel x 1.0
" " pentane " " " " x 0.25
" " hexane " " " " x 0.1

Referring to figure 2, it will be seen that the addition of alcohol to gasoline does not alter appreciably the volatility of these low boiling constituents which would distill over in the first 15 per cent of the fuel. Attention should also be called to the fact that the high latent heat of alcohol would tend to decrease the tendency of the fuel to give vapor lock.

The data of table 4 would also support this conclusion. These data report the loss in weight on exposure to air for varying lengths of time of

TABLE 4. *Evaporation rates of alcohol blends in open beakers at 29°C. in hood (no draft)*

Alcohol in blend	Evaporation loss percentage of original by weight					
Vol. pctg.	1 hour	3 hours	7 hours	17 hours	41 hours	65 hours
0	6.0	11.5	17.8	27.0	39.4	48.6
1	6.3	12.2	18.6	28.3	41.5	50.6
2	6.3	11.3	19.6	29.5	42.1	53.2
4	7.8	13.3	22.6	32.7	45.9	56.2
6	6.4	12.9	21.3	33.3	45.2	56.3
8	6.4	13.5	22.4	35.5	49.9	59.2
10	5.5	10.9	21.8	34.5	lost	—
15	5.4	11.6	19.7	32.1	56.7	65.9
20	5.3	11.3	19.4	32.3	53.6*	68.1
30	4.5	11.6	17.3	28.6	48.9*	66.4
50	3.5	8.3	14.3	24.1	41.5	61.6
100	0.7	2.3	4.5	10.2	24.6	42.0

NOTE: Separated into two phases.

a series of 150 cc. beakers containing 100 cc. of blends of varying percentages of alcohol in gasoline. These data are shown graphically in figure 3. It will be observed that for the first three hours the loss in weight due to evaporation decreased slowly as the alcohol concentration in the blend increased. After the more volatile fractions of the gasoline had vaporized (between 10 and 20 per cent) the rate of evaporation increased for those beakers containing alcohol, the 10 per cent and 20 per cent blends showing the maximum volatility after 17, 41, and 65 hours exposure. This relationship would be expected from the distillation curves but it could not be anticipated from the Reid vapor pressure measurements.

Observations regarding the tendency of various fuels to cause vapor lock have been made on a car particularly sensitive to this difficulty. While these observations have been qualitative in nature, they would indicate that vapor lock will not be encountered on blending alcohol with a gasoline which is itself free from this tendency. The addition of alcohol to a gasoline which would cause vapor lock in this motor did not appear either to increase or decrease this tendency. It is apparent that if such difficulty were encountered it could be eliminated by purchasing gasoline of lower volatility for use in preparing the alcohol blends.

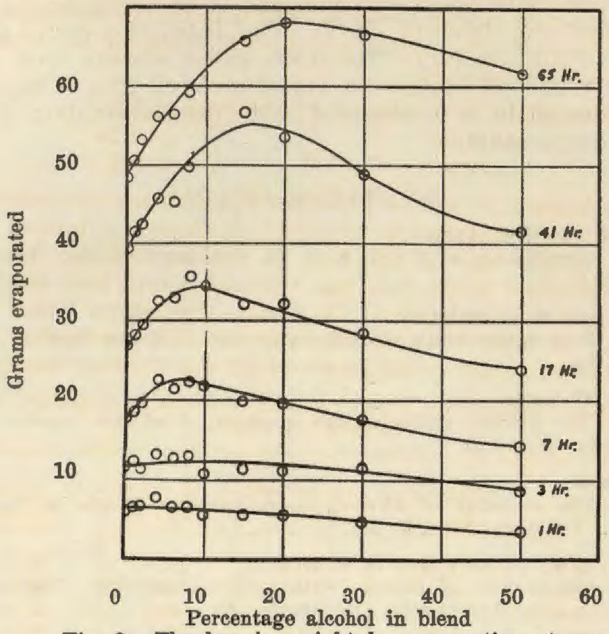

Fig. 3. The loss in weight by evaporation at room temperature from 100 gram samples of alcohol-gasoline blends at various periods of time as a function of the alcohol concentration in the blend.

STORAGE OF ALCOHOL BLENDS

It has been claimed that alcohol gasoline blends could not be stored under commercial conditions because of water absorption and evaporation.

TABLE 5. *Change in distillation range of alcohol blends during storage*

Percentage distilled	50,000 gallon tank		5500 gallon tank	
	Initial	After 66 days April 11-June 16	Initial	After 13 days April 28-May 11
Initial	95°F	104°F	113	110
10	130	137	140	140
20	143	143	149	148
30	139	150	158	157
40	—	160	213	212
50	168	212	237	238
60	—	247	259	257
70	—	298	—	—
80	—	334	—	—
90	378	380	—	—
Final	417	416	390	392
Residue %	1.5	1.5	1.4	1.2
Recovery %	96	97	97	96

Data are presented in table 5 for two separate storage tanks operating in regular commercial practice. The 50,000 gallon tank was under observation from the date the blend was prepared, April 11th, until emptied on June 16th. During this time alcohol-gasoline was withdrawn as needed to supply the trade. The blend still analyzed 10 per cent alcohol at the end of this time and was stable to –76°F. The distillation curve shows a loss of the more volatile fraction. The 5,500 gallon storage tank was also in regular commercial trade during the period of April 28th to May 11th. The changes were too slight to be observed in the distillation data or by change in turbidity temperature.

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THE PHYSICAL-CHEMICAL PROPERTIES OF ETHYL ALCOHOL GASOLINE SYSTEMS

IV. INFLUENCE OF ALCOHOL CONCENTRATION UPON SPECIFIC VOLUME, FLUIDITY, AIR-TO-FUEL RATIO, CALORIFIC VALUE, LATENT HEAT, AND FALL IN TEMPERATURE ON EVAPORATION

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As stated in the preceding papers of this series, it is the purpose of the researches here described to supply information on the physical-chemical properties of ethyl alcohol-gasoline blends which will be of value in the consideration of the proposal to utilize alcohol from agricultural products in motor fuel. In the first two papers of this series (4, 5) are given the results of studies on the water-holding capacity and water absorption of such blends and in the third paper (6) are given data on vapor pressure, distillation range and evaporation rates. In this paper there are presented data on specific volume, fluidity, correct air-to-fuel ratio, calorific value, latent heat, and fall in temperature on evaporation.

The blends were prepared with the same gasoline and alcohol used in the work previously described. The alcohol was dried over lime to a water content which could not be detected with potassium permanganate or anhydrous copper sulphate. The gasoline was dried over calcium chloride. The gasoline was a representative mid-continent grade purchased locally.

1. SPECIFIC VOLUME OF ETHYL ALCOHOL-GASOLINE SYSTEMS

The specific gravities were measured by means of a chainomatic Westphal balance. The data obtained for 25°/25° were calculated to 25°/4°. The data so obtained are given in table 1.

There are also given values calculated on the assumption that the density is a linear function of composition. It will be noted that these values are greater than the experimental values, that is the system has undergone an expansion on mixing. From the differences between the calculated and experimental specific volumes it is seen that the expansion is dependent upon the concentration, being at a maximum at about 8-10 per cent of alcohol. The expansion amounts to 0.2-0.3 per cent for alcohol concentrations from 4-30 per cent of alcohol.

These results are in harmony with those of Balada (2) who observed the expansion and also the fact that the systems show a cooling on mixing. In order to test the latter point qualitatively, ethyl alcohol and gasoline were mixed in flasks at room temperature and the temperature of the mixture measured. These preliminary data are given in table 1. It is evident that the temperature fall is easily detected and is apparently at a maximum at the concentrations which show a maximum expansion. Data are not available for the exact calculation of the heat absorption accompanying the mixing of the alcohol and gasoline. While the amount of heat absorbed may be small, it is of interest to note that the heat content of the blend will be increased by the amount of heat absorbed, compared to the values obtained by assuming a linear relationship of the heat contents of the pure substances.

The specific gravity of the fuel is of importance in carburetion since a large increase would cause a change in fuel level and in flow into the venturi. The data show the density of the 10 per cent alcohol-gasoline blend to be only 0.6 per cent greater than the gasoline used in making the blend. This is about 60 per cent of the increase to be expected without taking the expansion into consideration. This observed change in specific gravity of the 10 per cent blend corresponds to a difference of 1.2° Baumé, which is less than the variation in the specific gravity among various gasolines as shown by Ricardo (15). Evidently this slight increase is of no practical significance in carburation.

2. THE VISCOSITIES AND FLUIDITIES OF ETHYL ALCOHOL-GASOLINE SYSTEMS

The viscosities were measured by means of an Ostwald viscosimeter completely immersed in a water thermostat at 25°C. The values so obtained are given in table 2. The data were calculated to give the coefficients of viscosity and fluidities, making use of the densities of table 1. It

TABLE 1. *Densities and specific volumes of ethyl alcohol-gasoline systems*

Ethanol % by vol.[1]	Sp. G. 25°/4° exp.	Sp. G. 25°/4° calc.[2]	Sp. G. calc. minus Sp. G. obs	Specific volume exp.	Specific volume calc.[3]	Expansion per 100cc blend	Lowering in t°C. on mixing
0	0.7212	0.7212	0	1.3866	1.3866	0	0
1	0.7214	0.7219	0.0005	1.3863	1.3855	0.08	—
2	0.7217	0.7226	0.0009	1.3856	1.3843	0.13	—
4	0.7225	0.7239	0.0015	1.3841	1.3820	0.21	1.5
6	0.7236	0.7252	0.0016	1.3820	1.3797	0.23	—
8	0.7246	0.7265	0.0019	1.3800	1.3775	0.25	—
10	0.7257	0.7278	0.0021	1.3780	1.3752	0.27	2.5
15	0.7292	0.7310	0.0018	1.3714	1.3695	0.19	—
20	0.7323	0.7342	0.0019	1.3656	1.3638	0.18	2.2
30	0.7384	0.7406	0.0022	1.3543	1.3523	0.20	2.0
50	0.7520	0.7537	0.0017	1.3298	1.3295	0.03	1.9
100	0.7859	0.7859	0	1.2724	1.2724	0	0

[1] refers to cc. of alcohol per 100cc. blend before mixing
[2] Sp. G. = 0.7212 + 0.000647 × per cent alcohol
[3] Sp. V. = 1.3866 + 0.001142 × per cent alcohol

will be noted that neither the viscosities nor fluidities are additive. It will be noted that the addition of alcohol up to 6 per cent yields systems of lower viscosity than either liquid alone. Up to, and including 50 per cent alcohol, the highest concentration in the series, the observed viscosities are less than those calculated on a linear basis. Up to and including 5 per cent alcohol the fluidity is greater than that of either liquid alone. Up to 20 per cent alcohol the fluidities are greater than those calculated on the additive basis while above 20 per cent, and up to 50 per cent, the highest concentration of alcohol used, the fluidities are less than those calculated on the additive basis.

Bingham (3) outlines four classes of fluidity curves: I. The simplest case in which the fluidity is additive. There is no volume change on mixing, and it is assumed that the components neither dissociate nor interact with each other on mixing. II. There is a well defined expansion on mixing, accompanied by the absorption of heat. In such mixtures the fluidity is generally greater than calculated. This increase in fluidity may be attributed to breaking down of association or to dissociation which give rise to the increase in volume. III. There is a contraction on mixing, accompanied by the evolution of heat. In such cases the fluidity is generally less than calculated. IV. When there is a combination of dissociation and association the curve may show a positive curvature over a part of its course and a negative curvature over a part, there being a point of inflection. A pair of liquids may fall into type II and yet have a tendency to unite chemically, provided the effect of dissociation predominates in all mixtures.

Evidently the fluidity curve for ethyl alcohol-gasoline mixtures falls into type IV. An examination of the data in the International Critical Table (11) shows the following systems of ethyl alcohol with another organic liquid which produce mixtures with fluidites greater than those calculated. Ethyl alcohol benzene (Dunstan (7), Getman (10), Findley (9);

TABLE 2. *Viscosities and fludities of ethyl alcohol-gasoline systems*

Ethanol % by vol.	relative viscosity 25°C. (a)	Coeff. of viscosity x10³ (b)	Coeff. of vis. x10³ calc.[1] (c)	c-b (d)	Fluidity observed (e)	Fluidity calc. (f)	e-f (g)
				0			
0	0.723	4.645	4.645	0	215.3	215.3	±0
1	0.711	4.569	4.701	0.132	218.9	214.1	+4.8
2	0.710	4.555	4.758	0.223	219.1	212.9	+6.2
4	0.714	4.596	4.871	0.275	217.6	210.6	+7.0
6	0.723	4.661	4.984	0.323	214.5	208.2	+6.3
8	0.724	4.673	5.097	0.424	213.9	205.8	+8.1
10	0.745	4.816	5.209	0.493	207.6	203.5	+4.1
15	0.767	4.983	5.492	0.509	200.6	197.6	+3.0
20	0.800	5.219	5.774	0.555	191.6	191.7	—0.1
30	0.868	5.711	6.339	0.628	175.1	179.8	—4.1
50	1.040	6.968	7.467	0.459	143.5	156.2	—12.1
100	1.470	10.29	10.29	0	97.1	97.1	±0

[1] coeff. of viscosity = 4.645 + 0.05645 × per cent alcohol
[2] fluidity = 215.3 — 1.182 × per cent alcohol

ethyl alcohol-ethyl acetoacetate (Dunstan and Stubbs (8)); ethyl alcohol paraldehyde (Muchin (13); and ethyl alcohol-benzaldehyde (Dunstan (7); ethyl alcohol-anisol Baker (1).

The data on the ethyl alcohol-gasoline systems are especially analogous to the data (Dunstan (7)) on ethyl alcohol-benzene systems. The alcohol concentrations up to 20 per cent by weight (at 25°) show fluidities greater than for either solvent alone. The fluidities are greater than calculated up to 71 per cent by weight from which point the fluidity is as calculated. The effect of temperature upon such systems is striking. The data of Getman (10) and Findlay (9) show that at 15°, 20°, 25° and 30° there is a range of high concentrations of alcohol in which the fluidity is less than calculated while for 35° and 40° at concentration of alcohol greater than 70 per cent the fluidity is as calculated. At all temperatures the fluidities for alcohol concentrations less than 70 per cent are greater than calculated.

The data in table 2 show the fluidity of a 10 per cent alcohol-gasoline blend to be only 3.5 per cent less than for the gasoline and viscosity to be only 2.0 per cent greater than for gasoline. This variation is less than the variation among various gasolines as shown by the data of Ricardo (15). This change in viscosity is so small as to be of no practical significance.

3. THE AIR-FUEL RATIOS OF ETHYL ALCOHOL-GASOLINE SYSTEMS

Ricardo (15) gives the air-fuel ratios of ethyl alcohol and of various gasolines. The air fuel ratio is the weight of air required to completely burn a pound of fuel. In table 3 are found calculated values for the air-fuel ratios of alcohol-gasoline systems. The value for gasoline is the average for eight gasolines. The theoretically correct air-fuel ratios will be a linear function of the composition by weight.

These calculations show that the 10 per cent blend requires about 4 per cent lower air-fuel ratio than does the gasoline. The data of Ricardo (15) for eight gasolines show a variation among the samples of 5 per cent. It is doubtful whether carburetor adjustments, in commercial practice are made to such close limits.

4. THE CALORIFIC VALUES OF ETHYL ALCOHOL-GASOLINE BLENDS

Ricardo (15) calculated the calorific value of ethyl alcohol and of various gasolines. The values include the latent heat of evaporation of the fuel and do not include the latent heat of the water formed by the combustion. In table 3 are given calorific values for ethyl alcohol-gasoline systems assuming these to be a linear function of composition. The data show the calorific value of the 10 per cent blend to be 3 per cent less than that of the gasoline. The variation in the calorific values of the eight gasolines amounts to 7 per cent. Because of the lower air-fuel ratio and the lower calorific value of the 10 per cent blend, it would be expected that the heat content of the air-fuel mixture would not be greatly affected and Ricardo (15) shows this to be practically the case for pure alcohol and gasoline.

5. THE LATENT HEATS OF ETHYL ALCOHOL-GASOLINE BLENDS

In table 3 are given values for the latent heats of evaporation of ethyl alcohol-gasoline systems on the assumption that they are a linear function of composition. The values for gasoline and ethyl alcohol are taken from Ricardo (15). There are also given calculated values for the fall in tem-

TABLE 3. *Air-fuel ratios, calorific values, latent heats, and fall in temperature on evaporation of ethyl alcohol-gasoline systems*

Ethanol % by vol.	Air-fuel ratios for complete combustion by wt.	Calorific values including latent heat at constant volume B T U/gal	Latent heat at constant pressure of 1 atm. B T U/gal.	Fall in temp. of correct air-fuel ratios due to latent heat F°
0	14.8	116,000	820	33.8
1	14.7	115,650	837	34.9
2	14.7	115,290	850	36.0
4	14.6	114,590	880	38.2
6	14.5	113,880	910	40.4
8	14.3	113,180	940	42.5
10	14.2	112,470	975	44.7
15	13.9	110,700	1060	50.2
20	13.6	108,940	1140	55.6
30	13.1	105,410	1300	66.3
50	11.9	98,350	1650	88.4
100	9.0	80,700	2560	143.0

perature, on evaporation, of the alcohol-gasoline systems at the proper air-fuel ratio.

Since the latent heat of alcohol is nearly three times that for gasoline, it is evident that this factor is of considerable importance in carburation. The air-fuel mixture will become colder upon evaporation for the blend than for gasoline. Ross and Ormandy (14) state that greater heat input to the intake manifold is desirable when using alcohol blends than when using gasoline. Practically, this is subject to some correction in view of the effect of alcohol upon the distillation range as shown in a previous paper of this series.

6. AIR-FUEL RATIOS IN PRACTICAL USE

From the data presented it can be predicted that the carburetor setting for a 10 per cent blend should be the same as that for gasoline and that the same air-fuel ratio will result. Information supplied by L. T. Brown of the Mechanical Engineering Department, Iowa State College (unpublished) shows this to be the result observed in dynammeter test. Numerous road tests by Moyer and Paustian (12) show that the 10 per cent blend can be used interchangeably with gasoline without any carburetor adjustments whatever.

SUMMARY

1. Systems of ethyl alcohol and gasoline expand on mixing. The maximum expansion is 0.2-0.3 per cent at 4-30 per cent alcohol. The density of the 10 per cent alcohol blend is about 0.6 per cent greater than for the basal gasoline. This difference is well within the limits of variation for various gasolines.
2. Neither the viscosities nor fluidities are additive. Systems containing up to 6 per cent alcohol have lower viscosities and higher fluidities than either the ethyl alcohol or gasoline alone. Up to 20 per cent alcohol the fluidities are greater than calculated on an additive basis while from 20 per cent up to 50 per cent alcohol, the highest concentration used, the fluidities are less than calculated on the additive basis. The viscosity of the 10 per cent blend is only 3.0 per cent greater than for gasoline. This is well within the limits of variation for various gasolines.
3. Using the values of Ricardo (13) for gasoline and alcohol the following characteristics were considered. The air-to-fuel ratio of a 10 per cent blend is about 4 per cent lower than for gasoline, while the variation among gasolines may be 5 per cent.
4. The calorific value of the 10 per cent blend is 3 per cent less than for the base gasoline while the variation among gasolines may be 7 per cent. Data are calculated for the latent heats and fall in temperature upon evaporation for the various blends. These factors show that with the blends there will be a greater heat input to the intake manifold which is equivalent to an increase in heat content.
5. All these data indicate that the carburetor setting for a 10 per cent blend should be the same as for gasoline and that the same air-to-fuel ratio would result. This is in harmony with data from dynammeter and road tests.

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A BOTANICAL SURVEY OF LEE COUNTY, IOWA

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This botanical survey of Lee County in southeastern Iowa was made because of the unique location, climate and soil of this area, and because the herbarium of Iowa State College contained few plants from this part of the state.

Lee County occupies a broadly triangular elevated plateau, bounded on its southeast and southwest sides along the Mississippi and Des Moines rivers by strips of low bottomlands that vary from five miles wide near Wever to a few hundred yards at Keokuk, where its point projects some fifteen miles further south into Missouri than any other section of Iowa. It is separated from Illinois on the east by the Mississippi River and from Missouri on the west and south by the Des Moines.

Between the upland plateau and the bottomlands is an extensive area of rolling hills more or less covered with timber. The uplands are cut by two trough-like drainage systems, both of which rise in the northwest corner of the county and proceed in a southeast direction through the timbered hills and down to the Mississippi and Des Moines rivers respectively. Between these two drainage systems is a broad flat ridge which roughly divides the county into equal parts.

According to the records of the United States Weather Bureau the annual mean temperature at Keokuk, situated at the southern tip of the county, is 52°F. which is 3° warmer than Des Moines. The average annual precipitation is 35.1 inches at Keokuk and 32.4 at Des Moines. The 25° isotherm for January runs a little north of Lee County as compared to the 20° isotherm through Des Moines.

There are three major groups of soil types in Lee County, which are distributed as follows: (1) the silt loams of the upland prairie in the northern half of the county which are adapted to corn production; (2) the poorer loam and silt loams in the hilly part of the southern half of the county that are suited chiefly to small grains and hay, and (3) the fertile but mostly poorly drained bottomland clays, loams and sands; the two former being suited to corn and the latter to truck crops.

The time available made it necessary to confine the work to a consideration of the flowering plants and ferns with particular attention to exact locations of plants and their distribution within the county, to soil relationships of the flora, to a general survey of the distribution of crop plants in their relation to the native and introduced vegetation, to the wider

[1] The author is deeply indebted to R. I. Cratty, Curator of the Iowa State College Herbarium, for assistance in identification, criticism, and suggestions in making the study comprising this paper; and to Dr. I. E. Melhus for generous assistance in organization of the problem, carrying out the field studies, and assisting in the preparation of the manuscript.

distribution in Iowa of the trees and shrubs of Lee County, and to plants not heretofore reported in the state.

EARLIER PLANT COLLECTIONS IN LEE COUNTY

Although there has been no published account of the flora of Lee County, at least three other collections had been made prior to June 1931. These plants were examined and the records included in this paper. The earliest collections were those of the late Dr. Ehringer of Keokuk who made a collection of Lee County plants about thirty years ago which are now preserved in the herbarium of Carthage College at Carthage, Illinois. There were 22 species in this collection which were labeled "from Lee County" and a number more labeled "from Iowa" that undoubtedly came from Lee County. In this paper only those labeled "from Lee County" are recorded.

Another collection made by Mrs. Kate O'Bleanus about 30 years ago is preserved by her at her home near Keokuk. In this collection there were approximately 87 species from Lee County whose names, with a few changes, are included in this paper.

The most recent collection from Lee County is deposited in the herbarium of Iowa Wesleyan at Mt. Pleasant, Iowa, and was made by Professor H. E. Jaques and some of his students during the summer of 1929. There were 87 species in this collection, all of which have been included.

Besides these three collections, there are 14 species, mostly trees and shrubs, which were collected by the late Dr. L. H. Pammel and deposited in the Iowa State College Herbarium before June 1931.

RESULTS OF THE SURVEY

INCLUDED SPECIES

After our plants were collected, and identified, and the identification of the specimens in the previously mentioned collections were checked, they were listed in the order of Gray's Manual (7th edition). Locations and field notes were given in each case where available. In addition part of the names included in a list of plants published in the Iowa Farmer and Horticulturist at Burlington and Fairfield, Iowa, about seventy-five years ago[2] were included.

The following is a list of the capital letters used to indicate the several collections:

F = Plants collected and identified by Jess L. Fults.
I = Plants in the Iowa State College Herbarium before June 1, 1931.
O = Plants in the collection of Mrs. Kate O'Bleanus.
W = Plants collected by Prof. H. E. Jaques and students of Iowa Wesleyan at Mount Pleasant, Iowa.
C = Plants collected by Dr. Ehringer of Keokuk, Iowa, and placed in the herbarium of Carthage College, Carthage, Illinois.
B = Plant names published in the Iowa Farmer and Horticulturist, Vol. 1, Nos. 2, 3, 4, and 7, as occurring in southeastern Iowa, about 75 years ago.

SYSTEMATIC LIST AND FIELD NOTES

The nomenclature of Gray's Manual (7th edition) was followed, or of Britton and Brown's Flora of the Northern States and Canada in those

[2] Our Native Plants, Iowa Farmer and Horticulturist, Vol. I., Nos. 2, 3, 4 and 7.

cases where the plant was not described in Gray or when the name in Britton and Brown seemed preferable.

SYSTEMATIC LIST AND FIELD NOTES

POLYPODIACEAE

Adiantum pedatum L.
FWC
Sec 8 T68N—R5W Marion silt loam.
Asplenium acrostichoides SW.
C
Asplenium platyneuron (L.) Oakes
F
Sec 24 T68N—R4W Lindley loam.
Athyrium Filix-femina (L). Roth.
FC
Sec 13 T66N—R6W Memphis silt loam.
Infrequent in this locality.
Botrychium virginianum (L.) Sw.
F
Sec 26 T66N—R5W
Infrequent.
Filix fragilis (L.) Underw.
FC
Sec 13 T66N—R6W Marion silt loam.
Onoclea sensibilis L.
W
Osmunda Claytoniana L.
FC
Sec 26 T66N—R6W Genesee very fine sandy loam.
Polystichum acrostichoides (Michx.) Schott.
FW
Sec 13 T63N—R6W Marion silt loam.
Infrequent in this locality.
Woodsia obtusa (Spreng.) Torr.
FWC
Sec 23 T66N—R6W Genesee very fine sandy loam.
Fairly common.
Sec 19 T65N—R5W
Equisetum arvense L.
F
Vicinity of the Gabel Farm[3].
Equisetum Kansanum Schaffner
F
Sec 33 T67N—R6W
Infrequent.
Sec 28 T67N—R5W Buckner loam.
Frequent on this soil.
Equisetum robustum A. Br.
F
Sec 27 T67N—R7W Genesee silt loam.
Only two or three plants.
Sec 13 T65N—R5W Genesee silt loam.
Sec 29 T65N—R5W Wabash fine sandy loam.

PINACEAE

Juniperus virginiana L.
F
Sec 26 T66N—R5W Lindley loam.
Associated with *Gleditsia triacanthos* in open park-like stands.

[3] Sec 19 T65N—R5W.

TYPHACEAE

Typha latifolia L.
FW
Sec 33 T68N—R3W Wabash clay.
Common in wet places.

NAJADACEAE

Potamogeton dimorphus Raf.
W

ALISMACEAE

Alisma Plantago-aquatica L.
FB
Sec 13 T66N—R5W Genesee very fine sandy loam.
Infrequent.

Sagittaria latifolia Willd.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Common in very wet locations.

GRAMINEAE

Agropyron repens (L.) Beauv.
F
Sec 1 T65N—R5W Genesee very fine sandy loam.
Along railroad track. Naturalized from Europe.

Agropyron Smithii Rydb.
F
Sec 2 T66N—R6W Lindley loam.
Common along railroad track.

Agrostis alba L.
FW
Sec 8 T67N—R5W Marion silt loam.
Frequent in shady woods.
Sec 2 T66N—R6W Marion silt loam.
Common along roadsides.
Sec 23 T66N—R5W Genesee silt loam.
Frequent.
Sec 3 T65N—R6W Buckner fine sandy loam.
Infrequent.

Agrostis hyemalis (Walt.) B.S.P.
FC
Vicinity of Gabel Farm[4].

Agrostis perennans (Walt.) Tuckerm.
F
Sec 19 T67N—R5W Genesee very fine sandy loam.
Frequent in shady woods.

Alopecurus geniculatus L.
F
Vicinity of Gabel farm.

Andropogon furcatus Muhl.
F
Sec 34 T68N—R7W Lindley loam.

Aristida gracilis Ell.
F
Infrequent.

Aristida oligantha Michx.
F
Sec 36 T67N—R6W Putnam silt loam.

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[4] Sec. 19 T65N—R5W.

Avena sativa L.
W
Introduced from Europe.

Bouteloua curtipendula (Michx.) Torr.
F
Sec 30 T68N—R3W Buckner silt loam.
Infrequent.

Bromus japonicus Thunb.
F
Vicinity of Gabel farm. Introduced from Japan by way of Europe.

Bromus purgans L.
F
Sec 26 T66N—R5W Lindley loam.
Infrequent in shady woods.
Sec 13 T66N—R6W Marion silt loam.
In deep shady woods.

Bromus secalinus L.
F
Naturalized—from Europe.

Bromus tectorum L.
F
Sec 36 T67N—R6W Lindley loam.
Common along railroad track.
Extensively naturalized from Europe.

Calamagrostis Macouniana Vasey.
F
Sec 27 T69N—R7W Grundy silt loam.
Infrequent.

Cenchrus pauciflorus Benth.
= *Cenchrus carolinianus* Walt.
F
Sec 28 T67N—R5W Buckner fine sand.
Frequent in sand.

Dactylis glomerata L.
F
Sec 16 T65N—R5W Marion silt loam.
Infrequent near lake shores.
Naturalized from Europe.

Danthonia spicata (L.) Beauv.
F

Diarrhena americana Beauv.
F
Sec 14 T66N—R6W Genesee very fine sandy loam.
Rare in this locality.

Digitaria sanguinalis (L.) Scop.
F
Sec 36 T67N—R6W Lindley loam.
Frequent. Naturalized from Europe.

Echinochloa Crus-galli (L.) Beauv.
F
Sec 29 T67N—R7W Union stony loam.
Frequent in wet ditches along the road. Naturalized from Europe.

Elymus striatus Willd.
F
Sec 29 T65N—R5W Wabash silt loam.
Frequent.

Elymus glabriflorus (Vasey) Scrib. & Ball.
F
Sec 14 T66N—R6W Genesee very fine sandy loam.
Frequent in shady woods. First specimen to be placed in Iowa State College Herbarium from Iowa.

Elymus virginicus L.
F
Sec 8 T67N—R5W Marion silt loam.

Elymus robustus Scribn. and J. G. Sm.
F
Sec 22 T67N—R5W Buckner loam.
Frequent.
Sec 28 T68N—R5W Genesee very fine sandy loam.
Sec 2 T66N—R6W Lindley loam.
Common.

Elymus virginicus var. *submuticus* Hook.
FW
Sec 8 T67N—R5W Genesee very fine sandy loam.

Eragrostis hypoides (Lam.) B.S.P.
F
Sec 24 T69N—R4W Genesee very fine sandy loam.
Infrequent.

Eragrostis cilianensis (All.) Link.
= *E. megastachya* (Koeler) Link.
F
Sec 24 T69N—R4W Genesee very fine sandy loam.
Infrequent in a wet sand creek bottom.
Sec 21 T66N—R6W Buckner silt loam.
Frequent. Naturalized from Europe.

Eragrostis pectinacea (Michx.) Steud.
FW
Sec 34 T67N—R5W Buckner loam.
Frequent.

Eragrostis pilosa (L.) Beauv.
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Infrequent. Found between ties of railroad track.

Festuca nutans Willd.
F
Sec 29 T65N—R5W Wabash fine sandy loam.
Frequent in shady woods.

Festuca octoflora Walt.
FC
Sec 16 T65N—R5W Marion silt loam.

Glyceria borealis (Nash) Batch.
F
Sec 20 T68N—R3W Wabash silty clay loam.
Infrequent. In standing water.

Glyceria nervata (Willd.) Trin.
F
Vicinity of Gabel farm.

Hordeum jubatum L.
F
Sec 19 T65N—R5W Putnam loam.
A miserable weed introduced from Europe.

Hordeum pusillum Nutt.
F
Vicinity of Gabel Farm.

Hystrix patula Moench.
= *H. Hystrix* Millsp.
F
Sec 8 T65N—R5W Marion silt loam.
Infrequent.

Leersia oryzoides (L.) Sw.
F
Sec 21 T68N—R3W Wabash silt loam.
Only location found.

Leersia virginica Willd.
F
Frequent in shady woods.

Leptoloma cognatum (Schultes) Chase
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Rather rare. Growing in a road.

