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Biology and Economic Importance of Seed Chalcids Infesting Red Clover and Alfalfa in Oregon

Agricultural Experiment Station
Oregon State University
Corvallis

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AUTHORS: José L. Carrillo S. is a former graduate student (Rockefeller Foundation Scholarship) at Oregon State University. This bulletin is based on a thesis completed in partial fulfillment of the requirements for his Master of Science degree. Present address: Departamento de Entomologia, Instituto Nacional de Investigaciones Agrícolas, México, D. F., México. E. A. Dickason is associate professor of entomology, Oregon State University.

Biology and Economic Importance of Seed Chalcids Infesting Red Clover and Alfalfa in Oregon

J. L. Carrillo S. and E. A. Dickason

SUMMARY

The seed chalcids of the *Bruchophagus gibbus* (Boh.) complex are members of the family Eurytomidae, order Hymenoptera. They are phytophagus insects that feed in the larval stage within the growing plants of several legumes. They are economically important pests in the seed production of plants such as alfalfa (*Medicago sativa* L.), birdsfoot trefoil (*Lotus corniculatus* L.), crimson clover (*Trifolium incarnatum* L.), and red clover (*T. pratense* L.).

The complex was originally described as a single species, *Eurytoma gibba,* by Boheman in 1836. Subsequently, and up until 1950, this species has been referred to as *Bruchophagus gibbus* (Boh.). Based on host relationships and morphological differences, three different species have been designated in the complex. They are: *B. gibbus* (Boh.) found in red clover, *B. roddi* Guss. found in alfalfa, and *B. kolobovae* Fed. found in birdsfoot trefoil.

Three field generations (broods) of the seed chalcid *B. gibbus* were observed in red clover fields at the Hyslop Agronomy Experimental Farm near Corvallis, Oregon, throughout the season of 1961. Dates for the peak generations were July 14 for the spring brood, August 5 for the summer brood, and September 6 for the fall brood.

Observations on adult feeding were made in the laboratory. Although the adults seemed to feed on the calyx teeth of the florets on red clover heads, no definite conclusions were obtained on adult feeding. Adult activity in the field had a closer relationship to sunlight than to temperature. No valid conclusions were drawn from the study on the dispersal of adults in the field; however, it is of interest that the flight recoveries were at right angles to the dominant winds. Chalcid infestation in red clover heads exposed to the overwintering and first field generation was low when compared to chalcid infestation in heads exposed to the second and third field generations. The seed chalcid overwinters in the larval stage under field conditions, but completes development during the winter months under laboratory conditions.

Three known hosts were sampled in the Willamette Valley of Oregon; birdsfoot trefoil, crimson clover, and red clover. Although seed samples of these three hosts were maintained in the laboratory, chalcids were reared only from red clover. This suggests that the only species present in the Willamette Valley samples was *B. gibbus*.

Alfalfa and red clover seed samples were brought from 14 Oregon counties for adult rearing in the laboratory in the fall of 1960. Adult emergence started in the same month of collection in samples of both hosts. Peak emergence of *B. gibbus* was reached in January in the red clover samples, while peak emergence of *B. roddi* was reached in February in the alfalfa samples.

In the clover seed samples, infestation of the chalcid by geographical areas varied as follows: eastern Oregon, from 15.8 to 21.5 percent with an average of 18.5 percent; south-central Oregon, from 2.06 to 5.4 percent with an average of 3.73 percent; western Oregon, from 0.06 to 11 percent with an average of 3.03 percent; and northeastern Oregon, 1.3 percent. Infestation of the seed chalcid in the samples of alfalfa seed by geographical areas varied as follows: central Oregon, 28.9 percent; eastern Oregon, from 0.04 to 33.7 percent with an average of 10.88 percent; northeastern Oregon, from 0.5 to 14.5 percent with an average of 6.83 percent; southwestern Oregon, 0.2 to 2.2 percent with an average of 1.01 percent; and south-central Oregon, 0.4 percent. It is evident from the above discussion that the seed chalcid *B. gibbus* caused economic damage to the clover seed samples from eastern Oregon. Similarly, the seed chalcid *B. roddi* caused economic damage to the alfalfa seed samples from central, eastern, and northeastern Oregon.

Four parasite species of the seed chalcid were reared from the clover seed samples: *Habrocytus medicaginis* Gahan, *Liodontomerus longfellowi* (Girault), *Tetrastichus bruchophagi* Gahan, and *Trimeromicrus maculatus* Gahan. In the alfalfa seed samples parasites reared were: *Amblymerus bruchophagi* (Gahan), *H. medicaginis*, *L. perplexus* Gahan, *T. bruchophagi*, and *T. maculatus*. Percentage of parasitism averaged 3.18 percent in the clover seed samples, and 23.12 in the alfalfa seed samples. This is the first record of the following parasite species from Oregon: *A. bruchophagi*, *L. perplexus*, and *T. maculatus*.

Seasonal population of the parasite *L. longfellowi* was followed in relation to the life history studies of *B. gibbus* in the Willamette Valley of Oregon. Two peak generations of the parasite were observed; the first occurred four days after the peak of the second seed chalcid generation was reached; the second parasite peak occurred two weeks after the peak of the third seed chalcid generation.

INTRODUCTION

Seed chalcids of the *Bruchophagus gibbus* (Boh.) complex are members of the family Eurytomidae, order Hymenoptera. They are phytophagous insects that feed within the growing seeds of several leguminous plants, while in the larval stage. They are economically important pests in the seed production of alfalfa, (*Medicago sativa* L.) ; birdsfoot trefoil, (*Lotus corniculatus* L.) ; crimson clover, (*Trifolium incarnatum* L.); and red clover, (*T. pratense* L.).

A study of the biology of legume-seed chalcids was undertaken to acquire knowledge of these insects in Oregon. Seed infestation records for only three Oregon locations were found in the literature reviewed, although studies on seed chalcids have been made in other areas of the United States and the world.

Research was started in the fall of 1960 by collecting a number of alfalfa-and red-clover seed samples in several locations in 14 Oregon counties. During the following year, biological studies in the field were carried out at the Hyslop Agronomy Experimental Farm, near Corvallis, Oregon.

REVIEW OF THE LITERATURE

The first contribution to the knowledge of the chalcids was the original description by Boheman (1836), who described the species from Europe as *Eurytoma gibba.* Howard (1880) described the insect from the United States as *E. funebris* and stated that it was very close to the European species *E. gibba.* He erroneously considered the insect as a parasite of the clover seed midge, *Dasyneura leguminicola* (Lintner). His described species was moved to the genus *Bruchophagus* by Ashmead (1894) and later *B. funebris* was found to be a synonym of *B. gibbus.*

Hopkins (1896) first discovered the phytophagous habit of the insect. After this discovery, contributions leading to the knowledge of seed chalcids have been published by many workers relating to such aspects as distribution, biology, hosts, parasites, economic importance, and control (Titus, 1904; Folsom, 1909; Urbahns, 1916, 1917, 1919, 1920; Sorenson, 1930; Vinogradov, 1941; De Figueiredo and Lima, 1942; App, 1960; Smith and Franklin, 1961).

