

more recently called at the Division of Insects, U. S. National Museum, on November 2 and 3, and examined the genera *Ixodiphagus* and *Hunterellus*.

Montana State College, Bozeman, Mont., visited the National Museum, on November 2 and 3, and examined the genera *Ixodiphagus* and *Hunterellus*.

who has been engaged in a mosquito survey of Argentina, returned to Washington early in December. He has been in Peru under the Rockefeller Foundation, to study the transmission of Verruga by insects, and will sail for Europe in June.

#### ENTOMOLOGICAL SOCIETY OF PENNSYLVANIA

was held at Harrisburg, January 17th, conjointly with the Pennsylvania Entomological Society. The morning session and part of the afternoon was devoted to the Oriental Fruit Moth workers of Pennsylvania and the Pennsylvania Entomological Society. Dozier addressed the conference on the subject of the Pennsylvania Entomology. An opening meeting was held in the afternoon, at which Mr. R. H. Bell explained the status of the Pennsylvania Entomology, Mr. C. C. Hill discussed the present Hessian fly situation in Pennsylvania, Mr. B. Stichter presented data concerning the Japanese beetle quarantine on this pest, and Mr. J. N. Knull discussed the Mexican Bean Beetle and its spread in Pennsylvania. The society adjourned for supper at the University Hotel. H. Dusham gave an address on the history of dusting for the control of the Hessian fly, and Dr. J. L. King gave an illustrated talk on the Hessian fly in connection with Japanese Beetle control work. The speakers present were, Dr. A. H. Peterson, Dr. T. J. Head, Dr. J. W. Lipp, and Mr. G. T. Haeussler, of New Jersey; Mr. W. A. Ross, of Maryland; Mr. H. S. McConnell, of Maryland; Dr. H. L. Dozier, of Delaware; Dr. J. S. Houser, of Pennsylvania; Mr. W. A. Ross, of Canada; Dr. J. L. King, of the University of Pennsylvania. Officers for the ensuing year were elected: President, E. H. Dusham.

C. C. HILL, *Secretary*

#### ERRATA

October, 1927, issue, insert "March" for "April," and "April." These lines would then read—"Larvae were preparing to pupate on March 7. The first puparium was observed on last larva April 7."

October, 1927, JOURNAL, the last column (Grubs per sq. ft.) should read 0.8, 1.3, and 0.0 instead of 3, 0, 4, 6.5, and 0. The above is quantitative work but not for qualitative purposes.

On pages 36 and 37, the illustrations only should be transposed.

# JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

VOL. 21

APRIL, 1928

No. 2

## Proceedings of the Fortieth Annual Meeting of the American Association of Economic Entomologists

(Continued)

Friday Morning Session, December 30

The meeting convened at 9:40 o'clock, First Vice-President W. P. Flint in the Chair.

FIRST VICE-PRESIDENT W. P. FLINT: The first paper on the program this morning is by J. W. McColloch and W. P. Hayes.

### ECOLOGICAL STUDIES OF KANSAS SCARABÆID LARVÆ (COLEOP.)<sup>1</sup>

By WM. P. HAYES and J. W. MCCOLLOCH

#### ABSTRACT

A collection of 18,781 scarabæid larvæ made in Kansas during a period of eight years includes 37 species representing 17 genera. Seventeen species of the genus *Phyllophaga* are considered. The data included show the percentage of rearing mortality, the seasonal distribution, relative abundance, habit at preferences, food habits and parasitism by *Tiphia* wasps.

#### INTRODUCTION

During the course of a series of biological studies of the family Scarabæidæ carried on at the Kansas Agricultural Experiment Station, Manhattan, Kansas, considerable data were amassed on the relative numbers, as well as the habitat and food preferences of larvæ of various common species of this family. Since they are of general ecological and biological interest the statistical results of these studies are presented here.

<sup>1</sup>Contribution No. 364 of the Department of Entomology of the Kansas State Agricultural College and No. 118 of the Department of Entomology of the University of Illinois. This paper embodies some of the results of Project No. 100 of the Kansas Agricultural Experiment Station.

Collections of larvæ of this family of beetles were begun in 1916 and extended over a period of eight years, to and including 1923. The specimens collected were transported to the laboratory and reared to the adult stage in individual salve boxes in an underground cave. Because of the difficulty in rearing, and in some cases the presence of a long life cycle, the relative proportion of those reared to adult, for determination of the species, compared to the numbers collected in the field shows that less than one-third of the total were so reared. During the eight years 18,781 grubs were collected, of which 5,884 were matured under artificial conditions. Among these 5,884 reared specimens, 17 genera are involved with a total of 37 species. The largest number of species belonging to a single genus are represented by 17 species of the genus *Phyllophaga*. The other 16 genera distributed among the various subfamilies of Scarabæidæ contain but one, two, three or four species.

With but very few exceptions, these larvæ were collected in the vicinity of Manhattan, Kansas. Numerous student assistants have aided in the work, both in collecting and rearing, to whom the writers acknowledge their indebtedness.

PERCENTAGE OF MORTALITY IN REARING

Because of the difficulty of determining the various species in the immature stages, the data here discussed are based on those species actually reared and identified instead of on the total numbers collected. Such a condition would not be necessary if we were able to identify specifically each specimen collected. Table 1 shows the total individuals collected in each of the eight seasons as well as the numbers reaching maturity and the percentage of those reared. In other words, the table is an indication of the percentage of mortality in rearing as shown in the last column.