Panicum agrostoides Spreng.
C

Panicum capillare L.
F
Sec 11 T68N—R5W Grundy silt loam.
Frequent in upland soils.

Panicum dichotomiflorum Michx.
F
Frequent.

Panicum huachucae Ashe.
F
Sec 23 T68N—R5W Lindley loam.
Very variable in its characters.

Panicum implicatum Scribn.
F

Panicum latifolium L.
= *macrocarpon* Le Conte
F
Sec 29 T65N—R5W Wabash fine sandy loam.

Panicum Scribnerianum Nash.
F
Sec 34 T67N—R5W Buckner loam.
Infrequent.

Phleum pratense L.
W
Commonly cultivated. Introduced from Europe.

Poa compressa L.
F
Naturalized from Europe.

Poa pratensis L.
W
Very common.

Setaria glauca (L.) Beauv.
F
Sec 11 T68N—R5W Grundy silt loam.
Common. Naturalized from Europe.

Setaria viridis (L.) Beauv.
F
Sec 1 T65N—R5W Genesee very fine sandy loam.
Infrequent along roads.
Naturalized from Europe.

Sorghum halepense (L.) Pers.
F
Sec 29 T68N—R3W Wabash clay.

Spartina Michauxiana Hitchc.
F
Sec 22 T68N—R3W Wabash clay.
Common along roads.

Sphenopholis pallens (Spreng.) Scribn.
C

Sorghastrum nutans (L.) Nash
F
Sec 21 T67N—R7W Lindley loam.
Infrequent.

Sporobolus cryptandrus (Torr.) Gray
F
Sec 28 T67N—R5W Buckner fine sand.

Triodia flava (L.) Hitchc.
= *Tridens flavus* (L.) Hitchc.
F
T

Triplasis purpurea (Walt.) Chapm.
F
Sec 27 T67N—R5W Buckner loam.
Infrequent. Leaves have a very acid taste.

Carex Asa-Grayi Bailey
= *Carex Grayi* Carey
= *Carex Grayi* Carey
F
Sec 33 T68N—R3W Wabash clay.
Rare. Only one plant found.

Carex brachyglossa Mack.[5]
F
Sec 29 T65N—R5W Wabash fine sandy loam.

Carex brevior (Dewey) Mack.[5]
F
Sec 36 T66N—R6W Marion silt loam.
Infrequent on upland soils.

Carex Bicknellii Britt.
F
Sec 16 T65N—R5W Marion silt loam.
Rare at this date—June 29, 1932.

Carex cephalophora Muhl.
FC
Sec 13 T66N—R6W Marion silt loam.
Frequent in shady woods.

Carex cristatella Britt.
= *cristata* Schwein.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Sec 4 T66N—R7W Buckner very fine sandy loam.
Frequent.

Carex conjuncta Boott.
F
Sec 14 T66N—R6W Genesee very fine sandy loam.

Carex crus-corvi Schuttlw.
F
Sec 33 T68N—R3W Wabash clay.

Carex Davisii Schwein. & Torr.
F
Sec 29 T65N—R5W Wabash fine sandy loam.
Seemed to spread by rhizomes.

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[5] Described by Mr. Kenneth K. Mackenzie since the last editions of Gray's "New Manual of Botany" and Britton and Brown's "Flora of the Northern States and Canada."

Carex festucacea Willd.
F
Sec 32 T67N—R7N Buckner very fine sandy loam.
Note the hollow stems which are rare in this genus.
Carex gravida Bailey.
F
Carex hirsutula Mack.
F
Sec 36 T66N—R6W Marion silt loam.
Note the hairy leaves.
Carex hystricina Muhl.
C
Carex Jamesii Schwein.
F
Carex lanuginosa Michx.
F
Sec 36 T67N—R6W Lindley loam.
Carex laxiflora Lam.
C
Carex lupuliformis Sartwel.
F
Sec 20 T68N—R3W Wabash silty clay loam.
Carex lupulina Muhl.
F
Sec 19 T65N—R5W Wabash clay.
Sec 28 T67N—R6W Lindley loam.
Sec 33 T68N—R3W Wabash clay.
Infrequent.
Carex muskingumensis Schwein.
F
Sec 33 T68N—R3W Wabash clay.
Frequent.
Carex pennsylvanica Lam.
F
Carex plana Michx. (*C. Muhlenbergii* var. *enervis* Boott.)
F
Sec 28 T67N—R5W Buckner fine sand.
Carex retrorsa Schwein.
F
Sec 29 T67N—R7W Marion silt loam.
Common in wet ravines.
Carex rosea Schkuhr.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Carex scoparia Schkuhr.
F
Sec 29 T65N—R5W Wabash fine sandy loam.
Infrequent.
Carex Shriveri Britt.
= *C. granularis* var. *Haleana* (Olney) Porter
F
Sec 13 T66N—R6W Marion silt loam.
Infrequent.
Carex straminea var. *echinodes* Fernald
F
Sec 19 T65N—R5W Putnam silt loam.
Carex tenella Schkuhr.
F
Carex tribuloides Wahlenb.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Frequent.
Sec 19 T65N—R5W Wabash clay.
Infrequent on this soil.

Carex typhina Michx.
F
Sec 33 T68N—R3W Wabash clay.
Carex umbellata Schkuhr.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Infrequent in damp woods.
Carex vulpinoidea Michx.
F
Sec 28 T68N—R4W Lindley loam.
Carex xanthocarpa Bicknell.
= *C. setacea* var. *ambigua* (Barratt) Fernald
F
Sec 13 T66N—R6W Marion silt loam.
Frequent in shady woods.
Cyperus acuminatus Torr. & Hook.
F
Sec 5 T67N—R5W Marion silt loam.
Rare. An annual.
Cyperus esculentus L.
F
Sec 27 T67N—R7W Union stony loam.
Cyperus filiculmis Vahl.
F
Sec 3 T65N—R6W Buckner fine sandy loam.
Rare. In the school house yard ¼ mile west of Connables, Iowa.
Cyperus Schweinitzii Torr.
F
Sec 27 T67N—R5W Buckner loam.
Frequent on sandy bottom soils.
Heavily infected with *Puccinia cyperii* Arth.
Sec 34 T67N—R5W Buckner loam.
Frequent.
Sec 36 T67N—R6W Lindley loam.
Infrequent in this soil.
Cyperus speciosus Vahl.
= *C. ferax* Rich. of Gray's Manual
C
Eleocharis acicularis (L.) R. & S.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Common in wet mud.
Eleocharis obtusa (Willd.) Schultes
F
Sec 19 T65N—R5W Wabash clay.
Infrequent.
Sec 36 T67N—R6W Lindley loam.
Common on railroad track ballast.
Eleocharis palustris (L.) R. & S.
F
Sec 19 T65N—R5W Wabash clay.
Common in wet places.
Scirpus americanus Pers.
F
Sec 2 T66N—R6W Marion silt loam.
Rare along railroad track.
Scirpus atrovirens Muhl.
F
Sec 16 T65N—R5W Marion silt loam.
Common in wet ground.
Scirpus cyperinus (L.) Kunth.
F
Sec 20 T68N—R3W Wabash silty clay loam.
Infrequent.

Scirpus lineatus Michx.
F

Scirpus validus Vahl.
FC
Sec 33 T68N—R3W Wabash clay.
Infrequent.

ARACEAE

Arisaema Dracontium (L.) Schott.
W

Arisaema triphyllum (L.) Schott.
FOB

COMMELINACEAE

Commelina virginica L.
F
Sec 28 T67N—R5W Buckner loam.

Tradescantia reflexa Raf.
F

Tradescantia virginiana L.
OCB

JUNCACEAE

Juncus acuminatus Michx.
F
Sec 19 T65N—R5W Wabash clay.
Infrequent.

Juncus balticus var. *littoralis* Engelm.
F
Sec 36 T67N—R6W Lindley loam.
Infrequent.

Juncus bufonius L.
F
Sec 33 T68N—R4W Lindley loam.

Juncus effusus L.
F

Juncus secundus Beauv.
var.?
F
Sec 29 T65N—R5W Wabash fine sandy loam.
Infrequent.

Juncus tenuis Willd.
F
Sec 33 T67N—R6W Putnam loam.
Frequent to common in shady places along paths.
Sec 19 T65N—R5W Putnam loam.
Common in shady places.

Juncus Torreyi Coville.
F
Sec 36 T67N—R6W Lindley loam.
Frequent along railroad tracks.

LILIACEAE

Allium canadense L.
F

Allium mutabile Michx.
F
Sec 36 T67N—R6W Lindley loam.
Infrequent.

Asparagus officinalis L.
FW
Sec 13 T65N—R5W Grundy silt loam.
A common escape. Introduced from Europe.

Erythronium albidum Nutt.
O

Hemerocallis fulva L.
F
Sec 31 T66N—R5W Genesee very fine sandy loam. Frequent as an escape.

Lilium Michiganense Farw.
F
Sec 36 T67N—R6W Lindley loam.
Rare. ¼ mile S.W. of Junction of the A. T. and S. F. railroad with the hard road from Donnellson to Keokuk, Iowa.

Polygonatum commutatum (R. & S.) Dietr.
F
Sec 13 T66N—R5W Genesee very fine sandy loam.

Polygonatum commutatum (R. & S.) Dietr.
O

Smilacina racemosa (L.) Desf.
FO
Sec 14 T66N—R6W Genesee very fine sandy loam.
Frequent under dense shade.

Smilax ecirrhata (Engelm.) Wats.
F

Smilax rotundifolia L.
F
Sec 11 T65N—R5W Lindley loam.
Infrequent.

Trillium recurvatum Beck.
OBF

Uvularia grandiflora Sm.
FB

Uvularia perfoliata L.
W

AMARYLLIDACEAE

Hypoxis hirsuta (L.) Coville.
O

IRIDACEAE

Belamcanda chinensis (L.) DC.
F
Sec 25 T68N—R4W Marion silt loam.
Infrequent as an escape. Introduced from Europe.

Iris versicolor L.
FWB
Sec 19 T65N—R5W Wabash clay.
Infrequent.

Sisyrinchium campestre Bicknell
FO
Sec 28 T64N—R4W Memphis silt loam.
Rare.

ORCHIDACEAE

Cypripedium parviflorum Salisb.
var. *pubescens* (Willd.) Knight
O

SALICACEAE

Populus alba L.
F
Sec 27 T67N—R7W Marion silt loam.
Introduced from Europe.

Populus deltoides Marsh.
F
Sec 17 T65N—R5W Lindley loam.
In a dry creek bottom. Frequent.

Populus tremuloides Michx.
F
Sec 28/33 T67N—R6W Putnam loam.

Salix amygdaloides Anders.
I

Salix discolor Muhl.
I

Salix nigra Marsh.
F
Sec 27 T67N—R7W Genesee silt loam.
Sec 28 T66N—R5W Memphis silt loam.
Sec 26 T66N—R5W Genesee silt loam.

Salix interior Rowlee.
= *S. longifolia* Muhl.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Common.
Sec 4 T67N—R5W Memphis silt loam.
Frequent.

JUGLANDACEAE

Carya alba (L.) K. Koch.
F
Infrequent.

Carya cordiformis (Wang.) K. Koch.
F
Sec 30 T69N—R3W Lindley loam.
Frequent.

Carya ovata (Mill.) K. Koch.
F
Sec 27 T67N—R7W Marion silt loam.
Common.

Juglans cinerea L.
F

Juglans nigra L.
I

BETULACEAE

Betula nigra L.
F
Sec 12 T65N—R6W
Frequent along Sugar Creek.

Carpinus caroliniana Walt.
FB

Corylus americana Walt.
FW
Sec 17 T65N—R5W Lindley loam.

Ostrya virginiana (Mill.) Willd.
FWB
Common in shady woods.

FAGACEAE

Quercus alba L.
FW
Sec 30 T69N—R3W Lindley loam.
Common.

Quercus bicolor Willd.
F
Sec 20 T65N—R5W Putnam loam.
Sec 28 T67N—R6W Genesee silt loam.
Sec 14 T66N—R6W Genesee very fine sandy loam.

X Quercus Bushii Sargent
(*Quercus velutina* x *marilandica*)
F
Sec 33 T67N—R7W

Quercus imbricaria Michx.
W

Quercus macrocarpa Michx.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Sec 34 T68N—R7W Lindley loam.
Common on this soil.

Quercus marilandica Muench.
F
Sec 8 T65N—R5W Marion silt loam.
Quite common in one location near Summit School.

Quercus maxima Ashe.
FI
Sec 8 T67N—R5W Marion silt loam.

Quercus Muhlenbergii Engelm.
F

Quercus palustris Muench.
F
Frequent.

Quercus stellata Wang.
FW
Sec 36 T66N—R6W
Sec 25 T66N—R6W Marion silt loam.

Quercus velutina Lam.
FW

URTICACEAE

Cannabis sativa L.
F
Sec 34 T67N—R5W Buckner loam.
Frequent. An introduction from Europe.

Celtis occidentalis L.
FW
Sec 32 T66N—R6W Buckner loam.

Celtis occidentalis
var. *crassifolia* (Lam.) Gray
I

Humulus Lupulus L.
F

Laportea canadensis (L.) Gaud.
= *Urticastrum divaricatum* (L.) Kuntze
F
Sec 32 T66N—R6W Wabash silt loam.
Frequent in shady woods along streams.
Maclura pomifera (Raf.) Schneider.
F
Sec 2 T66N—R5W Lindley loam.
An escape in the southern part of Iowa. Native from Missouri to Texas.

Morus alba L.
F
Frequent as an escape. Naturalized from Europe.

Morus rubra L.
I

Parietaria pennsylvanica Muhl.
C

Ulmus americana L.
FW
Sec 34 T66N—R6W Buckner silt loam.
Common.

Ulmus fulva Michx.
W

Ulmus racemosa Thomas.
I

Urtica gracilis Ait.
F

SANTALACEAE

Comandra umbellata (L.) Nutt.
O

ARISTOLOCHIACEAE

Asarum canadense L.
FOB

POLYGONACEAE

Dioscorea villosa L.
FW
Sec 19 T65N—R5W
In second growth hickory woods.
Sec 2 T66N—R6W Genesee very fine sandy loam.
Common.

Polygonum acre HBK.
F
Frequent.

Polygonum aviculare L.
F

Polygonum Convolvulus L.
F
Sec 1 T65N—R5W Genesee very fine sandy loam.
Infrequent. Naturalized from Europe.

Polygonum Hydropiper L.
C

Polygonum lapathifolium L.
F

Polygonum Muhlenbergii (Meisn.) Wats.
C

Polygonum pennsylvanicum L.
F
Sec 21 T66N—R6W Marion silt loam.
Common along roads in loose soil.
Sec 22 T68N—R3W
Sec 1 T65N—R5W Genesee very fine sandy loam.
Infrequent along railroad tracks.

Polygonum Persicaria L.
W
Naturalized from Europe.

Polygonum ramosissimum Michx.
F
Sec 28 T67N—R5W Buckner loam.
Infrequent.

Polygonum sagittatum L.
Sec 19 T67N—R5W Genesee very fine sandy loam.
Infrequent.

Polygonum scandens L.
F

Polygonum tenue Michx.
F
Sec 28 T64N—R4W Memphis silt loam.
Infrequent on dry hill knolls.

Polygonum virginianum L.
F
Sec 30 T68N—R3W Buckner silt loam.
Frequent.

Rumex Acetosella L.
FW
Introduced from Europe.

Rumex altissimus Wood.
F

Rumex Britannica L.
C

Rumex crispus L.
F
Naturalized from Europe.

Rumex verticillatus L.
F
Sec 28 T67N—R6W Lindley loam.
Infrequent. Growing in water with some sedges.

CHENOPODIACEAE

Chenopodium album L.
FB
Sec 29 T65N—R5W Wabash fine sandy loam.
Common. Naturalized from Europe.

Chenopodium ambrosioides L.
FB
Sec 10 T66N—R6W Putnam loam.
Infected with *Cercospora dubia* (Riess.) Wint.

Chenopodium urbicum L.
C

Cycloloma atriplicifolium (Spreng.) Coulter.
F
Sec 36 T67N—R6W Lindley loam.
Common on railroad ballast.
Sec 28 T65N—R5W Buckner fine sand.
Sec 27 T67N—R5W Buckner loam.

AMARANTHACEAE

Acnida tuberculata Moq.
F
Sec 33 T68N—R3W Wabash clay.
Frequent.

Amaranthus blitoides Wats.
F
Sec 14 T67N—R5W Buckner very fine sandy loam.
Frequent. Naturalized from west of the Rocky Mountains.

Froelichia campestris Small.
= *F. floridana* (Nutt.) Moq.
F
Sec 28 T67N—R5W Buckner fine sand.
Infrequent. Along fences.
Sec 32 T67N—R5W Buckner fine sandy loam.

PHYTOLACCACEAE

Phytolacca decandra L.
F
Sec 13 T65N—R6W
Infrequent.
Sec 36 T68N—R3W Wabash clay.
Rare at this date, July 29, 1931.

NYCTAGINACEAE

Allionia nyctaginea Michx.
= *Oxybaphus nyctaginea* (Michx.) Sweet.
F

CARYOPHYLLACEAE

Cerastium nutans Raf.
CF
Cerastium viscosum L.
C
Cerastium vulgatum L.
F
Sec 17 T65N—R5W Lindley loam.
Common but only a few flowers at this date. Naturalized from Europe.
Dianthus barbatus L.
W
Saponaria officinalis L.
F
Sec 1 T65N—R5W Genesee very fine sandy loam.
Common along railroad track.
Sec 28 T67N—R5W Buckner loam.
Frequent to common. Naturalized from Europe.
Silene alba Muhl.
= *S. nivea* (Nutt.) Otth.
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Silene antirrhina L.
C
Silene media (L.) Cyrill.
C
Silene stellata (L.) Ait.
FB
Sec 4 T66N—R7W Buckner very fine sandy loam.
Infrequent.

AIZOACEAE

Mollugo verticillata L.
F
Sec 29 T67N—R7W Marion silt loam.
Naturalized from further south.

PORTULACACEAE

Claytonia virginica L.
OFB
Portulaca oleracea L.
F
Sec 10 T66N—R6W Putnam loam.
Infrequent. In plowed corn fields.
Naturalized from Europe.

NYMPHAEACEAE

Castalia tuberosa (Paine) Greene.
C

RANUNCULACEAE

Anemone canadensis L.
F

Sec 33 T68N—R3W Wabash clay.
Common in wet bottomland soils.
Anemone quinquefolia L.
O
Anemone virginiana L.
FB
Sec 13 T66N—R6W Marion silt loam.
Infrequent in damp shady woods.
Sec 2 T65N—R5W Lindley loam.
Sec 13 T65N—R6W
Anemonella thalictroides (L.) Spach.
F
Aquilegia canadensis L.
OWB
Clematis Pitcheri T. & G.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Sec 2 T66N—R5W Genesee very fine sandy loam.
Delphinium azureum Michx.
WB
Delphinium tricorne Michx.
C
Hepatica acutiloba DC.
O
Ranunculus acris L.
O
Ranunculus abortivus L.
FO
In shady woods.
Ranunculus fascicularis Muhl.
FOB
Ranunculus septentrionalis Poir.
F
Thalictrum dasycarpum Fisch. & Lall.
F
Sec 23 T68N—R5W Grundy silt loam.
Frequent.

MENISPERMACEAE

Menispermum canadense L.
FB
Sec 2 T66N—R6W Marion silt loam.

ANONACEAE

Asimina triloba Dunal.
FW
Sec 1 T65N—R5W Memphis silt loam.
Frequent on north slopes to Mississippi River.
Podophyllum peltatum L.
FO

BERBERIDACEAE

Berberis vulgaris L.
I
Naturalized from Europe.
Caulophyllum thalictroides (L.) Michx.
C

PAPAVERACEAE

Sanguinaria canadensis L.
OB

FUMARIACEAE

Corydalis aurea Willd.
OF

Dicentra canadensis (Goldie) Walp.
FB

CRUCIFERAE

Arabis canadensis L.
F

Barbarea vulgaris R.Br.
C

Brassica juncea (L.) Cosson
F
Naturalized from Europe.

Brassica nigra (L.) Koch.
FW
Sec 1 T65N—R5W Genesee very fine sandy loam.
Common along railroad near Sandusky, Iowa.
Naturalized from Europe.

Capsella Bursa-pastoris (L.) Medic.
WO
Naturalized from Europe.

Cardamine hirsuta L.
C

Cardamine parviflora L.
F

Draba caroliniana Walt.
F

Erysimum cheiranthoides L.
FB
Sec 24 T69N—R4W Genesee very fine sandy loam.
Frequent.

Lepidium densiflorum Schrad.
= *L. apetalum* in Gray's Manual.
F

Lepidium virginicum L.
FW
Sec 27 T67N—R7W Genesee silt loam.

Radicula palustris (L.) Muench.
F
Sec 31 T67N—R5W Putnam loam.
Infrequent.

Raphanus sativus L.
W

Sisymbrium altissimum L.
F

Sisymbrium canescens Nutt.
F

Sisymbrium officinale (L.) Scop.
FO
Sec 24 T69N—R4W Genesee very fine sandy loam.
Naturalized from Europe.

CAPPARIDACEAE

Polanisia trachysperma T. & G.
F
Sec 32 T66N—R6W Buckner very fine sandy loam.
Frequent in this soil.
Sec 33 T68N—R3W
Common in sand along levees, etc.

SAXIFRAGACEAE

Heuchera hispida Pursh.
F
Sec 9 T65N—R5W Lindley loam.
Rare.

Penthorum sedoides L.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Infrequent in wet soil.

Ribes missouriense Nutt.
= *gracile* Michx.
F
Sec 1 T65N—R5W Memphis silt loam.

PLATANACEAE

Platanus occidentalis L.
I

ROSACEAE

Agrimonia gryposepala Wallr.
F
Sec 15/22 T66N—R6W Grundy silt loam.
Infrequent.

Agrimonia parviflora Ait.
F

Aruncus sylvester Kosteletzsky
= *A. Aruncus* (L.) Karst.
FB
Sec 9 T65N—R5W Lindley loam.
Infrequent.
Sec 23 T66N—R6W Genesee very fine sandy loam.
Infrequent.

Crataegus Crus-galli L.
F
Sec 19 T65N—R5W

Crataegus Margaretta Ashe.
F
Sec 8 T67N—R5W Marion silt loam.

Crataegus mollis (T. & G.) Scheele.
IF

Fragaria virginiana Duchesne
F
Sec 20 T65N—R5W Wabash fine sandy loam.

Geum canadense Jacq.
= *album* J. F. Gmel.
F
Sec 14 T66N—R6W Genesee very fine sandy loam.

Geum virginianum L.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Frequent.
Sec 3 T65N—R6W Wabash silt loam.
Infrequent.

Malus ioensis (Wood) Britt.
= *Pyrus ioensis* (Wood) Bailey
F
Sec 23 T68N—R5W Lindley loam.
Frequent.
Sec 30 T65N—R5W
Abundant.

Potentilla arguta Pursh.
F
Sec 36 T67N—R6W Lindley loam.
Infrequent.

Potentilla canadensis L.
FO
Sec 29 T67N—R7W Marion silt loam.
Potentilla monspeliensis L.
FW
Sec 23 T66N—R6W Genesee very fine sandy loam.
Prunus americana Marsh.
F
Sec 36 T66N—R6W Buckner silt loam.
Prunus Persica (L.) Stokes.
I
Prunus serotina Ehrh.
F
Sec 2 T65N—R5W Lindley loam.
Infrequent.
Prunus virginiana L.
F
Sec 13 T66N—R5W Genesee very fine sandy loam.
Rosa setigera Michx.
C
Rosa virginiana Mill.
F
Sec 13 T66N—R6W Marion silt loam.
Frequent.
Sec 14 T67N—R5W Buckner fine sand.
Frequent.
Rosa Woodsii Lindl.
I
Rubus Baileyanus Britt.
= *R. villosus* var. *humifusus* T. & G.
I
Rubus villosus Ait.
FW
Sec 36 T66N—R6W Buckner silt loam.
Along railroad tracks.
Spiraea alba DuRoi.
F
Sec 19 T65N—R5W Wabash clay.
Infrequent.

LEGUMINOSAE

Amorpha canescens Pursh.
F
Sec 17 T65N—R5W Marion silt loam.
Frequent.
Sec 28 T67N—R6W
Found on a steep eroded slope.
Amorpha fruticosa L.
IB
Amphicarpa Pitcheri T. & G.
F
Sec 36 T66N—R6W Buckner fine silt loam.
Apios tuberosa Muench.
F
Sec 9 T65N—R5W Lindley loam.
Infrequent in shady woods.
Astragalus canadensis L.
F
Sec 14 T66N—R6W Marion silt loam.
Astragalus distortus T. & G.
F

Baptisia bracteata (Muhl.) Ell.
F
Sec 33 T68N—R4W Lindley loam.
Baptisia leucantha T. & G.
F
Sec 15/22 14/23 T66N—R6W Putnam silt loam.
Frequent.
Sec 17 T65N—R5W Marion silt loam.
Infrequent.
Cassia Chamaecrista L.
FWB
Sec 32 T67N—R7W Memphis silt loam.
Common along roadbanks.
Cercis canadensis L.
FW
Crotalaria sagittalis L.
F
Sec 15 T66N—R6W Putnam loam.
Infrequent.
Desmodium bracteosum var. *longifolium* (T. & G.) Robinson
F
Sec 25 T66N—R4W Marion silt loam.
Infrequent.
Desmodium canadense (L.) DC.
FB
Sec 11 T65N—R5W Grundy silt loam.
Infrequent along railroad tracks.
Desmodium Dillenii Darl.
C
Desmodium grandiflorum (Walt.) DC.
F
Sec 13 T66N—R6W Marion silt loam.
Infrequent.
Sec 9 T65N—R5W Lindley loam.
Desmodium illinoense Gray
F
Sec 14 T67N—R5W Buckner very fine sandy loam.
Frequent.
Desmodium nudiflorum (L.) DC.
F
Sec 23 T68N—R5W Lindley loam.
Desmodium paniculatum (L.) DC.
C
Gleditsia triacanthos L.
FW
Sec 26 T66N—R5W Memphis loam.
Lespedeza capitata Michx.
F
Sec 24 T66N—R6W Marion silt loam.
Infrequent.
Lespedeza violacea (L.) Pers.
F
Sec 13 T66N—R6W Marion silt loam.
Infrequent.
Lespedeza virginica (L.) Britt.
F
Sec 20 T67N—R7W Union stony loam.
Infrequent.
Medicago lupulina L.
F
Sec 36 T67N—R6W Lindley loam.
Frequent along railroad.

Medicago sativa L.
FW
Sec 14 T65N—R5W Genesee silt loam.
Along roadsides.

Melilotus alba Desr.
FWO
Sec 1 T66N—R6W Lindley loam.
Naturalized from Europe.

Petalostemum purpureum (Vent.) Rydb.
F

Psoralea Onobrychis Nutt.
F
Sec 36 T68N—R4W Marion silt loam.
Infrequent.
Sec 1 T65N—R5W Genesee very fine sandy loam.

Robinia Pseudo-Acacia L.
F
Native further south.

Strophostyles helvola (L.) Britt.
F
Sec 32 T67N—R7W Memphis silt loam.
Frequent.
Sec 28 T67N—R6W Genesee silt loam.
Frequent. Found on a steep eroded slope.

Tephrosia virginiana (L.) Pers.
FB
Sec 28 T67N—R5W Buckner fine sand.

Trifolium hybridum L.
F
Introduced from Europe.

Trifolium pratense L.
FWO
Sec 1 T66N—R6W Lindley loam.
Infrequent along roadsides.
Introduced from Europe.

Trifolium repens L.
FO
Sec 2 T66N—R6W Lindley loam.
Infrequent along roads. Doubtfully indigenous to America.

OXALIDACEAE

Oxalis cymosa Small
= *corniculata* L. (Gray's Manual)
F
Sec 26 T66N—R5W Genesee silt loam.
Infrequent. Nearly prostrate.
Sec 14 T66N—R6W Genesee very fine sandy loam.

Oxalis stricta L.
FOW

Oxalis violacea L.
OB

GERANIACEAE

Geranium carolinianum L.
F

Geranium maculatum L.
FO

RUTACEAE

Ptelea trifoliata L.
WB

Zanthoxylum americanum Mill.
FW
Sec 30 T69N—R3W Lindley loam.
Infrequent. Leaves have a lemon odor.
Sec 1 T65N—R5W Memphis silt loam.
Infrequent on north slopes to Mississippi River.

SIMARUBACEAE

Ailanthus glandulosa Desf.
I
Introduced from Asia.

POLYGALACEAE

Polygala sanguinea L.
CF
Sec 8 T65N—R5W Marion silt loam.
Infrequent.
Sec 23 T66N—R6W Genesee very fine sandy loam.
Sec 33 T68N—R4W Memphis silt loam.
Frequent.
Polygala verticillata L.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Infrequent.

EUPHORBIACEAE

Acalypha virginica L.
F
Sec 36 T67N—R6W Lindley loam.
Common on railroad track ballast.
Croton capitatus Michx.
C
Croton glandulosus L.
var. *septentrionalis* Muell. Arg.
F
Sec 33 T67N—R5W Buckner fine sand.
Infrequent.
Sec 28 T66N—R5W Buckner fine sand.
Frequent.
Sec 10 T66N—R6W Putnam silt loam.
Frequent. Said to make horses slobber.
Croton monanthogynus Michx.
C
Euphorbia corollata L.
FB
Sec 11 T68N—R5W
Common.
Sec 32 T67N—R7W
Frequent along railroads.
Euphorbia Cyparissias L.
C
Euphorbia maculata L.
FCB
Sec 29 T67N—R7W Lindley loam.
Infrequent.
Euphorbia Peplus L.
C

ANACARDIACEAE

Rhus canadensis Marsh.
F
Quite common.

Rhus glabra L.
F
Sec 10 T68N—R4W Lindley loam.
Common.
Sec 29 T65N—R5W Wabash fine sandy loam.
Sec 33 T67N—R6W Putnam loam.
Frequent along roads.

Celastrus scandens L.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.

Evonymus atropurpureus Jacq.
WB

ACERACEAE

Acer Negundo L.
F
Sec 32 T66N—R6W Wabash silt loam.
Frequent.

Acer nigrum Michx.
= *A. saccharum* var. *nigrum* (Michx.) Britt.
F
Sec 33 T67N—R7W Memphis silt loam.
Common.

Acer saccharinum L.
FW
Sec 2 T66N—R6W Marion silt loam.
Frequent on upland soils.

Acer saccharum Marsh.
W

STAPHYLEACEAE

Staphylea trifolia L.
WF

SAPINDACEAE

Aesculus glabra Willd.
F

Aesculus glabra Willd.
var. *arguta* (Buckley) Robinson
FW
Sec 1 T65N—R5W Memphis silt loam.
Infrequent in hickory maple woods.

BALSAMINACEAE

Impatiens biflora Walt.
F
Sec 13 T66N—R5W Genesee very fine sandy loam.

Impatiens pallida Nutt.
FWB
Sec 23 T66N—R6W Genesee very fine sandy loam.
Common.

RHAMNACEAE

Ceanothus americanus L.
FWB
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Sec 28 T67N—R6W Genesee silt loam.
Frequent.

Rhamnus lanceolata Pursh.
F
Sec 26 T67N—R7W Memphis loam.
Infrequent.

VITACEAE

Psedera quinquefolia (L.) Greene.
C
Vitis cordifolia Michx.
F
Rare
Vitis labrusca L.
W
Cultivated.
Vitis vulpina L.
F

TILIACEAE

Tilia americana L.
F
Sec 32 T67N—R7W Lindley loam.
Infrequent to frequent.
Tilia europaea L.
C
Cultivated.