Based on host relationships, Kolobova (1950) reported (from the Soviet Union) the existence of three different races of the species that had been known as *B. gibbus* (Boh.). These relationships were studied in the United States by Neunzig and Gyrisco (1958, 1959) who found that *B. gibbus* was restricted to red clover and *Trifolium*

medium; B. roddi Guss. to alfalfa and *Medicago falcata;* and *B. kolobovae* Fed. to plants of the genus *Lotus.* Morphological characters for separating the species of the complex were pointed out by Strong (1962).[1]

Distribution

The geographical origin of the seed chalcids which attack legumes is uncertain. They are cosmopolitan in distribution (Muesebeck, 1951); apparently they may occur wherever the host plants produce seeds. *Bruchophagus gibbus* (=*B. roddi*) has been known to occur in Germany, Turkestan, Chile, Turkey, and Siberia (Urbahns, 1914). The species has also been reported from South Africa (Urbahns, 1920). Alfalfa seed arriving in Brazil from France and the Canary Islands was found to be infested by a seed chalcid (De Figueiredo, 1942). The complex was found to be present wherever clover was cultivated in the Soviet Union (Vinogradov, 1941), and has been considered a widely distributed pest of clover and alfalfa seed there (Kolobova, 1950). The chalcid was reported to occur in Canada as a pest of alfalfa seed (Treherne, 1919), and it was also reported in Mexico causing important losses in alfalfa-seed production (Gibson and Carrillo, 1959).

The first United States record of the seed-chalcid complex was in the District of Columbia (Howard, 1880). In this country the seed-chalcid complex apparently occurs wherever red clover or alfalfa are grown; it is economically important in areas where the crops are grown for seed, that is, the western and southwestern states (App, 1960). The distribution of the complex by states has been recorded chronologically as follows: California, Colorado, Illinois, Indiana, Kansas, Michigan, Minnesota, Mississippi, New York, Oregon, Rhode Island, Vermont, Virginia, and Washington (Titus, 1904); Delaware, Ohio, and West Virginia (Folsom, 1909); Arizona (Morrill, 1913); Idaho, Iowa, Maryland, Massachusetts, Missouri, Nebraska, Nevada, New Hampshire, New Mexico, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, and Utah (Urbahns, 1920).

Oregon distribution was recorded in literature at Corvallis (Titus, 1904), and Albany and Pendleton (Urbahns, 1920), although

[1] Recently, in the Report of the Eighteenth Alfalfa Improvement Conference (October 1962), Dr. Strong reported that an English worker has declared that the name *Bruchophagus gibbus* (Boh.) is invalid and that the seed chalcid reared from red clover is *B. platyptera* (Wlk.).

there were unpublished accounts of the insect complex occurring in most small-seeded legume producing areas of the state. During this study, the insect complex was found in the following Oregon counties: Benton, Clatsop, Columbia, Deschutes, Jackson, Klamath, Lincoln, Linn, Malheur, Marion, Polk, Umatilla, Washington, and Yamhill.

Economic Importance and Hosts

Hopkins (1896), while examining a sample of stored, ripened heads of crimson clover (*Trifolium incarnatum* L.) found that the chalcid was not a parasite of the clover seed midge, *Dasyneura leguminicola* (Lintner), as it had been considered. He found that the insect was breeding in the seed, and that scarcely a seed could be found in the sample which was not infested. He stated that the chalcid was far more destructive to the growing seed crop of crimson and red clover (*Trifolium pratense* L.) than the clover seed midge. The species he found in clover seeds is presently known as *Bruchophagus gibbus* (Boh.). Breeding of the *B. gibbus* (=*B. roddi*) in alfalfa seed (*Medicago sativa* L.) was first reported by Titus (1904). The first record reporting infestation of the *B. gibbus* (=*B. kolobovae*) in birdsfoot trefoil (*Lotus corniculatus* L.) was that of Vassiliev (1914).

The species involved are economically important since they cause important losses, sometimes very high, to the seed production of several cultivated plants such as alfalfa, crimson clover, red clover, and birdsfoot trefoil. The chalcids do not cause damage to any other part of the plant but the seeds. Damage is caused by the larvae of these insects which develop inside the seeds; they may eat everything except the seed coat. The hollow seeds (Figure 1) left by the larvae are easily blown out with the chaff when the crop is harvested, thus growers are not always aware of the amount of infestation (Webster, 1906).

Burks (1957), gave the following list of hosts (all of Leguminosae) for *B. gibbus: Astragalus* sp., *Lespedeza* sp., *Lotus corniculatus, L. decumbens, Medicago arabica, M. falcata, M. hispida, M. ruthemia, M. sativa, M. tornata, M. tuberculata, M. tunetana, Melilotus sp., Oxytropis lambertii, Trifolium incarnatum, T. pratense,* and *Trigonella* sp. In addition to *B. gibbus* from these hosts, he also included in the list the species *B. kolobovae* Fed. from birdsfoot trefoil and *B. roddi* Guss. from alfalfa.

Figure 1. Photograph of red clover seeds showing seeds with adults emerging, exit holes in seeds from which adults have emerged, and adults of *Bruchophagus gibbus* (Boh.).

RESEARCH PROCEDURE

Sampling to study the abundance of the clover seed chalcid was carried out at the Hyslop Agronomy Experimental Farm near Corvallis, Oregon. Unless otherwise specified, the numbers of chalcids recorded are those recovered in 100 sweeps with a 15-inch insect net.

For the study of dispersal of adults in the field, 12 by 12 inch cardboards were fastened to stakes two feet from the soil surface. The yellow-painted surface of the boards was smeared with Deadline,[2] a sticky substance.

Insects brought to the laboratory for studies on adult feeding, mating, and oviposition were caged with a clover head in either a

[2] Deadline is manufactured by the California Spray Chemical Company; butylene polymers 93 percent and inert ingredients 7 percent.

lamp chimney (Figure 2A) or a box made out of glass microscope slides (Figure 2B).

Females brought from the field to study fecundity were placed in 70 percent alcohol in a Syracuse dish. Under a microscope, the abdomen was dissected at about the third segment, and the eggs removed.

The seeds from the heads exposed to oviposition by the chalcids were hand removed (one by one) and dissected under a microscope. The same technique was used to examine seeds brought from the field to study the life-cycle and infestation of the chalcid.

Alfalfa and red clover seed samples were collected from several locations in 14 Oregon counties for laboratory rearing of the chalcids. Alfalfa seed samples were made by collecting 100 racemes at random from one field in each location. Red clover seed samples were made by collecting 100 heads at random from one field in each location. One hundred heads of crimson clover and 100 pods of birdsfoot trefoil were collected in one location in Benton County. In all the cases, the samples collected were threshed by hand, and the seeds were

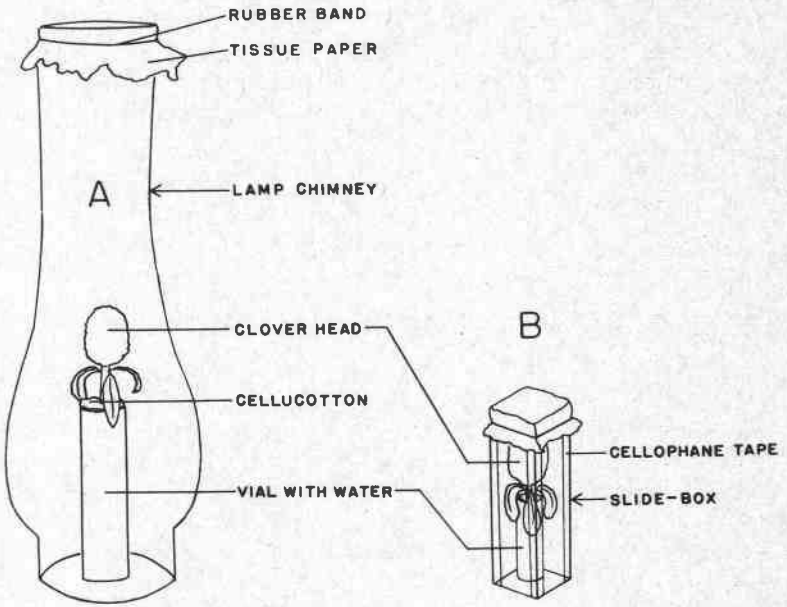

Figure 2. Sketches of the types of cages used to study adult feeding, mating, and oviposition of the clover seed chalcid, *Bruchophagus gibbus* (Boh.): A. Glass lamp chimney. B. Glass microscope slides fastened together to form a box.

kept in individual rearing cartons under laboratory conditions at room temperature.