TABLE 1. SHOWING THE PERCENTAGE OF REARING AND MORTALITY OF SCARABÆID LARVAE

Year	Total Numbers Collected	Total Numbers Reared	Percentage of Rearing	Percentage of Mortality
1916	716	270	37.7	62.3
1917	251	99	39.4	60.6
1918	814	302	37.1	62.9
1919	790	372	47.0	53.0
1920	4004	1431	33.2	66.8
1921	3044	630	20.6	79.4
1922	3617	1508	41.6	58.4
1923	5545	1272	22.8	77.2
Total	18781	5884	31.3	68.7

From the foregoing data it is apparent that the grubs collected were reared to maturity, 31.3 per cent. It is interesting to note that the numbers reared show a wide variance. The percentage of rearing in each year shows a variation of from 20.6 per cent in 1921 to 47.0 per cent in 1919.

The smallest collection was made in 1917 while in 1923, 5545 individuals were obtained. The numbers of specimens collected in any one season do not always correspond to the season or even the next year must be borne in mind because of the various lengths of the life-cycle in this family. For example, specimens collected in 1917 may not reach maturity until 1918, or 1919, or even 1920, no matter what the length of the life-history, or they may be collected in 1918 and still others in 1919 which, of course, is due to the overlapping of the various broods.

THE COLLECTIONS OF THE GENUS *PHYLLOPHAGA*

*Seasonal Distribution.*—The following table shows the collections, for convenience, is divided into two groups, *Phyllophaga* with 17 species represented while the remaining 16 genera will be covered in another paper. It shows the various species as to the year in which they were collected and not on their relationships.

TABLE 2. SHOWING THE COLLECTIONS OF PHYLLOPHAGA BY REARING

Species of <i>Phyllophaga</i>	1916	1917	1918	1919	1920
<i>P. crassissima</i> .....	15	36	40	33	19
<i>P. rubiginosa</i> .....	11	7	15	22	1
<i>P. rugosa</i> .....	14	4	9	33	2
<i>P. lanceolata</i> .....	2	16	9	50	
<i>Pl. submucida</i> .....		2	2		
<i>P. implicita</i> .....	6	4	4	8	2
<i>P. hirticula</i> var. <i>comosa</i>		2			
<i>P. praetermissa</i> .....			3		
<i>P. longitarsa</i> .....		1	4		
<i>P. bipartita</i> .....			1	3	
<i>P. futilis</i> .....					
<i>P. corrosa</i> .....			2		
<i>P. glabricula</i> .....		2			
<i>P. fusca</i> .....					
<i>P. crenulata</i> .....				1	
<i>P. tristis</i> .....	1				
<i>P. affabilis</i> .....					
Total.....	49	74	90	149	264

of this family of beetles were begun in 1916 and continued for a period of eight years, to and including 1923. The larvae were transported to the laboratory and reared in individual salve boxes in an underground cave. The results of rearing, and in some cases the presence of a particular proportion of those reared to adult, for different species, compared to the numbers collected in the field, one-third of the total were so reared. During the course of the work 5,884 were matured. Among these 5,884 reared specimens, 17 species of the genus are represented by 17 species of the genus, and the other 16 genera distributed among the various species contain but one, two, three or four species. In all these reptions, these larvæ were collected in the field. Numerous student assistants have aided in the collecting and rearing, to whom the writers are indebted.

PERCENTAGE OF MORTALITY IN REARING

The purpose of determining the various species in the field here discussed are based on those species reared instead of on the total numbers collected. It would not be necessary if we were able to identify the specimens collected. Table 1 shows the total individuals collected in different seasons as well as the numbers reaching maturity of those reared. In other words, the table shows the percentage of mortality in rearing as shown in the

PERCENTAGE OF REARING AND MORTALITY OF SCARABÆID LARVAE

Total Numbers	Percentage of Reared	Percentage of Mortality
270	37.7	62.3
99	39.4	60.6
302	37.1	62.9
372	47.0	53.0
1431	23.2	66.8
630	20.6	79.4
1508	41.6	58.4
1272	22.8	77.2
5884	31.3	68.7

From the foregoing data it is apparent that only 31.3 per cent of all grubs collected were reared to maturity, giving a mortality of 68.7 per cent. It is interesting to note that the mortality for each year did not show a wide variance. The percentage of reared specimens for the eight years shows a variation of from 20.6 per cent to 47 per cent.

The smallest collection was made in 1917 when 251 larvæ were collected while in 1923, 5545 individuals were obtained. The fact that specimens collected in any one season do not always mature that particular season or even the next year must be borne in mind. This is because of the various lengths of the life-cycle in the different species. For example, specimens collected in 1917 may have some individuals, no matter what the length of the life-history, maturing in 1917, others in 1918 and still others in 1919 which, of course, is also due, in part, to the overlapping of the various broods.

THE COLLECTIONS OF THE GENUS *Phyllophaga*

*Seasonal Distribution.*—The following discussion of the various collections, for convenience, is divided into two groups. The genus *Phyllophaga* with 17 species represented will be considered as one unit while the remaining 16 genera will be considered jointly. Table 2 shows the various species as to the year in which they were collected and not the year of maturity. The order of arrangement is based on numbers collected and not on their relationships.