MALVACEAE

Abutilon Theophrasti Medic.
F
Sec 20 T68N—R4W Grundy silt loam.
A common cornfield and barnyard weed.
Althaea rosea Cav.
F
Sec 13 T65N—R5W Genesee silt loam.
An escape from cultivation.
Introduced from China.
Hibiscus militaris Cav.
FB
Sec 36 T63N—R3W Wabash clay.
Infrequent.
Malva rotundifolia L.
O
Naturalized from Europe.
Sida spinosa L.
F
Sec 10 T66N—R6W Marion silt loam.
Sec 33 T68N—R3W Wabash clay.
Infrequent. Naturalized from the tropics.

HYPERICACEAE

Hypericum Ascyron L.
F
Sec 27 T67N—R7W Lindley loam.
Very infrequent. A shrub with large yellow flowers.
Hypericum cistifolium Lam.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Hypericum ellipticum Hook.
C
Hypericum perforatum L.
FB
Sec 15 T66N—R6W Putnam loam.
Frequent.
Sec 29 T65N—R5W Wabash sandy loam.
Hypericum prolificum L.
FB
Sec 26 T67N—R7W Memphis silt loam.
Infrequent.

Hypericum punctatum Lam.
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Frequent along railroad tracks.

CISTACEAE

Lechea tenuifolia Michx.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Sec 28 T64N—R4W Lindley loam.
Frequent.

VIOLACEAE

Viola palmata L.
O
Viola papilionacea Pursh.
F
Viola pedata L.
OB
Viola scabriuscula Schwein.
= *eriocarpa* Schwein.
FOB
Viola striata Ait.

THYMELAEACEAE

Dirca palustris L.

LYTHRACEAE

Cuphea petiolata (L.) Koehne.
C
Lythrum alatum Pursh.
FB
Sec 1 T65N—R5W Genesee very fine sandy loam.
Infrequent in wet ditches.
Sec 2 T66N—R6W Genesee very fine sandy loam.

ONAGRACEAE

Circaea lutetiana L.
FB
Sec 33 T67N—R6W Putnam loam.
Common in shady woods.
Ludwigia polycarpa Short & Peter.
FB
Sec 29 T67N—R7W Lindley loam.
Infrequent along roads.
Oenothera laciniata Hill.
F
Sec 29 T67N—R7W Lindley loam.
Infrequent. Introduced from the western plains.
Oenothera muricata L.
F
Sec 28 T68N—R4W Genesee very fine sandy loam.
Infrequent. Found in a timothy field.
Oenothera rhombipetala Nutt.
F
Sec 32 T66N—R6W Buckner fine sand.

UMBELLIFERAE

Anethum graveolens L.
W
Chaerophyllum procumbens (L.) Crantz.
F

Cicuta maculata L.
FB
Sec 32 T67N—R6W Marion silt loam.
Infrequent.
Sec 2 T65N—R5W Lindley loam.
Along a roadside.
Cryptotaenia canadensis (L.) DC.
FC
Sec 29 T65N—R5W Wabash fine sandy loam.
Infrequent in shady woods.
Daucus Carota L.
F
Sec 36 T68N—R6W Putnam loam.
Infrequent on upland soils.
Sec 2 T65N—R5W Lindley loam.
Naturalized from Europe.
Eryngium yuccifolium Michx.
F
Sec 36 T67N—R6W Lindley loam.
Infrequent.
Osmorrhiza longistylis (Torr.) DC.
FC
Sec 29 T65N—R5W Wabash fine sandy loam.
Frequent in shady woods.
Osmorhiza Claytoni (Michx.) Clarke.
W
Pastinaca sativa L.
FW
Sec 1 T65N—R5W Genesee very fine sandy loam.
Common along railroad banks.
Sec. 28 T68N—R4W Grundy silt loam.
Naturalized from Europe.
Sanicula canadensis L.
FW
Sec 13 T65N—R6W
In shady woods.
Taenidia integerrima (L.) Drude.
F
Thaspium barbinode (Michx.) Nutt.
F
Sec 23 T68N—R5W Lindley loam.
Zizia aurea (L.) Koch.
F
Sec 9 T65N—R5W Lindley loam.
Infrequent.
Sec 32 T67N—R6W Marion silt loam.

CORNACEAE

Cornus alternifolia L.f.
I
Cornus Amomum Mill.
IC
Cornus asperifolia Michx.
FW
Sec 14 T65N—R5W
In shady woods.
Sec 25 T66N—R4W Marion silt loam.
Frequent.
Cornus circinata L'Hér.
I

Cornus paniculata L'Hér.
FB
Sec 28/33 T67N—R6W Putnam loam.
Fairly common.

PRIMULACEAE

Anagallis arvensis L.
C

Androsace occidentalis Pursh.
F

Steironema ciliatum (L.) Raf.
F
Sec 9 T65N—R5W Lindley loam.
Infrequent in shady woods.
Sec 29 T67N—R7W Union stony loam.
Infrequent.
Sec 23 T66N—R6W Genesee very fine sandy loam.
Infrequent.

Steironema lanceolatum (Walt.) Gray.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Frequent.

OLEACEAE

Fraxinus americana L.
= *F. pennsylvanica* var. *lanceolata* (Borkh.) Sarg.
F
Sec 36 T66N—R6W Buckner silt loam.

Fraxinus lanceolata Bork.
F
Sec 14 T66N—R6W Genesee very fine sandy loam.
Infrequent.

Fraxinus nigra Marsh.
I

Fraxinus pennsylvanica Marsh.
F
Sec 32 T67N—R5W Buckner fine sandy loam.
A small tree.
Sec 29 T65N—R5W Wabash fine sandy loam.
Infrequent to rare.

Syringa vulgaris L.
W
Cultivated.

GENTIANACEAE

Sabbatia campestris Nutt.
F
Sec 33 T68N—R4W Lindley loam.
Very rare.

APOCYNACEAE

Apocynum cannabinum L.
F
Sec 22 T68N—R3W Wabash clay.
Growing in water.

Apocynum medium Greene.
F
Sec 26 T68N—R4W Marion silt loam.
Infrequent.

ASCLEPIADACEAE

Acerates floridana (Lam.) Hitchc.
FO
Sec 15/22 T66N—R6W Buckner silt loam.
Sec 19 T65N—R5W Putnam loam.

Asclepias amplexicaulis Sm.
F
Sec 33 T67N—R5W Buckner fine sand.
Infrequent.
Asclepias incarnata L.
FB
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Sec 4 T68N—R3W Wabash silty clay loam.
Infrequent.
Asclepias purpurascens L.
FWB
Asclepias quadrifolia Jacq.
FOB
Asclepias syriaca L.
F
Sec 20 T68N—R4W Grundy silt loam.
Common.
Asclepias tuberosa L.
FWB
Sec 19 T65N—R5W Wabash clay.
Infrequent.
Asclepias verticillata L.
F
Sec 36 T66N—R6W Marion silt loam.
Infrequent.
Gonolobus laevis Michx.
C

CONVOLVULACEAE

Convolvulus arvensis L.
FW
Sec 13 T66N—R5W Genesee very fine sandy loam.
Frequent along roads and fences.
Naturalized from Europe.
Convolvulus sepium L.
FW
Sec 17 T65N—R5W Marion silt loam.
Fairly common.
Cuscuta glomerata Chois.
C
Ipomoea coccinea L.
C
Ipomoea hederacea Jacq.
F
Sec 26 T67N—R6W Grundy silt loam.
Infrequent. Introduced from tropical America.
Ipomoea pandurata (L.) G.F.W. Mey.
F
Sec 28 T64N—R4W Lindley loam.
Frequent.

POLEMONIACEAE

Phlox divaricata L.
FOB
Phlox paniculata L.
O
Phlox maculata L.
O
Polemonium reptans L.
FOB
Sec 14 T66N—R4W

HYDROPHYLLACEAE

Ellisia Nyctelea L.
OWFB
Hydrophyllum appendiculatum Michx.
WCO
Hydrophyllum virginianum L.
FOB

BORAGINACEAE

Cynoglossum officinale L.
FO
Sec 26 T66N—R5W Lindley loam.
Rare in this soil.
Sec 20 T65N—R5W Wabash fine sandy loam.
Infrequent. Naturalized from Europe.
Echium vulgare L.
C
Lappula virginiana (L.) Greene.
F
Sec 24 T67N—R4W Lindley loam.
Infrequent.
Lithospermum Gmelini (Michx.) Hitchc.
O
Mertensia virginica (L.) D.C.
O
Myosotis virginica (L.) B.S.P.

VERBENACEAE

Lippia lanceolata Michx.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Common in wet places.
Sec 1 T65N—R5W Genesee very fine sandy loam.
Frequent in wet soils.
Verbena bracteosa Michx.
FW
Sec 36 T65N—R6W Lindley loam.
Common on railroad ballast.
Verbena stricta Vent.
FW
Sec 6 T68N—R3W Buckner very fine sandy loam.
Pink flowers. Rather rare.
Sec 29 T67N—R5W Buckner very fine sandy loam.
White flowers. Very rare.
Sec 14 T66N—R6W Genesee very fine sandy loam.
Blue flowers. Common in overgrazed pastures.
Verbena urticifolia L.
FB
Sec 33 T67N—R6W Lindley loam.
Infrequent at this date (July 14, 1931).
Sec 28 T68N—R4W Lindley loam.
Frequent at this date (July 21, 1931).

LABIATAE

Agastache nepetoides (L.) Kitze.
C
Blephilia ciliata (L.) Raf.
WB
Blephilia hirsuta (Pursh.) Benth.
FB

Hedeoma hispida Pursh.
F
Sec 28 T64N—R4W Memphis silt loam.
On dry hills under shade.
Sec 36 T66N—R6W Buckner silt loam.
Hedeoma pulegioides (L.) Pers.
F
Lamium amplexicaule L.
CF
Leonurus Cardiaca L.
FW
Sec 3 T65N—R6W Wabash silt loam.
Naturalized from Europe.
Lycopus americanus Muhl.
FC
Sec 30 T68N—R3W Buckner silt loam.
Infrequent.
Lycopus virginicus L.
CB
Marrubium vulgare L.
F
Sec 19 T65N—R5W Putnam loam.
Naturalized from Europe.
Monarda didyma L.
W
Monarda mollis L.
FW
Sec 2 T66N—R6W Genesee very fine sandy loam.
On dry hills.
Monarda punctata L.
F
Nepeta Cataria L.
FW
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Sec 4 T66N—R5W Buckner fine sand.
Frequent. Naturalized from Europe.
Nepeta hederacea (L.) Trevisan
OC
Prunella vulgaris L.
FB
Pycanthemum flexuosum (Walt.) B.S.P.
F
Sec 2 T66N—R6W Marion silt loam.
Frequent.
Pycnanthemum pilosum Nutt.
FB
Sec 28 T68N—R4W Memphis silt loam.
Frequent.
Scutellaria lateriflora L.
F
Sec 30 T68N—R3W Buckner silt loam.
Infrequent.
Scutellaria parvula Michx.
F
Sec 13 T66N—R6W Marion silt loam.
Infrequent. An annual.
Scutellaria versicolor Nutt.
FW
Sec 1 T65N—R5W Memphis loam.
Frequent under maple-hickory shade.

Stachys palustris L.
F
Sec 4 T68N—R3W Wabash silty clay loam.
Frequent.

Stachys tenuifolia Willd.
F
Sec 30 T68N—R3W Buckner silt loam.
Frequent.

Teucrium canadense L.
FB
Sec 2 T66N—R6W Lindley loam.
Frequent in damp ground.

SOLANACEAE

Datura Stramonium L.
F
Sec 14 T68N—R3W Wabash loam.
Infrequent. Naturalized from Asia.

Physalis heterophylla Nees.
FW
Sec 33 T67N—R7W Marion silt loam.
Infrequent.

Physalis lanceolata Michx.
F
Sec 2 T66N—R6W Marion silt loam.
Rare.

Physalis longifolia Nutt.
F
Sec 28 T64N—R4W Lindley loam.
Infrequent.

Solanum carolinense L.
FW
Sec 29 T65N—R5W Wabash fine sandy loam.
Sec 28 T67N—R5W Buckner fine sand.
Naturalized from the south.

Solanum Dulcamara L.
FB
Introduced from Europe.

Solanum nigrum L.
FB
Sec 28 T67N—R5W Buckner fine sand.
Frequent.

Solanum rostratum Dunal.
F
Sec 26 T67N—R7W. Putnam loam.
Infrequent. Found in a barnyard.
Adventive from the western plains.

SCROPHULARIACEAE

Agalinis tenuifolia (Vahl.) Raf.
FB
= *Gerardia* of Gray's Manual.

Castilleja coccinea (L.) Spreng.
OC

Dasystoma grandiflora (Benth.) Wood.
= *Gerardia grandiflora* Benth.
F
Sec 20 T67N—R7W Union stony loam.
Infrequent.

Gratiola neglecta Torr.
= *virginiana* L. in part
F

Linaria vulgaris Hill.
FW
Naturalized from Europe.

Otophylla auriculata (Michx.) Small.
= *Gerardia* of Gray's Manual.
F
Sec 2 T66N—R6W Lindley loam.
Infrequent.

Pentstemon Digitalis (Sweet) Nutt.
= *P. laevigatus* var. *Digitalis* (Sweet) Gray
F
Sec 33 T68N—R4W Memphis silt loam.
Frequent.

Pentstemon hirsutus (L.) Willd.
= *P. pubescens* Ait.
OCB

Scrophularia lanceolata Pursh.
= *S. leporella* Bicknell.
F
Sec 33 T67N—R5W Buckner fine sandy loam.
Infrequent.

Verbascum Blattaria L.
FB
Sec 1 T65N—R5W Memphis silt loam.
Infrequent in shady woods.
Introduced from Europe.

Verbascum Thapsus L.
FWB
Sec 2 T66N—R6W Lindley loam.
Infrequent along roads.
Sec 22 T67N—R5W Buckner loam.
Frequent. Naturalized from Europe.

Veronica arvensis L.
C

Veronica peregrina L.
F

Veronica serpyllifolia L.
C

Veronica virginica L.
F
Sec 24 T68N—R4W Lindley loam.
Frequent.
Sec 2 T66N—R6W Marion silt loam.
Infrequent.

OROBANCHACEAE

Orobanche uniflora L.
C

BIGNONIACEAE

Tecoma radicans DC.
FB
Sec 2 T66N—R6W Lindley loam.
An escape from cultivation.

Catalpa speciosa Warder.
F
Sec 2 T65N—R5W Lindley loam.
Frequent.

MARTYNIACEAE

Martynia louisiana Mill.
C

ACANTHACEAE

Dianthera americana L.
F
Ruellia ciliosa Pursh.
F
Sec 20 T65N—R5W Putnam loam.
Common along roads.

PHRYMACEAE

Phryma Leptostachya L.
F

PLANTAGINACEAE

Plantago aristata Michx.
FW
Plantago lanceolata L.
FW
Naturalized from Europe.
Plantago major L.
W
Plantago Purshii R. & S.
C
Plantago Rugelii Dcne.
F
Sec 23 T66N—R6W Genesee very fine sandy loam.
Sec 24 T68N—R7W Lindley loam.
Common.
Plantago virginica L.
F

RUBIACEAE

Cephalanthus occidentalis L.
FB
Galium Aparine L.
F
Galium concinnum T. & G.
FW
Galium triflorum Michx.
FW
Sec 28 T68N—R4W Memphis silt loam.
Frequent in damp woods.

CAPRIFOLIACEAE

Lonicera dioica L.
O
Sambucus canadensis L.
FW
Symphoricarpos orbiculatus Muench.
W
Symphoricarpos racemosus Michx.
F
Native further north and east.
Triosteum aurantiacum Bicknell.
F
Viburnum Lentago L.
F
Sec 2 T66N—R6W Genesee very fine sandy loam.
Infrequent.
Viburnum prunifolium L.
F

CAMPANULACEAE

Campanula americana L.
FWB
Sec 2 T66N—R6W Lindley loam.
Frequent.
Sec 14 T66N—R6W Genesee very fine sandy loam.
Sec 13 T66N—R5W Genesee very fine sandy loam.

Specularia perfoliata (L.) A. DC.
FW

Lobelia cardinalis L.
C

Lobelia inflata L.
FOB
Sec 29 T68N—R4W
Infrequent.

Lobelia spicata Lam.
W

Lobelia syphilitica L.
FB

COMPOSITAE

Achillea lanulosa Nutt.
F
Native from Saskatchewan to New Mexico and westward.

Achillea Millefolium L.
F
Adventive from Europe.

Ambrosia psilostachya DC.
C

Ambrosia trifida L.
FB
Very common along roads.

Antennaria neglecta Greene.
F
Sec 30 T69N—R3W Lindley loam.
Infrequent.

Antennaria plantaginifolia (L.) Richards.
F

Anthemis Cotula L.
FCW
Sec 19 T65N—R5W Putnam loam.
Very common. Naturalized from Europe.

Arctium minus Bernh.
F
Sec 8 T67N—R5W Marion silt loam.
Frequent. Naturalized from Europe.

Artemisia annua L.
C

Aster azureus Lindl.
C

Aster cordifolius L.
C

Aster Drummondii Lindl.
C

Aster ericoides L.
FC

Aster laevis L.
FCB
Sec 21 T67N—R7W Lindley loam.
Infrequent.

Aster lateriflorus (L.) Britt.
C
Aster lateriflorus (L.) Britt.
var. *bifrons* (Gray) Fernald.
C
Aster multiflorus Ait.
FB
Frequent.
Aster sagittifolius Wedemeyer.
W
Aster salicifolius Ait.
C
Aster sericeus Vent.
O
Aster Shortii Lindl.
CB
Aster tenuifolius L.
C
Aster Tradescanti L.
F
Sec 13 T65N—R5W Genesee very fine sandy loam.
Bidens bipinnata L.
F
Sec 33 T67N—R5W Buckner fine sand.
Infrequent. First specimen from Iowa to the I.S.C. Herbarium.
Bidens frondosa L.
C
Bidens involucrata (Nutt.) Britt.
F
Sec 36 T67N—R6W Grundy silt loam.
Very common. A bad fall weed.
Brauneria pallida (Nutt.) Britt.
FW
Sec 36 T67N—R6W Lindley loam.
Infrequent.
Centaurea Cyanus L.
W
Introduced from Europe.
Chrysanthemum Leucanthemum L.
F
Sec 26 T67N—R6W Grundy silt loam.
Infrequent. Naturalized from Europe.
Chrysanthemum Parthenium (L.) Bernh.
W
Cirsium altissimum (L.) Spreng.
C
Cirsium discolor (Muhl.) Spreng.
F
Very common.
Cirsium undulatum (Nutt.) Spreng.
F
Sec 21 T67N—R5W Buckner fine sand.
Along railroad. Fairly common.
Coreopsis palmata Nutt.
FW
Sec 29 T65N—R5W Wabash fine sandy loam.
Only one specimen found at this date (June 15, 1932).
Coreopsis tripteris L.
C

Erechtites hieracifolia (L.) Raf.
C
Erigeron annuus (L.) Pers.
W
Erigeron canadensis L.
C
Erigeron ramosus (Walt.) BSP.
F
Eupatorium altissimum L.
F
Sec 11 T66N—R6W Genesee very fine sandy loam.
Fairly common on creek banks.
Eupatorium purpureum L.
F
Eupatorium serotinum Michx.
F
Sec 20 T65N—R5W Wabash fine sandy loam.
Infrequent.
Eupatorium urticaefolium Reichard.
F
Frequent.
Gnaphalium purpureum L.
F
Sec 27 T67N—R7W Genesee silt loam.
Infrequent. A low annual.
Helenium autumnale L.
FB
Sec 11 T66N—R6W Genesee very fine sandy loam.
Frequent.
Helianthus annuus L.
F
Sec 33 T68N—R3W Wabash clay.
Common.
Helianthus doronicoides Lam.
C
Helianthus petiolaris Nutt.
F
Sec 27 T67N—R5W Buckner loam.
Native of the western plains.
Probably introduced in Iowa.
Helianthus scaberrimus Ell.
W
Helianthus strumosus L.
F
Sec 25 T68N—R4W Lindley loam.
Frequent.
Sec 28 T68N—R4W Genesee very fine sandy loam.
Frequent.
Heliopsis helianthoides (L.) Sweet.
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Krigia amplexicaulis Nutt.
(*Cynthia virginica* (L.) D. Don.)
F
Sec 9 T65N—R5W Lindley loam.
Rare.
Kuhnia eupatorioides L.
F
Sec 28 T67N—R5W Buckner fine sand.
Infrequent.

Lactuca canadensis L.
FC
Sec 4 T66N—R7W Buckner very fine sandy loam.
Sec 20 T68N—R4W Grundy silt loam.
Common.
Sec 2 T65N—R5W Lindley loam.
Lactuca floridana (L.) Gaertn.
C
Lactuca scariola L.
F
Sec 4 T66N—R7W Buckner very fine sandy loam.
Very common. Naturalized from Europe.
Lactuca villosa Jacq.
F
Blue flowers.
Lepachys pinnata (Vent.) T. & G.
CF
Leptilon canadense (L.) Britt.
= *Erigeron canadensis* L.
F
Sec 8 T65N—R5W Marion silt loam.
Infrequent.
Leptilon divaricatus Michx.
F
Sec 27 T67N—R7W Genesee silt loam.
Frequent in low ground.
Sec 14 T67N—R5W Buckner very fine sandy loam.
Frequent in bottomland soils.
Liatris cylindracea Michx.
C
Liatris pycnostachya Michx.
FB
Sec 24 T66N—R6W Marion silt loam.
Liatris scariosa Willd.
FB
Frequent on upland soils.
Parthenium integrifolium L.
FWB
Sec 36 T66N—R6W Marion silt loam.
Infrequent.
Sec 8 T65N—R5W Marion silt loam.
Frequent on upland soils.
Polymnia canadensis L.
W
Prenanthes alba L.
F
Infrequent.
Prenanthes aspera Michx.
C
Rudbeckia hirta L.
FWB
Sec 29 T65N—R5W Wabash fine sandy loam.
Only one specimen at this date (June 25, 1932).
Sec 17 T65N—R5W Putnam loam.
Frequent.
Rudbeckia subtomentosa Pursh.
C
Rudbeckia triloba L.
FB
Sec 26 T66N—R5W Genesee silt loam.
Infrequent.

Silphium integrifolium Michx.
F
Sec 6 T66N—R6W Genesee very fine sandy loam.
Frequent.
Silphium laciniatum L.
FB
Sec 1 T66N—R6W Putnam loam.
Infrequent.
Silphium perfoliatum L.
FB
Sec 36 T66N—R6W Marion silt loam.
Infrequent to common.
Solidago canadensis L.
C
Solidago latifolia L.
C
Solidago rigidiuscula Porter.
= *S. speciosa* var. *angustata* T. & G.
F
Solidago serotina Ait.
F
Frequent.
Solidago speciosa Nutt.
CB
Solidago tenuifolia Pursh.
CB
Sonchus oleraceus L.
WC
Tanacetum vulgare L.
F
Sec 20 T65N—R5W Wabash fine sandy loam.
A frequent escape along fences.
Taraxacum erythrospermum Andrz.
F
Taraxacum officinale Weber.
W
Vernonia altissima Nutt.
Sec 20 T68N—R3W Wabash loam.

DISCUSSION OF THE SURVEY

Herbaceous Plants

This survey showed that of the 648 species known to occur in Lee County, 550 of them were herbaceous plants. Of this number, 337 species belonged to the ten most common families as follows: 64 grasses (*Gramineae*), 58 composites (*Compositae*), 44 sedges and rushes (*Cyperaceae* and *Juncaceae*), 35 species in the pea family (*Leguminosae*), 23 species in the rose family (*Rosaceae*), 21 mints (*Labiatae*), 18 buckwheats (*Polygonaceae*), 16 buttercups (*Ranunculaceae*), 16 mustards (*Cruciferae*), 15 species in the lily family (*Liliaceae*), 13 in the carrot family (*Umbelliferae*), and the same number in the figwort family (*Scrophulariaceae*).

In the grass family there was a wide variety of species scattered through 35 genera. Some of the more common ones were Alopecurus along roadsides, Cenchrus in sandy fields and railroad ballast, Digitaria often a pest in cornfields, Elymus species along roads, Hystrix in dense shady woods, Panicum species in uplands and bottomlands, Poa species in pastures where the shade was moderate, and Setaria along the edges of fields and roads. Some of the genera, which were rare were Aristida and Bouteloua in the Mississippi bottom northeast of Fort Madison, Calamagrostis on the upland soils, Danthonia along the top of the Des Moines bluffs, Diarrhena in the hilly sections near Argyle, and Triplasis in the sandy soils between Montrose and Fort Madison.

Some of the most abundant genera of the composite family (*Compositae*) were Achillea in the hilly sections, Ambrosia along roads and creeks and in wet bottomlands, Anthemis which is abundant in the hill sections June 15 to August 1, and Bidens, a troublesome and abundant weed in September, in upland and hill sections. Erigeron is another genus which was abundant in June and July. Lactuca species were common along railroad tracks and Silphium was common in the bottomlands. Vernonia was a common summer pasture weed. The uncommon genera were Brauneria, Chrysanthemum, Gnaphalium and Krigia.

The most abundant sedges (*Cyperaceae*) in uplands, hills and bottomlands, were species of Carex although Eleocharis was probably the most common genus in wet or swampy bottomlands. Scirpus species were commonly found in wet roadside ditches in the hill and upland sections. Some of the rarest sedges were *Carex Asa-Grayi* in the undrained bottom northeast of Fort Madison and *Scirpus americanus* along a railroad track near New Boston.

Trees and Shrubs

The available data show that 97 species of trees and shrubs occur in Lee County of which 56 are trees and 41 shrubs; 68 species were collected by this survey, 18 by Professor H. E. Jaques, and 20 by other collectors.

One tree and one shrub new to Iowa were found in this survey, as follows:

1. An oak hybrid (*Quercus marilandica* x *Quercus velutina* = *Quercus Bushii* Sarg.)
2. Black Haw (*Viburnum prunifolium* L.)

The oak hybrid was found only once in a grove of Black Jack Oak near Summit School and the Black Haw was found along the Mississippi bluffs, south of Montrose, on a shady, damp, east exposure.

Five other species and one variety which are particularly characteristic of Lee County and southeastern Iowa were found. The one species particularly adapted to Lee County was the Papaw which was found exclusively and in abundance along the warm, damp Mississippi bluffs above Keokuk. It is found mostly further south and east, in Illinois, etc. The Ohio Buckeye (*Aesculus glabra* L.) and its variety (*A. glabra* var. *arguta*) were found along the bluffs below Montrose. Both of these are found native in the extreme southern counties although there is one station of the species as far north as Boone county. The Hop Tree or Wafer Ash (*Ptelea trifoliata* L.) occurred mostly in sandy bottoms along the Des Moines. It is further distributed in Iowa along the Mississippi to Scott County and west to Wapello although there is one specimen from Cass county in the Iowa State College Herbarium. The Red Bud (*Cercis canadensis* L.) was found growing vigorously along the Des Moines River. It is native from Lee county to Muscatine and as far west as Mills county. In Illinois it is well distributed except in the northwest corner of the state. The Overcup Oak (*Quercus lyrata*) has been recorded by Dr. L. H. Pammel from a single station north of Keokuk. Otherwise it is known only in Appanoose county. In Illinois it has only been found in the southern quarter of the state. There are many other species of trees and shrubs in Lee county but they are either widely distributed in Iowa or not particularly abundant.

Plant Indicators

From an examination of the field notes and from field experience, it seems that the plants of Lee County are either sub-specific or quite general in their local soil requirements. Many of the plants of sandy, sandy loam, and clay soils were found to be relatively specific while most of the species on silt loam, and loam soils were very general in their requirements.

It was found that *Cenchrus pauciflorus, Cycloloma atriplicifolium, Polanisia trachysperma, Sporobolus cryptandrus, Cyperus esculentus,* and *Cyperus Schweinitzii* were good indicators of sandy areas.

Typha latifolia, Eleocharis acicularis, Eleocharis palustris, Hibiscus militaris, Carex lupulina and *Anemone canadensis* were particularly characteristic of the clay soils northeast of Fort Madison. *Phytolacca decandra* is a very large shrub-like herb that was found only once along the Mississippi in this area.

The largest number of species found on any one soil type was 120 on the silt loam soils. *Abutilon Theophrasti, Bidens involucrata, Cassia Chamaecrista, Leptilon canadense, Panicum capillare, Scirpus atrovirens* and *Ulmus americana* seemed to be the best indicators.

The number of species on the loam soils was practically the same as on the silt loam types (117 species). The most common species were *Baptisia bracteata, Carex vulpinoidea, Daucus Carota, Digitaria sanguinalis, Elymus robustus, Hibiscus Trionum, Malus ioensis, Prunus serotina, Quercus alba* and *Rhus glabra.*

The commonest species of the flora on the sandy loams in the bottomlands were such species as *Agropyron repens, Amaranthus blitoides, Cyperus filiculmis, Eragrostis hypnoides, Leptilon divaricatum, Monarda mollis, Polanisia trachysperma,* and *Verbena stricta.*

The flora of the stony loam soils near Croton and northeast of Denmark was very limited but distinctive. *Dasystoma grandiflora* and *Steironema ciliatum* were the most characteristic species.

The higher yearly average temperature and precipitation as compared to the rest of Iowa[6] was reflected in the flora by the presence of such species as *Allium mutabile, Commelina virginica, Elymus glabriflorus, Gnaphalium purpureum, X Quercus Bushii,* and *Viburnum prunifolium* which have not been found in Iowa before as far as known. Two of these, *Allium mutabile,* and *Gnaphalium purpureum* are at the northern limits of their ranges in Lee County, while the other five species are well within their ranges and will probably be found later at other stations in the state.

The Papaw (*Asimina triloba*) is another species which, although found in Des Moines and Fremont counties, is particularly adapted to the local

[6] There were no available data on soil moisture in Lee County, but from United States Weather Bureau records (data from July 15, 1871, to December 31, 1908) it was found that the annual mean precipitation at Keokuk was 35.1 inches as compared to 32.4 at Des Moines. The mean annual temperature was 3°F. higher and the minimum January temperatures 10°F. higher at Keokuk.

conditions along the Mississippi bluffs above Keokuk where the precipitation and temperature are very similar to those further south and east.

SUMMARY

1. A systematic list of the 645 known species of flowering plants of Lee County, Iowa, was made of which 456 species were collected and identified by this survey; 92 species by the late Dr. Ehringer of Keokuk, Iowa, whose specimens are now in the Carthage College Herbarium, Carthage, Illinois; 87 species by Professor H. E. Jaques, Iowa Wesleyan, Mt. Pleasant, Iowa; 87 species by Mrs. Kate O'Bleanus of Lee County, Iowa; and 17 species by various collectors whose plants were in the Iowa State College Herbarium prior to June 15, 1931.

2. It was found that 333 species of the 645 were contained in the ten largest families as follows: *Gramineae* 63, *Compositae* 58, *Cyperaceae* and *Juncaceae* 44, *Leguminosae* 35, *Rosaceae* 23, *Labiateae* 21, *Polygonaceae* 19, *Ranunculaceae* 15, *Cruciferae* 16, *Liliaceae* 15, *Umbelliferae* 13, and *Scrophulariaceae* 13.

2. A total of 97 species of trees and shrubs were recorded.

4. One tree *X Quercus Bushii*, and one shrub, *Viburnum prunifolium*, were recorded the first time for Iowa. These two species and *Asimina triloba, Aesculus glabra, Aesculus glabra* var. *arguta, Petelea trifoliata, Cercis canadensis*, and *Quercus lyrata* were found to be the most distinctive species of Lee county and southeastern Iowa.

5. An unusual number of *Quercus* species was found which were as follows: *Quercus alba, Quercus bicolor, Quercus imbricaria, Quercus macrocarpa, Quercus marilandica, Quercus maxima, Quercus Muhlenbergii, Quercus palustris, Quercus rubra, Quercus stellata, Quercus velutina*, and X *Quercus Bushii* (*Quercus velutina* x *marilandica*).

6. Practically all the plants collected by this survey were listed according to the soil type on which they occurred. From this list and field experience it was found that the flora on sandy and clay soils was made up of a much smaller number of species than the loam, silt loam or sandy loam soils, but was more definitely characteristic.