The samples were examined for adult emergence once or twice a week. The emerged adults were preserved in vials with 70 percent alcohol, noting the sample from where they emerged and the date of emergence in each vial.

Seed chalcids and their chalcid parasites were identified using the key given by Butler and Hansen (1958). Identification of a synoptic collection of 38 specimens of seed chalcids and 30 specimens of 6 parasitic species was confirmed by Dr. B. D. Burks.[3] For subsequent identification, the rest of the specimens obtained were compared with the confirmed species.

Determination of the extent of seed chalcid infestation in the alfalfa and red clover seed samples was based on emergence of adults in the field prior to sampling, emergence of adults in the laboratory, and mortality of larvae, pupae, and adults in the seeds. In any of these three cases, chalcids or parasites might have been involved. The emergence of adults in the field was calculated by counting the number of hollow seeds and the adults emerged in the laboratory in each sample. If the number of hollow seeds was larger than the number of chalcids emerged, the difference was considered as the field emergence. Numbers of chalcids and parasites which emerged from samples kept in the laboratory were obtained from the records of adult emergence. Mortality percent in the seeds was based on the number of larvae, pupae, and adults found dead in a subsample of 1,000 seeds selected at random from each sample.

[3] Appreciation is expressed to Dr. Burks, United States National Museum, for confirming identification of specimens.

RESULTS

Life History and Habits

Seasonal history

Red clover fields at the Hyslop Agronomy Experimental Farm were sampled with an insect sweep net at intervals of about one or two weeks starting late in March 1961. By that time the clover plants were starting to grow, averaging about four to five inches in height. The following discussion is based on the male and female population shown in Figure 3. Since this study was conducted in red clover, the following discussion of life history refers to the species *Bruchophagus gibbus*. The overwintering generation of the clover seed chalcid first appeared at some time between the sampling periods of May 23 and June 1, since the latter was the date of the first recorded recovery. Warmer weather as compared to cold winter weather preceded the emergence date. The clover plants were 24 to 26 inches high, showing an estimated average of six blossoms per square yard. From this period on, it was estimated that seed was available for oviposition in the field throughout the remainder of the growing season.

Three adult generations developed in the field. The overwintering and first field generations (spring brood) apparently were mixed, at

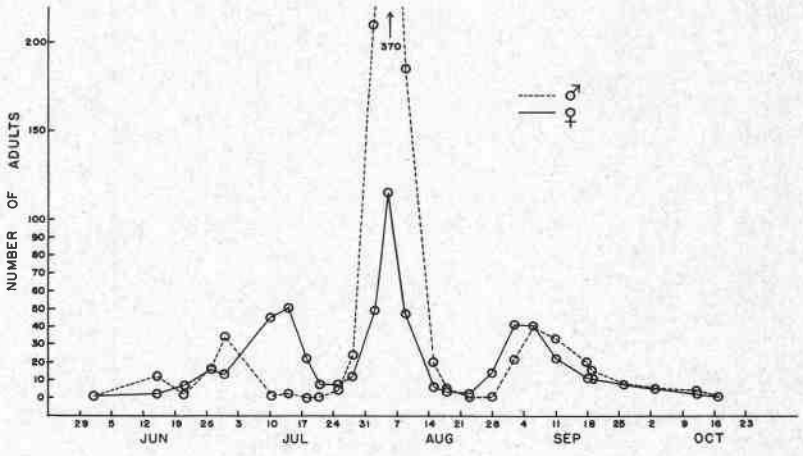

Figure 3. Variation of the male and female populations of the clover seed chalcid, *Bruchophagus gibbus* (Boh.), in red clover fields at the Hyslop Agronomy Experimental Farm throughout the season of 1961.

least in the final emergence of the former and starting emergence of the latter. This is based on the fact that recently developed clover heads were collected in the field on June 21 and brought to the laboratory for examination of the seeds. Four full grown larvae were found in the seeds of one of the heads. Under laboratory conditions, one of the larvae reached the adult stage on July 10. The highest population of the first field generation (spring brood) was recorded on July 14. At about this time, field sampling was continued at shorter intervals, that is, once or twice a week.

The second generation (summer brood) was isolated from the first. Adults of this generation started to emerge on the third week of July. This was the largest generation in number of adults, and the highest population density was reached within two weeks. This point was nine and six times as great as the corresponding points for the first (spring brood) and third (fall brood) generations, respectively. The second generation coincided with the warmest period of the summer. After the highest point was reached, the population dropped down rapidly. As a result, by the third week of August the second generation had almost disappeared from the field.

At about this time the adults of the third generation started to emerge. A fairly rapid increase in population took place, and again the highest density was reached within two weeks. From this point, the population decreased slowly. Adults were found during the following four weeks in decreasing numbers, until they finally disappeared from the field by the third week of October. The first frost of the year was reported on October 8 at the Hyslop Farm, lasting from 3:30 a.m. to 8:15 a.m. However, sampling was continued up to December 7.

The variation of the sex ratio of the clover seed chalcid in the field throughout the season is shown in Table 1. Females were always present in the field, although in low numbers when the populations of the first and second generations diminished. Males apparently disappeared from the field at the two lowest levels between field generations. In the first field generation, females predominated over males. Males predominated over females in the second generation, and the average sex ratio recorded for the third generation was 1:1.

Adult feeding

No definite conclusions were obtained on adult feeding. Adults were brought from the field to the laboratory. They were kept in glass containers with available young red clover heads. Clover heads did not seem too attractive to adults, although many were observed visiting the heads at different times. In only a few instances did it

TABLE 1. SEX RATIO OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), THROUGHOUT THE SEASON OF 1961 AT THE HYSLOP FARM, CORVALLIS

Generation and sampling date	Number of adults in the sample	Sex ratio (males vs. females)
OVERWINTERING PLUS FIRST GENERATION		
June 1	2	1:1
June 15	14	6:1
June 21	9	1:3.5
June 27	33	1:1
June 30	47	2.6:1
July 10	46	1:45
July 14	52	1:25
July 18	22	0:22
July 21	8	0:8
Total adults and average sex ratio	233	1:2.3
SECOND GENERATION		
July 25	11	1:1.7
July 28	36	2:1
August 2	259	4.3:1
August 5	486	3.2:1
August 9	232	3.9:1
August 15	26	3.3:1
August 18	8	1.6:1
August 23	2	0:2
Total adults and average sex ratio	1,060	3.4:1
THIRD GENERATION		
August 28	14	0:14
September 2	62	1:2
September 6	79	1:1
September 11	55	1.5:1
September 18	31	2:1
September 19	26	1.5:1
September 26	14	1:1
October 3	8	1:1
October 12	4	3:1
Total adults and average sex ratio	293	1:1
SEASONAL TOTAL	1,586	
AVERAGE		1.8:1

appear that adults were feeding. If they did, they fed mostly in the area of the calyx teeth, since they seemed to move their mouth parts on these floral parts. However, when the florets were closely examined, no apparent damage was visible.

Fecundity

Mating was observed under laboratory conditions when males and females were confined in a lamp chimney with a clover head or confined in glass vials.