TABLE 2. SHOWING THE COLLECTIONS OF PHYLLOPHAGA AS DETERMINED BY REARING

Species of <i>Phyllophaga</i>	Year of Collection								Total
	1916	1917	1918	1919	1920	1921	1922	1923	
<i>P. crassissima</i> . . . . .	15	36	40	33	196	52	18	6	396
<i>P. rubiginosa</i> . . . . .	11	7	15	22	10	41	25	4	135
<i>P. rugosa</i> . . . . .	14	4	9	33	22	24	14	5	125
<i>P. lanceolata</i> . . . . .	2	16	9	50	1		1		79
<i>P. submucida</i> . . . . .		2	2				66	9	79
<i>P. implicata</i> . . . . .	6	4	4	8	20	1	28	5	76
<i>P. hirticula</i> var. <i>comosa</i>		2			4	18			24
<i>P. praetermissa</i> . . . . .			3		8			2	13
<i>P. longitarsa</i> . . . . .		1	4				3		8
<i>P. bipartita</i> . . . . .			1	3				2	6
<i>P. fulvipes</i> . . . . .					3			2	5
<i>P. corrosa</i> . . . . .			2			1		2	5
<i>P. glabricula</i> . . . . .		2						3	5
<i>P. fusca</i> . . . . .						3			3
<i>P. crenulata</i> . . . . .			1				1		2
<i>P. tristis</i> . . . . .	1							1	2
<i>P. affabilis</i> . . . . .						1			1
Total . . . . .	49	74	90	149	264	141	156	41	964

As shown in Table 2, there were a total of 964 individuals representing 17 species reared from the total of 18,781 (See Table 1) grubs of all species collected. Of course, many individuals of this genus failed to live through the rearing period so a percentage of those reared based on the number collected would be unfair. However, the percentage reared based on the total species gives an inkling of the relative proportions of *Phyllophaga* to other species of the family. Of the total (5,884) beetles, only 964 or 16.3 per cent belonged to this genus. Neither Table 1 nor Table 2 shows any evidence of the presence of the definite broods (Brood A, B, and C) which have been long known through the various collections of adults. However, Table 2, as indicated in the column of totals, offers further data on the relative numbers of the various species found in the locality considered. Of the total of all species (964) reared, *P. crassissima* ranks first with a total of 396 individuals or about 41 per cent; *P. rubiginosa* ranks second with about 14 per cent and *P. rugosa* nearly 13 per cent.

*Relative Abundance.*—If we compare the individual total of each species with the total adults collected during the first seven years (1916–1922) of the eight during which this study was in progress,

TABLE 3. SHOWING A COMPARISON OF THE RELATIVE ABUNDANCE OF *Phyllophaga* ADULTS AND REARED LARVÆ

Rank	Species of <i>Phyllophaga</i>	Total Larvae Reared	Adults Collected 1916–1922	Comparative Ranking of Adult Abundance
1	<i>P. crassissima</i>	396	31,966	First
2	<i>P. rubiginosa</i>	135	15,130	Third
3	<i>P. rugosa</i>	125	4,010	Fifth
4	<i>P. lanceolata</i>	79	15,851	Second
5	<i>P. submucida</i>	79	57	Eighteenth
6	<i>P. implicita</i>	76	982	Tenth
7	<i>P. hirticula</i> var. <i>comosa</i>	24	1,696	Ninth
8	<i>P. praetermissa</i>	13	115	Sixteenth
9	<i>P. longitarsa</i>	8	909	Eleventh
10	<i>P. bipartita</i>	6	3,523	Seventh
11	<i>P. fulvipes</i>	5	10,362	Fourth
12	<i>P. corrosa</i>	5	3,732	Sixth
13	<i>P. glabricula</i>	5	440	Twelfth
14	<i>P. fusca</i>	3	135	Fourteenth
15	<i>P. crenulata</i>	2	127	Fifteenth
16	<i>P. tristis</i>	2	114	Seventeenth
17	<i>P. affabilis</i>	1	44	Nineteenth
18	<i>P. vehemens</i>	0	2,001	Eighth
19	<i>P. congrua</i>	0	135	Thirteenth

(Table 3) some interesting facts are shown. *P. crassissima* is the most numerous among the adults collected, second in number of adults is fourth among those species collected. This may be, in part, due to the slightly longer life cycle of *P. crassissima* (1919).<sup>2</sup> *P. rubiginosa* while third among the grubs and *P. rugosa* was fifth among the larvae. On the whole the numbers are very close while greater differences are observed among the adults. An interesting observed fact is that the species which were collected as grubs and reared were *P. crassissima* and *P. rubiginosa*. The two species, *P. vehemens* and *P. rugosa*, were eighth and thirteenth, respectively, reared from grubs.

#### COLLECTIONS OF ADULTS

*Seasonal Abundance.*—In addition to the 20 species representing 16 other grubs available for comparison with the adults, the most part, incidental to the whole, were found were collected, the data are available as well as the relative numbers of the various species and the years in which they were collected. It will be noted that the two most numerous species, *Cyclocephala immaculata* (Oliv.) and *Ochrosidia* reared far outnumbered the *Phyllophaga* being represented by 3070 individuals. *Ochrosidia* with those of *Phyllophaga* combined, whose total number is over three times as many *Ochrosidia* as *Phyllophaga* combined, whose total number is in mind, however, that the one year cycle of *Ochrosidia* is easier with less mortality. Space does not permit a full discussion of the facts apparent in Table 4, but it will be noted that the most important representatives of the most important species are shown.