7. The most characteristic species of *sand soil* were found to be *Cenchrus pauciflorus, Cycloloma atriplicifolium, Polanisia trachysperma, Sporobolus cryptandrus* and *Cyperus esculentus*; those of *clay* soils were *Typha latifolia, Eleocharis palustris, Eleocharis acicularis, Hibiscus militaris, Carex lupulina* and *Anemone canadensis;* those of *silt loams* were *Abutilon Theophrasti, Bidens involucrata, Cassia Chamaecrista, Leptilon canadensis, Panicum capillare, Scirpus atrovirens* and *Ulmus americana*; those of *loam soils* were *Baptisia bracteata, Carex vulpinoidea, Daucus Carota, Digitaria sanguinalis, Elymus robustus, Hibiscus Trionum* and *Quercus alba*; those on *sandy loams* were *Agropyron repens, Amaranthus blitoides, Cyperus filiculmis, Eragrostis hypnoides, Leptilon divaricatum*, and *Polanisia trachysperma*; and those on *stony loams* were *Dasystoma grandiflora* and *Steironema ciliatum*.

9. The more favorable temperature and precipitation conditions of the county as compared to the rest of Iowa are reflected in the flora by the presence of such species as *Allium mutabile, Commelina virginica, Elymus glabriflorus, Gnaphalium purpureum, X Quercus Bushii, Viburnum prunifolium*, and *Asimina triloba* which, with the exception of the last, probably occur in Iowa exclusively in Lee County.

LINKAGE DATA ON THE R-g_1 CHROMOSOME OF MAIZE[1]

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The corn plant has been more completely analyzed genetically than any other plant species. Through the individual and co-operative efforts of geneticists working with maize, approximately 300 genes have been studied and ten linkage groups have been established. The R-g_1 group gets its designation from the fact that R, a factor for aleurone color, and g_1, a factor causing golden plants, were the first genes found to be in this group.

In 1930 Dr. R. A. Emerson and his associates at Cornell University compiled all the linkage data available on maize and distributed a mimeographed report showing the linkage groups as they had been built up to that time. At that time the R-g_1 group contained 14 genes, some of which had been definitely located on the chromosome.

The present paper presents linkage data on the R-g_1 chromosome collected by the authors since the report of Emerson and his associates in 1930.

SUMMARY OF DATA

Table 1 presents a summary of the data on all characters studied and indicates whether the linkages are in the coupling or repulsion phase. Following the table there is a list of the gene symbols used together with the characters of the plant or seed affected by these genes.

All the data in table 1 are from F_2 progenies. All seedling counts were made in the greenhouse including golden plants. Wherever gm_2 is involved the percentages of recombination were necessarily determined from the proportion of normal and abnormal seedlings grown from normal seeds taken from ears segregating for germless seeds. This makes it necessary to determine the linkage relations by the use of only two phenotypic classes. In most cases where two seedling characters are involved only three phenotypes could be distinguished.

Where only two or three phenotypic classes were available the percentage of recombinations was determined by reducing the numbers to percentages and making comparisons in Owen's tables (6). The numbers obtained by use of Owen's tables were further checked by use of a formula suggested by Collins (1). In the one case where all four phenotypes could be distinguished Emerson's formula (2) was used to calculate the gametic ratio and the corresponding crossover value was checked by Immer's tables (3).

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[1] Journal Paper No. J125 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 182.

TABLE 1. *Summary of linkage data on the R-g_1 chromosome*

Genes XY	Linkage phase	Number of individuals					Percentage recomb.
		XY	Xy	xY	xy	Total	
Gm_2G_1	Coupling	4402	1335			5737	44.8
Gm_2Pg_1	Coupling	3552	1023			4575	42.6
Pg_1G_1	Coupling	2519	325	332	626	3802	19.2
Gm_2L_2	Repulsion	1958	560			2518	50.0
Gm_2L_4	Repulsion	1799	625			2424	50.0
G_1L_2	Repulsion	2957	1011	1409		5377	48.0
G_1L_4	Repulsion	2525	991	1292		4808	39.0
Pg_1L_4	Repulsion	1303	521	632		2456	37.0
Pg_1L_2	Coupling	1725	531	758		3014	46.0

List of gene symbols

Gm_2 gm_2—Germless seeds
Pg_1 pg_1—Pale green seedlings
L_2 l_2—Yellow seedlings
L_4 l_4—Yellow seedlings
G_1 g_1—Golden plants

DISCUSSION

Each of the linkages reported in table 1 will be discussed separately along with any explanatory notes which seem necessary.

gm_2 and g_1

In an earlier paper Wentz (7) reported independent inheritance of these two genes. In the earlier paper, however, the data were on the repulsion phase and were not so extensive. It is entirely possible that the low linkage value shown in table 1 would not be indicated in the repulsion data.

On the basis of the 44.8 per cent of recombinations the gametic ratio would be 1.23:1. Table 2 shows the observed numbers of normal and golden plants and the numbers calculated on the basis of the 1.23:1 gametic ratio.

TABLE 2. *Observed and calculated numbers of normal and golden plants on the basis of a gametic ratio of 1.23:1*

	Normal	Golden	Total
Observed	4402.00	1335.00	5737
Calculated	4406.59	1330.41	5737
Deviation	—4.59	+4.59	

For comparison, seed was planted from ears from the same progenies but which were not segregating for germless seeds. The numbers of normal and golden plants obtained from these ears were 4,897 and 1,633 respectively. This is an excèss of just 0.5 golden plants. This indicates that the shortage of golden plants from the ears segregating for gm_2 must have been due to linkage of the g_1 factor with the lehtal gm_2 factor.

gm_2 and pg_1

Earlier F_2 repulsion data (7) gave only a slight indication of linkage between these two factors. The coupling data in table 1 indicate quite definitely that there is a loose linkage between the two genes. The 42.6 per cent of recombinations corresponds to a gametic ratio of 1.35:1 and the numbers of normal and pale green seedlings calculated on this basis fit the observed numbers very closely as seen in table 3.

TABLE 3. *Observed and calculated numbers of normal and pale green seedlings on the basis of a gametic ratio of 1.35:1*

	Normal	Pale green	Total
Observed	3552.00	1023.00	4575.00
Calculated	3552.95	1022.05	4575.00
Deviation	+0.95	—0.95	

When seed was planted from ears not segregating for gm_2 the ratio of normal to pale green seedlings was 3,728 to 1,190. This is a shortage of 39.5 pale green seedlings as compared to a probable error of 20.48. This is a fair fit indicating that the large shortage of pale green seedlings from the ears segregating for gm_2 was no doubt due to linkage between the genes causing germless seeds and pale green seedlings.

pg_1 and g_1

Less extensive data published by the senior author (7) in 1930 showed a recombination percentage of 14.5 in the coupling phase. This is reasonably close to the 19.2 per cent shown in table 1. The gametic ratio corresponding to 19.2 per cent of recombinations is 4.23:1. The observed number in each of the F_2 phenotypes is shown in table 4 as compared to the numbers calculated on the basis of the gametic ratio of 4.23:1. It will be seen that the calculated numbers fit the observed numbers very closely giving a P value of .95.

TABLE 4. *Observed and calculated numbers in each phenotypic class calculated on the basis of a gametic ratio of 4.23:1*

	Pg_1G_1	pg_1G_1	Pg_1g_1	pg_1g_1	Total
Observed	2519.00	325.00	332.00	626.00	3802.00
Calculated	2519.96	329.25	329.25	623.54	3802.00
Deviation	—.96	—4.25	+2.75	+2.46	

$$X^2 = .0878$$
$$P = .95$$

gm_2 and l_2

The data in table 1 show a small deficiency of l_2 seedlings while linkage in the repulsion phase should have caused an excess of l_2 seedlings. When seed was planted from ears not segregating for gm_2 the ratio of normal to yellow seedlings was 3,352 to 1,080. This is a deficiency of 28 yellow seedlings which is not quite as large a deficiency as observed from the ears segregating for gm_2.

The data in table 1 do not show evidence of linkage between gm_2 and l_2. This is surprising as previous data on gm_2 by Wentz (7) and on l_2 by Jenkins and Bell (4) and Lindstrom (5) place gm_2 and l_2 both to the left of R. Dr. R. A. Emerson who is preparing a new summary of the linkage groups has reported, by correspondence with the senior author, other irregularities in the R-g_1 group. There may be some peculiarity about the structure of the R-g_1 chromosome.

gm_2 and l_4

The numbers in table 1 show a slight excess of yellow seedlings but hardly enough to suggest linkage. The deviation from the expected number of yellow seedlings on the basis of independent inheritance is only 19 with a probable error of 14.37.

When seed was planted from ears not segregating for gm_2 the ratio of normal to yellow seedlings was 1,113 to 393. Here there is an excess of 16.5 yellow seedlings with a probable error of 11.32.

g_1 and l_2

The data on g_1 and l_2 fit fairly well the numbers expected on the basis of independent inheritance as shown in table 5. Here the value of P is .10.

TABLE 5. *Observed and calculated numbers in each phenotypic class on the basis of independent inheritance*

	Observed	Calculated	Deviation
G_1L_2	2957	3024.56	—67.56
g_1L_2	1011	1008.19	+ 2.81
$G_1l_2+g_1l_2$	1409	1344.25	+64.75

$$X^2 = 4.6358$$
$$P = .10$$

The shortage of normal green plans with the very slight excess of golden plants might indicate a small amount of linkage. When the theoretical numbers are calculated on the basis of 48 per cent of recombinations or a gametic ratio of 1 : 1.08 they fit the observed numbers a very little closer than when independent inheritance is assumed. Table 6 compares the observed and theoretical numbers calculated on the basis of the 1 : 1.08 gametic ratio.

TABLE 6. *Observed and calculated numbers in each phenotypic class calculated on the basis of a gametic ratio of 1:1.08*

	Observed	Calculated	Deviation
G_1L_2	2957	2999.21	—42.21
g_1L_2	1011	1033.54	—22.54
$G_1l_2+g_1l_2$	1409	1344.25	+64.75

$$X^2 = 4.2920$$
$$P = .10$$

It will be noted that the fit would have been much closer except for the rather large excess of yellow seedlings. This excess of yellow seedlings can be largely accounted for by the fact that the yellow seedling counts were made about three weeks earlier than the green and golden counts. The golden plants cannot be classified satisfactorily until they are 12 to 15 inches tall. There was no doubt some loss of plants by injury and disease between the time the yellow seedlings were counted and the time that the green and golden plants were counted.

When the yellow seedlings are disregarded the numbers of green and golden plants observed fit very closely the numbers calculated on the basis of the gametic ratio of 1 : 1.08 as shown in table 7.

TABLE 7. *Observed and calculated numbers of green and golden plants on the basis of a gametic ratio of 1:1.08*

	Observed	Calculated	Deviation
G_1L_2	2957	2951.05	+5.95
g_1L_2	1011	1016.95	—5.95

g_1 and l_4

The observed numbers in table 1 indicate linkage in the repulsion phase. By reducing the numbers to percentages and comparing them in Owen's tables it is found that they come nearest fitting the percentages corresponding with 39 per cent of recombinations. This is a gametic ratio of 1 : 1.56. When the theoretical numbers are calculated on the basis of this gametic ratio they compare with the observed numbers as shown in table 8.

TABLE 8. *Observed and calculated numbers in each phenotypic class calculated on the basis of a gametic ratio of 1:1.56*

	Observed	Calculated	Deviation
G_1L_4	2525	2587.42	—62.42
g_1L_4	991	1018.59	—27.59
$G_1l_4+g_1l_4$	1292	1202.00	+90.00

$$X^2 = 8.9916$$
$$P = .01$$

The value of P in table 8 is only .01. It can be seen, however, that the big deviation is in the third class which consists of G_1l_4 and g_1l_4 seedlings. There is an excess of the yellow seedlings. This excess can at least partly be accounted for by the fact that the counts on normal green and golden plants were necessarily made after the plants were 12 to 15 inches tall while the counts on yellow seedlings were made when the seedlings were still small. There no doubt was some loss of plants through injury and disease between the time the yellow seedlings were counted and the time that the counts were made on green and golden plants. In order to eliminate this possible error the theoretical numbers of green and golden plants were calculated disregarding the yellow seedlings. Table 9 shows that the fit is very close when the yellow seedlings are disregarded.

TABLE 9. *Observed and calculated numbers of green and golden plants on the basis of a gametic ratio of 1:1.56*

	Observed	Calculated	Deviation
G_1L_4	2525	2522.83	+2.17
g_1L_4	991	993.17	—2.17

pg_1 and l_4

The data on pg_1 and l_4 indicate linkage in the repulsion phase. By comparison in Owen's tables we find that the recombination percentage must be about 37. This is a gametic ratio of 1 : 1.7. When the theoretical numbers are calculated on the basis of this gametic ratio they fit the observed numbers very closely as shown in table 10 where the value of P is .70.

TABLE 10. *Observed and calculated numbers in each phenotypic class on the basis of a gametic ratio of 1:1.7*

	Observed	Calculated	Deviation
Pg_1L_4	1303	1212.23	— 9.23
pg_1L_4	521	529.78	— 8.78
$Pg_1l_4+pg_1l_4$	632	614.00	+18.00

$$X^2 = .7381$$
$$P = .70$$

pg_1 and l_2

The data on pg_1 and l_2 fit reasonably well the numbers expected on the basis of independent inheritance. Table 11 shows the value of P to be .30 when the observed numbers are compared with the numbers calculated on the basis of independent inheritance.

TABLE 11. *Observed and calculated numbers in each phenotypic class on the basis of independent inheritance*

	Observed	Calculated	Deviation
Pg_1L_2	1725	1695.38	+29.62
pg_1L_2	531	565.13	—34.13
$Pg_1l_2+pg_1l_2$	758	753.50	+ 4.50

$$X^2 = 2.6075$$
$$P = .30$$

Although the observed numbers are close to those calculated on the basis of independent inheritance it can be seen that the deviations present are in the right direction to indicate a low linkage value in the coupling phase. Table 12 was prepared to compare the observed numbers with calculated numbers on the basis of a low linkage. A recombination value of 46 per cent was assumed. This is a gametic ratio of 1 : 1.17. The numbers calculated on this basis fit very closely the numbers observed. The value of P is .98.

TABLE 12. *Observed and calculated numbers in each phenotypic class on the basis of a gametic ratio of 1:1.17*

	Observed	Calculated	Deviation
Pg_1L_2	1725	1726.04	—1.04
pg_1L_2	531	534.45	—3.45
$Pg_1l_2+pg_1l_2$	758	753.50	+4.50

$$X^2 = .0498$$
$$P = .98$$

SUMMARY AND CONCLUSIONS

In this paper linkage data are presented on five genes previously found to be located on the R-g_1 chromosome.

In the main these data substantiate the relative positions of the genes on the chromosome as summarized by Emerson and his associates in 1930. There is, however, one decided inconsistency. Data presented here on the linkage relations of gm_2 with pg_1 and g_1, and previous data on gm_2 and R, place gm_2 at the left end of the chromosome and since previous data place l_2 and l_4 at opposite ends of the chromosome there should be linkage between gm_2 and either l_2 or l_4. At the present time there is no way of explaining this lack of agreement in the relative positions of the genes. It is hoped that further data bringing in other genes on the chromosome will afford some solution.

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IRREGULAR SPOROGENESIS AND POLYEMBRYONY IN SOME LEGUMINOSAE

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The prevalence in species of Angiosperms of irregularities in meiosis, polymorphism in spores, multiple embryo sacs, or polyembryony is commonly regarded as indicative of a hybrid constitution. Since plants so constituted are generally quite variable in many of their features, they are usually not dependable as to types but are inviting of improvement by selection and other breeding methods. Any disclosures, therefore, pertaining to the constitution of crop plants as important as the clovers and alfalfa are worthy of consideration.

Although the features herein considered pertain especially to *Trifolium pratense* L., *T. repens* L., *Melilotus alba* Des., *Medicago sativa* L., and *Vicia americana* Muhl. of the family Leguminosae, they are probably as prevalent in other species of the family but have escaped notice owing to limited morphological studies.

In *Melilotus alba* two types of pollen (fig. 5), the larger of which was commonly multinucleate and several times the size of the normal type, were observed by Rogers (8) and Castetter (1). The study of the development of the giant pollen grains furnished considerable evidence that they were tetrads in which the division walls had been omitted.

The origin of the embryo sac directly from the mother cell, a method characteristic of the Lily family, has been reported to occur in *Melilotus alba* by Guignard (2) and Young (9) and in *Medicago arborea* by Guignard (2) and Hèrail (3), whereas, in *Melilotus alba* and in the Grimm and common varieties of *Medicago sativa* the senior writer (5, 6) and Reeves (7) found that the embryo sacs in the ovules observed were the products of one megaspore as is customary in Dicotyledons. Although these discrepancies may be due to errors in observation, marked variations in the forming of embryo sacs would be in accord with the other irregularities prevalent in the ovules of these species.

Much variation in the number of mother cells per ovule (figs. 1, 4, 7, 8, and 9) have been observed in *Trifolium pratense, T. repens, Medicago sativa, Melilotus alba,* and *Vicia americana* by the senior author (6). Multiple tetrads of megaspores were noted in all the species, and occasionally in *Melilotus alba* and *Medicago sativa* two or more embryo sacs in the process of development in the same ovule were observed (figs. 1 and 4). The other extreme in which the ovules form no mother cells was found to occasionally occur in *Trifolium pratense.* Several mother cells and as many as three embryo sacs in the same ovule in process of development were observed by Reeves (7) in both the Grimm and common strains of alfalfa.

The development that several embryo sacs in the same ovule may attain and the possibility of two or more of them functioning have received very little attention in the legumes. Jönsson (4) reported polyembryony in

Trifolium pratense. How the embryos were formed was not ascertained, but in view of the tendency of *Trifolium pratense* to form multiple mother cells, it is quite plausible that they were the products of separate embryo sacs.

OBSERVATIONS ON POLYEMBRYONY IN ALFALFA AND SWEET CLOVER

In some experiments on the germination of alfalfa seeds[1] at Iowa State College in 1930 one seed with two radicles protruding was discovered (fig. 2). The removal of the testa revealed two separate, perfect embryos equal in size. They were oppositely oriented and one cotyledon of each embryo was enclosed between the cotyledons of the other (fig. 3.) The axes of the hypocotyls and radicles, although oppositely oriented, were parallel except for the slight opposite curving of the tips of the radicles. The position and orientation of the embryos with reference to the micropyle were very similar and corresponded to the relative position and orientation of multiple embryo sacs in ovules. There was considerable evidence that the embryos were products of separate embryo sacs.

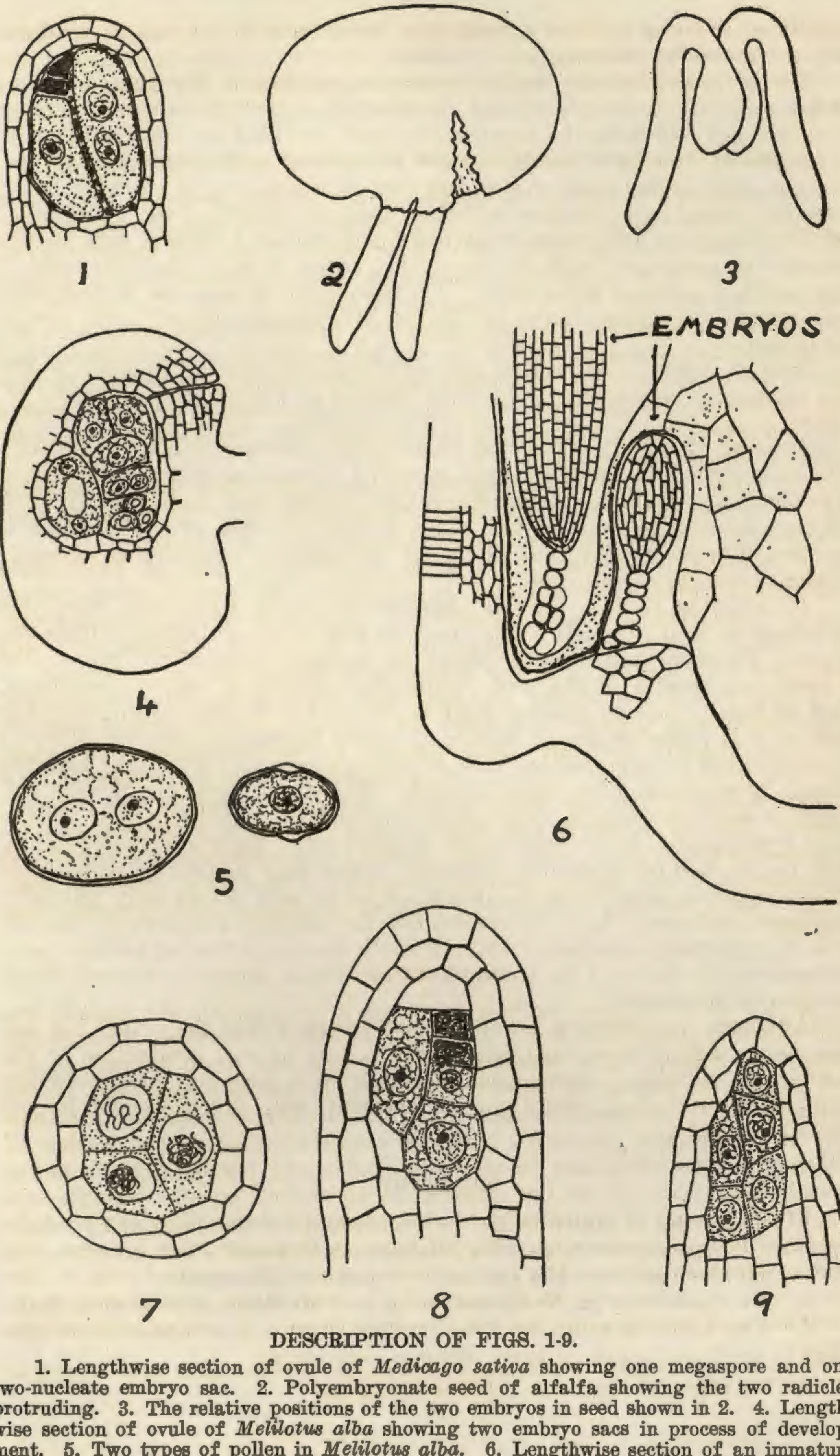
Owing to the close fitting together of their cotyledons, the two embryos did not require much extra space and their presence in the dormant seed was probably scarcely manifest in the size and shape of the seed.

Morphological studies of the seeds of *Melilotus alba* at Iowa State College have occasionally disclosed, in addition to the normal embryo, other structures suggestive of aborted embryos. A case in which polyembryony was quite evident is shown in figure 6 which represents a section of a seed more than half mature with one normal and one miniature embryo in an early stage of differentiation. The secondary embryo, excepting its arrested development, was apparently normal, for it was typical of normal embryos at certain stages in their early development. It was terminal on a suspensor that was nearly normal in type. It occupied an area that resembled an embryo sac and that was separate from the embryo sac of the primary embryo. The two embryos and areas occupied by them were similarly located and oriented in the seed. Their location and orientation corresponded to those of multiple embryo sacs in an ovule. The zygotic origin of both embryos was, therefore, indicated by both morphological and circumstantial evidence.

DISCUSSION

In the ovules of the legumes included in this article the nucelli are slender, seldom more than five or six layers of cells in thickness through the sporogenous region. The competition, therefore, for space as well as for food and water among multiple mother cells or embryo sacs must be exceedingly severe, the result being that all but the survivor usually succumb early in the struggle. In case a parity in competition between a number of mother cells or embryo sacs in an ovule occurs and persists, the situation is much more favorable to the abortion of all mother cells or embryo sacs than to the normal development of two or more of them. The early establishment and maintenance thereafter of a parity in competition between two embryo sacs that permits the normal development of two embryos in the same ovule, as in the polyembryonate alfalfa seed, must be extremely rare. A condition of multiple mother cells or embryo sacs in ovules is therefore

[1] The seeds were brought from Montana by the junior author. They were claimed to be Grimm but origin and strain were not definitely known.



DESCRIPTION OF FIGS. 1-9.

1. Lengthwise section of ovule of *Medicago sativa* showing one megaspore and one two-nucleate embryo sac. 2. Polyembryonate seed of alfalfa showing the two radicles protruding. 3. The relative positions of the two embryos in seed shown in 2. 4. Lengthwise section of ovule of *Melilotus alba* showing two embryo sacs in process of development. 5. Two types of pollen in *Melilotus alba*. 6. Lengthwise section of an immature seed of *Melilotus alba* showing two embryos. 7. Three mother cells shown in the cross section of an ovule of *Trifolium pratense*. 8. One mother cell and one row of megaspores in *Trifolium repens*. 9. A number of mother cells in *Vicia americana*.

usually so obscured by later growth that traces of it in the mature seed are only detectable by microscopical studies.

Owing to the delicacy in the technique required in the study of sporogenesis and the development and functioning of embryo sacs, the number of ovules and especially the number of plants included are relatively small. Consequently, irregularities of common occurrence in the reproductive processes in both anthers and ovules may escape notice. It is quite probable, therefore, that further studies will show that the nucelli of these and other species of legumes are generally arenas where mother cells and embryo sacs compete for supremacy with the result that traces of more than one embryo in a seed is a common occurrence. The frequency of multiple mother cells and embryo sacs in the ovules of the few species investigated favor such a prediction.

Some features in connection with seed production in the clovers, alfalfa, and vetch may be related to the irregularities in the ovules previously described.

In most, if not all, cultivated legumes the abortion of ovules is a common occurrence. In the five species included in this discussion, the abortion of ovules that regularly occurs ranges from 50 per cent in red clover to 80 per cent or more in sweet clover. This regular abortion of ovules which is manifested in their resorption soon after fertilization is apparently a result of competition between ovules.

In addition to this regular abortion of ovules there are other disturbances in seed production that may be due to irregularities within the ovules. Throughout the middle states the average yield of red clover seed is about one-twelfth of the seed production capacity of red clover plants. Most of this failure to produce seed is due to insufficient pollination, but some of it is probably due to failure of ovules to produce mother cells and to competition between mother cells or embryo sacs that interferes with the normal development of ovules and seeds. The dropping of the flowers and young pods so common in sweet clover and alfalfa may be in part due to these irregularities in the ovules, the seriousness of their effects depending upon environmental conditions. Similar causes, may in part be responsible for the common occurrence in alfalfa of seeds with no or only partially developed embryos. In *Vicia americana* the failure of ovules to become seeds is apparently associated with an early disintegration of embryo sacs, a phenomenon that may be traceable to an innate tendency toward irregularities in the ovules.

Although the tendency toward irregularities within the ovules has not been shown definitely to contribute to the failure of seed production in the legumes, it certainly deserves consideration in a program of developing better seed producing plants, an achievement very much needed in red clover and alfalfa.

SUMMARY

1. Two types of pollen in *Melilotus alba* and the tendency of *Trifolium pratense, T. repens, Melilotus alba, Medicago sativa* and *Vicia americana* to produce multiple mother cells and embryo sacs are discussed.

2. Polyembryony in *Medicago sativa* and *Melilotus alba* is described.

3. The probable relation of the irregularities in the reproductive processes to seed production in these legumes is discussed.

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NOTES ON THE IMMIGRANT FLORA OF IOWA, I

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Accepted for publication September 24, 1933

In the year 1929[1] the writer offered for publication a systematic list of the introduced plants of the state, which grew without cultivation and had become more or less naturalized, with notes regarding their frequency, range within the state, and their native habitat. Special attention was called also to those introduced plants which were dangerous to agriculture, and whose eradication or control was advisable.

In the three years since the paper was prepared, much work has been done in securing additional data regarding our introduced flora, and at this time the following appended list, systematically arranged, numbering thirty-five species worthy of recognition, is offered.

The original list contained 263 numbers and those now offered increase the list to 298. The total number of Iowa Pteridophyta and Flowering Plants represented in the Herbarium at this date, September 15, 1933, is 1,613, of which the immigrant flora forms 18.4 per cent. This percentage will be greatly increased as time passes, through the destruction of many of our native plants, and the introduction of foreign species, many of them undesirable. In the appended list additional data are given, especially regarding those plants which threaten to become serious pests.

264. *Sorghum halepense* (L.) Pers. Johnson Grass. Frequent in cultivation and often escaped. It is a native of Asia.
265. *Phalaris canariensis* L. Bird-seed Grass. Frequent as an escape around dwellings; a native of Europe.
266. *Arrhenatherum elatius* (L.) Beauv. Oat-grass. Occasional in fields and waste places. Introduced from Europe.
267. *Hemerocallis fulva* L. Yellow Day Lily. Frequent as a garden escape. A native of Europe.
268. *Betula pendula* Roth. (*B. alba* L. in part). The common European White Birch in cultivation, but rare as an escape. This tree is especially liable to insect injury.
269. *Polygonum dumetorum* L. A European perennial. Rare unless overlooked on account of its close resemblance to one of our native species.
270. *Fagopyrum esculentum* Moench. Buckwheat. This common cultivar often persists for several years. Owing to our early frosts it is becoming less common in cultivation in this latitude.
271. *Amaranthus spinosus* L. The Thorny Amaranth. A rare introduction from Tropical America. It is common and very troublesome in our Southern States.

[1] Cratty, R. I. 1929. The immigrant flora of Iowa, Iowa State College Jour. Sci. 3: 247-269.

272. *Arenaria serpyllifolia* L. Rare in dry soil, Emmet Co. A native of Europe.

273. *Delphinium cultorum* Voss. The common Candle Larkspur of the gardens. It is very hardy and profuse bloomer and a frequent escape. It is of hybrid origin, a mingling of several Old World species.

274. *Berberis Thunbergii* DC. The Japanese Barberry, and a frequent escape. It is a valuable ornamental shrub, being immune to the grain rust which uses its near relative *B. vulgaris* as a winter host.

275. *Alyssum alyssoides* L. The common Sweet Alyssum which occasionally escapes to pastures and waste places. A native of Europe.

276. *Chorispora tenella* DC. This little crucifer from Asia has become established along a highway north-east of Sioux City.

277. *Erysimum parviflorum* Nutt. Western Wormseed. Infrequent; an introduction from the Western Plains.

278. *Radicula amphibia* (L.) Druce. An aquatic species, recently introduced from Europe to a river bank in Emmet Co.

279. *Reseda lutea* L. Sweet Mignonette. A garden cultivar from Europe, and an occasional escape.

280. *Geranium pusillum* Burm. fil. An occasional weed in lawns. A native of Europe.

281. *Oxalis corniculata* L. This is the species common around greenhouses. It is not the *O. corniculata* of our older manuals which is now *O. cymosa* Small.

282. *Ailanthus altissima* (Mill.) Swingle. The Chinese Tree-of-Heaven. It is quite common in cultivation and occurs as an escape from seed and also by suckering.

283. *Euphorbia Peplus* L. A rare introduction from Europe, and fortunately not likely to prove troublesome.

284. *Falcaria vulgaris* Bernh. Sicklewort. A deep-rooted perennial from Europe. It spreads both by seeds and by running roots. It has been found well established in Sioux and Guthrie counties, and should be eradicated.

285. *Borago officinalis* L. Borage. This garden escape was collected in Benton County by the late Dr. L. H. Pammel. It is a native of Europe.

286. *Madia glomerata* Hook. Tarweed. This common native of the western plains has been collected as a waif in Mahaska and Emmet counties.

287. *Bidens bipinnata* L. This European Spanish Needle has made its appearance in S.E. Iowa. It is very common in the Atlantic States.

288. *Anthemis tinctoria* L. The Yellow Ox-eye Camomile of Europe occurs as a garden escape in Clayton Co.

289. *Centaurea diffusa* Lam. This Bachelor's Button or Knap-weed is thoroughly established in Sioux Co. It is a native of S.E. Europe.

290. *Centaurea repens* L. Russian Knap-weed. This noxious introduction from S.E. Europe has made its appearance in Sioux Co. It is a hardy perennial and spreads by seed and by its extensive running roots. It should be added to our list of unlawful weeds.