Potential fecundity was measured by dissecting the abdomen of gravid females and recording the numbers of eggs or oöcytes (Table 2). Females for this purpose were collected in the field throughout the season. They were dissected as soon as possible after collection. The number of eggs per gravid female varied from 1 to 95. The average number of eggs per gravid female, based on 166 dissections, was 21.05. Of the total of 185 females dissected, 89 percent were gravid. Apparently the eggs were more numerous in females of the second field generation than in those of the first and third generations. No definite conclusions are drawn on actual fecundity, since it was not known whether the females had oviposited in the field before they were collected.

Sorenson (1930), working with chalcids from alfalfa found that in 50 gravid females the number of eggs varied from 24 to 66 with an average of 42.24. The minimum number and the average that he found were higher than the minimum and average obtained during this study.

Oviposition

Attempts to observe oviposition in the field were not successful, probably because of the low numbers of adults present when the observations were made. Observations on chalcid oviposition were then attempted under laboratory conditions. Adults brought from the field were kept in either a glass chimney or a slide box. Clover heads with young seeds developing were available to the insects. In a few instances the adults visited the heads, but they remained at the top of the cage most of the time.

In only one instance was oviposition activity observed. The female, after walking around the head, entered and located itself in one floret just inside the calyx teeth, between the calyx and the petals. It died in this position, with the ovipositor extended toward the seed. When the seeds of the head were dissected one week later,

TABLE 2. NUMBERS OF EGGS (OÖCYTES) FOUND IN THE ABDOMEN OF DISSECTED GRAVID FEMALES OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), COLLECTED IN RED CLOVER FIELDS AT THE HYSLOP FARM, CORVALLIS, 1961

Collection date	Gravid females dissected	Maximum number of eggs per sample	Minimum number of eggs per sample	Average number of eggs per female
June 21	14	32	3	10.9
June 27	10	23	3	10.4
June 30	8	17	3	12.5
July 5	4	25	11	18.2
July 10	10	30	11	18.3
July 14	5	12	1	6.5
July 18	4	9	2	4.8
July 25	4	6	1	2.8
August 2	10	76	7	34.9
August 5	10	70	5	24.3
August 9	10	75	10	34.6
August 15	6	95	35	59.7
August 18	3	25	13	19.7
August 23	2	12	11	11.5
August 28	14	30	7	18.8
September 2	10	63	15	30.9
September 6	10	25	4	13.3
September 11	10	34	7	14.8
September 18	5	60	20	38.0
September 19	5	35	11	21.6
September 26	7	33	6	17.1
October 3	4	45	31	38.2
October 12	1	....	....	15.0
Total number of females	166			
Average number of eggs per female				21.05

the seed in which the female had oviposited contained one small larva. The egg was apparently deposited just inside the seed coat and hatched within one week. The small larva had started to feed on one of the cotyledons. Eight more small larvae from heads of other oviposition cages were found. Unlike the observed example, they were located between the cotyledons of the seed.

It was noticed that some of the females readily laid eggs on the wall of the vials used to collect them in the field. They also laid eggs on the glass of the cages used in the laboratory. The eggs were encircled with wax pencil to observe them daily. In all cases, the eggs laid on glass failed to hatch. Five females were kept in indi-

vidual vials and the number of eggs laid on the glass by each female was counted. The numbers of eggs laid varied from 10 to 37 with an average of 23.2 eggs.

The eggs laid on the glass cages had the same shape as those seen when females were dissected. They were white, opaque, elliptical, with one end rounded and the other bearing a long stalk, and about 0.2 mm. in length.

Incubation periods in alfalfa were reported as being from 7 to 12 days in the spring in Pasadena, California (Urbahns, 1920), and from three to six days during the summer in Fort Duchesne, Utah (Sorenson, 1930).

Larvae

Several hundred field-collected young seeds from red clover heads were dissected in the laboratory and larvae of the clover seed chalcid were found in various stages of growth. Small larvae were of about the same size as an egg. The full grown larvae were white, stout, without legs, somewhat C-shaped, and about 2 mm. in length. The mouth parts consisted of a pair of brown, sharp, opposable mandibles.

Attempts to rear larvae outside of the seeds were not successful. The main difficulty in rearing larvae was maintaining the seeds in which they were found in satisfactory condition in the laboratory. The seeds dried and shrank before the larvae, particularly the small ones, could develop any further. The larvae were transferred to clover seeds freshly collected from the field, of about the same stage of development as those in which the larvae were found, but in all the cases they died.

Smith and Franklin (1961), working with chalcids in alfalfa, had similar difficulties in studying the larval stages. They brought apparently oviposited seed pods to the laboratory. When the seeds were examined, they were dried and shrunken and no larvae were found inside.

Sorenson (1930), worked with caged larvae of the chalcid on alfalfa in the field. He reported a feeding period varying from 10 to 15 days with an average of 10.5 days. Urbahns (1920), reported that under the most favorable conditions the larvae of the chalcid on alfalfa completed development in 12 days, whereas in early spring this period was prolonged to 30 days.

Pupae

The pupal stage was studied under laboratory conditions. Seeds of red clover heads brought from the field contained either larvae or pupae in different stages of development. Full grown larvae were

separated and placed on paper toweling in petri dishes; about 50 percent of them died either before pupation or during the pupal period. Dates of pupation and emergence for the individuals which reached the adult stage are recorded in Table 3.

The duration of the pupal stage varied from 7 to 9 days with an average of 7.9 days for the 10 individuals reared from red clover.

Sorenson (1930), working with chalcids in alfalfa, reported a pupal period ranging from 8 to 16 days with an average of 11.8 days during the summer in the laboratory, and from 7 to 10 days under field conditions. Urbahns (1920) reported an average duration of 30 days for the pupal period early in spring, and from 6 to 10 days in midsummer for the chalcids in alfalfa.

Newly formed pupae were white. Approximately one day after pupation began, some areas of the body started to darken. Within three days, the head, the antennae, the thorax, and the legs became brownish-white, as well as a narrow colored strip along the ventral midline of the abdomen in female specimens. The eyes became red and the mouth parts brown. On the fourth day, the femur and the tibia of the third pair of legs became black. The first three segments of the abdomen showed distally on the dorsum a black band covering about one third of the area of each segment.

By the fifth day, the areas which were brownish-white two days before became black, as well as the dorsum of the abdomen. The venter of the abdomen and the wings remained light colored. The following day, with the exception of the red eyes and the light

TABLE 3. PUPATION PERIOD OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), UNDER LABORATORY CONDITIONS, CORVALLIS, 1961

Larva number	Date of collection of the larva	Date of pupation	Adult emergence date	Length of pupation period
1.	June 21	July 1	July 10	9 days
2.	Aug. 18	Aug. 24	Aug. 31	7 days
3.	Aug. 18	Aug. 24	Sept. 1	8 days
4.	Aug. 18	Aug. 24	Sept. 1	8 days
5.	Aug. 18	Aug. 26	Sept. 4	9 days
6.	Aug. 18	Aug. 26	Sept. 4	9 days
7.	Aug. 18	Aug. 27	Sept. 4	8 days
8.	Aug. 23	Aug. 28	Sept. 4	7 days
9.	Aug. 23	Aug. 29	Sept. 5	7 days
10.	Aug. 28	Aug. 28	Sept. 4	7 days
Average				7.9 days

colored tarsi, all the body appeared black. No more changes were observed until the adult emerged.

Adults

The adult emerges from the seed through a round exit hole made either by the larva or by the adult itself (see Figure 1).