If the total collections of *Ochrosidia* for various years, as is done in Table 4, are compared with the complete absence from the soil of larvae

<sup>2</sup>Hayes, W. P. The life cycle of *Lachnospidius* 12:109–117, 1919.

were a total of 964 individuals representing a total of 18,781 (See Table 1) grubs of all many individuals of this genus failed to live to a percentage of those reared based on the unfair. However, the percentage reared gives an inkling of the relative proportions of species of the family. Of the total (5,884) per cent belonged to this genus. Neither Table 1 nor the presence of the definite broods have been long known through the various years, Table 2, as indicated in the column headed "Relative numbers of the various species considered." Of the total of all species (964) collected first with a total of 396 individuals or about 41 per cent second with about 14 per cent and *P.*

we compare the individual total of each species collected during the first seven years during which this study was in progress,

COMPARISON OF THE RELATIVE ABUNDANCE OF ADULTS AND REARED LARVAE

Larvae	Adults Collected 1916-1922	Comparative Ranking of Adult Abundance
1	31,966	First
2	15,130	Third
3	4,010	Fifth
4	15,851	Second
5	57	Eighteenth
6	982	Tenth
7	1,696	Ninth
8	115	Sixteenth
9	909	Eleventh
10	3,523	Seventh
11	10,362	Fourth
12	3,732	Sixth
13	440	Twelfth
14	135	Fourteenth
15	127	Fifteenth
16	114	Seventeenth
17	44	Nineteenth
18	2,001	Eighth
19	135	Thirteenth

(Table 3) some interesting facts are brought out. The most abundant species among the adults collected, (*P. crassissima*) is seen to be the most numerous among those species collected as grubs. *P. lanceolata* while second in number of adults is fourth in the grub collections. This may be, in part, due to the slightly longer life-cycle of *P. lanceolata* (Hayes, 1919).<sup>2</sup> *P. rubiginosa* while third among the adults was second among the grubs and *P. rugosa* was fifth in the beetle collections and third among the larvae. On the whole, these four important species rank very close while greater differences are disclosed among the other species. An interesting observed fact is that more individuals of *P. submucida* were collected as grubs and reared to adult than were taken in the adult collections. The two species, *P. vehemens* and *P. congrua*, which ranked eighth and thirteenth, respectively, in the adult collections, were not reared from grubs.

COLLECTIONS OF OTHER GENERA

*Seasonal Abundance.*—In addition to the collections of *Phyllophaga*, 20 species representing 16 other genera of the family Scarabæidæ are available for comparison with the genus *Phyllophaga*. These were, for the most part, incidental to the white grub collections but, since all that were found were collected, the data available show the years of abundance as well as the relative numbers. These data are summarized for the various species and the years in which they were collected in Table 4. It will be noted that the two most numerous species are *Ochrosidia* (*Cyclocephala*) *immaculata* (Oliv.) and *Ligyris gibbosus* (DeG.). The numbers of *Ochrosidia* reared far outnumber those of any other species, being represented by 3070 individuals. Comparing the number of *Ochrosidia* with those of *Phyllophaga* (Table 2) it will be noted that over three times as many *Ochrosidia* were collected and reared as all *Phyllophaga* combined, whose total figure is 964. It must be borne in mind, however, that the one year life-cycle of *Ochrosidia* compared to the two and three year cycles of *Phyllophaga* makes rearing much easier with less mortality. Space does not permit a discussion of all the facts apparent in Table 4, but it will be noted that the collection contains representatives of the most important sub-families of the Scarabæidæ.

If the total collections of *Ochrosidia* are summarized by months for the various years, as is done in Table 5, a striking feature is the almost complete absence from the soil of larvae during June with relatively few

<sup>2</sup>Hayes, W. P. The life cycle of *Lachnosterna lanceolata*. In Jour. Econ. Ent. 12:109-117, 1919.

TABLE 4. SHOWING A COMPARISON OF THE RELATIVE ABUNDANCE OF SCARABÆID LARVÆ OTHER THAN *Phyllophaga* SPP.

Miscellaneous Species of Scarabæid Larvæ	Year of Collection								Total
	1916	1917	1918	1919	1920	1921	1922	1923	
<i>Ochrosidia immaculata</i>	32	2	155	155	723	315	973	715	3070
<i>Ligyris gibbosus</i> .....	5	17	2	2	227	23	116	27	302
<i>Anomala binotata</i> .....	145	4			37	42	47	37	256
<i>Anomala kansana</i> .....			3	1	154	4	57	37	144
<i>Anomala innuba</i> .....	1		9	45	21		15	53	144
<i>Anomala undulata</i> .....							7	1	8
<i>Cotalpa lanigera</i> .....						1	23	125	149
<i>Pelidnota punctata</i> ....		2	10	1	1	7	5	92	118
<i>Ligyrodus relictus</i> .....	13		10	19	1	74	6		123
<i>Euphoria inda</i> .....	25				1	14	6		46
<i>Euphoria sepulchralis</i> ..			1			4	2	2	9
<i>Aphodius sp.</i> .....								53	53
<i>Canthon laevis</i> .....						4			4
<i>Trox sp.</i> .....								122	122
<i>Polymoehus brevipes</i> ..							12		12
<i>Cremastocheilus nitens</i>			20				1		21
<i>Ataenius inops</i> .....							81		81
<i>Trichiotinus piger</i> ....			2		2	1		3	8
<i>Stephanucha pilipennis</i>							1		1
<i>Polyphylla hammondi</i> ..								1	1
Total.....	221	25	212	223	1167	489	1352	1231	4920

present in July. This fact is explained and correlated with the life history of the species for during these months the adult stage is found both in the soil by day and at lights at night. The collections of grubs

TABLE 5. SHOWING THE MONTHLY ABUNDANCE OF *Ochrosidia immaculata* FOR THE YEARS 1916 TO 1923

Month	1916	1917	1918	1919	1920	1921	1922	1923	Total
January.....								26	26
February.....						1			1
March.....	13			16	2			4	35
April.....	4		11	14	146	35	43	101	354
May.....	3		12	27	15		91	20	168
June.....							5		5
July.....			9		4	72		1	86
August.....	5	1	28		317	199	671	522	1743
September.....	7	1	56	70	232	8	100	32	506
October.....			39	28	7		31	5	110
November.....							2		2
December.....							30	4	34
Total.....	32	2	155	155	723	315	973	715	3070

made in June are individuals hatching and maturing while those of July are recently hatched.