291. *Sonchus uliginosus* Bieb. One of our Perennial Sow Thistles. This European plant is frequent in N.E. Iowa. It is a close relative, perhaps only a variety, of the unlawful species, *S. arvensis.*

292. *Crepis capillaris* (L.) Wallr. A harmless little plant introduced from Europe into waste places.

293. *Hieracium virosum* Pall. One of the European Hawkweeds. It has been collected in Floyd and Howard counties. This is its first recorded appearance in the United States.

294. *Hartmannia speciosa* (Nutt.) Small. (*Oenothera Nutt.*) White Primrose. Introduced on R.R. right-of-way, Kossuth Co. and probably elsewhere. A perennial plant worthy of cultivation.

295. *Anethum graveolens* L. Dill. An escape around gardens.

296. *Centaurea diffusa* Lam. One of the Star Thistles. Established in Sioux Co. (Dr. A. L. Bakke).

297. *Centaurea repens* L. Russian Knap-weed. A deep-rooted perennial, recently introduced in Sioux Co. (Dr. A. L. Bakke). It should be classed with our unlawful weeds.

298. *Hieracium virosum* Pallas. One of the Hawkweeds. Floyd Co. (Dr. Ada Hayden). Howard Co. (Kathryn Shields). The only known localities in America.

PHYLLOPHAGA OF IOWA[1]

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Accepted for publication November 29, 1933

The genus Phyllophaga Harris (Gr. *phyllon* -leaf; *phagein*—to eat) includes a large group of beetles popularly known as "June-bugs" or "May-beetles" whose larvae are the common white grubs of the fields. From an economic point of view the depredations of both larvae and adults are well known. The adults frequently defoliate trees and shrubs by night and deposit their eggs in the soil by day, whereas the larvae or "grubs" are subterranean in habit and destroy the roots of numerous acres of farm, truck, and garden crops as well as great areas of grassland.

The contents of this paper are based upon data from 102,258 adult specimens taken in Iowa by various collectors during the past ten years. These specimens are represented by thirty-three species, one of which, *P. gracilis* (Burm.), is recorded in this state for the first time.

It has been impossible to compare specimens with the original types, so the synonymy given is that recorded in the literature. The species will be discussed in the order as given by Leng (1920) in his catalogue. The keys are adapted from Horn (1887), and since the females are so very similar the keys are of necessity arranged from the male characters.

DISTRIBUTION

The genus Phyllophaga is known to occur only in the Western Hemisphere from Hudson Bay to Argentine, including the West Indian Islands. From fifteen to twenty species may be found in most localities except along the Western Coast. Many species are known to have a rather wide distribution, whereas others have been taken only in limited areas. Junk (1912) listed 231 species for the world, many of which are synonyms or races; Leng (1920) catalogued 97 species from the United States and Canada; Leng and Mutchler (1927) reported 10 more species, and since that time 11 additional ones have been described from the United States and Canada, making a total of 118 species north of Mexico.

HISTORICAL REVIEW

Genus PHYLLOPHAGA Harris (1926)

Logotype—*hirticula* Knoch.

Melolontha Fabricius, 1775, Syst. Ent. :31.
Phyllophaga Harris, 1826, Mass. Agr. Jour. and Rpts., 10:6. (Facsimile seen).
Stenothorax Harris, 1826, Mass. Agr. Jour. and Rpts., 10:8. (Facsimile seen).
Rhizotrogus Berthold, 1827, Nat. Fam. d. Thierreichs: 362 (original not seen).
Lachnosterna Hope, 1837, Coleop. Man., pt. 1:99.
Holotricha Hope, 1837, Coleop. Man., pt. 1:99.
Ancylonycha Blanchard, 1845, Hist. Ins., 1:216.

[1] Journal Paper No. J129 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 128.

Trichesthes Erichson, 1847, Nat. Ins. Deutschl., 3:658. (Original not seen).
Trichestes Blanchard, 1850, Cat. Coll. Ent., 1:141.
Tostegoptera Blanchard, 1850, Cat. Coll. Ent., I:149.
Eugastra Le Conte, 1856, Acad. Phil., Jour., (2), 3:233.
Endrosa Le Conte 1856, Acad. Phil., Jour., (2), 3:234.
Gynnis Le Conte, 1856, Acad. Phil., Jour., (2), 3:262.

Harris (1826) separated the species of *Melolontha* into two genera; he retained *Melolontha* for those species with an antennal club of four segments, and proposed the name *Phyllophaga* for those species with an antennal club of three segments. The generic name *Phyllophaga* was rejected by most early workers on the grounds that the original description failed to mark the limits of the genus. Melsheimer (1853) accepted the latter name in his catalogue, but his paper does not seem to have been followed by later systematists. The species now included in this genus have been placed in numerous genera by different authors, and European workers still recognize *Lachnosterna* Hope. Glasglow (1912) revived the name *Phyllophaga* because the original publication was accompanied by the valid species *quercina, hirsuta, hirticula,* and *balia.* He designated *P. hirticula* (Knoch) as the genotype (logotype).

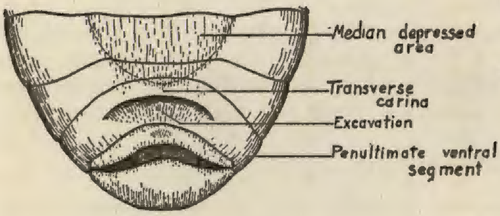

Fig. 1. Ventral view of tip of male abdomen showing charactres.

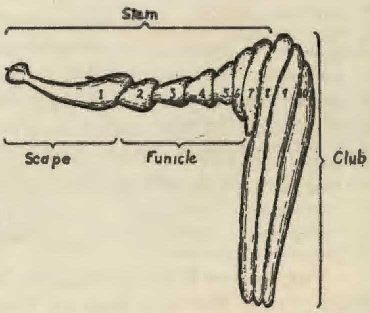

Fig. 2. Antenna showing parts.

DESCRIPTION OF GENUS

Body oval, oblong, or cylindrical, yellowish brown to piceous. Elytra without striae or grooves. Six visible ventral segments rather firmly united, but with distinct sutures. Mesosternum densely punctate, with more or less dense vestiture of hair. Coxae transverse, not prominent. Antennae lamellate with a three-jointed club. Tarsal claws with a single tooth beneath near the middle.

BROODS

Life histories of June-beetles vary in length from one to four years, depending upon biotic conditions and the species concerned. In general, however, it requires three years in Iowa to complete the development from egg to adult. There are three broods, designated as broods A, B, and C, the adults of one brood appearing each year. Four species, namely, *P. quercus, gracilis, ephilida,* and *spreta* have been reported in the literature as occurring in Iowa, but since the year in which the adults of these species were taken was not recorded, it is impossible to determine the brood to which they should be referred. Records of the species for these three broods are shown in table 1. The data include the notes published by H. E. Jaques in 1926, 1927, and 1928; many records kindly sent to the writer by Dr. H. B. Hungerford and Prof. M. H. Swenk; unpublished notes of R. L. Webster, formerly of the Iowa Agricultural Experiment Station; many unpublished records of Dr. W. F. Wickham and Prof. H. E. Jaques; data from specimens in the collection of Iowa State College and several thousand collected by members of the department and the writer during the past three years.

TABLE 1. *Phyllophaga of Iowa*

Phyllophaga Species	Number of specimens of each species			
	Brood A	Brood B	Brood C	Total
P. hirticula (Knoch)	41,084	825	193	42,102
P. implicita (Horn)	9,980	14,662	1,609	17,208
P. fusca (Froel.)	937	38	5,531	15,549
P. tristis (Fab.)	10,647	75	10	10,732
P. futilis (Lec.)	2,062	3,440	1,914	7,416
P. rugosa (Mels.)	2,993	1,363	733	5,089
P. inversa (Horn)	507	316	83	906
P. crassissima (Blanch.)	157	111	381	649
P. hornii (Smith)	560	3		563
P. vehemens (Horn)	255		179	434
P. anxia (Lec.)	352	4	41	397
P. drakii (Kirby)	211	5	124	340
P. fraterna Harris	206	3	4	213
P. ilicis (Knoch)	140	5	4	149
P. micans (Knoch)	91	31	15	137
P. crenulata (Froel.)	53	13	36	102
P. marginalis (Lec.)	53			53
P. prunina (Lec.)	52	1		53
P. congrua (Lec.)	44			44
P. fervida (Fab.)	14		14	28
P. nitida (Lec.)	25	1		26
P. balia (Say)	23			23
P. bipartita (Horn)	14	1	2	17
P. fosteri (Burm.)	3	2	6	11
P. corrosa (Lec.)	8	1		9
P. vilifrons (Lec.)	4			4
P. barda (Horn)	2			2
P. lanceolata (Say)			1	1
P. longitarsa (Say)		1		1
P. gracilis (Burm.)				
P. quercus (Knoch)				
P. spreta (Horn)				
P. ephilida (Say)				
Total	70,477	20,901	10,880	102,258

KEY TO THE MALES OF GENUS PHYLLOPHAGA

1. Hind tibia with both spurs free 2
   Hind tibia with one spur fixed 5

2. Body more or less pruinose .... *quercus* ....p. 340
   Body with vestiture of scales or hair 3

3. Body with vestiture of scales .... *lanceolata* ....p. 317
   Body with vestiture of hair 4

4. Margin of pronotum crenulate .... *crenulata* ....p. 339
Margin of pronotum entire or irregular .... *tristis* ....p. 341

5. Fixed spur of hind tibia not more than one-third length of free spur (plate IX, fig. 41) 6
Fixed spur of hind tibia more than one-third length of free spur (Plate IX, fig. 38) 7

6. Antennae ten-segmented .... *ephilida* ....p. 318
Antennae nine-segmented .... *longitarsa* ....p. 319

7. Hind tibia excavated at base of fixed spur (Plate IX, figs. 39, 40) 8
Hind tibia truncate at apex (Plate IX, fig. 38) 12

8. Mesosternum with sparse vestiture of long hair .... *gracilis* ....p. 319
Mesosternum with dense vestiture of long hair 9

9. Fixed spur of hind tibia strongly arcuate, angularly bent at tip (Plate IX, fig. 39) .... *futilis* ....p. 320
Fixed spur on hind tibia straight or feebly arcuate (Plate IX, fig. 38) 10

10. Penultimate ventral segment without tranverse elevation .... *congrua* ....p. 321
Penultimate ventral segment with transverse elevation 11

11. Elytra pruinose .... *prunina* ....p. 322
Elytra glabrous .... *corrosa* ....p. 333

12. Antennae ten-segmented 13
Antennae nine-segmented 30

13. Elytra with vestiture of hair 14
Elytra without vestiture of hair 15

14. Body with rows of erect hair .... *hirticula* ....p. 337
Body uniformly clothed with hair .... *ilicis* ....p. 338

15. Elytra pruinose 16
Elytra glabrous 17

16. Body robust, slightly iridescent; small roughened area at apex of penultimate ventral segment .... *crassissima* ....p. 322
Body elongate; feebly elevated, arcuate ridge on penultimate ventral segment .... *micans* ....p. 325

17. Ridge of penultimate ventral segment divided (smooth at middle) 18
Ridge of penultimate ventral segment not divided 19

18. Ridge of penultimate ventral segment narrowly and deeply divided .... *bipartita* ....p. 324
Ridge of penultimate ventral segment broadly divided .... *hornii* ....p. 327

19. Hind tibia with fixed spur hooked at tip .... *vehemens* ....p. 325
Hind tibia with fixed spur feebly arcuate or straight 20

20. Punctures on pronotum coarse, evenly and closely placed .... *rugosa* ....p. 334
Punctures on pronotum fine and rather evenly placed, or moderately coarse and unevenly placed 21

21. Ridge of penultimate ventral segment overhanging at ends 22
Ridge of penultimate ventral segment feebly elevated, not overhanging at ends, roughened, often with cupuliform excavation behind ridge 25

22. Ridge of penultimate ventral segment rather strongly arcuate (Plate IV, fig. 34) 23
Ridge of penultimate ventral segment nearly straight (Plate IX, fig. 35) 24

23. Ends of ridge on penultimate ventral segment reaching hind margin of segment .... *fervida* .... p. 327
Ends of ridge on penultimate ventral segment not reaching apex of segment .... *anxia* .... p. 328

24. Last segment with strong, median, transverse ridge at base; hind tibia with spurs slender, lanceolate........ *fusca* .... p. 326
Last segment without median transverse ridge at base; hind tibia with spurs broad, flattened, lanceolate........ *drakii* .... p. 329

25. Club of antennae one-third longer than stem........ *spreta*[2] .... p. 331
Club of antennae little if any longer than stem........ 26

26. Pronotum with punctures moderately coarse, irregularly placed, with large irregular smooth spaces........ *marginalis* .... p. 330
Pronotum with punctures moderately fine, rather regularly placed...... 27

27. Ridge on penultimate ventral segment feebly elevated, broad, feebly excavated behind 28
Ridge on penultimate ventral segment, narrow, strongly arcuate, smooth, moderately to deeply excavated behind........ 29

28. Color usually dark brown; hind tibia with fixed spur broad, much flattened, rather obliquely truncate........ *fraterna* .... p. 332
Color usually reddish brown; hind tibia with fixed spur feebly flattened, tip acuminate .... *fosteri* .... p. 332

29. Ridge of penultimate ventral segment with deep cupuliform excavation behind .... *barda* .... p. 330
Ridge of penultimate segment with shallow cupuliform excavation behind .... *inversa* .... p. 323

30. Ridge of penultimate ventral segment broadly divided........ *nitida* .... p. 337
Ridge of penultimate ventral segment not divided........ 31

31. Ridge of penultimate ventral segment narrow, deeply excavated behind .... *balia* .... p. 335
Ridge of penultimate ventral segment narrow, feebly excavated behind 32

32. Ridge of penultimate ventral segment feebly elevated, with small tuberosity on each side; body ovate........ *implicita* .... p. 335
Ridge of penultimate ventral segment with feebly arcuate ridge, without the tuberosity; body elongate........ *vilifrons* .... p. 336

DESCRIPTION OF SPECIES

Phyllophaga lanceolata (Say)

(Plate I, fig. 1)

1824 *Melolontha lanceolata* Say, Acad. Phil., Jour., 3: 242, Le Conte ed. 2, 1869, p. 298.
1850 *Tostegoptera lanceolata* Blanchard, Cat. Coll. Ent., 1:149.
1855 *Tostegoptera lanceolata* Burmeister, Handb. Ent., 4, pt. 2: 356.
1856 *Ancylonycha lanceolata* Lacordaire, Gen. Coleop., 3: 285.
1856 *Lachnosterna lanceolata* Le Conte, Acad. Phil., Jour., (2), 3: 237.
1887 *Lachnosterna lanceolata* Horn, Am. Ent. Soc., Trans., 14: 216.
1887 *Lachnosterna lanceolata* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna lanceolata* Smith, U. S. Nat. Mus., Proc., 11: 493.
1916 *Lachnosterna lanceolata* Davis, Jour. Econ. Ent., 9: 277.
1916 *Phyllophaga lanceolata* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1919 *Lachnosterna lanceolata* Hayes, Jour. Econ. Ent., 12: 109.
1928 *Phyllophaga lanceolata* Sim, N. J. Dept. Agr., Circ. 145: 9.

[2] Specimen not seen.

Body robust, subopaque, brownish to piceous, with vestiture of elongate, yellowish scales. Clypeus subconcave, rather broadly and vaguely emarginate, moderately reflexed; coarsely, deeply punctate; suture sinuate. Frons convex; punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum subconvex, short and broad, widest in front of middle, sides angulate, crenate; punctures similar to those on frons, not so dense. Mesosternum with sparse vestiture of moderately long, scale-like hairs. Tooth of claw subbasal, small. Elytra granulate, rugulose, punctures similar to those on pronotum, much sparser; costae broad, feebly elevated, more or less glabrous.

Length, 13-17 mm.; width, 7-9 mm.

Male: Antennal club equal to stem. Abdomen with second, third, and fourth ventral segments with short, strongly elevated carina at middle; penultimate ventral segment with deep, transverse depression, apex abruptly and deeply emarginate; last ventral segment vaguely depressed, apex broadly and deeply emarginate. Hind tibia obliquely truncate; upper spur long, slender, slightly curved, acute; lower spur movable, slender, slightly curved, twisted at tip, acute, three-fourths length of upper.

Female: Antennal club shorter than funicle. Body ovate, wingless. Abdomen with second, third, and fourth ventral segments glabrous at middle, with piceous, roughened, elevated carinae; penultimate ventral segment vaguely concave; last ventral segment convex, apex broadly, not deeply emarginate.

Collected only at Ames and Sioux City. Food plants unknown.

Phyllophaga ephilida (Say)

(Plate I, fig. 3)

1825 *Melolontha ephilida* Say, Acad. Phil., Jour., 5: 196, in Le Conte ed. 2, 1869, p. 298.
1853 *Phyllophaga ephilida* Melsheimer, Cat. Coleop. U. S.: 59
1855 *Trichestes ephilida* Burmeister, Handb. Ent., 4: 359.
1855 *Trichestes ephilida* var. *longitarsis* Burmeister, Handb. Ent., 4: 359. (not Say).
1856 *Lachnosterna ephilida* Le Conte, Acad. Phil., Jour., (2), 3: 241.
1856 *Lachnosterna burmeisteri* Le Conte, Acad. Phil., Jour., (2), 3: 144.
1887 *Lachnosterna ephilida* Horn, Am. Ent. Soc., Trans., 14: 225.
1887 *Lachnosterna ephilida* Horn, Ent. Am., 3: 144.
1889 *Lachnosterna ephilida* Smith, U. S. Nat. Mus., Proc., 11: 496.
1916 *Lachnosterna burmeisteri* Davis, Jour. Econ. Ent., 9: 273.
1916 *Phyllophaga ephilida* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1927 *Phyllophaga ephilida* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 13.
1928 *Phyllophaga ephilida* Sim, N. J. Dept. Agr., Circ. 145: 16.

Body elongate, moderately shiny, rufocastaneous, head and thorax darker. Clypeus concave, broadly, feebly emarginate, broadly reflexed; punctures moderately fine, dense, not deeply impressed; suture subangulate. Frons subconvex; punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum short and convex, widest at middle, sides arcuate, entire; more coarsely, not so closely punctate as frons. Mesosternum with sparce vestiture of yellowish hair. Tooth of claw intramedian, strong. Elytra with punctures finer and denser than on pronotum; sutural costae strong, discal, and submarginal costae broad, feebly elevated.

Length, 14-19 mm.; width, 8-10 mm.

Male: Antennal club subequal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with roughened, semicircular depression near apex, apex feebly emarginate; last ventral segment with rough, median depression, apex with moderately narrow and deep emargination. Hind tibia squarely truncate; upper spur long, lanceolate, subacute; lower spur fixed, obliquely truncate, obtuse, one-third length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with shallow, transverse depression near apex; last ventral segment convex, apex entire.

Jaques (1926) reported this insect as occurring in Iowa.

Phyllophaga longitarsa (Say)

(Plate I, fig. 2)

1824 ***Melolontha longitarsa*** **Say, Acad. Phil., Jour., 3: 241, in Le Conte ed. 2, 1889, p. 141.**
1853 ***Phyllophaga longitarsa*** **Melsheimer, Cat. Coleop. U. S.: 59.**
1855 ***Trichestes longitarsis*** **Burmeister, Handb. Ent., 4, pt. 2: 359.**
1856 ***Lachnosterna longitarsis*** **Le Conte, Acad. Phil., Jour., (2), 3: 240.**
1856 ***Lachnosterna longitarsis*** **var. *frontalis*** **Le Conte, Acad. Phil., Jour., (2), 3: 239.**
1887 ***Lachnosterna longitarsus*** **Horn, Am. Ent. Soc., Trans., 14: 226.**
1889 ***Lachnosterna longitarsis*** **Smith, U. S. Nat. Mus., Proc., 11: 496.**
1916 ***Phyllophaga longitarsa*** **Glasglow, Ill. Nat. Hist., Bul. 11: 371.**
1916 ***Phyllophaga longitarsa*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 234.**
1925 ***Phyllophaga longitarsa*** **Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 23-28.**
1927 ***Phyllophaga longitarsa*** **Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 17.**
1928 ***Phyllophaga longitarsa*** **Sim, N. J. Dept. Agr., Circ.. 145: 11.**

Body slender, elongate, moderately shiny, pale yellow, head fuscous to piceous. Clypeus concave, abruptly and deeply emarginate, broadly reflexed; smooth, to coarsely and feebly punctate; suture angulate. Frons convex; coarsely, densely, rather deeply punctate. Antennae composed of nine segments. Pronotum convex, widest at middle, sides subangulate, entire; punctures coarser, sparser, and more feebly impressed than on frons. Mesosternum with sparse vestiture of long yellowish hair. Tooth of claw different in male and female. Elytra rugulose, punctures much finer and denser than on pronotum; sutural costae strong, discal and submarginal costae indistinct.

Length, 10-13 mm.; width, 5-7 mm.

Male: Antennal club subequal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with narrow, longitudinal, median depression; last ventral segment concave, apex broadly, feebly emarginate. Hind tibia obliquely truncate; upper spur lanceolate, curved, acute; lower spur fixed, slender, lanceolate, acute, one-third length of upper. Tooth of claw near base.

Female: Antennal club slightly shorter than funicle. Penultimate ventral segment with transverse, lateral depression; last ventral segment convex, apex entire. Tooth of claw nearly median.

A small light brown species, collected at Columbus Junction, Ames, Iowa City and Sioux City. Nothing is known regarding its feeding habits.

Phyllophaga gracilis (Burmeister)

(Plate I, fig. 5)

1855 ***Trichestes gracilis*** **Burmeister, Handb. Ent., 4: 361.**
1856 ***Endrosa volvula*** **Le Conte, Acad. Phil., Jour., (2), 3: 335.**

1856 *Lachnosterna inana* Le Conte, Acad. Phil., Jour., (2), 3: 242.
1887 *Lachnosterna inana* Horn, Am. Ent. Soc., Trans., 14: 242.
1887 *Lachnosterna inana* Horn, Ent. Am., 3: 144.
1887 *Endrosa volvula* Horn, Am. Ent. Soc., Trans., 14: 235.
1887 *Lachnosterna gracilis* Horn, Am. Ent. Soc., Trans., 14: 230.
1887 *Lachnosterna gracilis* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna gracilis* Smith, U. S. Nat. Mus., Proc., 11: 497.
1916 *Phyllophaga gracilis* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1927 *Phyllophaga gracilis* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 23.
1928 *Phyllophaga gracilis* Sim, N. J. Dept. Agr., Circ. 145: 13.
1928 *Phyllophaga gracilis* Luginbill, Ann. Ent. Soc. Am., 21: 84.

Body elongate, moderately shiny, pale brown, head and thorax darker. Clypeus concave, rather deeply and abruptly emarginate, broadly reflexed; punctures moderately coarse, not deeply impressed; suture angulate. Frons broad, flat; punctures similar to those on clypeus, not so dense. Antennae normally composed of ten segments. Pronotum convex, widest in front of middle, sides arcuate, vaguely crenate; punctures similar to those on frons, not so dense. Mesosternum with sparse vestiture of short, inconspicuous, yellowish hairs. Tooth of claw intramedian, small. Elytra with punctures similar to those on pronotum, denser; sutural costae strong, discal and submarginal costae indistinct.

Length, 10-13 mm.; width, 5-6 mm.

Male: Antennal club equal to stem. Abdomen flattened at middle; penultimate ventral segment with narrow, arcuate ridge; last ventral segment feebly depressed at middle, apex with shallow, rather broad emargination. Hind tibia excavated at base of lower spur; upper spur long, lanceolate, curved, subacute; lower spur fixed, linear, decurved, subacute, equal to upper.

Female: Antennal club equal to funicle. Penultimate ventral segment slightly depressed at sides; last ventral segment narrow, apex entire.

One female specimen bearing the label "Iowa" is in the collection of Iowa State College.

Phyllophaga futilis (Le Conte)

(Plate I, fig. 4)

1850 *Lachnosterna futilis* Le Conte, Agassiz, Lake Superior: 226.
1853 *Phyllophaga futilis* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha gibbosa* Burmeister, Handb. Ent., 4: 324.
1856 *Lachnosterna decidua* Le Conte, Acad. Phil., Jour., (2), 3: 246.
1856 *Lachnosterna serricornis* Le Conte, Acad. Phil., Jour., (2), 3: 247.
1856 *Lachnosterna futilis* Le Conte, Acad. Phil., Jour., (2), 3: 243.
1873 *Lachnosterna futilis* Le Conte, Acad. Phil., Proc., 330.
1887 *Lachnosterna futilis* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna serricornis* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna gibbosa* Horn, Am. Ent. Soc., Trans., 14: 230.
1887 *Lachnosterna gibbosa* Horn, Ent. Am., 3: 143.
1916 *Lachnosterna gibbosa* Davis, Jour. Econ. Ent., 9: 275.
1916 *Phyllophaga futilis* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga futilis* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 225.
1927 *Phyllophaga futilis* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 25.
1928 *Phyllophaga futilis* Sim, N. J. Dept. Agr., Circ. 145: 43.

Body ovate, moderately shiny, rufotestaceous, head darker. Clypeus flat, feebly and abruptly emarginate, moderately reflexed; closely, rather coarsely punctate; suture sinuate. Frons convex; punctured similar to clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest in front of middle, sides arcuate, entire or vaguely irregular; punctures similar to those on frons, much sparser. Tooth of claw median, long. Elytra rugulose, punctures similar to those on pronotum, more closely placed; sutural costae strong, narrow, discal costae wide, elevated, submarginal costae indistinct.

Length, 12-17 mm.; width, 7-9 mm.

Male: Antennal club subequal to stem. Abdomen with moderately broad, median, longitudinal depression; penultimate ventral segment with arcuate roughened ridge; last ventral segment with deep cupuliform concavity, with elevation overhanging at apex. Hind tibia excavated; upper spur broad, lanceolate, obtuse; lower spur fixed, lower half strongly arcuate, apical half straight, subequal to upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with transverse depression; last ventral segment convex, apex excavated on either side of middle, leaving median triangular tooth.

Many specimens from Ames, Des Moines, Central City, Leon, Clermont, Muscatine, Hampton, Mt. Pleasant, Amana, Bloomfield, Pleasant Valley, Dubuque, Dyersville, Davenport, Atlantic, Farmersburg, Marshalltown, Waverly, Missouri Valley, Onawa, Chariton, Grinnell, Sioux City, Oakland, Creston, Keokuk, Morning Sun, Mt. Union, Iowa City, Kossuth County, Appanoose County, Lee County, Cerro Gordo County, Clayton County, Fremont County, Sioux County, Monroe County, Floyd County, Des Moines County, Wapello County, Page County, and Lyon County. Collected feeding on bur oak, elm, butternut, hawthorne, gooseberry, hazel, cherry, plum, privet, Cornus, Caragana, apple, linden, birch, buckeye, and wild plum.

Phyllophaga congrua (Le Conte)

(Plate II, fig. 6)

1850 *Ancylonycha fervens* Blanchard, Cat. Coll. Ent., 1: 133 (preoccupied).
1856 *Lachnosterna congrua* Le Conte, Acad. Phil., Jour., (2), 3: 243.
1873 *Ancylonycha congrua* Le Conte, Acad. Phil., Proc., 330.
1887 *Lachnosterna congrua* Horn, Am. Ent. Soc., Trans., 14: 232.
1887 *Lachnosterna congrua* Horn, Ent. Am. 3: 144.
1889 *Lachnosterna congrua* Smith, U. S. Nat. Mus., Proc., 11: 498.
1916 *Lachnosterna congrua* Davis, Jour. Econ. Ent., 9: 273.
1916 *Phyllophaga congrua* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1916 *Phyllophaga congrua* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 233.
1927 *Phyllophaga congrua* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15. 27.
1928 *Phyllophaga congrua* Sim, N. J. Dept. Agr., Circ. 145: 37.

Body rather robust, moderately shiny, castenous to piceous. Clypeus concave, with moderately broad, shallow emargination, broadly reflexed; punctures coarse and dense, not deeply impressed; suture sinuate. Frons convex; more closely and coarsely punctate than clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at base, sides sinuous, margin entire; punctures similar to those on frons, not so dense or so deeply impressed. Tooth of claw moderately strong, median. Elytra rugulose, punctures similar to those on pronotum; sutural costae broad, strong, discal costae vague, submarginal costae narrow.

Length, 15-19 mm.; width, 8-11 mm.

Male: Antennal club subequal to stem. Abdomen with moderately broad, median depression; penultimate ventral segment acutely notched at middle by longitudinal, median depression, with roughened, semicircular area near apex; last ventral segment with deep, triangular depression, apex sinuous, bilobed at middle. Hind tibia with deep excavation at base of fixed spur; upper spur slender, lanceolate, slightly decurved, acute; lower spur fixed, linear-lanceolate, slightly twisted and decurved, acute, three-fourths length of upper.

Female: Antennal club shorter than funicle. Abdomen with vague, longitudinal depression; penultimate ventral segment feebly depressed laterally; last ventral segment broadly, and shallowly emarginate.

Known only from Missouri Valley and Onawa. Found feeding on the leaves of ash and walnut.

Phyllophaga prunina (Le Conte)

(Plate II, fig. 7)

1846 ***Ancylonycha pruinosa*** **Melsheimer, Acad. Phil., Proc., 2: 139 (preoccupied).**
1850 ***Ancylonycha pruinosa*** **Blanchard, Cat. Coll. Ent., 1: 133.**
1853 ***Phyllophaga pruinosa*** **Melsheimer, Cat. Coleop. U. S.. 59.**
1855 ***Ancylonycha fraterna*** **Burmeister, Handb. Ent., 4, pt. 2: 322 (not Harris).**
1856 ***Lachnosterna prunina*** **Le Conte, Acad. Phil., Jour. (2), 3: 251.**
1887 ***Lachnosterna prunina*** **Horn, Am. Ent. Soc., Trans., 14: 234.**
1887 ***Lachnosterna prunina*** **Horn, Ent. Am., 3: 144.**
1889 ***Lachnosterna prunina*** **Smith, U. S. Nat. Mus., Proc., 11: 498.**
1916 ***Phyllophaga prunina*** **Glasglow, Ill. Nat. Hist., Bul. 11: 371.**
1916 ***Phyllophaga prunina*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 234.**
1927 ***Phyllophaga prunina*** **Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 29.**

Body ovate, elytra pruinose, head, pronotum, scutellum, and pygidium shiny, castaneous to piceous. Clypeus flat, rather abruptly and deeply emarginate, narrowly reflexed; coarsely, moderately deeply punctate; suture angulate. Frons convex; coarser and more deeply punctate than clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides subangulate, serrate; punctures variolate, not so dense as on frons. Tooth of claw median, strong. Elytra rugulose, finely and moderately closely punctate; costae distinct, broad, feebly elevated.

Length, 17-18 mm.; width, 9-11 mm.

Male: Antennal club subequal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with strongly elevated, roughened, transverse ridge; last ventral segment concave, elevated at base, apex broadly, rather deeply emarginate. Hind tarsa deeply excavated at base of lower spur; upper spur slender, lanceolate, subacute; lower spur cylindrical, subacute, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment feebly, transversely depressed; last ventral segment deeply depressed at middle, apex broadly and deeply emarginate.

Specimens have been taken at Leon, Ames, Dyersville, Manchester, Mt. Pleasant, and Keosauqua. Collected on the leaves of white oak, hazel and hawthorne.