Dispersal. A preliminary study on dispersal of adults in the field was attempted at the Hyslop Farm in the summer of 1961. The field available for the study was about 500 feet long and about 200 feet wide. About one-half of the area had unclipped red clover with mature heads. There were three other legumes in smaller areas within the experimental area; of these, alfalfa and birdsfoot trefoil were known hosts of the seed-chalcid complex. The nearest red clover fields were located about 400 feet south and 1,000 feet east of the experimental field. The experiment started when the chalcids of the third generation were present (Figure 3). It was learned later that this generation produced a low number of adults.

Recoveries were too low to draw any valid conclusions on the traps located outside of the field. However, it was observed that the flight recoveries were at right angles to the prevailing winds, which came from the west.

The traps placed within the area of clipped, newly headed red clover, trapped individually more insects than any others. This may suggest that adults were more abundant in this area than in the others. From this group, trap number 9 recovered four times as many chalcids as any other (Table 4). It was noticed that this trap received more sunshine during the day than the others of the group. The reflection of the sunshine from the smeared surface possibly attracted the chalcids.

Urbahns (1914) reported that chalcids in alfalfa are very active in their flight, and may be carried long distances by summer winds. He stated that chalcids were observed in great numbers carried by the winds on a hot summer day, alighting on almost any object in their course.

Host preference. Fields of four different hosts of the seed-chalcid complex were sampled with an insect sweep net at the Hyslop Farm during the season of 1961. The hosts were crimson clover, birdsfoot trefoil, alfalfa, and red clover.

Crimson clover was sampled between May 11 and June 15 at weekly intervals, while the plants were blooming. No adults were recovered by sweeping in this known host. A seed sample of crimson

TABLE 4. ADULTS OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), TRAPPED ON YELLOW PAINTED 12 BY 12 INCH CARDBOARDS SMEARED WITH AN ADHESIVE, HYSLOP FARM, CORVALLIS, SUMMER 1961

Trap number	Location of trap	Direction trap faced	Number of adults				
			First trial		Second trial		Total of two trials
			24 hr. count	72 hr. count	5 day count	12 day count	
1	North of field	Mixed legumes	1	0	0	0	1
2	North of field	Unclipped red clover	0	0	1	0	1
3	East of field	Unclipped red clover	0	0	0	0	0
4	South of field	Unclipped red clover	0	2	3	0	5
5	South of field	Clipped red clover	0	1	2	0	3
6	West of field	Mixed legumes	0	0	0	0	0
7. [a]	Clipped red clover	North	1	1	4	1	7
8. [a]	Clipped red clover	East	0	0	3	3	6
9. [a]	Clipped red clover	South	10	18	2	6	36
10. [a]	Clipped red clover	West	0	3	6	0	9
11. [b]	Between fields	Clipped red clover	0	2	0	0	2
12. [b]	Between fields	Unclipped red clover	0	0	0	0	0
13	Alfalfa	West	0	1	0	0	1
14	Alfalfa	East	1	1	1	0	3

[a] Traps formed as a square almost touching at the edges.
[b] Between clipped and unclipped red clover.

clover was collected on July 14, and maintained in the laboratory for possible adult emergence. No adults were obtained from this sample.

Birdsfoot trefoil was sampled throughout the season at intervals of about one or two weeks. Chalcids were occasionally collected from this host in low numbers. The highest number of chalcids (486 per 100 sweeps) was collected in red clover; in birdsfoot trefoil the number of chalcids obtained was six per 100 sweeps. There were some isolated plants of red clover within the field of birdsfoot trefoil. This raises the possibility that the few chalcids collected in this field were actually *B. gibbus* after the isolated clover plants, and that *B. kolobovae* was not present. A birdsfoot trefoil seed sample was collected on August 18 and taken to the laboratory for possible adult emergence. No adults were obtained from this sample.

Alfalfa was sampled at irregular intervals. In some instances no chalcids were collected, particularly where pure alfalfa was growing in the sampled area. However, in areas where isolated plants of red clover were present, chalcids were found. Adult emergence from alfalfa seed samples could not be observed, since the available plants did not produce any seeds. Possibly *B. roddi* was not present in the area.

Red clover was sampled throughout the season, as previously mentioned. This host was preferred by the chalcids, which strongly suggests that only *B. gibbus* was present in this area. Whenever clover fields were sampled during the season, chalcids could be obtained (Figure 3). A seed sample of red clover, collected in the sampled area during the fall of 1960, was maintained in the laboratory, and 11 percent of the seeds were infested. Red clover seed samples collected in the fall of 1961 from this area ranged from 6.3 to 33.46 percent infested.

Seasonal infestation. An experiment on seasonal infestation of the clover seed chalcid in red clover was started about the third week of July 1961 at the Hyslop Farm. The plants in one of the two areas selected had been clipped recently, and a few flower buds were present. Ten plants were selected in this area. The flower buds present were tagged with the date, and a number assigned to each one. New buds which appeared later were similarly tagged.

The other area selected had plants which were not clipped. Mature heads of five plants in this area were also tagged in order to compare the infestation of the chalcid before the experiment started with infestation during the experiment. At the end of the season, heads of both areas were harvested and taken to the laboratory to examine the seeds.

In the clipped areas, 108 heads were harvested; from these, 31 did not produce seeds. Three different intensities of seed infestation were noticed (Table 5). The first occurred on the heads tagged on July 21, July 25, and July 28. Seed infestation of the heads tagged on August 3, August 9, and August 15 was lower than the infestation of the three previous dates. Availability of heads to be infested by the chalcids in the field was presumably higher in the period August 3 to August 15 than in the previous and following periods; however, this cannot be demonstrated. A third intensity of seed infestation was noticed on the heads tagged on August 22 and September 2; this was definitely higher than the infestation to the seeds of the two previous periods. It might be possible that the seed infestation appeared heavier in the last period because at that time chalcid oviposition to produce the overwintering generation was taking place. Percentage of infested heads appeared also to be higher in the last period. There was no visible relationship between the variation of the chalcid population in the field (Figure 3) and the seed infestation as shown in Table 5.

In the unclipped area, 56 heads were harvested; from these, 22 did not produce seeds. Of the 34 seeded heads, 52.94 percent were infested. The percent of infestation of the 1,032 seeds in the seeded heads was 4.06.

The percent of infested heads on unclipped plants was lower than the average percent of infested heads on clipped plants. Also, the percent of infestation of the seeds of the unclipped plants was about four times lower than the average percent of seed infesta-

TABLE 5. SEASONAL INFESTATION OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), IN CLIPPED NEWLY HEADED RED CLOVER PLANTS, HYSLOP FARM, CORVALLIS, SUMMER 1961

Date tagged	Number of plants	Number of heads	Number of seeds	Percent of heads infested	Percent of seeds infested
July 21	3	4	82	75.0	15.85
July 25	3	6	335	66.6	16.41
July 28	5	6	276	83.3	17.75
August 3	4	8	428	75.0	6.30
August 9	7	14	773	57.1	8.15
August 15	6	16	900	62.5	6.55
August 22	8	12	517	91.6	33.46
September 2	6	11	317	81.8	24.60
Total		77[a]	3,628		
Average				74.11	16.13

[a] Includes only heads that produced seeds; 108 were actually tagged.

tion of the clipped plants. Heads on plants which were not clipped were exposed to chalcids of the overwintering and first generations. Heads on clipped plants were exposed to chalcids of the second and third generations, which produced a higher number of adults than the overwintering and first generation (Figure 3). This may explain the difference in chalcid infestation between the plants of the two areas studied.

Field activity. Flight of adults between plants was slow, and it was possible to follow them visually. Sometimes they hovered near a clover head and then alighted on it, or they would settle on the stems of clover or adjacent weeds. They walked around for brief periods on the plants and then resumed flight.