## HABITAT PREFERENCE

The various sources of the collection and the numbers collected and summarized in Table 6. It is preferred type of soil, inasmuch as 7, compared to 1,749 grubs in blue grass habitats are represented by over 1, land, and under or in logs and stumps are said to prefer sod land, it is surmised they were in wheat land which is usual vicinity of Manhattan, Kansas. No such data it must be remembered that in land disturbed more frequently than ever, are so strikingly different than. The collections listed under "Logs and *punctata* (Linn.) but also includes species which lives in logs and also some made under logs.

The following situations are included: "lanceous" and the number of grubs taken: sumac 5, bindweed 131, sunflower 5, ghum 58, petunia 1, ironweed 3, John tree nursery 8, dock, 19, agronomy straw stack 25, cowpeas 73, grass r sudan grass 13, campfire wood ash horse 301. The figures above are the total of those reared.

## FOOD PREFERENCE

*Food Preference of Phyllophaga.*—W habitat preferences of the various species the individual preference of the different of the various species of *Phyllophaga* of other genera in Table 8.

In Table 7 it is shown that the most taken in blue-grass sod where 234 species

COMPARISON OF THE RELATIVE ABUNDANCE OF  
OTHER THAN *Phyllophaga* SPP.

	Year of Collection						Total
	1918	1919	1920	1921	1922	1923	
1918	155	155	723	315	973	715	3070
2	2	227	23	116			392
		37	42	47	27		302
3	1	154	4	57	37		256
9	45	21		15	53		144
				7	1		8
			1	23	125		149
10	1	1	7	5	92		118
10	19	1	74	6			123
		1	14	6			46
1			4	2	2		9
					53		53
			4				4
					122		122
				12			12
20				1			21
				81			81
2		2	1		3		8
				1			1
					1		1
12	223	1167	489	1352	1231		4920

explained and correlated with the life of these months the adult stage is found at night. The collections of grubs

RELATIVE ABUNDANCE OF *Ochrosidia immaculata*  
YEARS 1916 TO 1923

	1918	1919	1920	1921	1922	1923	Total
						26	26
				1			1
	16	2				4	35
1	14	146	35	43	101		354
2	27	15		91	20		168
				5			5
9		4	72		1		86
8		317	199	671	522		1743
6	70	232	8	100	32		506
9	28	7		31	5		110
				2			2
				30	4		34
5	155	723	315	973	715		3070

April, '28]

HAYES AND MCCOLLOCH: SCARABAEID LARVAE

255

made in June are individuals hanging on from the old generation just maturing while those of July are usually young larvæ which have recently hatched.

## HABITAT PREFERENCE OF ALL SPECIES

The various sources of the collections were grouped into 12 categories and the numbers collected and those reared from these places are summarized in Table 6. It is apparent that wheat land is the preferred type of soil, inasmuch as 7,912 grubs were taken in such land compared to 1,749 grubs in blue grass sod and lawns. The following habitats are represented by over 1,000 specimens each; oat land, corn land, and under or in logs and stumps. In view of the fact that grubs are said to prefer sod land, it is surprising to find grubs as numerous as they were in wheat land which is usually plowed each year in the general vicinity of Manhattan, Kansas. Nevertheless, in the consideration of such data it must be remembered that collections are more easily made in land disturbed more frequently than sod land. The numbers, however, are so strikingly different that they must have some significance. The collections listed under "Logs and Stumps" were mostly *Pelidnota punctata* (Linn.) but also includes species like *Trichiotinus piger* (Fab.) which lives in logs and also some miscellaneous species found in the soil under logs.

The following situations are included under the heading "Miscellaneous" and the number of grubs taken from each is given:—weeds 405, sumac 5, bindweed 131, sunflower 53, strawberry 26, rhubarb 6, sorghum 58, petunia 1, ironweed 3, Johnson grass 8, cabbage and rape 85, tree nursery 8, dock, 19, agronomy small gain nursery 84, hay stack 5, straw stack 25, cowpeas 73, grass roots on sand dunes 1, pigweed 1, sudan grass 13, campfire wood ashes 45, brome grass 15, under dead horse 301. The figures above are the total numbers collected and not the total of those reared.

## FOOD PREFERENCE

*Food Preference of Phyllophaga.*—While the data in Table 6 show the habitat preferences of the various species as a whole, they do not show the individual preference of the different species. The apparent choice of the various species of *Phyllophaga* is shown in Table 7 and those of other genera in Table 8.

In Table 7 it is shown that the most individuals of *Phyllophaga* were taken in blue-grass sod where 234 specimens were found. The next in

TABLE 6. SHOWING THE HABITAT PREFERENCE OF ALL SPECIES

Habitat	1916		1917		1918		1919		1920		1921		1922		1923		Total		
	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	Col.	Reared	
Wheat.....	123	36	17	11	24	18	202	76	1728	746	459	110	2030	860	3329	657	7912	2514	
Blue Grass																			
Lawns...	85	15			152	32	8	4	1404	199	9	1	87	25	4	3	1749	279	
Oats.....	312	144			2	2			239	144	610	93	193	106	194	37	1550	526	
Corn.....	44	26			41	118	264	135	274	195	48	10	281	139	165	80	1394	744	
Logs and																			
Stumps..									6	3	43	9	40	15	886	107	1201	214	
Pasture..	40	8			221	75	3	3	3	3	65	26	13	7	195	62	530	155	
Manure...	78	37			141	21	24	15	3		388	97	194	76	170	63	946	310	
Orchard...	4	1			18	12	89	23			37	4	93	10	56	37	192	54	
Alfalfa...							1	1			85	21	805	150	61	22	1021	217	
Potatoes...					9	6	8	3			3	3	85	21	805	150	61	21	
Garden....	5	2			31	17	103	61	45	26	93	22	115	46	146	64	538	238	
Miscellan.	25	1			1	1	87	50	167	79	172	73	510	203	338	140	1370	576	
Total....	716	270	251	99	814	302	790	372	4004	1431	3044	630	3617	1508	5545	1272	18781	5884	