Phyllophaga crassissima (Blanchard)

(Plate II, fig. 8)

1850 ***Ancylonycha crassissima*** **Blanchard, Cat. Coll. Ent., 1: 133.**
1850 ***Ancylonycha fervida*** **Blanchard, Cat. Coll. Ent., 1: 133 (not Fab.).**
1853 ***Phyllophaga crassissima*** **Melsheimer, Cat. Coleop. U. S.: 59.**
1856 ***Lachnosterna obesa*** **Le Conte, Acad. Phil., Jour., (2), 3: 251.**

1856 *Lachnosterna robusta* Le Conte, Acad. Phil., Jour., (2), 3: 257.
1873 *Lachnosterna obesa* Le Conte, Acad. Phil., Proc.: 330.
1875 *Lachnosterna robusta* Horn, Am. Ent. Soc., Trans., 5: 143.
1887 *Lachnosterna obesa* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna robusta* Horn, Ent. Am., 3: 145.
1887 *Lachnosterna generosa* Horn, Am. Ent. Soc., Trans., 14: 222.
1887 *Lachnosterna crassissima* Horn, Am. Ent. Soc., Trans., 14: 239.
1889 *Lachnosterna crassissima* Smith, U. S. Nat. Mus., Proc., 11: 499.
1916 *Lachnosterna crassissima* Davis, Jour. Econ. Ent., 9: 273.
1916 *Phyllophaga crassissima* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1916 *Phyllophaga crassissima* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 233.
1922 *Lachnosterna crassissima* Hayes, Am. Micr. Soc., Trans., 41: 1-29.

Body ovate, robust, feebly iridescent, pruinose, rufocastaneous. Clypeus concave, rather abruptly and shallowly emarginate, broadly reflexed; punctures moderately coarse, closely placed, not deeply impressed; suture subangulate. Frons subconvex; punctures coarser and less deeply impressed than on clypeus. Antennae composed of ten segments. Pronotum short, broad, convex, widest in front of middle, sides arcuate, crenate; punctures similar to those on frons, evenly placed, but not so deeply impressed. Tooth of claw strong, different in male and female. Elytra slightly rugulose, less densely punctate than pronotum; sutural costae strong, discal and submarginal costae indistinct.

Length, 15-21 mm.; width, 9-12 mm.

Male: Antennal club longer than stem. Abdomen flattened at middle; penultimate ventral segment with feeble, roughened, transverse ridge; last ventral segment with smooth, median depression, rather broadly, moderately deeply emarginate. Hind tibia squarely truncate; upper spur slender, slightly curved, acute; lower spur fixed, sublinear, obtuse, about one-half length of upper. Tarsal claw with tooth intramedian.

Female: Antennal club subequal to funicle. Penultimate ventral segment with vague, median, longitudinal depression; last ventral segment slightly flattened, with moderately wide, deep depression. Tarsal claw with tooth median.

Taken only at lights; Pleasant Valley, Bloomfield, Sioux City, Davenport, Keosauqua and Muscatine.

Phyllophaga inversa (Horn)

(Plate II, fig. 9)

1887 *Lachnosterna inversa* Horn, Am. Ent. Soc., Trans., 14: 241.
1889 *Lachnosterna inversa* Smith, U. S. Nat. Mus., Proc., 11: 500.
1916 *Lachnosterna inversa* Davis, Jour. Econ. Ent., 9: 276.
1916 *Phyllophaga inversa* Glasglow, Ill. Nat. Hist., Bul. 11. 373.
1916 *Phyllophaga inversa* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 224.
1928 *Phyllophaga inversa* Sim, N. J. Dept. Agr., Circ. 145: 36.

Body ovate, moderately shiny, rufocastaneous to dark brown. Clypeus subconcave, rather abruptly and shallowly emarginate, broadly reflexed; punctures moderately coarse, not deeply impressed; suture sinuate. Frons convex; more coarsely and closely punctate than clypeus. Antennae composed of ten segments. Pronotum irregularly convex, short and broad, widest at middle, sides angulate, vaguely crenate; coarser, more sparsely, and not so deeply punctate as frons. Tooth of claw median, moderately large. Elytra rugulose, punctures indistinct, finer, more closely placed and not so deeply impressed as on pronotum; sutural costae broad, strong, discal and submarginal costae broad, moderately elevated.

Length, 15-18 mm.; width, 8-11 mm.

Male: Antennal club subequal to stem. Abdomen with broad, median depression; penultimate ventral segment with median, semicircular, roughened depression; last ventral segment with broad, transverse depression, apex slightly sinuous. Hind tibia obliquely truncate; upper spur slender, lanceolate, twisted at apex, acute; lower spur fixed, broad, curved, obtuse, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with transverse depression; last ventral segment convex, apex broadly and feebly emarginate.

Recorded from Leon, Ames, Dubuque, Dyersville, Iowa City, Chariton, Davis County, and Appanoose County. The known host plants are white oak, hickory, willow, hazel, hawthorne, cherry, Caragana, plum, and walnut.

Phyllophaga bipartita (Horn)

(Plate III, fig. 10)

1887 *Lachnosterna bipartita* Horn, Am. Ent. Soc., Trans., 14: 242.
1889 *Lachnosterna bipartita* Smith, U. S. Nat. Mus., Proc., 11: 500.
1916 *Lachnosterna bipartita* Davis, Jour. Econ. Ent., 9: 272.
1916 *Phyllophaga bipartita* Glasglow, Ill. Nat. Hist., Bul. 11: 373.
1916 *Phyllophaga bipartita* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 228.
1925 *Phyllophaga bipartita* Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 28.
1927 *Phyllophaga bipartita* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 34.
1928 *Phyllophaga bipartita* Sim, N. J. Dept. Agr., Circ. 145: 29.

Body oblong, moderately shiny, castaneous to piceous. Clypeus subconcave, broadly, not deeply emarginate, moderately reflexed; coarsely, rather deeply punctate; suture sinuate. Frons with punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides arcuate, crenate; punctured similar to frons. Tooth of claw long, median. Elytra somewhat rugulose, punctures similar to those on pronotum, less deeply impressed; sutural costae strong, first discal costae broad, distinct, submarginal costae indistinct in posthumeral region.

Length, 15-19 mm.; width, 8-10 mm.

Male: Antennal club equal to stem. Abdomen with moderately broad, longitudinal depression; penultimate ventral segment with roughened, transverse carina, narrowly divided at middle; last ventral segment concave, with vague longitudinal depression, apex acutely emarginate. Hind tibia obliquely truncate; upper spur flattened, slightly curved, lanceolate, subacute; lower spur fixed, broad, lanceolate, curved, acute, two-thirds length of upper.

Female: Antennal club slightly shorter than funicle. Penultimate ventral segment with feeble, transverse depression extending obliquely foreward; last ventral segment excavated on each side of middle, leaving broad, triangular, median tooth at apex.

Taken at McGregor, Dyersville, Keokuk, and Keosauqua on white oak, the only known food plant in the state.

Phyllophaga micans (Knoch)

(Plate III, fig. 11)

1801 *Melolontha micans* Knoch, Neue Beytr. Ins., 1: 77.
1817 *Melolontha micans* Schönherr, Syn. Ins., 1: 171.
1850 *Ancylonycha micans* Blanchard, Cat. Coll. Ent., 1: 138.
1855 *Ancylonycha micans* Burmeister, Handb. Ent., 4, pt. 2: 323.
1856 *Lachnosterna sororia* Le Conte, Acad. Phil., Jour., (2), 3: 246.
1856 *Lachnosterna micans* Le Conte, Acad. Phil., Jour., (2), 3: 247.
1887 *Lachnosterna micans* Horn, Am. Ent. Soc., Trans., 14: 242.
1887 *Lachnosterna micans* Horn, Ent. Am., 3: 142.
1889 *Lachnosterna micans* Smith, U. S. Nat. Mus., Proc., 11: 500.
1916 *Phyllophaga micans* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga micans* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 227.
1927 *Phyllophaga micans* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 35.
1928 *Phyllophaga micans* Luginbill, Ann, Ent. Soc. Am., 21: 76.

Body elongate, pruinose, brownish-black. Clypeus concave, feebly and broadly emarginate, moderately reflexed; punctures moderately coarse and deeply impressed; suture sinuous. Frons convex; slightly more coarsely and sparsely punctate than clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides arcuate, entire, much coarser and more sparsely punctate than frons. Tooth of claw median, strong. Elytra with punctures like pronotum but finer; sutural costae broad, not strongly elevated, discal and submarginal costae broad, indistinct.

Length, 15-17 mm.; width, 8-9 mm.

Male: Antennal club shorter than stem. Abdomen broadly flattened at middle; penultimate ventral segment with feebly elevated, roughened, arcuate ridge; last ventral segment deeply depressed at middle, apex broadly, rather deeply emarginate. Hind tibia obliquely truncate; upper spur lanceolate, curved, subacute; lower spur fixed, broad, squarely truncate, one-half length of upper.

Female: Antennal club shorter than funicle. Abdomen with vague longitudinal depression; penultimate ventral segment feebly and transversely depressed; last ventral segment strongly elevated at base, feebly flattened at middle, apex rather deeply and broadly emarginate.

Collections have been made at Leon, Iowa City, Mt. Pleasant, and Keosauqua. Found feeding on hickory and shingle oak.

Phyllophaga vehemens (Horn)

(Plate III, fig. 12)

1887 *Lachnosterna vehemens* Horn, Am. Ent. Soc., Trans., 14: 244.
1889 *Lachnosterna vehemens* Smith, U. S. Nat. Mus., Proc., 11: 501.
1916 *Lachnosterna vehemens* Davis, Jour. Econ. Ent., 9: 277-278.
1916 *Phyllophaga vehemens* Glasglow, Ill. Nat. Hist., Bul. 11. 373.
1916 *Phyllophaga vehemens* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 231.
1925 *Phyllophaga vehemens* Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 35-41.
1927 *Phyllophaga vehemens* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 38.
1928 *Phyllophaga vehemens* Sim, N. J. Dept. Agr., Circ. 145: 28.
1928 *Phyllophaga vehemens* Luginbill, Ann. Ent. Soc. Am. 21: 67.

Body ovate, widened posteriorly, shiny, dark brown to piceous. Clypeus subconcave, rather broadly, not deeply emarginate; punctures moderately coarse, not deeply impressed; suture angulate. Frons convex; punctures similar to those on clypeus, more deeply impressed and less dense near suture. Antennae composed of ten segments. Pronotum convex, widest in front of middle, sides arcuate, vaguely crenate; punctures finer, not so deeply impressed as on frons. Tooth of claw median, strong. Elytra rugulose, punctures similar to those on pronotum, finer; sutural costae broad, distinct, discal and submarginal costae broad, feebly elevated.

Length, 21-23 mm.; width, 11-13 mm.

Male: Antennal club shorter than stem. Abdomen broadly flattened at middle; penultimate ventral segment with strong, sinuate, roughened ridge; last ventral segment with cupuliform depression, apex broadly, not deeply emarginate. Hind tibia squarely truncate; upper spur long, linear, obtuse; lower spur fixed, linear, hooked at tip, three-fourths as long as upper. Metathoracic femur broadly angulate.

Female: Antennal club shorter than funicle. Penultimate ventral segment with transverse depression; last ventral segment convex, apex broadly, not deeply emarginate.

This species has been collected at Onawa, Missouri Valley, Sioux City, Oskaloosa, Wapello County, Van Buren County, and Iowa County. Taken on ash and walnut.

Phyllophaga fusca (Froelich)

(Plate III, fig. 13)

1789 ***Melolontha fervida*** **Oliver, Entom., 1: 24 (preoccupied).**
1792 ***Melolontha fusca*** **Froelich, Natur., Stueck., 26: 99.**
1817 ***Melolontha fervens*** **Gyllenhall, Syn. Ins., 1, pt. 3: 74.**
1837 ***Rhizotrogus fervens*** **Kirby, Faun. Bor.-Am., 4: 132.**
1850 ***Ancylonycha fusca*** **Blanchard, Cat. Coll. Ent., 1: 133.**
1856 ***Lachnosterna fusca*** **Le Conte, Acad. Phil., Jour., (2), 3: 244.**
1884 ***Lachnosterna fusca*** **Casey, N. Am. Coleop., pt. 1: 39.**
1887 ***Lachnosterna fusca*** **Horn, Am. Ent. Soc., Trans., 14: 245.**
1887 ***Lachnosterna fusca*** **Horn, Ent. Am., 3: 144.**
1889 ***Lachnosterna fusca*** **Smith, U. S. Nat. Mus., Proc., 11: 505.**
1916 ***Lachnosterna fusca*** **Davis, Jour. Econ. Ent., 9: 274.**
1916 ***Phyllophaga fusca*** **Glasglow, Ill. Nat. Hist., Bul. 11: 373.**
1916 ***Phyllophaga fusca*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 223.**
1925 ***Phyllophaga fusca*** **Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 41-45.**
1928 ***Phyllophaga fusca*** **Sim, N. J. Dept. Agr., Circ. 145: 24.**
1928 ***Phyllophaga fusca*** **Luginbill, Ann. Ent. Soc. Am., 21: 66.**

Body oblong, shiny, light brown to piceous. Clypeus concave, broadly and feebly emarginate, broadly reflexed; punctures moderately fine, not deeply impressed; suture subangulate. Frons convex; punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides arcuate, indented where hairs arise from margin; punctures similar to those on frons, more sparse. Tooth of claw median, strong. Elytra vaguely rugulose; punctures denser, not so coarse as on pronotum; sutural costae strong, first discal costae wide, feebly elevated, submarginal costae narrow, distinct.

Length, 17-23 mm.; width, 10-12 mm.

Male: Antennal club subequal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with transverse ridge, roughened at middle, overhanging at ends; last ventral segment with roughened, median depression, apex entire. Hind tibia obliquely truncate; upper spur long, slender, acuminate; lower spur fixed, slightly curved, obliquely truncate, two-thirds length of upper.

Female: Antennal club shorter than funicle. Abdomen with vague, median depression; penultimate ventral segment with transverse depression extending obliquely forward to base; last ventral segment convex, apex rather broadly and feebly emarginate.

Common, known from Central City, Ames, Des Moines, Leon, Sioux City, Hampton, Marquette, Amana, Bloomfield, Dubuque, Dyersville, Davenport, Edgewood, Manchester, Keokuk, Farmersburg, Waukon, Oneida, Arlington, Iowa City, Mt. Pleasant, Stockport, Chariton, Muscatine, Grinnell, Clermont, Oakland, New Hampton, Mt. Union, Boone County, Taylor County, Allamakee County, Iowa County, Des Moines County, Poweshiek County, Van Buren County, Louisa County and Hamilton County. The host plants include bur oak, hickory, elm, willow, butternut, shingle oak, red oak, white oak, walnut, silver poplar, large-toothed aspen, gooseberry, hazel, poplar, privet, plum, box elder, birch, Caragana, linden, cherry, hawthorne, quaking aspen, Cornus and wild plum.

Phyllophaga hornii (Smith)

(Plate IV, fig. 14)

1889 ***Lachnosterna hornii*** **Smith, Ent. Am., 5: 95.**
1889 ***Lachnosterna hornii*** **Smith, U. S. Nat. Mus., Proc., 11: 510.**
1912 ***Lachnosterna horni*** **Junk, Cat. Coleop., pt. 49: 192.**
1916 ***Phyllophaga hornii*** **Glasglow, Ill. Nat. Hist., Bul. 11: 373.**
1916 ***Phyllophaga hornii*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 234.**
1927 ***Phyllophaga hornii*** **Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 40.**
1928 ***Phyllophaga hornii*** **Sim, N. J. Dept. Agr., Circ. 145: 21.**

Body oblong, moderately shiny, deep brown to piceous. Clypeus flat, moderately broad, not deeply emarginate, narrowly reflexed; punctures coarse, dense, rather deeply impressed; suture sinuate. Frons subconvex; punctures similar to those on clypeus, but less dense. Antennae composed of ten segments. Pronotum convex, widest back of middle, sides broadly angulate, feebly crenate; punctures much coarser, not so dense as on frons. Tooth of claw median, long. Elytra rugulose, with punctures as dense as on pronotum, much finer, not so deeply impressed; sutural, discal, and submarginal costae wide, moderately strong.

Length, 19-21 mm.; width, 10-12 mm.

Male: Antennal club slightly longer than funicle. Abdomen broadly flattened at middle; penultimate ventral segment with strong arcuate ridge broadly divided, smooth at middle; last ventral segment deeply, rather broadly depressed at middle, apex deeply and abruptly emarginate. Hind tibia squarely truncate; upper spur flattened, curved, subacute; lower spur lanceolate, obtuse, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with strong, transverse depression near apex; last ventral segment with shallow, transverse depression near apex, apex sinuate.

A large dark species, taken at Leon, Mt. Pleasant, Mahaska County, and Davis County on hickory and shingle oak.

Phyllophaga fervida (Fabricius)

(Plate IV, fig. 15)

1775 ***Melolontha fervida*** **Fabricius, Species Ins.: 32.**
1801 ***Melolontha quercina*** **Knoch, Neue Beytr. Ins., 1: 74.**
1826 ***Phyllophaga quercina*** **Harris, Mass. Agr. Jour. and Rpts., 10: 1-12.**
1853 ***Phyllophaga fervida*** **Melsheimer, Cat. Coleop. U. S.: 59.**
1855 ***Ancylonycha quercina*** **Burmeister, Handb. Ent., 4, pt. 2: 319.**

1888 *Lachnosterna arcuata* Smith, Ins. Life, 1: 183.
1889 *Lachnosterna arcuata* Smith, U. S. Nat. Mus., Proc., 11: 503.
1889 *Lachnosterna fervida* Chittenden, U. S. Dept. Agr., Bur. Ent. Bul. 19: 1-77.
1916 *Phyllophaga fervida* Glasglow, Ill. Nat. Hist., Bul. 11: 370.
1916 *Phyllophaga fervida* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 230.
1927 *Phyllophaga fervida* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 42.
1928 *Phyllophaga fervida* Sim, N. J. Dept. Agr., Circ. 145: 28.
1928 *Phyllophaga fervida* Luginbill, Ann. Ent. Soc. Am., 21: 65.

Body ovate, shiny, brown to piceous. Clypeus flat, abruptly, not deeply emarginate, narrowly reflexed; punctures moderately fine, not deeply impressed; suture sinuate. Frons convex; punctures similar to those on clypeus, less dense. Antennae composed of ten segments. Pronotum convex, widest at middle, sides broadly arcuate, irregular; punctures similar to those on frons. Tooth of claw median, strong. Elytra rugulose, punctures finer and denser than on pronotum; sutural costae broad, strong, discal and submarginal costae moderately broad, indistinct.

Length, 18-21 mm.; width, 10-11 mm.

Male: Antennal club slightly longer than stem. Abdomen broadly flattened at middle; penultimate ventral segment with transverse, arcuate, overhanging ridge reaching hind margin of segment; last ventral segment flattened, apex broadly, moderately deeply emarginate. Hind tibia obliquely truncate; upper spur lanceolate, obtuse; lower spur lanceolate, subacute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment transversely depressed; last ventral segment convex, apex broadly and deeply emarginate.

Collected in Hamilton and Van Buren Counties. Food plants unknown.

Phyllophaga anxia (Le Conte)

(Plate IV, fig. 16)

1850 *Lachnosterna anxia* Le Conte, Agassiz, Lake Superior: 226.
1850 *Ancylonycha brevicollis* Blanchard, Cat. Coll. Ent., 1: 132.
1850 *Ancylonycha puncticollis* Blanchard, Cat. Coll. Ent. 1: 133.
1853 *Phyllophaga anxia* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha puncticollis* Burmeister, Handb. Ent., 4, pt. 2: 319.
1855 *Ancylonycha brevicollis* Burmeister, Handb. Ent., 4, pt. 2: 322.
1856 *Lachnosterna anxia* Le Conte, Acad. Phil., Jour., (2), 3: 245.
1856 *Lachnosterna brevicollis* Le Conte, Acad. Phil., Jour., (2), 3: 245.
1856 *Lachnosterna puncticollis* Le Conte, Acad. Phil., Jour., (2), 3: 245.
1856 *Lachnosterna cephalica* Le Conte, Acad. Phil., Jour., (2), 3: 256.
1866 *Ancylonycha uninotata* Walker, Natur. in Vanc. Isl., B. C., 2: 323.
1873 *Lachnosterna puncticollis* Le Conte, Acad. Phil., Proc.: 330.
1873 *Lachnosterna brevicollis* Le Conte, Acad. Phil., Proc.: 350.
1884 *Lachnosterna anxia* Casey, N. Am. Coleop., pt. 1: 29.
1887 *Lachnosterna cephalica* Horn, Ent. Am., 3: 144.
1888 *Lachnosterna dubia* Smith, Ins. Life, 1: 183.
1889 *Lachnosterna dubia* Smith, U. S. Nat. Mus., Proc., 11: 504.
1889 *Lachnosterna inseparata* Smith, Ent. Am., 5: 93.
1897 *Lachnosterna alpina* Linell, U. S. Nat. Mus., Proc., 18: 726.
1916 *Phyllophaga anxia* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga anxia* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 227.
1927 *Phyllophaga anxia* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 47.
1928 *Phyllophaga anxia* Luginbill, Ann. Ent. Soc. Am., 21: 71.
1928 *Phyllophaga anxia* Sim, N. J. Dept. Agr., Circ. 145: 29

Body oblong, shiny, light brown to piceous. Clypeus concave, rather abruptly, not deeply emarginate, moderately reflexed; punctures moderately coarse, evenly placed, denser at base, not deeply impressed; suture sinuate. Frons convex; less densely, more irregularly punctate than base of clypeus. Antennae composed of ten segments. Pronotum convex, widest in front of middle, sides angulate, vaguely indented; punctures evenly placed, feebly impressed, not so dense as on frons. Tooth of claw moderately strong, median. Elytra rugulose, punctures similar to those on pronotum, not so coarse or so deeply impressed; sutural, discal, and submarginal costae prominent and narrow.

Length, 19-24 mm.; width, 10-12 mm.

Male: Antennal club slightly longer than stem. Abdomen broadly flattened at middle; penultimate ventral segment with arcuate, transverse ridge not reaching hind margin, overhanging at ends, roughened at middle; last ventral segment with smooth median depression, apex broadly, not deeply emarginate. Hind tibia obliquely truncate; upper spur flattened, lanceolate, slightly curved, subacute; lower spur fixed, broad, lanceolate, curved, obtuse, two-thirds length of upper.

Female: Antennal club much shorter than funicle. Abdomen with vague, median depression; penultimate ventral segment transversely depressed at apex; last ventral segment with apex broadly, not deeply emarginate.

Locality records are: Marquette, Leon, Ames, Edgewood, Manchester, Ruthven, Farmersburg, Arlington, Dubuque, Iowa City, Mt. Pleasant, Chariton, New Hampton, Van Buren County, and Davis County. Hazel, wild plum, white oak, quaking aspen, elm, willow, large-toothed aspen, linden, privet, and poplar are the known host plants in Iowa.

Phyllophaga drakii (Kirby)

(Plate V, fig. 18)

1837 ***Rhizotrogus drakii*** **Kirby, Fauna Br.-Am., pt. 4: 133.**
1850 ***Lachnosterna consimilis*** **Le Conte, Agassiz, Lake Superior: 226.**
1853 ***Phyllophaga consimilis*** **Melsheimer, Cat. Coleop. U. S.: 59.**
1856 ***Lachnosterna drakii*** **Le Conte, Acad. Phil., Jour., (2), 3: 245.**
1884 ***Lachnosterna consimilis*** **Casey, N. A. Coleop., pt. 1. 39.**
1884 ***Lachnosterna drakei*** **Casey, N. A. Coleop., pt. 1: 39.**
1888 ***Lachnosterna grandis*** **Smith, Ins. Life, 1: 181.**
1889 ***Lachnosterna grandis*** **Smith, U. S. Nat. Mus., Proc., 11: 505.**
1912 ***Lachnosterna drakei*** **Junk, Coleop. Cat., pt. 49: 190.**
1916 ***Lachnosterna grandis*** **Davis, Jour. Econ. Ent., 9: 275.**
1916 ***Phyllophaga drakii*** **Glasglow, Ill. Nat. Hist., Bul. 11: 371.**
1916 ***Phyllophaga drakii*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 232.**
1927 ***Phyllophaga drakii*** **Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 44.**
1928 ***Phyllophaga drakei*** **Sim, N. J. Dept. Agr., Circ. 145: 25.**

Body oblong, shiny, light to dark brown. Clypeus concave, abruptly, rather deeply emarginate, moderately reflexed; densely and finely punctate; suture subangulate. Frons convex; punctures similar to those on clypeus, slightly coarser. Antennae composed of ten segments. Pronotum convex, widest in front of middle, sides arcuate, entire; punctures irregularly placed, much finer, sparser, and not so deeply impressed as on frons. Tooth of claw median, long and strong. Elytra vaguely rugulose, more closely and finely punctate than pronotum; sutural costae narrow, strong, discal, and submarginal costae indistinct.

Length, 26-27 mm.; width, 12-14 mm.

Male: Antennal club longer than stem. Abdomen broadly flattened at middle; penultimate ventral segment with transverse ridge roughened at middle; overhanging at ends; last ventral segment with median, roughened depression, apex sinuous. Hind tibia obliquely truncate; upper spur slender, lanceolate, slightly curved, subacute; lower spur fixed, slender, lanceolate, acute, two-thirds length of upper.

Female: Antennal club much shorter than funicle. Penultimate ventral segment with vague, transverse depression at apex extending obliquely to base on either side; last ventral segment convex, apex broadly emarginate.

This large species has been collected at Ames, Central City, Dyersville, Manchester, Farmersburg, Arlington, Dubuque, Iowa City, Chariton, Oakland, New Hampton, Grinnell, Cerro Gordo County, and Van Buren County. The food plants are white oak, wild plum, hazel, poplar, willow, birch, and large-toothed aspen.

Phyllophaga barda (Horn)

(Plate V, fig. 17)

1887 *Lachnosterna barda* Horn, Am. Ent. Soc., Trans., 14: 248.
1889 *Lachnosterna barda* Smith, U. S. Nat. Mus., Proc., 11: 507.
1916 *Phyllophaga barda* Glasglow, Ill. Nat. Hist., Bul. 11: 373.
1916 *Phyllophaga barda* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 325.
1927 *Phyllophaga barda* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 47.
1928 *Phyllophaga barda* Sim, N. J. Dept. Agr., Circ. 145: 31.

Body oblong, moderately shiny, dark brown to piceous. Clypeus subconcave, rather broadly and deeply emarginate; punctures coarse, not deeply impressed; suture sinuate. Frons convex; more coarsely punctate than clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides angulate, irregular; punctures variolate. Tooth of claw median, strong. Elytra rugulose, less coarsely, more densely punctate than pronotum; sutural costae broad, strong, discal, and submarginal costae broad, feebly elevated.

Length, 21-22 mm.; width, 10-12 mm.

Male: Antennal club slightly shorter than stem. Abdomen broadly flattened at middle; penultimate ventral segment with broad, strongly arcuate carina, deeply excavated behind; last ventral segment concave, apex feebly emarginate. Hind tibia squarely truncate; upper spur lanceolate, curved, obtuse; lower spur fixed, broad, linear, obtuse, two-thirds length of upper.

Female: Antennal club shorter than funicle. Abdomen vaguely flattened at middle; penultimate ventral segment deeply, broadly, and transversely depressed; last ventral segment convex, apex rather broadly and deeply emarginate.

Only two specimens have been taken in Iowa, both of which were secured by Prof. H. E. Jaques at Mt. Pleasant. There have been no food plants recorded for this state.

Phyllophaga marginalis (Le Conte)

(Plate V, fig. 19)

1856 *Lachnosterna marginalis* Le Conte, Acad. Phil., Jour., (2), 3: 250.
1887 *Lachnosterna marginalis* Horn, Am. Ent. Soc., Trans., 14: 250.
1887 *Lachnosterna marginalis* Horn, Ent. Am., 3: 144.
1889 *Lachnosterna marginalis* Smith, U. S. Nat. Mus., Proc., 11: 508.
1916 *Phyllophaga marginalis* Glasglow, Ill. Nat. Hist., Bul. 11: 272.
1928 *Phyllophaga marginalis* Sim, N. J. Dept. Agr., Circ. 145: 39.
1928 *Phyllophaga marginalis* Luginbill, Ann. Ent. Soc. Am., 21: 70.

Body oblong, shiny, rufocastaneous to piceous. Clypeus subconcave, rather abruptly and deeply emarginate, narrowly reflexed; coarsely and deeply punctuate; suture sinuate. Frons convex; punctured similar to clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest back of middle, sides angulate, crenate; punctures of thorax very sparse, especially on disc, coarse and deeply impressed. Tooth of claw median, long. Elytra rugulose, punctures moderately dense, fine, and deeply impressed; sutural costae strong, discal costae rather broad, distinct, submarginal costae strong.

Length, 16-21 mm.; width, 8-11 mm.

Male: Antennal club longer than stem. Abdomen broadly flattened at middle; penultimate ventral segment with short, strongly arcuate ridge; last ventral segment with median depression, apex entire. Hind tibia obliquely truncate; upper spur long, slightly curved, acute; lower spur fixed, broad, acute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment transversely and laterally depressed; last ventral segment subdepressed, apex broadly, feebly emarginate.

Specimens have been taken on bur oak, gooseberry, and hazel at Hampton, Leon, Marquette, and Iowa City.

Phyllophaga spreta (Horn)

(Plate VI, fig. 20)

1887 *Lachnosterna spreta* Horn, Am. Ent. Soc., Trans., 14: 250.
1889 *Lachnosterna spreta* Smith, U. S. Nat. Mus., Proc., 11: 508.
1916 *Phyllophaga spreta* Glasglow, Ill. Nat. Hist., Bul. 11: 373.

Specimens of this species were not available so the following is a copy of Horn's original description.

"Oblong, elytra slightly wider at middle, castaneous or fuscous, shining. Clypeus feebly emarginate, margin very narrowly reflexed, densely and moderately coarsely punctured, front rather more coarsely but less densely. Thorax narrower in front, sides posteriorly nearly parallel, in front oblique, the margin entire, with short distinct ciliae, disc moderately convex, the punctures small, sparsely but equally placed, a slight depression of the base on each side. Elytral punctures equal to those of the thorax, more closely placed, surface slightly rugulose on each side of the suture, the costae distinct but feebly elevated, the submarginal distinct posteriorly. Pygidium sparsely punctate, smoother near the apex. Metasternum densely punctate, the hair moderately long and close; sides of abdomen with sparse punctures bearing short hairs. Claws curved, the tooth moderate in size and median ♂. Last joint of maxillary palpi short, fusiform, not impressed. Length .66-.72 inch; 16.5-18 mm.

"Male.—Antennal club nearly a third longer than the entire stem. Abdomen slightly flattened at middle, penultimate segment with a short, feeble elevated, transverse ridge a short distance in front of the posterior margin. Last segment very slightly concave. Inner spur of hind tibia two-thirds the length of the outer and broader.

"Variations.—The two male specimens before me do not vary, except slightly in color and size.

"In this species the clypeus is more feebly emarginate than usual in those with the punctures of its surface dense and the border narrowly reflexed. On the other hand the antennal club of the male is unusually long, exceeding that of any species of the fusca group. The facies and sculpture are very like a small *fusca*."

A very rare species known only from the type specimens. (Iowa and Maryland, Horn, 1887).