Activity of the chalcids at four different times during the day was studied on August 9, 1961, in a red clover field at the Hyslop Farm. The times were 6:00 a.m., 12:00 noon, 6:00 p.m., and 12:00 midnight (Pacific standard time). Activity was measured by the number of adults per 25 sweeps recovered at each sampling time.

Activity of the chalcids at 12:00 noon, when 97 adults were recovered, was the greatest recorded. Activity of the chalcids at 6:00 a.m. and at 6:00 p.m. was about the same, with 46 and 48 chalcids recovered at these sampling times, respectively. The lowest activity of the chalcids was recorded at 12:00 midnight. Sixteen chalcids were recovered at that sampling time.

There was no apparent relationship between the temperatures registered at the sampling times and the activity of the chalcids. The highest temperature, 81° F., was registered at 6:00 p.m., whereas the lowest temperature, 54° F., was registered at 6:00 a.m. At noon, when the greatest activity was recorded, the temperature registered was 70° F., and at midnight the temperature registered was 61° F. This suggests a possible relationship to sunlight rather than to temperature.

Overwintering. Four samples of red clover seed were collected in the field at different dates during the fall and the winter of 1960-61. Later sampling from this area was not possible, because the clover heads weathered and shattered in the field. The four samples were kept frozen in the refrigerator until the seeds could be examined in the laboratory. From each sample, 1,000 seeds were selected to examine.

The numbers of larvae found within the seeds of the samples (Table 6), compared with the absence of pupae and adults, indicates that the clover seed chalcid overwinters in the field in the larval stage.

TABLE 6. OVERWINTERING OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), UNDER NATURAL CONDITIONS BASED ON 1,000 SEED SAMPLES FOR EACH COLLECTION DATE, CORVALLIS, 1960-61

Sample	Collection date	Larvae	Pupae	Adults
I	October 14	166	0	0
II	November 30	160	1	0
III	January 27	180	0	0
IV	March 20	166	0	0

A seed sample brought from the same area was maintained under laboratory conditions at room temperature. Adult emergence continued from September, the month of collection, until February. This showed that the insects in the seeds held at room temperature completed development without interruption, whereas those in the field remained in the larval stage throughout the winter. Chalcid infestation of the sample held at room temperature was 9.7 percent.

Parasites in the field

One of the known parasite species of the clover seed chalcid occurred at the Hyslop Farm during the 1961 crop season. This parasite was *Liodontomerus longfellowi* (Girault). The parasite population was sampled in conjunction with the population sampling of the clover seed chalcid. The parasite appeared in the field about three weeks after the clover seed chalcid. Small numbers of parasites were recovered from the samplings up to the end of July (Figure 4A). At that time numbers of the second generation of the clover seed chalcid started to rise (Figure 3).

Two peaks of the parasite population were recorded. The first peak occurred on August 9, four days after the peak of the second generation of the clover seed chalcid was reached. The second parasite peak occurred on September 19. The average sex ratio recorded through the season for a total number of 520 parasites was 1:1 (Figure 4A). The parasite disappeared from the field by the third week of October.

Females of the clover seed chalcid are responsible for the seed infestation on the host plants, since they lay eggs to perpetuate the species. On the other hand, females of the parasite help in reduction of the chalcid population by ovipositing on the chalcid larvae, producing parasites instead of chalcids. For this reason, the difference in variation of female populations between the two species was studied.

At the time the first field generation of female chalcids was present female parasites occurred in low numbers (Figure 4B). When the first generation of seed chalcids reached its peak abundance, 50 females per 100 sweeps were recovered; the highest number of female parasites recovered during the first chalcid generation period was two per 100 sweeps. At the time the first peak population of parasites was reached, 32 female parasites and 47 female chalcids per 100 sweeps were recovered. When the second peak population of parasites was reached, 59 female parasites and 11 female chalcids per 100 sweeps were recovered.

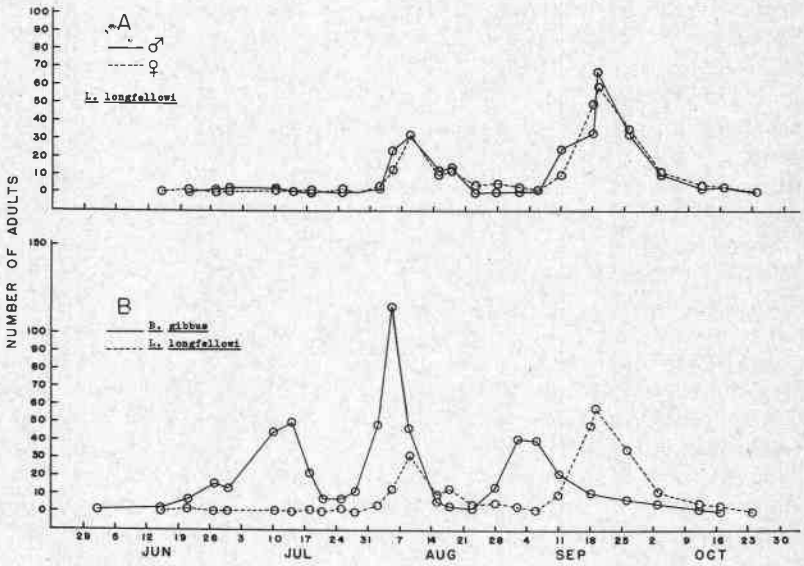

Figure 4. A. Variation of the male and female populations of *Liodontomerus longfellowi* (Girault), a parasite of the clover seed chalcid, *Bruchophagus gibbus* (Boh.), in red clover fields at the Hyslop Farm throughout the season of 1961. B. Population relationships between the females of the clover seed chalcid, *B. gibbus*, and the females of the parasite *L. longfellowi*, in red clover fields at the Hyslop Farm throughout the season of 1961.

Laboratory Rearing

Alfalfa

Alfalfa seed samples were brought from 21 different locations in five Oregon counties in the fall of 1960. The samples were kept for adult rearing in the laboratory at room temperature. The following discussion of rearing from alfalfa seed samples refers to the seed chalcid species *Bruchophagus roddi* Gussakovskii.

Seasonal emergence of the seed chalcid. Few adults from four samples from eastern Oregon (Malheur County) and one sample from northeastern Oregon (Umatilla County) emerged in September (Table 7). Low adult emergence was observed in all the samples up to December. Peak emergence of adults was reached in February 1961, when a total of 267 adults (177 males and 150 females) for all the alfalfa seed samples was recorded. Adult emergence continued in decreasing numbers. From three southwestern Oregon (Jackson County) samples the last adult emergence was July 1961, and the last three adults from alfalfa seed samples emerged from one sample from eastern Oregon (Malheur County) in August. Sex ratio of the total of 735 adults emerged from the alfalfa seed samples was 1:1.3, males vs. females.

Parasites. The following five known species of legume seed chalcid parasites were reared from the alfalfa seed samples kept in the laboratory: *Amblymerus bruchophagi* (Gahan), *Habrocytus medicaginis* Gahan, *Liodontomerus perplexus* Gahan, *Tetrastichus bruchophagi* Gahan, and *Trimeromicrus maculatus* Gahan. Of these, *A. bruchophagi, L. perplexus,* and *T. maculatus* have not been reported previously from Oregon (Butler et al., 1958; Muesebeck et al., 1951).

Percentage of parasitism, based on the numbers of chalcids and parasites emerged, varied in samples from the different areas studied. Parasitism for a given sample includes all the parasite species found in the sample.