TABLE 7. SHOWING THE P

Species of <i>Phyllophaga</i>	Wheat		Blue Grass and Lawns	
	Col.	Reared	Col.	Reared
<i>P. crassissima</i> .....	23	202		
<i>P. rubiginosa</i> .....	10	16		
<i>P. rugosa</i> .....	18	4		
<i>P. lanceolata</i> .....	45	1		
<i>P. submucida</i> .....	7			
<i>P. implicita</i> .....	10	1		
<i>P. hirticula</i> var. <i>comosa</i> ..	5			
<i>P. praetermissa</i> .....	2	8		
<i>P. longitarsa</i> .....	3			
<i>P. bipartita</i> .....	1			
<i>P. futilis</i> .....		2		
<i>P. corrosa</i> .....	1			
<i>P. glabricula</i> .....				
<i>P. fusca</i> .....	1			
<i>P. crenulata</i> .....				
<i>P. tristis</i> .....				
<i>P. affabilis</i> .....				
Total.....	126	234	2	

preference is corn land with 140 by the 126 larvæ taken from fifth and probably to this type those listed under the heading located on pasture land. It is *implicita* and *rugosa* are quite shows a preference for wheat first of the 56 grubs of *submucida* This species seems to have a preference. The data on the other species are known that *longitarsa* and *praeter* the Kansas river while *tristis* is on the uplands along Wildcat cre The food preferences of other indicated in Table 8. In the predominance of individuals with given. Analyzing the data by points. *Ochrosidia immaculata* i



Blue Grass	85	15	2	32	8	4	1404	199	9	1	87	25	4	3	1749	279
Lawns...	312	144	2	2	24	15	239	144	610	93	193	106	194	37	1550	526
Oats.....	44	26	118	2	264	41	274	195	48	10	281	139	165	80	1394	744
Corn.....																
Logs and Stumps																
Pasture....	40	8	75	221	3	2	6	3	43	9	40	15	886	107	1201	214
Manure....	78	37	12	141	24	13	3	3	65	26	13	7	195	62	530	155
Orchard....	4	1	18	2	89	2			388	97	194	76	170	63	946	310
Alfalfa....					1	1			37	4	93	10	56	37	192	54
Potatoes...				9	8	3	85	21	805	150	61	21	62	22	1021	217
Garden....				31	1	1	53	15	315	35	115	46	146	64	538	238
Miscellan..	5	2	17	61	103	61	45	26	93	22	510	203	338	140	1370	576
Total....	716	270	302	814	790	372	4004	1431	3044	630	3617	1508	5545	1272	18781	5884

TABLE 7. SHOWING THE FOOD PREFERENCE OF *Phyllophaga* GRUBS

Species of <i>Phyllophaga</i>	Blue Grass and Lawns		Oats	Corn	Logs and Stumps							Miscellaneous	Total
	Wheat	Blue Grass and Lawns			Pasture	Manure	Orchard	Alfalfa	Potatoes	Garden			
<i>P. crassissima</i> .....	23	202	7	45		9	2	2	19	5	45	37	396
<i>P. rubiginosa</i> .....	10	16	1	18	2	16	1	1	16	20	14	20	135
<i>P. rugosa</i> .....	18	4	6	19		3			6	19	36	14	125
<i>P. lanceolata</i> .....	45	1		5		26	1					1	79
<i>P. submucida</i> .....	7		2	6	1	3	56				1	3	79
<i>P. implicita</i> .....	10	1	3	44	1		1	1		2	4	9	76
<i>P. hirticula</i> var. <i>comosa</i> .....	5		9	2		1			6			1	24
<i>P. praetermissa</i> .....	2	8				3							13
<i>P. longitarsa</i> .....	3					5							8
<i>P. bipartita</i> .....	1					1	4						6
<i>P. fulvipes</i> .....		2				1						1	5
<i>P. corvosa</i> .....	1						4						5
<i>P. glabricula</i> .....							4					1	5
<i>P. fusca</i> .....	1		1							1			3
<i>P. crenulata</i> .....				1							1		2
<i>P. tristis</i> .....						1	1						2
<i>P. affabilis</i> .....										1			1
Total.....	126	234	29	140	11	74	62	4	50	46	101	87	964

preference is corn land with 140 individuals which is closely approached by the 126 larvæ taken from wheat. Pasture land with 74 grubs ranks fifth and probably to this type of food should be added a majority of those listed under the heading "manure" which in many cases was located on pasture land. It is perceivable that *crassissima*, *rubiginosa*, *implicita* and *rugosa* are quite generally distributed, while *lanceolata* shows a preference for wheat first and pasture sod second. The majority of the 56 grubs of *submucida* taken under manure were in pasture land. This species seems to have a preference for the upland soils of the region. The data on the other species are limited but from adult collections it is known that *longitarsa* and *praetermissa* prefer the sand hill regions along the Kansas river while *tristis* is usually taken near the oaks growing on the uplands along Wildcat creek.