Phyllophaga fraterna Harris

(Plate VI, fig. 21)

1841 ***Phyllophaga fraterna*** **Harris, Rpt. Ins. Inj. Veg.: 29.**
1850 ***Ancylonycha fraterna*** **Blanchard, Cat. Coleop. Ent., 1: 133.**
1853 ***Phyllophaga fraterna*** **Melsheimer, Cat. Coleop. U. S.: 59.**
1855 ***Ancylonycha cognata*** **Burmeister, Handb. Ent., 4: 322.**
1856 ***Lachnosterna cognata*** **Le Conte, Acad. Phil., Jour., (2), 3: 248.**
1856 ***Lachnosterna fraterna*** **Le Conte, Acad. Phil., Jour., (2), 3: 249.**
1887 ***Lachnosterna fraterna*** **Horn, Am. Ent. Soc., Trans., 14: 251.**
1887 ***Lachnosterna cognata*** **Horn, Am. Ent. Soc., Trans., 14: 252.**
1887 ***Lachnosterna fraterna*** **Horn, Ent. Am., 3: 144.**
1889 ***Lachnosterna fraterna*** **Smith, U. S. Nat. Mus., Proc., 11: 508.**
1889 ***Lachnosterna nova*** **Smith, U. S. Nat. Mus., Proc., 11: 508.**
1889 ***Lachnosterna nova*** **Smith, Ent. Am., 5: 95.**
1889 ***Lachnosterna nova*** **Smith, U. S. Nat. Mus., Proc., 11: 509.**
1916 ***Lachnosterna fraterna*** **Davis, Jour. Econ. Ent., 9: 274.**
1916 ***Phyllophaga fraterna*** **Glasglow, Ill. Nat. Hist., Bul. 11: 371.**
1916 ***Phyllophaga fraterna*** **Forbes, Ill. Agr. Expt. Sta., Bul. 186: 228.**
1927 ***Phyllophaga fraterna*** **Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 48.**
1928. ***Phyllophaga fraterna*** **Sim, N. J. Dept. Agr., Circ. 145: 36.**

Body elongate, sides nearly parallel, shiny, rufocastaneous to piceous. Clypeus flat, with abrupt, moderately deep emargination, rather broadly reflexed; punctures moderately coarse, dense, deeply impressed; suture subangulate. Frons convex; punctures similar to those on clypeus, slightly coarser. Antennae composed of ten segments. Pronotum convex, widest at middle; sides subangulate, feebly crenate; punctures irregularly placed, sparser, coarser, and more feebly impressed than on pronotum. Tooth of claw median, strong. Elytra rugulose, more finely and closely punctate than pronotum; sutural costae broad, strong, discal and submarginal costae indistinct.

Length, 15-18 mm.; width, 7-8 mm.

Male: Antennal club subequal to funicle. Abdomen depressed at middle; penultimate ventral segment with roughened, feebly arcuate ridge; last ventral segment concave, apex feebly emarginate. Hind tibia obliquely truncate; upper spur long, lanceolate, obtuse; lower spur fixed, broad, curved, subacute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with transverse depression at apex; last ventral segment convex, apex with broad, shallow emargination.

This species has been collected at Iowa City, Columbus Junction, Dyersville, Keosauqua, Mt. Pleasant, and Jackson County. White oak and hazel are the host plants.

Phyllophaga fosteri (Burmeister)

(Plate VI, fig. 22)

1855 ***Ancylonycha fosteri*** **Burmeister, Handb. Ent., 4: 325.**
1856 ***Lachnosterna semicribrata*** **Le Conte, Acad. Phil., Jour., (2), 3: 247.**
1856 ***Lachnosterna lugubris*** **Le Conte, Acad. Phil., Jour., (2), 3: 248.**
1856 ***Lachnosterna lutescens*** **Le Conte, Acad. Phil., Jour., (2), 3: 249.**
1887 ***Lachnosterna semicribrata*** **Horn, Am. Ent. Soc., Trans., 14: 252.**

1887 *Lachnosterna lutescens* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna politula* Horn, Am. Ent. Soc., Trans., 14: 248.
1887 *Lachnosterna fosteri* Horn, Am. Ent. Soc., Trans., 14: 252.
1889 *Lachnosterna semicribrata* Smith, U. S. Nat. Mus., Proc., 11: 508.
1889 *Lachnosterna fosteri* Smith, U. S. Nat. Mus., Proc., 11: 508.
1889 *Lachnosterna nova* Smith, Ent. Am., 5: 95.
1889 *Lachnosterna nova* Smith, U. S. Nat. Mus., Proc., 11: 509.
1916 *Phyllophaga fosteri* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1916 *Phyllophaga fosteri* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 233.
1927 *Phyllophaga fosteri* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 50.
1928 *Phyllophaga fosteri* Luginbill, Ann. Ent. Soc. Am., 21: 74.
1928 *Phyllophaga fosteri* Sim, N. J. Dept. Agr., Circ. 145: 39.

Body oblong, moderately shiny, rufocastaneous. Clypeus flat, deeply, almost abruptly emarginate, feebly, rather broadly reflexed; punctures moderately coarse, deeply impressed; suture subangulate. Frons subconvex; punctures similar to those on clypeus, not so dense. Antennae composed of nine segments. Pronotum convex, widest at middle, sides arcuate, crenate; punctures irregular, much coarser, not so dense or deeply impressed as on frons. Tooth of claw median, strong. Elytra with punctures finer, more closely placed, not so deeply impressed as on pronotum; sutural costae strong, discal costae broad, feebly elevated, submarginal costae narrow, strong.

Length, 14-18 mm.; width, 8-10 mm.

Male: Antennal club subequal to funicle. Abdomen broadly flattened at middle; penultimate ventral segment with moderately arcuate roughened ridge; last ventral segment with smooth cupuliform depression, apex feebly emarginate. Hind tibia squarely truncate; upper spur lanceolate, slightly curved, obtuse; lower spur fixed, broad, acute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with narrow, transverse depression at apex extending obliquely forward; last ventral segment strongly elevated at base, apex feebly, broadly emarginate.

Collected at Marquette, Iowa City, and Mt. Pleasant. The food plants have not been reported for Iowa.

Phyllophaga corrosa (Le Conte)

(Plate VI, fig. 23)

1856 *Lachnosterna corrosa* Le Conte, Acad. Phil., Jour., (2), 3: 249.
1856 *Lachnosterna affinis* Le Conte, Acad. Phil., Jour., (2), 3: 256.
1887 *Lachnosterna affinis* Horn, Am. Ent. Soc., Trans., 14: 233.
1887 *Lachnosterna affinis* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna corrosa* Horn, Ent. Am., 3: 144.
1889 *Lachnosterna affinis* Smith, U. S. Nat. Mus., Proc., 11: 498.
1916 *Phyllophaga corrosa* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga corrosa* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 232.
1925 *Phyllophaga corrosa* Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 45.
1928 *Phyllophaga corrosa* Sim, N. J. Dept. Agr., Circ. 145: 24.

Body oblong, moderately shiny, castaneous to piceous. Clypeus concave, rather abruptly and deeply emarginate, narrowly reflexed; coarsely and closely punctate; suture sinuate. Frons subconvex; punctuation similar to that of clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides angulate, serrate; more coarsely, less closely punctate than frons. Mesosternum with sparse vestiture of moderately long, yellowish hair. Tooth of claw median, slender and long. Elytra rugulose, more closely, less coarsely punctate than pronotum; sutural costae wide and strong, discal costae indistinct, submarginal costae indistinct in posthumeral region.

Length, 17-20 mm.; width, 8-10 mm.

Male: Antennal club shorter than stem. Abdomen flattened medially; penultimate ventral segment with feebly arcuate, roughened ridge, slightly excavated behind; last ventral segment with smooth, median depression, with transverse ridge at base, apex feebly and broadly emarginate. Hind tibia vaguely excavated at base of lower spur; upper spur flattened, elliptical, slightly curved, obtuse; lower spur fixed, subacuminate, curved, two-thirds length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with oblique, lateral depression; last ventral segment with deep, subtriangular, median depression, apex excavated on each side of middle leaving broad, median tooth.

A few individuals have been taken at Ames, Dyersville and Iowa City. Feeds on white oak and hawthorne.

Phyllophaga rugosa (Melsheimer)

(Plate VII, fig. 24)

1846 *Ancylonycha rugosa* Melsheimer, Acad. Phil., Proc., 3: 140.
1853 *Phyllophaga rugosa* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha rugosa* Burmeister, Handb. Ent., 4, pt. 2: 328.
1856 *Lachnosterna rugosa* Le Conte, Acad. Phil., Jour., (2), 3: 252.
1887 *Lachnosterna rugosa* Horn, Am. Ent. Soc., Trans. 14: 259.
1887 *Lachnosterna rugosa* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna rugosa* Smith, U. S. Nat. Mus., Proc., 11: 513.
1916 *Lachnosterna rugosa* Davis, Jour. Econ. Ent., 9: 277.
1916 *Phyllophaga rugosa* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga rugosa* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 226.
1928 *Phyllophaga rugosa* Sim, N. J. Dept. Agr., Circ. 145: 18.

Body oblong, shiny, rufocastaneous to piceous. Clypeus flat, deeply, moderately broadly emarginate, punctures coarse, deeply impressed; suture angulate. Frons convex, more coarsely and deeply punctate than clypeus. Antennae composed of ten segments. Pronotum convex, widest at middle, sides angulate, vaguely crenate; irregularly and variolately punctate. Tooth of claw median, strong. Elytra rugulose, punctures similar to those on clypeus, not so dense; sutural costae broad, strong, discal and submarginal costae broad, feebly elevated.

Length, 18-23 mm.; width, 9-11 mm.

Male: Antennal club slightly longer than funicle. Abdomen broadly flattened at middle; penultimate ventral segment with strongly arcuate ridge, roughened at middle; last ventral segment concave, smooth, apex abruptly and deeply emarginate. Hind tibia obliquely truncate; upper spur lanceolate, obtuse; lower spur fixed, curved, acute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Abdomen vaguely flattened at middle; penultimate ventral segment with transverse depression; last ventral segment feebly concave, apex broadly, not deeply emarginate.

Extremely abundant: Des Moines, Ames, Hampton, Leon, Amana, Marquette, Ruthven, Maquoketa, Guttenburg, Dubuque, Dyersville, Pleasant Valley, McGregor, Algona, Sioux City, Davenport, Atlantic, Manchester, Marshalltown, Arlington, Iowa City, Mt. Pleasant, Muscatine, Sioux City, Clermont, Oakland, Keokuk, Grinnell, Marion County, Monona County, Sioux County, Linn County, Wapello County, Mills County, Lyon County, Boone County, Page County, Pottawattamie County, Davis County, Cedar County, Cherokee County, and Van Buren County. Collections have been made from buckeye, apple, linden, birch, walnut, silver poplar, privet, cherry, box elder, mock orange, Cornus, Caragana, bur oak, hickory, elm, willow, ash, butternut, quaking aspen, wild plum, hawthorne, red oak, white oak, hackberry, large-toothed aspen, hazel, cottonwood, and plum.

Phyllophaga implicita (Horn)

(Plate VII, fig. 25)

1887 *Lachnosterna implicita* Horn, Am. Ent. Soc., Trans., 14: 262.
1889 *Lachnosterna implicita* Smith, U. S. Nat. Mus., Proc., 11: 515.
1897 *Lachnosterna minor* Linell, U. S. Nat. Mus., Proc., 18: 728.
1916 *Lachnosterna implicita* Davis, Jour. Econ. Ent., 9: 276.
1916 *Phyllophaga implicita* Glasglow, Ill. Nat. Hist., Bul. 11: 373.
1916 *Phyllophaga implicita* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 221.
1927 *Phyllophaga implicita* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 57.
1928 *Phyllophaga implicita* Sim, N. J. Dept. Agr., Circ. 145: 42.

Body ovate, moderately shiny, brown to piceous, head and pronotum darker. Clypeus flat, deeply and abruptly emarginate, moderately reflexed; punctures moderately coarse, not deeply impressed; suture sinuate. Frons convex; punctures denser, slightly coarser than on clypeus. Antennae composed of ten segments. Pronotum convex, widest in front of middle, sides angulate, feebly crenate; punctures not so coarse, much sparser than on frons. Tooth of claw slightly intramedian. Elytra rugulose, punctures finer than on pronotum, not so deeply impressed; sutural costae wide, strong, discal, and submarginal costae indistinct.

Length, 14-18 mm.; width, 8-10 mm.

Male: Antennal club subequal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with strongly arcuate, feebly elevated, roughened transverse ridge; last ventral segment convex, apex broadly, not deeply emarginate. Hind tibia obliquely truncate; upper spur lanceolate, subacute; lower spur fixed, arcuate, one-half length of upper.

Female: Antennal club subequal to funicle. Penultimate ventral segment with feeble transverse depression; last ventral segment flattened, apex rather broadly and deeply emarginate.

Occurs almost everywhere: Ames, Des Moines, Keokuk, Central City, Hampton, Ruthven, Fort Dodge, Marquette, Maquoketa, Columbus Junction, Algona, Pleasant Valley, Iowa City, Cylinder, Sioux City, Dubuque, Davenport, Atlantic, Farmersburg, Bryant, Red Oak, Sharpsburg, Humbolt, Marshalltown, Grinnell, Clermont, Muscatine, Oakland, Creston, Boone, New Hampton, Morning Sun, Mt. Union, Keosauqua, Mt. Pleasant, Wapello County, Monroe County, Lee County, Boone County, Jefferson County, Des Moines County, Davis County, and Madison County. Collected from bur oak, hickory, elm, ash, butternut, red oak, white oak, hackberry, large-toothed aspen, quaking aspen, willow, cherry, hazel, poplar, gooseberry Caragana, birch, and silver poplar.

Phyllophaga balia (Say)

(Plate VII, fig. 27)

1825 *Melolontha balia* Say, Acad. Phil., Jour., 5: 194, in Le Conte ed., 1889, p. 297.
1826 *Phyllophaga balia* Harris, Mass. Agr. Jour. and Rpts., 10: 1-12.
1853 *Phyllophaga balia* Melsheimer, Cat. Coleop. U. S.: 59.

1855 *Ancylonycha comata* Burmeister, Handb. Ent., 4, pt. 2: 337.
1856 *Lachnosterna balia* Le Conte, Acad. Phil., Jour., (2), 3: 255.
1887 *Lachnosterna balia* Horn, Am. Ent. Soc., Trans., 14: 262.
1887 *Lachnosterna comata* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna balia* Smith, U. S. Nat. Mus., Proc., 11: 516.
1916 *Phyllophaga balia* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 235.
1916 *Phyllophaga balia* Glasglow, Ill. Nat. Hist., Bul. 11: 371.

Body elongate, moderately shiny, dark brown to piceous, head and thorax darker. Clypeus flat, broadly, moderately deeply emarginate, narrowly reflexed; punctures coarse, moderately closely placed, rather deeply impressed; suture sinuous. Frons subconvex; more coarsely and irregularly punctate than clypeus, with sparse vestiture of long erect hair. Antennae normally composed of nine segments. Pronotum convex, widest at middle, sides subarcuate, vaguely indented; punctures coarser, sparser and not so deeply impressed as on frons, more densely punctate at sides. Tooth of claw strong, median. Elytra rugulose, punctures indistinct; sutural costae strong, discal and submarginal costae indistinct.

Length, 15-16 mm.; width, 8-9 mm.

Male: Antennal club equal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with broad, obtusely arcuate, roughened ridge, deeply excavated behind; last ventral segment with a smooth, cupuliform, median depression, transversely elevated at base, apex entire. Hind tibia obliquly truncate; upper spur slender, lanceolate, subacute, lower spur fixed, lanceolate, subacute, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with moderately deep, transverse depression, apex of last ventral segment feebly excavated at sides leaving short, median, triangular tooth.

This species has been collected at Marquette, Ames, Dyersville, Farmersburg, Dubuque, Iowa City, and Mt. Pleasant. Food plants include white oak, willow, hazel, box elder, and birch.

Phyllophaga vilifrons (Le Conte)

(Plate VII, fig. 26)

1856 *Lachnosterna vilifrons* Le Conte, Acad. Phil., Jour., (2), 3: 255.
1856 *Lachnosterna hirticeps* Le Conte, Acad. Phil., Jour., (2), 3: 255.
1887 *Lachnosterna hirticeps* Horn, Ent. Am., 3: 145.
1887 *Lachnosterna villiforns* Horn, Am. Ent. Soc., Trans., 14: 144.
1889 *Lachnosterna villifrons* Smith, U. S. Nat. Mus., Proc., 11: 516.
1916 *Phyllophaga villifrons* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1916 *Phyllophaga villifrons* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 234.
1928 *Phyllophaga villifrons* Luginbill, Ann. Ent. Soc. Am., 21: 89.

Body elongate, shiny, rufocastaneous. Clypeus flat, abruptly, rather deeply emarginate, moderately reflexed; punctures coarse, deeply impressed; suture angulate. Frons convex; punctures similar to those on clypeus, less densely placed. Antennae composed of nine segments. Pronotum convex, widest at middle, sides arcuate, crenate at base; punctured similar to frons. Tooth of claw median, strong. Elytra more densely and more finely punctate than pronotum; sutural costae strong, discal and submarginal costae indistinct.

Length, 14-16 mm.; width, 7-9 mm.

Male: Antennal club equal to stem. Abdomen broadly flattened at middle; penultimate ventral segment with broad, feebly arcuate, roughened ridge; last ventral segment longitudinally depressed, apex feebly emarginate.

Hind tibia obliquely truncate; upper spur flattened, lanceolate, acute; lower spur fixed, broad, slightly curved, obtuse, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment vaguely and transversely depressed, with broad, roughened depression at sides; last ventral segment flat, apex feebly and broadly emarginate.

This rare species has been taken at McGregor, Ames, Dubuque, and Iowa City on linden and birch.

Phyllophaga nitida (Le Conte)

(Plate VIII, fig. 30)

1856 *Lachnosterna nitida* Le Conte, Acad. Phil., Jour., (2), 3: 256.
1887 *Lachnosterna nitida* Horn, Ent. Am., 3: 145.
1887 *Lachnosterna limula* Horn, Am. Ent. Soc., Trans., 14: 264.
1889 *Lachnosterna nitida* Smith, U. S. Nat. Mus., Proc., 11: 516.
1889 *Lachnosterna innominata* Smith, Ent. Am., 5: 98.
1916 *Phyllophaga nitida* Glasglow, Ill. Nat. Hist., Bul. 11: 372.
1916 *Phyllophaga nitida* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 233.
1928 *Phyllophaga nitida* Sim, N. J. Dept. Agr., Circ. 145: 33.

Body elongate, shiny, dark brown. Clypeus flat, abruptly, rather deeply emarginate, punctures coarse, deeply impressed; suture feebly sinuate. Frons convex; punctures similar to those on clypeus, but coarser, Antennae composed of nine segments. Pronotum convex, widest at middle, sides arcuate, irregular; punctures similar to those on frons, sparser and not so deeply impressed. Tooth of claw median, strong. Elytra rugulose, punctures much finer and denser than on pronotum; sutural costae strong, discal and submarginal costae narrow, feebly elevated.

Length, 20-21 mm.; width, 8-9 mm.

Male: Antennal club shorter than stem. Abdomen moderately depressed at middle; penultimate ventral segment with transverse ridge, strongly elevated at sides, divided at middle; last ventral segment with broad, median depression, apex feebly and broadly emarginate. Hind tibia obliquely truncate; upper spur lanceolate, curved, acute; lower spur fixed, broad, acute, two-thirds length of upper.

Female: Antennal club shorter than funicle. Abdomen with vague, median depression; penultimate ventral segment feebly, transversely depressed; last ventral segment slightly flattened, apex irregular, broadly and feebly emarginate.

The locality records include Hampton, Ames, Farmersburg, Dyersville and Dubuque. Feeds on hazel, white oak, linden, privet, cornus, and birch.

Phyllophaga hirticula (Knoch)

(Plate VIII, fig. 29)

1801 *Melolontha hirticula* Knoch, Neue Beytr. Ins., 1: 79.
1813 *Melolontha hirsuta* Say, Acad. Phil., Jour., 3: 243, in Le Conte ed., 2: 142 (not Knoch).
1817 *Melolontha hirticula* Schönherr, Syn. Ins., 1, (3): 173.
1826 *Phyllophaga hirticula* Harris, Mass. Agr. Jour. and Rpts., 10: 1-12.
1850 *Ancylonycha crenulata* Blanchard, Cat. Coll. Ent., 1: 133.
1853 *Phyllophaga hirticula* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha hirticula* Burmeister, Handb. Ent., 4: 327.
1856 *Lachnosterna hirticula* Le Conte, Acad. Phil., Jour., (12), 3: 254.
1873 *Lachnosterna crenulata* Le Conte, Acad. Phil., Proc.: 330.
1887 *Lachnosterna hirticula* Horn, Am. Ent. Soc., Trans., 14: 266.
1887 *Lachnosterna hirticula* Horn, Ent. Am., 3: 143.

1889 *Lachnosterna hirticula* Smith, U. S. Nat. Mus., Proc., 11: 516.
1916 *Lachnosterna hirticula* Davis, Jour. Econ. Ent., 9: 275-276.
1916 *Phyllophaga hirticula* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga hirticula* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 219.
1927 *Phyllophaga hirticula* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 58.
1928 *Phyllophaga hirticula* Luginbill, Ann. Ent. Soc. Am., 21: 57.

Body oblong, moderately shiny, dark brown, with sparse vestiture of both long and short hairs. Clypeus flat, deeply, and abruptly emarginate, moderately reflexed; punctures coarse, rather deeply impressed; suture sinuate. Frons convex; punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum irregularly convex, widest at middle, sides arcuate, coarsely serrate; punctures variolate, moderately dense. Tooth of claw median, strong. Elytra strongly rugulose, punctures finer than on frons; long, erect hairs in rows along costae; sutural costae broad, strong, discal and submarginal costae feebly elevated, rather broad.

Length, 16-19 mm.; width, 8-11 mm.

Male: Antennal club longer than funicle. Abdomen broadly flattened at middle; penultimate ventral segment with broad, arcuate, roughened, feebly elevated ridge; last ventral segment with broad, rather deep, median depression, apex with broad, moderately deep, emargination. Hind tibia obliquely truncate; upper spur long, curved, lanceolate, subacute; lower spur broad, curved, lanceolate, acute, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with vague, transverse depression; last ventral segment flattened, with semi-circular depression at apex, apex broadly and shallowly emarginate.

Very abundant, taken at Ames, Leon, Hampton, Maquoketa, Guttenburg, Dubuque, Marquette, Dyersville, Onawa, Missouri Valley, Davenport, Mt. Pleasant, Clermont, Chariton, Muscatine, Washington County, Marion County, Monroe County, Des Moines County, Van Buren County, and Wapello County. Elm, bur oak, hickory, willow, ash, butternut, shingle oak, hawthorne, red oak, white oak, gooseberry, hazel, and quaking aspen are the host plants.

Phyllophaga ilicis (Knoch)

(Plate VIII, fig. 28)

1801 *Melolontha ilicis* Knoch, Neue Beytr. Ins., 1: 71.
1830 *Melolontha porcina* Hentz, Am. Soc. Phil., Trans., (2), 3: 253.
1850 *Ancylonycha ilicis* Blanchard, Cat. Coll. Ent., 1: 133.
1853 *Phyllophaga ilicis* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha ilicis* Burmeister, Handb. Ent., 4, pt. 2: 326 (not Knoch).
1855 *Ancylonycha fimbriata* Burmeister, Handb. Ent., 4: 326.
1856 *Lachnosterna ilicis* Le Conte, Acad. Phil., Jour., (2), 3: 253.
1856 *Lachnosterna ciliata* Le Conte, Acad. Phil., Jour., (2), 3: 253.
1856 *Lachnosterna subtonsa* Le Conte, Acad. Phil., Jour., (2), 3: 254.
1887 *Lachnosterna ilicis* Horn, Am. Ent. Soc., Trans., 14: 268.
1887 *Lachnosterna ilicis* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna ciliata* Horn, Am. Ent. Soc., Trans., 14: 269.
1887 *Lachnosterna ciliata* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna subtonsa* Horn, Ent. Am., 3: 144.
1887 *Lachnosterna fimbriata* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna ilicis* Smith, U. S. Nat. Mus., Proc., 11: 517.
1912 *Lachnosterna ilicis* var. *Burmeisteri* Junk, Coleop. Cat., pt. 49: 193.
1916 *Lachnosterna ilicis* Davis, Jour. Econ. Ent., 9: 276.
1916 *Phyllophaga ilicis* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1916 *Phyllophaga ilicis* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 230.

1927 *Phyllophaga ilicis* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 61.
1928 *Phyllophaga ilicis* Luginbill, Ann. Ent. Soc. Am., 21: 62.

Body oblong, subopaque, castaneous, with vestiture of moderately long, recumbent hair. Clypeus flat, abruptly and deeply emarginate, moderately reflexed; densely, coarsely, and deeply punctate; suture subangulate. Frons subconvex; punctures coarser, not so dense as on clypeus. Antennae composed of ten segments. Pronotum convex, widest at middle, sides subangulate, crenate; punctures coarser, not so closely placed, more deeply impressed than on frons. Tooth of claw median, long. Elytra finely rugulose, punctures much finer than on pronotum; sutural, discal, and submarginal costae wide, feebly elevated.

Length, 19-23 mm.; width, 10-12 mm.

Male: Antennal club slightly longer than funicle. Abdomen with moderately wide depression at middle; penultimate ventral segment with arcuate ridge feebly elevated at middle; last ventral segment concave, apex broadly and feebly emarginate. Hind tibia obliquely truncate; upper spur long, lanceolate, curved, obtuse; lower spur fixed, slightly curved, subacute, one-half length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment with deep, transverse depression; last ventral segment convex, apex rather deeply and abruptly emarginate.

Marquette, Leon, Hampton, Maquoketa, Guttenberg, Dubuque, Dyersville, Arlington, Ames, Mt. Pleasant, Marengo, Clayton County, Buchanan County, Delaware County, Jones County, Woodbury County, Van Buren County, Lee County, Iowa County, Scott County, Jefferson County, Jackson County, and Appanoose County. Taken on hickory, ash, butternut, shingle oak, hawthorne, red oak, white oak, large-toothed aspen, hazel, Cornus, and linden.

Phyllophaga crenulata (Froelich)

(Plate IX, fig. 31)

1792 *Melolontha crenulata* Froelich, Natur. Stueck, 26: 94.
1817 *Melolontha georgicana* Gyllenhall, Syn. Ins., 1: 77.
1826 *Phyllophaga georgicana* Harris, Mass. Agr. Jour. and Rpts., 10: 1-12.
1850 *Ancylonycha crenulata* Blanchard, Cat. Coll. Ent., 1: 133.
1853 *Phyllophaga georgicana* Melsheimer, Cat. Coleop. U. S.: 59.
1855 *Ancylonycha crenulata* Burmeister, Handb. Ent., 4: 327.
1856 *Lachnosterna crenulata* Le Conte, Acad. Phil., Jour., (2), 3: 258.
1887 *Lachnosterna crenulata* Horn, Am. Ent. Soc., Trans., 14: 272.
1887 *Lachnosterna crenulata* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna crenulata* Smith, U. S. Nat. Mus., Proc., 11: 518.
1916 *Lachnosterna crenulata* Davis, Jour. Econ. Ent., 9: 273-274.
1916 *Phyllophaga crenulata* Glasglow, Ill. Nat. Hist., Bul. 11: 370.
1916 *Phyllophaga crenulata* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 231.
1925 *Phyllophaga crenulata* Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 58-63.
1927 *Phyllophaga crenulata* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 63.
1928 *Phyllophaga crenulata* Luginbill, Ann. Ent. Soc. Am., 21: 60.

Body oblong, moderately shiny, light brown to piceous, with conspicuous vestiture of moderately long, erect hairs. Clypeus subconcave, not broadly, rather abruptly, moderately deeply emarginate, broadly reflexed; punctures coarse, deeply impressed, finer at base; suture angulate. Frons convex; punctures similar to those on clypeus. Antennae composed of ten segments. Pronotum irregularly convex widest in front of middle, sides angulate, coarsely serrate; punctures similar to those on frons, less dense and not so deeply impressed. Mesosternum with sparse vestiture of long, yellowish hair. Tooth of claw median, long, moderately strong. Elytra with moderately fine, feebly impressed punctures, slightly denser than on pronotum; sutural costae broad; feebly elevated, discal and submarginal costae narrow, indistinct.

Length, 17-20 mm.; width, 9-11 mm.

Male: Antennal club equal to funicle. Abdomen convex; penultimate ventral segment vaguely concave, roughened at middle; last ventral segment smooth, almost glabrous, with median, transverse elevation, apex entire. Hind tibia obliquely truncate; upper spur long, slender, flattened, subacute; lower spur movable, slightly curved, slender, acute.

Female: Antennal club slightly shorter than funicle. Penultimate ventral segment slightly depressed laterally; last ventral segment pubescent, convex, apex entire.

This species has been taken at Ames, Clermont, Pleasant Valley, Columbus Junction, Hampton, Leon, McGregor, Iowa City, Mt. Union, Keokuk, Oakland, Muscatine, Mt. Pleasant, Linn County, Delaware County, Lee County, Appanoose County, and Hamilton County. Bur oak and gooseberry are the host plants.

Phyllophaga quercus (Knoch)

(Plate IX, fig. 32)

1801 *Melolontha quercus* Knoch, Neue Beytr. Ins., 1: 72.
1802 *Melolontha fervida* Illiger, Oliv. Ent., 2: 44.
1817 *Melolontha fervida* Schönherr, Syn. Ins., 1, pt. 3: 171.
1855 *Ancylonycha quercus* Burmeister, Handb. Ent., 4, pt. 2: 340.
1856 *Endrosa quercus* Le Conte, Acad. Phil., Jour., (2), 3: 235.
1887 *Lachnosterna quercus* Horn, Am. Ent. Soc., Trans., 14: 281.
1887 *Lachnosterna quercus* Horn, Ent. Am., 3: 138.
1889 *Lachnosterna quercus* Smith, U. S. Nat. Mus., Proc., 11: 520.
1916 *Phyllophaga quercus* Glasglow, Ill. Nat. Hist., Bul. 11: 371.
1927 *Phyllophaga quercus* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 66.
1928 *Phyllophaga quercus* Luginbill, Ann. Ent. Soc. Am., 21: 85.

Body elongate, pruinose, rufocastaneous. Clypeus concave, abruptly and deeply emarginate, moderately reflexed; punctures coarse, not deeply impressed; suture angulate. Frons convex; more coarsely, less closely punctate, than clypeus. Antennae composed of nine segments. Pronotum convex, widest at middle, sides arcuate, entire; punctures similar to those on frons, not so dense. Tooth of claw median, strong. Elytra punctures similar to those on pronotum, denser; sutural costae strong, narrow, discal, and submarginal costae narrow, indistinct.

Length, 14-16 mm.; width, 7-8mm.

Male: Antennal club equal to stem. Abdomen feebly flattened at middle; penultimate ventral segment vaguely depressed at middle, with broad, roughened area; last ventral segment rough, feebly, transversely impressed, apex vaguely and broadly emarginate. Hind tibia obliquely truncate; upper spur long, linear, slightly curved, obtuse; lower spur movable, slender, curved, obtuse, three-fourths length of upper.

Female: Antennal club shorter than funicle. Penultimate ventral segment transversely and feebly impressed, long, yellowish hairs at sides; last ventral segment small, slightly flattened, apex entire.

This species has been listed by Prof. H. E. Jaques as occurring in Iowa.

Phyllophaga tristis (Fabricius)

(Plate IX, fig. 33)

1781 *Melolontha tristis* Fabricius, Species Ins., 1: 39.
1801 *Melolontha pilosicollis* Knoch, Neue Beytr. Ins., 1: 85.
1817 *Melolontha pilosicollis* Schönherr, Syn. Ins., 1, pt. 3: 177.
1817 *Melolontha tristis* Schönherr, Syn. Ins., 1, pt. 3: 195.
1823 *Melolontha pilosicollis* Say, Acad. Phil., Jour., 3: 243, in Le Conte ed. 2, 1869, p. 143.
1826 *Phyllophaga tristis* Harris, Mass. Agr., Jour. and Rpts., 10: 1-12.
1847 *Trichesthes pilosicollis* Erickson, Natur. Ins. Deutschl., 3: 658.
1850 *Trichestes pilosicollis* Blanchard, Cat. Coll. Ent., 1: 141.
1855 *Trichestes pilosicollis* Burmeister, Handb. Ent., 4, pt. 2: 358.
1856 *Lachnosterna tristis* Le Conte, Acad. Phil., Jour., (2), 3: 261.
1856 *Lachnosterna crinita* Le Conte, Acad. Phil., Jour., (2), 3: 261, (not Burmeister).
1873 *Lachnosterna tristis* Le Conte, Acad. Phil., Proc.: 330.
1887 *Lachnosterna crinita* Horn, Ent. Am., 3: 145.
1887 *Lachnosterna tristis* Horn, Am. Ent. Soc., Trans., 14: 286.
1887 *Lachnosterna tristis* Horn, Ent. Am., 3: 143.
1889 *Lachnosterna tristis* Smith, U. S. Nat. Mus., Proc., 11: 522.
1913 *Lachnosterna tristis* Davis, Jour. Econ. Ent., 6: 277.
1916 *Lachnosterna tristis* Davis, Jour. Econ. Ent., 9: 277.
1916 *Phyllophaga tristis* Glasglow, Ill. Nat. Hist., Bul. 11: 370.
1916 *Phyllophaga tristis* Forbes, Ill. Agr. Expt. Sta., Bul. 186: 229.
1925 *Phyllophaga tristis* Hayes, Kans. Agr. Expt. Sta., Tech. Bul. 16: 66-72.
1927 *Phyllophaga tristis* Langston, Miss. Agr. Expt. Sta., Tech. Bul. 15: 72.
1928 *Phyllophaga tristis* Luginbill, Ann. Ent. Soc. Am., 21: 61.