Parasitism in the eight samples from eastern Oregon (Malheur County) ranged from 0 to 59.37 percent (Table 8), with an average of 41.4 percent. The dominant parasite species in the samples of this area was *H. medicaginis;* other parasite species in order of abundance were: *L. perplexus, T. maculatus,* and *A. bruchophagi.*

In the three samples from northeastern Oregon (Umatilla County) parasitism varied from 0 to 44.06 percent with an average of 31.4 percent. In these samples, the following parasite species were found in order of abundance: *T. bruchophagi, A. bruchophagi, H. medicaginis,* and *L. perplexus.*

TABLE 7. SEASONAL EMERGENCE OF THE SEED CHALCID, *Bruchophagus roddi* Guss., FROM ALFALFA SEED SAMPLES MAINTAINED AT ROOM TEMPERATURE, CORVALLIS, 1960-1961

Sample source (county)	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Total
Deschutes	0	0	0	0	15	36	24	7	4	6	0	0	0	92
Jackson	0	0	0	0	2	3	1	1	0	0	0	0	0	7
Jackson	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Jackson	0	0	0	0	1	4	1	0	1	0	0	0	0	7
Jackson	0	0	0	0	0	2	1	0	0	0	0	0	0	3
Jackson	0	0	0	0	1	5	1	1	1	0	2	0	0	11
Jackson	0	0	0	0	0	8	3	1	1	0	0	0	0	13
Jackson	0	0	0	0	3	8	7	4	2	0	1	0	0	25
Jackson	0	0	0	0	1	1	0	1	1	0	1	0	0	5
Klamath	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Malheur	3	0	0	0	0	4	0	1	0	0	0	0	0	8
Malheur	6	0	0	0	3	10	2	0	0	0	0	0	0	21
Malheur	5	0	0	2	14	13	13	11	2	6	0	0	0	66
Malheur	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malheur	0	1	1	0	4	6	16	8	3	1	0	0	0	40
Malheur	1	0	0	0	1	7	2	1	0	1	0	0	0	13
Malheur	..	0	1	1	13	50	82	24	6	5	0	3	0	185
Malheur	..	0	0	0	2	7	15	8	2	2	0	0	0	36
Umatilla	7	7	0	0	17	77	29	7	1	1	0	0	0	146
Umatilla	..	0	0	0	6	25	13	5	3	0	0	0	0	52
Umatilla	..	0	0	0	0	1	2	0	0	0	0	0	0	3
TOTAL	22	8	2	3	85	267	212	80	27	22	4	3	0	735

TABLE 8. PARASITES OF THE SEED CHALCID, *Bruchophagus roddi* GUSS., AND PERCENT OF PARASITISM FOUND IN ALFALFA SEED SAMPLES COLLECTED IN THE FALL OF 1960 IN SEVERAL OREGON LOCATIONS

Location (county)	Parasites[a]						Percent of parasitism
	A	B	C	D	E	F	
Deschutes	1	33				5	29.77
Jackson							0
Jackson							0
Jackson				1	1		22.22
Jackson							0
Jackson						2	15.38
Jackson				1	1		13.33
Jackson				1		2	10.71
Jackson							0
Klamath							0
Malheur		1		10			57.89
Malheur		4		16		5	54.34
Malheur		1		22		7	31.25
Malheur							0
Malheur	1	1		12			25.92
Malheur		1		16		2	59.37
Malheur	11	129		33		4	48.89
Malheur	1	28		7		6	53.84
Umatilla	22	13		11	69		44.06
Umatilla		9			3		18.75
Umatilla							0
Total	36	220		130	74	33	
Average percent							23.12

[a] Letters (A, B, C, D, E, and F) in the table refer to the following species of parasites:
A. *Amblymerus bruchophagi* (Gahan)
B. *Habrocytus medicaginis* Gahan
C. *Liodontomerus longfellowi* (Girault)
D. *Liodontomerus perplexus* Gahan
E. *Tetrastichus bruchophagi* Gahan
F. *Trimeromicrus maculatus* Gahan

Parasitism in the eight samples from southwestern Oregon (Jackson County) varied from 0 to 22.22 percent with an average of 7.7 percent. Parasite species emerged from these samples were: *T. maculatus, L. perplexus,* and *T. bruchophagi.*

Parasitism in the sample brought from central Oregon (Deschutes County) was 29.77 percent. Parasite species emerged from the sample were *H. medicaginis, T. maculatus,* and *A. bruchophagi.* In the sample brought from south-central Oregon (Klamath County) no parasitism was observed.

Parasitism in all of the alfalfa seed samples varied from 0 to 59.37 percent with an average of 23.12 percent.

Liodontomerus longfellowi (Girault), a parasite species known to be associated only with the clover seed chalcid in red clover (Butler et al., 1958), was not obtained from the samples of alfalfa seed.

Chalcid infestation of alfalfa. Seed chalcid infestation was based on the following: emergence in the field before the samples were collected, emergence of both chalcids and parasites in the laboratory, and mortality of chalcids in the seeds (Table 9).

In the sample brought from central Oregon (Deschutes County) the chalcid infestation was 28.9 percent. In the samples from eastern Oregon (Malheur County), the infestation of the chalcid ranged from 0.04 to 33.7 percent with an average of 10.88 percent. Infestation in the seed samples from northeastern Oregon (Umatilla County), ranged from 0.5 to 14.5 percent with an average of 6.83 percent. The samples from southwestern Oregon (Jackson County) showed a range of infestation from 0.2 to 2.2 percent, with an average of 1.01 percent. In the sample from south-central Oregon (Klamath County) the infestation obtained was 0.4 percent.

In all of the alfalfa seed samples, infestation of the seed chalcid ranged from 0.04 to 33.7 percent with an average of 6.9 percent.

Red clover

Seed samples of red clover were brought from 22 different locations in 12 Oregon counties in the fall of 1960. The following geographical areas and counties were sampled: south-central Oregon, Klamath County; eastern Oregon, Malheur County; northeastern Oregon, Umatilla County; and western Oregon, Linn, Marion, Polk, Washington, and Yamhill counties. The clover samples, similar to the alfalfa seed samples, were kept for adult rearing in the laboratory at room temperature. Since clover seed samples are involved, the following discussion of rearing refers to the species *Bruchophagus gibbus* (Boh.).

Seasonal emergence of the seed chalcid. Low emergence of adults was observed in September (Table 10). Adult emergence increased during the following three months. From red clover seed samples, peak emergence of 1,233 adults (309 males and 924 females) was reached in January 1961, one month earlier than chalcids from alfalfa seed. In February the adult emergence decreased to about one-ninth of the emergence in January and low emergence was observed during the following months up to September. Sex ratio of the total of 2,020 adults emerging from the red clover seed samples was 1:2.2, males vs. females. The sex ratio obtained from

Table 9. INFESTATIONS OF THE SEED CHALCID, *Bruchophagus roddi* GUSS., IN ALFALFA SEED SAMPLES COLLECTED IN THE FALL OF 1960 IN SEVERAL OREGON LOCATIONS

Location (county)	Number of seeds	Field emergence	Laboratory emergence		Mortality	Seeds infested
			B. roddi	Parasites		
					%	%
Deschutes	1,248	15	92	39	17.1	28.9
Jackson	3,768	4	7	0	0.2	0.5
Jackson	3,250	18	1	0	1.7	2.2
Jackson	4,220	0	7	2	0.5	0.7
Jackson	2,907	5	3	0	0.4	0.6
Jackson	3,912	3	11	2	0.5	0.9
Jackson	4,152	7	13	2	0.4	0.9
Jackson	4,136	12	25	3	1.2	2.1
Jackson	3,529	1	5	0	0.1	0.2
Klamath	1,016	1	1	0	0.2	0.4
Malheur	13,982	3	8	11	0.2	0.3
Malheur	1,870	43	21	25	8.0	12.7
Malheur	11,138	205	66	30	1.2	3.9
Malheur	5,229	2	0	0	0	0.04
Malheur	1,242	0	40	14	6.1	10.4
Malheur	4,620	11	13	19	4.3	5.2
Malheur	2,626	0	185	177	20.0	33.7
Malheur	1,073	22	36	42	11.5	20.8
Umatilla	4,596	6	146	115	8.7	14.5
Umatilla	2,808	2	52	12	3.2	5.5
Umatilla	782	0	3	0	0.1	0.5
Average of infestation						6.9