The food preferences of other larvæ of the family Scarabæidæ are indicated in Table 8. In the total numbers reared wheat shows a predominance of individuals with oats and corn following in the order given. Analyzing the data by species brings out some interesting points. *Ochrosidia immaculata* is taken far more abundantly in wheat

TABLE 8. SHOWING THE FOOD PREFERENCE OF OTHER SCARABÆID LARVÆ

Species	Wheat	Blue Grass and Lawns	Oats	Corn	Logs and Stumps	Pasture	Manure	Orchard	Alfalfa	Potatoes	Garden	Miscellaneous	Total
<i>Ochrosidia immaculata</i> . . . . .	1787	32	143	479	49	79	10	3	141	10	138	199	3070
<i>Ligyryus gibbosus</i> . . . . .	125		189	17		4	11	2	19		1	24	392
<i>Anomala binotata</i> . . . . .	122	2	164	4		1						9	302
<i>Anomala kansana</i> . . . . .	235	1	2	8	2	1			1	1	2	3	256
<i>Anomala innuba</i> . . . . .	5		70			48		12				9	144
<i>Anomala undulata</i> . . . . .		8											8
<i>Cotalpa lanigera</i> . . . . .	113			28			1	6				1	149
<i>Pelidnota punctata</i> . . . . .	2				114						1	1	118
<i>Ligyrodes relictus</i> . . . . .		1				2	120						123
<i>Euphoria inda</i> . . . . .			1				41					4	46
<i>Euphoria sepulchralis</i> . . . . .						3	6						9
<i>Aphodius sp.</i> . . . . .							53						53
<i>Canthon laevis</i> . . . . .						4							4
<i>Trox sp.</i> . . . . .												122	122
<i>Polymoechus brevipes</i> . . . . .					9		2					1	12
<i>Cremastocheilus nitens</i> . . . . .					21								21
<i>Ataenius inops</i> . . . . .							4					77	81
<i>Trichiotinus piger</i> . . . . .						8							8
<i>Stephanucha pilipennis</i> . . . . .							1						1
<i>Polyphylla hammondi</i> . . . . .					1								1
Total . . . . .	2389	44	569	536	204	143	248	17	167	11	142	450	4920

than elsewhere although it occurs rather abundantly in corn and oats. The adults apparently show a preference for land that is frequently plowed. *Ligyryus gibbosus* exhibits the same preference being found in oats and wheat while corn land is not so favorable. The same can be said for *Anomala binotata* while *A. kansana* occurs more frequently in wheat. *Cotalpa lanigera* occurs in wheat and corn usually in the sand hill area. Davis<sup>3</sup> has reported this species doing considerable damage to raspberry bushes, strawberries, corn and grasses.

The following species live in fallen logs and stumps:—*Pelidnota punctata*, *Polymæchus brevipes*, *Trichiotinus piger* and *Polyphylla hammondi*. The table shows 21 individuals of *Cremastocheilus nitens* taken from logs. These were in ant nests on the surface of the soil under a log on the sand dunes. Several species show a preference for manure and

<sup>3</sup>Davis, J. J. Common White Grubs. U. S. Dept. Agr. Farmers' Bull. 940:1-28. figs. 21. 1918.

decaying vegetation such as rotter are *Ligyrodes relictus*, *Euphoria inops* and *Aphodius sp.* The 122 miscellaneous were taken from undecaying

COLLECTIONS OF LARVÆ

The various species of *Tiphia* (larvæ account for the death of many of these collections numerous grubs and the parasite reared to adult. To determine the various species. for the death of one scarabæid larva in the foregoing data, but have shown in Table 9.

TABLE 9. SHOWING THE COLLECTIONS BY TIPHIA

Place Collected	1916	1917	1918
Wheat . . . . .	3		
Sod . . . . .			4
Manure . . . . .	34		
Oats . . . . .			
Under logs . . . . .			6
Pasture . . . . .			1
Corn . . . . .			1
Alfalfa . . . . .			
Orchard . . . . .			
Miscellaneous . . . . .			
Total . . . . .	37	0	12

Of the 359 parasitized grubs, 237 were taken from sod and 34 in or under manure. It is apparent that adult *Tiphia* parasites were taken in large numbers as shown by the numbers taken in that is packed more firmly.

SUMMARY

A study of the collections of 18,781 grubs over eight years in addition to 359 parasitized grubs, a mortality of 68.7 per cent. Of the 31,300 grubs, the genus *Phyllophaga* and the remainder belonged to 20 species of various genera.

D PREFERENCE OF OTHER SCARABÆID LARVÆ

Oats	Corn	Logs and Stumps	Pasture	Manure	Orchard	Alfalfa	Potatoes	Garden	Miscellaneous	Total
143	479	49	79	10	3	141	10	138	199	3070
189	17		4	11	2	19		1	24	392
164	4		1						9	302
2	8	2	1			1	1	2	3	256
70			48		12				9	144
										8
	28			1		6			1	149
		114						1	1	118
			2	120						123
1				41					4	46
			3	6						9
				53						53
			4							4
								122		122
	9			2				1		12
		21								21
				4				77		81
	8									8
			1							1
	1									1
569	536	204	143	248	17	167	11	142	450	4920

occurs rather abundantly in corn and oats. A preference for land that is frequently exhibits the same preference being found in and is not so favorable. The same can be while *A. kansana* occurs more frequently in in wheat and corn usually in the sand this species doing considerable damage to s, corn and grasses.

in fallen logs and stumps:—*Pelidnota*, *Trichiotinus piger* and *Polyphylla ham-* individuals of *Cremastocheilus nitens* taken nests on the surface of the soil under a log species show a preference for manure and

grubs. U. S. Dept. Agr. Farmers' Bull. 940:1-28.

decaying vegetation such as rotten hay or straw stacks. Among these are *Ligyrodus relictus*, *Euphoria inda*, *Euphoria sepulchralis*, *Atænius inops* and *Aphodius sp.* The 122 individuals of *Trox sp.* listed under miscellaneous were taken from under a dead horse.