Body oblong, moderately shiny, testaceous, with sparse vestiture of long, yellowish hair. Clypeus concave, entire; punctures sparse, coarse, rather feebly impressed; suture sinuous. Frons convex; with coarse, close, deeply impressed punctures. Antennae composed of ten segments. Pronotum convex, sides angulate, entire; punctures not so coarse or so closely placed as on frons. Tooth of claw different in male and female. Elytra more closely and finely punctate than pronotum; sutural costae broad, feebly elevated, discal and submarginal costae indistinct.

Length, 12-14 mm.; width, 6-8 mm.

Male: Antennal club subequal to stem. Abdomen vaguely flattened; penultimate ventral segment with short transverse ridge; last ventral segment elevated at base, apex entire. Hind tibia obliquely truncate; upper spur lanceolate, slightly curved, obtuse; lower spur movable, linear, obtuse, four-fifths length of upper. Tooth of claw intramedian.

Female: Antennal club equal to funicle. Penultimate ventral segment with feeble transverse depression; last ventral segment convex, apex entire. Tooth of claw more nearly median.

This species has been collected at Ames, Leon, Hampton, Farmersburg, Dyersville, Dubuque, Mt. Pleasant, Chariton, Muscatine, Iowa City, Allamakee County, Scott County, Appanoose County, Des Moines County, and Van Buren County. Bur oak, elm, willow, and white oak are the known host plants for Iowa.

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Many entomologists and collectors have given their kind assistance in the preparation of this paper and the writer wishes to express his appreciation of their help.

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EXPLANATION OF PLATES

The illustrations of the male and female organs are original, except number 20, which is a copy of the male genitalia, as drawn by Smith (1889). The sketches were all drawn to the same scale. Arrangements of the drawings for each species of the genus Phyllophaga are as follows: upper left, hind view of the male claspers; lower left, left male clasper; lower right, right male clasper; and the upper right ventral view of female genitalia. Since the penis sheath is not of great specific value, only the distal end of the sheath is figured. The page listed with the figure refers to the description of the species in the text.

PLATE I

PLATE I

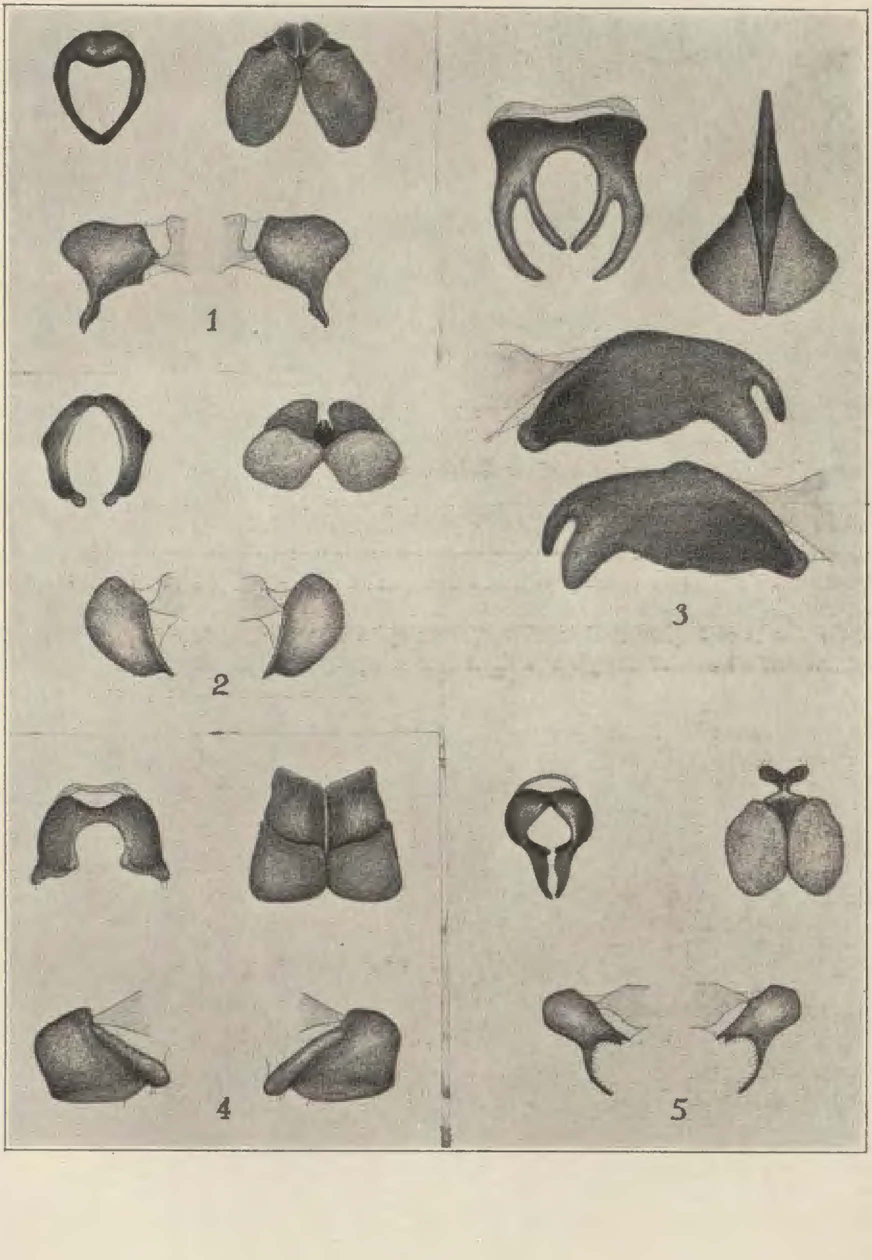

PLATE II

PLATE II

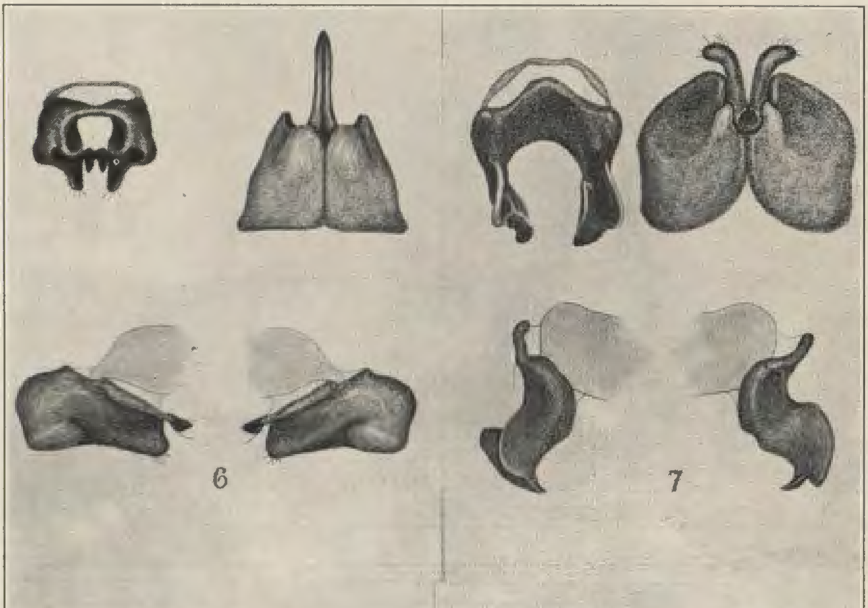

PLATE III

PLATE III

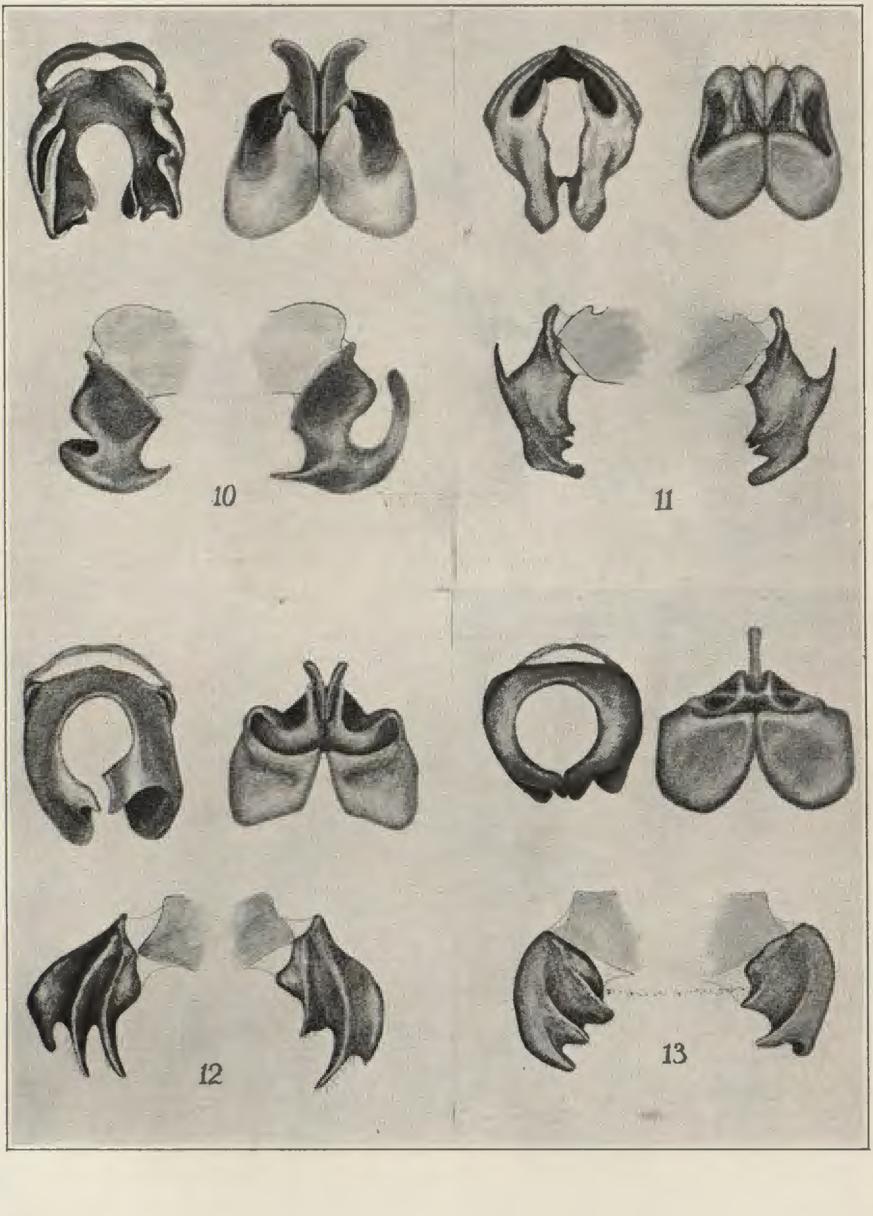

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PLATE IV

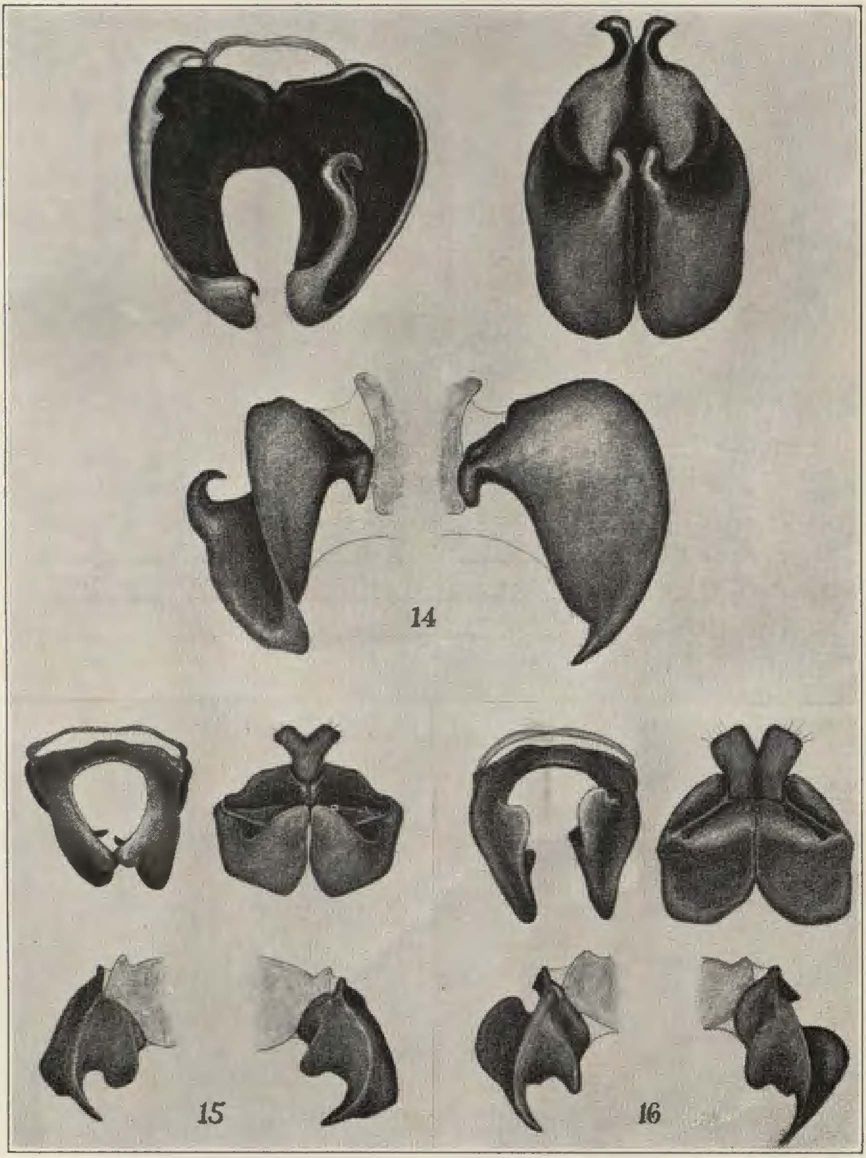

PLATE V

Fig. 17. *P. barda* (Horn) .... p. 330
Fig. 18. *P. drakii* (Kirby) .... p. 329
Fig. 19. *P. marginalis* (Lec.) .... p. 330

PLATE V

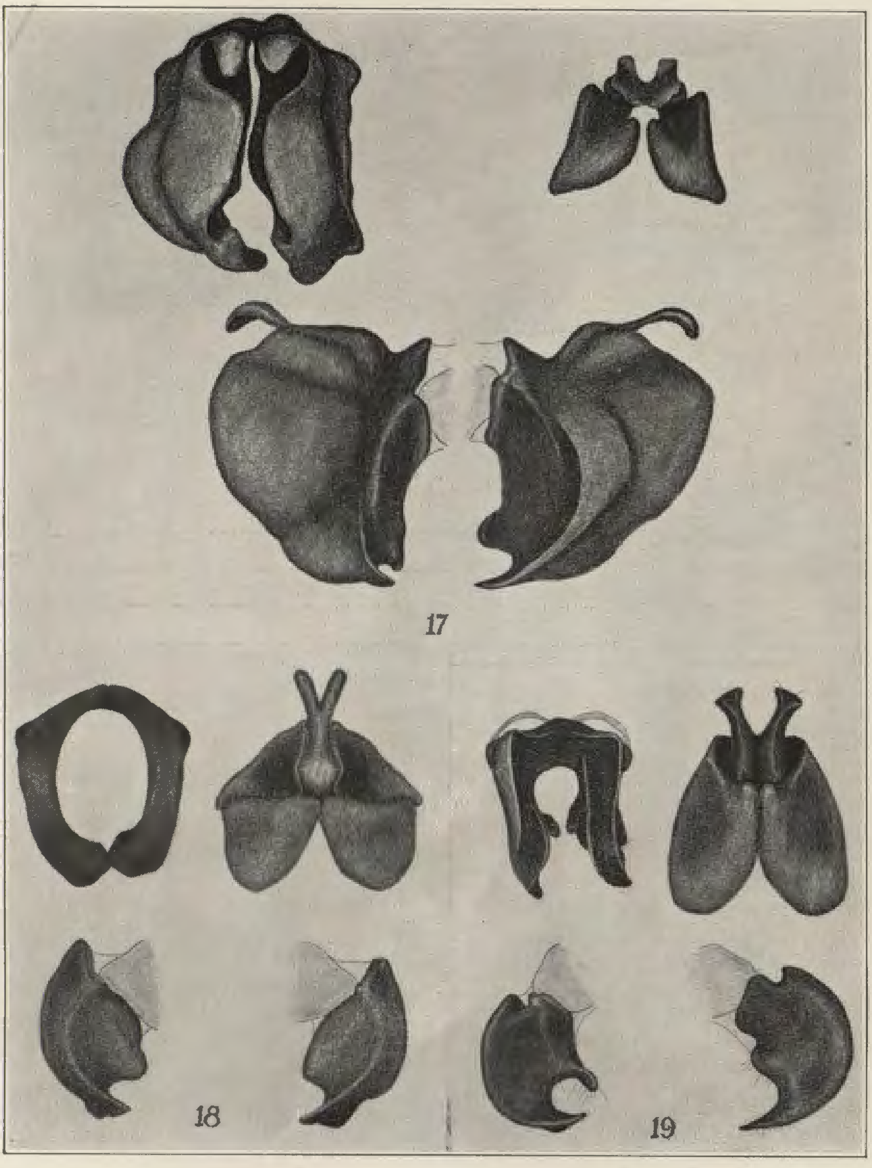

PLATE VI

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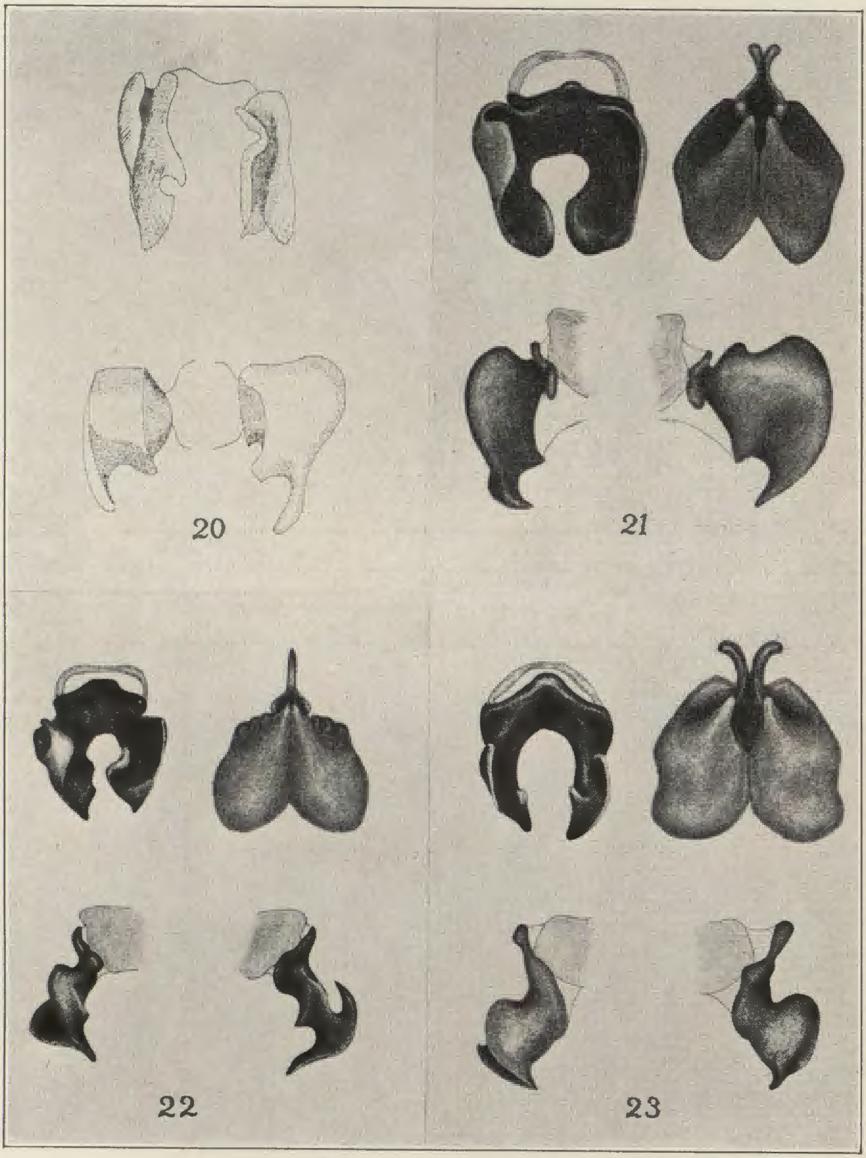

PLATE VII

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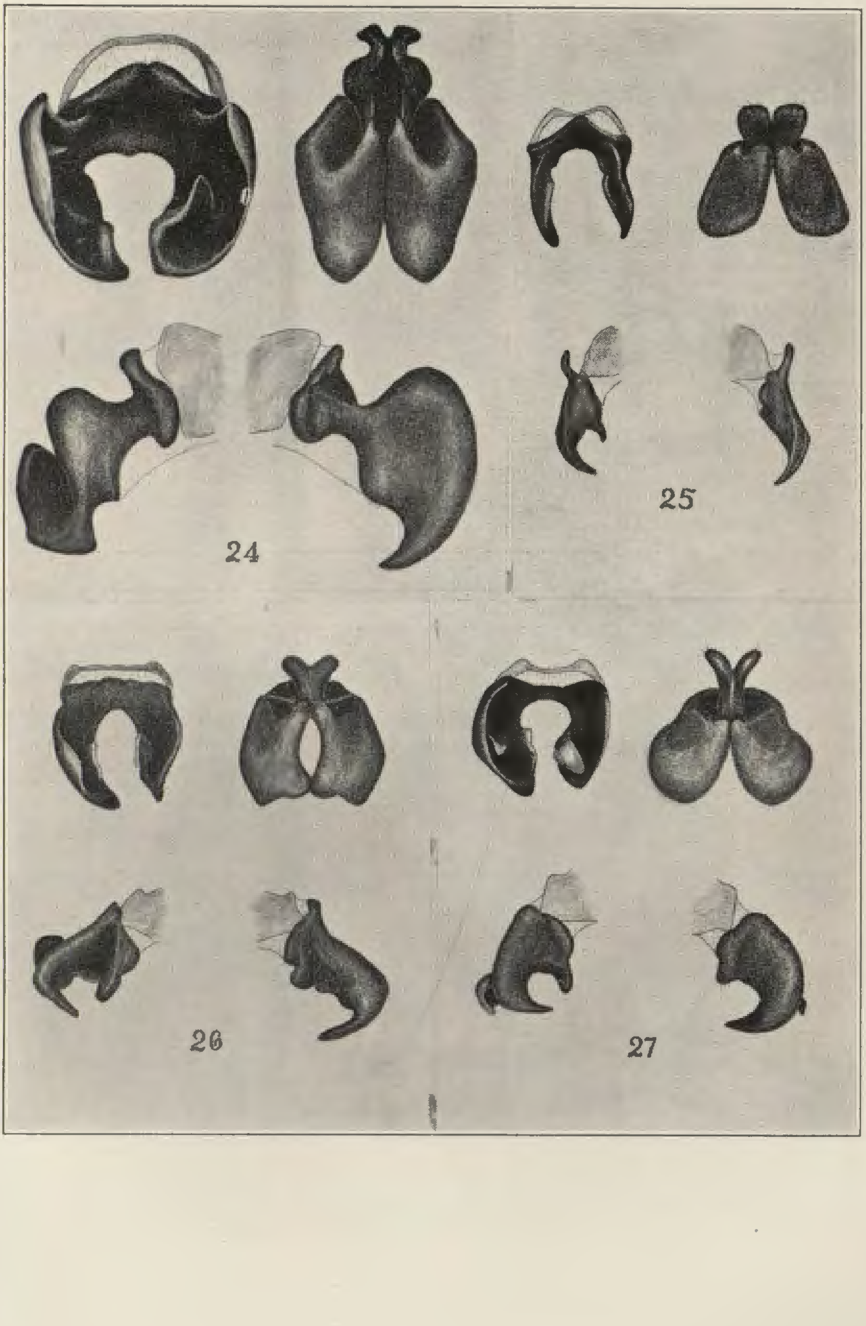

PLATE VIII

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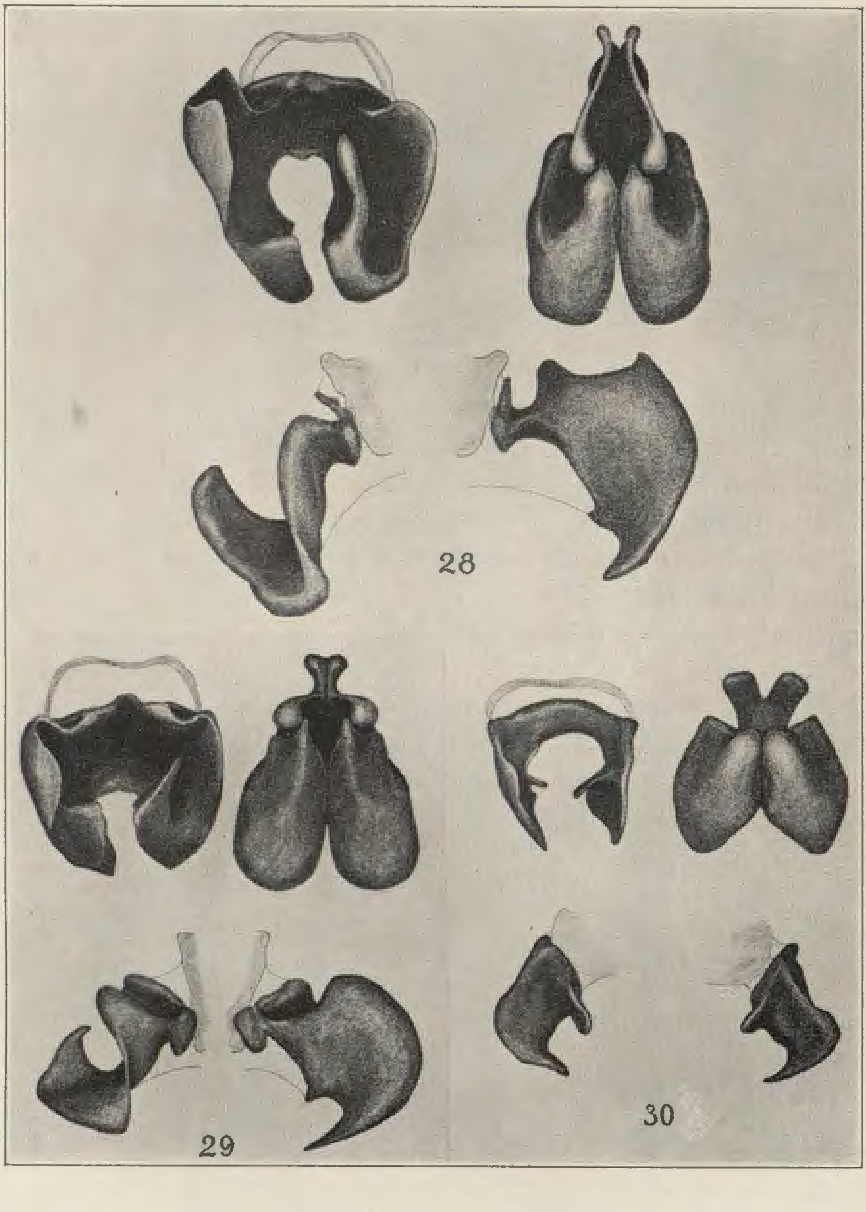

PLATE IX

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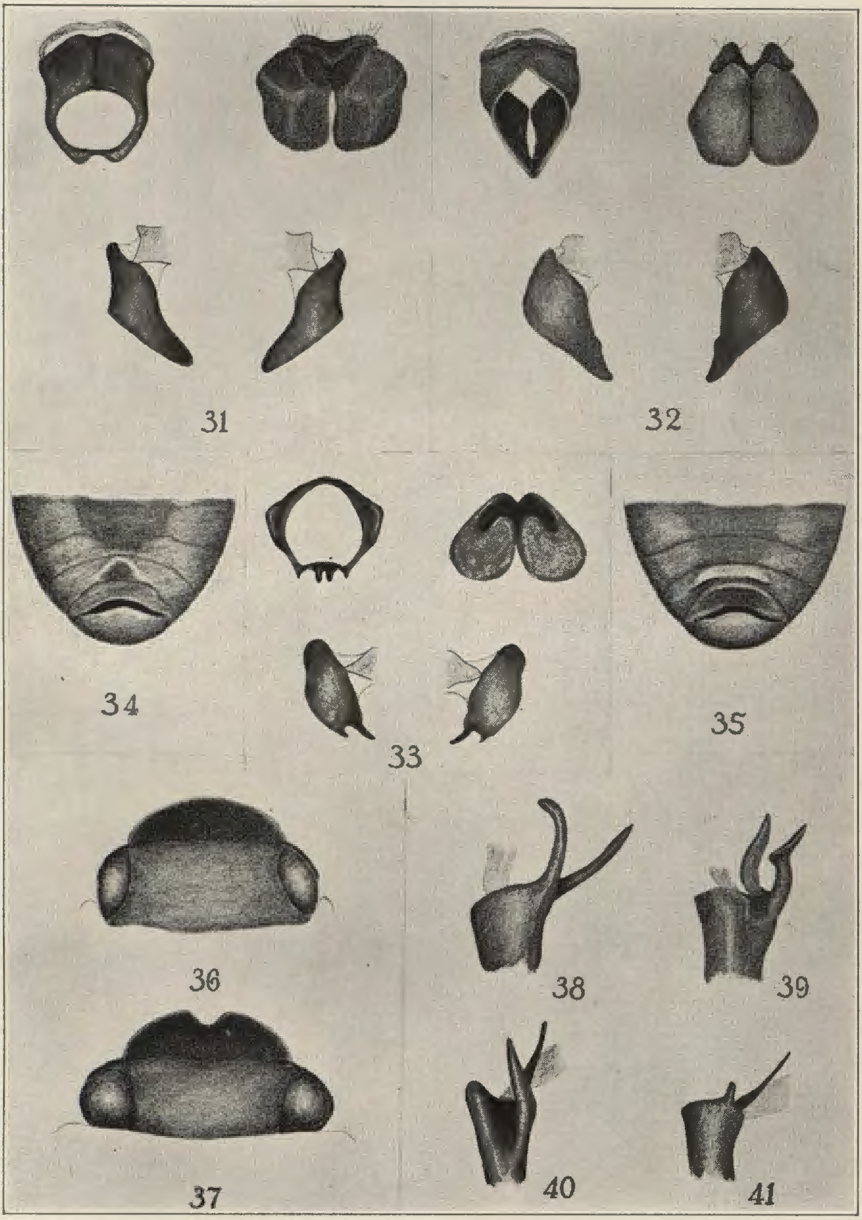

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