TABLE 10. SEASONAL EMERGENCE OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), FROM RED CLOVER SEED SAMPLES MAINTAINED AT ROOM TEMPERATURE, CORVALLIS, 1960-1961

Sample source (county)	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Total
Benton	7	0	0	0	0	0	0	0	0	0	0	0	0	7
Benton	3	1	2	33	52	5	2	2	0	2	6	0	0	108
Benton	1	0	5	35	45	4	0	0	0	0	0	0	1	91
Clatsop	0	8	0	0	1	0	0	0	0	0	0	0	0	9
Columbia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klamath	..	0	0	6	40	5	1	0	0	0	0	0	0	52
Klamath	..	0	0	21	124	1	2	0	0	0	0	0	0	148
Lincoln	0	10	20	52	93	9	2	0	0	1	0	2	0	189
Linn	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Linn	1	0	0	3	2	0	0	0	0	0	0	0	0	6
Malheur	0	7	7	58	207	25	13	7	4	4	3	4	1	340
Malheur	10	30	5	37	203	32	5	2	2	8	1	1	0	336
Malheur	..	0	3	93	400	47	35	4	5	6	0	1	2	596
Marion	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marion	1	0	0	1	1	0	0	0	0	0	0	0	0	3
Polk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umatilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington	0	0	0	0	1	1	0	0	1	0	0	0	0	3
Washington	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Washington	5	3	7	20	44	5	0	0	0	0	0	3	2	89
Yamhill	2	3	1	0	3	2	0	0	0	0	0	0	0	11
Yamhill	2	1	0	7	17	2	0	1	0	0	0	0	0	30
TOTAL	32	63	51	367	1,233	138	60	16	12	21	10	11	6	2,020

red clover field sampling at the Hyslop Farm during the season of 1961 was 1.8:1, males vs. females (Table 1).

Parasites. Four known parasite species of the clover seed chalcid were reared from the clover seed samples kept in the laboratory. They were *Habrocytus medicaginis* Gahan, *Liodontomerus longfellowi* (Girault), *Tetrastichus bruchophagi* Gahan, and *Trimeromicrus maculatus* Gahan.

Parasitism in the samples from western Oregon ranged from 0 to 25 percent with an average of 3.88 percent (Table 11). The parasite species found in the samples of this area in order of their abundance were *L. longfellowi, T. bruchophagi,* and *T. maculatus.*

In the samples from eastern Oregon, parasitism varied from 1.48 to 3.68 percent with an average of 2.49 percent. Parasite species emerged from these samples were *L. longfellowi* and *H. medicaginis.*

Parasitism in the samples from south-central Oregon was 0.67 percent in one sample and 3.70 in the other with an average of 2.18 percent. The parasite species emerged from these samples was *H. medicaginis.*

Parasitism in all the clover seed samples ranged from 0 to 25 percent with an average of 3.18 percent. Two parasite species of the seed chalcid reared from the alfalfa samples were not obtained from the red clover seed samples. They were *Amblymerus bruchophagi* and *Liodontomerus perplexus.* The latter is a parasitic species known to be associated only with the chalcid in alfalfa (Butler et al., 1958).

Chalcid infestation of red clover. As in the alfalfa seed samples, infestation in red clover was based on emergence in the field before the clover samples were collected, emergence of chalcids and parasites in the laboratory, and mortality of chalcids in the seeds (Table 12).

In the samples from eastern Oregon, the chalcid infestation varied from 15.8 to 21.5 with an average of 18.5 percent. Infestations in the seed samples from south-central Oregon were 2.06 and 5.4; the average was 3.73 percent. In the samples from western Oregon, the chalcid infestation ranged from 0.06 to 11 percent with an average of 3.03 percent. The infestation in a single sample from northeastern Oregon was 1.3 percent.

In all the red clover seed samples, infestations of *B. gibbus* ranged from 0.06 to 21.5 percent with an average of 5.13 percent. This is in contrast to all of the alfalfa seed samples in which infestations of *B. roddi* ranged from 0.04 to 33.7 percent with an average of 6.9 percent.

TABLE 11. PARASITES OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), AND PERCENT OF PARASITISM FOUND IN RED CLOVER SAMPLES COLLECTED IN THE FALL OF 1960 IN SEVERAL OREGON LOCATIONS

Location (county)	Parasites[a] A	B	C	D	E	F	Percent of parasitism
Benton							0
Benton			2				1.81
Benton			2				2.15
Clatsop							0
Columbia					1		[b]
Klamath		2					3.70
Klamath		1					0.67
Lincoln							0
Linn							0
Linn			1			1	25.00
Malheur		2	11				3.68
Malheur		1	7				2.32
Malheur		1	8				1.48
Marion							0
Marion			1				25.00
Polk							0
Umatilla							0
Washington							0
Washington							0
Washington			1				1.11
Yamhill							0
Yamhill			1				3.22
Total		7	34		1	1	
Average percent							3.18

[a] Letters (A, B, C, D, E, and F) in the table refer to the following species of parasites:
A. *Amblymerus bruchophagi* (Gahan)
B. *Habrocytus medicaginis* Gahan
C. *Liodontomerus longfellowi* (Girault)
D. *Liodontomerus perplexus* Gahan
E. *Tetrastichus bruchophagi* Gahan
F. *Trimeromicrus maculatus* Gahan

[b] Since no chalcids appeared in this sample, a percentage figure would be misleading.

TABLE 12. INFESTATION OF THE CLOVER SEED CHALCID, *Bruchophagus gibbus* (Boh.), IN RED CLOVER SEED SAMPLES COLLECTED IN THE FALL OF 1960 IN SEVERAL OREGON LOCATIONS

Location (county)	Number of seeds	Field emergence	Laboratory emergence		Mortality	Seeds infested
			B. gibbus	Parasites		
					%	%
Benton	11,383	0	7	0	0	0.06
Benton	3,552	0	108	2	8.2	11.0
Benton	5,201	0	91	2	7.9	9.7
Clatsop	6,403	0	9	0	2.0	2.1
Columbia	3,100	5	0	1	0	0.2
Klamath	6,188	0	52	2	1.2	2.06
Klamath	6,461	17	148	1	2.9	5.4
Lincoln	3,096	0	189	0	4.6	10.6
Linn	12,075	7	1	0	1.5	1.5
Linn	9,684	16	6	2	0	0.24
Malheur	8,946	20	340	13	11.7	15.8
Malheur	5,026	6	336	8	11.2	18.2
Malheur	10,422	0	596	9	15.7	21.5
Marion	6,888	8	0	0	0.1	0.2
Marion	4,800	5	3	1	0.2	0.4
Polk	5,459	17	0	0	0.5	0.8
Umatilla	1,295	6	0	0	0.8	1.3
Washington	4,198	44	3	0	0.3	1.4
Washington	6,387	51	1	0	0.3	1.1
Washington	8,648	28	89	1	2.1	3.4
Yamhill	3,783	0	11	0	0.4	0.7
Yamhill	5,931	38	30	1	4.1	5.2
Average of infestation						5.13

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