COLLECTIONS OF LARVÆ PARASITIZED BY *Tiphia spp.*

The various species of *Tiphia* (Tiphidae, Hym.) attacking scarabæid larvæ account for the death of many individuals. During the course of these collections numerous grubs parasitized by *Tiphia* were collected and the parasite reared to adult. No attempt, so far, has been made to determine the various species. However, each parasite accounted for the death of one scarabæid larva. These grubs are not included in the foregoing data, but have been considered separately and are shown in Table 9.

TABLE 9. SHOWING THE COLLECTIONS OF SCARABÆID LARVÆ PARASITIZED BY *Tiphia Spp.*

Place Collected	1916	1917	1918	1919	1920	1921	1922	1923	Total
Wheat.....	3			1	22		20	191	237
Sod.....			4		45				49
Manure.....	34								34
Oats.....							13	11	24
Under logs.....			6						6
Pasture.....			1		1		1		3
Corn.....			1	1					2
Alfalfa.....						1		1	2
Orchard.....						1			1
Miscellaneous.....					1				1
Total.....	37	0	12	2	69	2	34	203	359

Of the 359 parasitized grubs, 237 were collected in wheat land, 49 in sod and 34 in or under manure. Oat land yielded 24 parasitized grubs. It is apparent that adult *Tiphia* prefer to attack grubs in plowed land, as shown by the numbers taken in wheat and oats, rather than in soil that is packed more firmly.

SUMMARY

A study of the collections of 18,781 scarabæid larva over a period of eight years in addition to 359 parasited grubs indicates a rearing mortality of 68.7 per cent. Of the 31.3 per cent reared 964 belong to the genus *Phyllophaga* and the remaining 4,920 specimens matured belonged to 20 species of various genera of the family Scarabæidæ. The

seasonal distribution of the various species is shown, as well as their relative abundance. The collections of *Ochrosidia* (*Cyclocephala*) show a correlation between their presence in the soil and their life history as previously determined by rearing. The habitat preferences of all species are indicated which show, in several instances, a preference for unplowed soil, contrary to the older, accepted statements, that hard, packed soil is more to their liking. The food preferences of the 37 species, as brought out by the studies show some interesting facts as regards the kinds chosen. In addition, the data on the grubs parasitized by *Tiphia spp.* indicate that the parasite is more abundant in plowed soils than in sod land.

MR. L. O. HOWARD: I would like to ask why there is more infestation in cultivated soil than in uncultivated soil.

MR. J. W. MCCOLLOCH: I presume that is associated with the greater ease with which the adult can get into the ground. That is the interpretation put on it at the present time.

MR. ARTHUR GIBSON: Have you found the parasite *Microphthalma* in great abundance?

MR. J. W. MCCOLLOCH: No.

MR. ARTHUR GIBSON: This parasite is quite common in certain sections of eastern Canada including Quebec.

MR. J. W. MCCOLLOCH: We have only two or three records of that.

MR. C. L. METCALF: How did the *Tiphia* parasitism compare in cultivated and uncultivated soils?

MR. J. W. MCCOLLOCH: As near as we can tell it was about the same. In fact, in some cases we got a little higher parasitism in cultivated soil. That may be due to the fact that the grubs were more abundant in the soil.

MR. L. O. HOWARD: Would it attack any white grub?

MR. J. W. MCCOLLOCH: We have not been able to run our various species of *Tiphia* down. We have a mass of material on hand now and we hope to get that done within the next year. Apparently they are the same species, and they attack the different grubs in the same place, which is more or less of a specific character.

FIRST VICE-PRESIDENT W. P. FLINT: The next paper is by A. A. Granovsky.

## ALFALFA "YELLOW TOP"

By A. A. GRANOVSKY, U

ABSTR

The purpose of this paper is definitely of the observations and experimental data, common potato leafhopper, *Empoasca fabae* known as alfalfa "yellows" or "yellow top."

Healthy alfalfa plants in the field and in with leafhoppers collected from the affected

The initial symptoms on older plants were feeding. The young seedlings showed wilting of a single nymph on a young succulent feeding resulted in badly discolored, stunted often killed outright.

The root system of the infested plants was considered an important contributing factor in

Alfalfa "yellows" or "yellow top" has an unknown cause and is looked upon as a perplexing troubles of the alfalfa plant.

It has been reported from year to year as occurring in the alfalfa growing belt of the arid region of North America. Only a few fragments of the alfalfa growing belt of the arid region

Earlier workers observed that the susceptible plants suffer the most and that the affected plants show a gradual discoloration of the apical leaves which becomes yellowing, which in time becomes more orange yellow color with a purplish tinge. The shoots lose their fresh green color much earlier than the leaves. The discolored leaves do not drop throughout the growing season and have a marked effect on the alfalfa foliage. The affected plants which usually results in a great reduction of yield.

The economic aspect of the problem is of great importance. Since that time a number of agronomists and entomologists have paid particular attention to the problem. After considerable effort to isolate a causal agent from portions of the plants, it was evident that the causal organisms could be found constantly on the plants. As a consequence, alfalfa "yellows" has

<sup>1</sup>Contribution from the Department of Economic Entomology, Agricultural Experiment Station.