BIOLOGICAL STUDIES OF THE VETCH BRUCHID
BRUCHUS BRACHIALIS FAHRAEUS
IN OREGON

by

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BIOLOGICAL STUDIES OF THE VETCH BRUCHID, BRUCHUS BRACHIALIS FAHRAEUS,[1] IN OREGON

INTRODUCTION

The vetch bruchid, Bruchus brachialis Fahraeus, is an important seed pest of hairy vetch, Vicia villosa Roth. The insect attacks only the seed and does not affect the crop when it is grown for forage or as a cover crop. The vetch bruchid is well established in Oregon, and since Oregon is one of the leading hairy vetch seed producing areas in the United States (25, p.66) this pest assumes a role of major importance.

The vetch bruchid was first recorded in Oregon in 1936 (18, p.59), and by 1942 it had become so abundant that many growers of hairy vetch were forced out of seed production. The urgency of this situation prompted the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine and the Oregon State College, Department of Entomology to initiate a cooperative project in an attempt to find means of controlling the vetch bruchid. In 1946 these two agencies devised control measures for this pest that enabled the growers to produce hairy vetch seed economically once again (19, pp.1-3). At that time research on the life history and habits of the vetch

1. The bruchids studied were identified by Mr. G. B. Vogt, Insect Identification and Parasite Introduction Section, Entomology Research Branch, Plant Industry Station, Beltsville, Maryland.

bruchid was abandoned before life history studies had reached completion. This paper presents the life history and habits of the vetch bruchid in the Willamette Valley of Oregon.

WORLD DISTRIBUTION

The vetch bruchid is a native of Europe where it was once found only in the southern areas of the continent around the Mediterranean Sea (22). It originally lived on wild species of Vicia, but shortly after the beginning of the twentieth century it spread northward and was found attacking cultivated Vicia villosa in France (22). Since that time the bruchid has spread into central Europe (9, p.50) and to the United States (6, p.739).

The present old world distribution of the vetch bruchid, as compiled from the literature, includes Spain, France, Italy, Greece, Asia Minor and Algeria, in the Mediterranean region, and France, Austria, Germany, Hungary, Poland, and Czechoslavakia in central Europe (16, pp.630-631), (9, p.50) and (15, pp.253-254). In North America the distribution is confined to the United States.

HISTORY AND DISTRIBUTION IN THE UNITED STATES

The rapid dissemination of the vetch bruchid into previously uninfested areas is readily understandable since the developing larvae are often contained in the seed at harvest. If seed is shipped from one area to another before the adults have died, the possibility of introducing this pest is great. This is apparently the reason for the presence of the bruchid in the United States. From 1920 to 1935 a yearly average of 2,454,167 pounds of vetch seed was imported into the United States (16, p.631). As early as 1921, dead bruchids were found in a shipment of hairy vetch seed from Europe, and in 1930 a shipment of seed from Hungary was found containing living adult bruchids (16, p.631). Between 1926 and 1935 the Division of Foreign Plant Quarantine intercepted seven commercial shipments containing dead adult vetch bruchids (16, p.631). It was on June 24, 1930, at Haddon Heights, New Jersey, that the first vetch bruchid was collected in the field in North America (16, p.621).

Since that discovery the bruchid has spread, either naturally or in seed shipments, to almost all of the hairy vetch growing areas of the country. The distribution in the United States as compiled from the available literature includes New Jersey, Delaware, Pennsylvania, Maryland, the District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, Texas, Ohio, Michigan, Idaho, Washington, Oregon and California. From the wide distribution of this insect it probably occurs in areas other than those mentioned, but there are no literature records to substantiate this.

HOSTS

The vetch bruchid feeds almost exclusively in seeds of species of _Vicia_. Pinckney and Stitt (17, pp.1-6) tested numerous species and varieties of _Vicia_ for susceptibility to the vetch bruchid at Statesville, North Carolina. Four species, _Vicia villosa_, _Vicia dasycarpa_ Ten., _Vicia atropurpurea_ Desf., and _Vicia caroliniana_ Walt., were found to be heavily infested with the bruchid. Eggs were laid on the pods of _Vicia sativa_ L., _Vicia pannonica_ Crantz, and _Vicia melanops_ Sibth. and Sm., but did not develop. Weimer and Bissell (26, p.794) also tested seven species of _Vicia_ in Georgia, and of these, only _Vicia villosa_ and _Vicia dasycarpa_ were infested. Contrary to the findings of Pinckney and Stitt, there were no eggs on pods of _Vicia sativa_. Bridwell and Bottimer (6, p.748) reported _Vicia_ cracca L. and Vicia pannonica to be lightly infested with this bruchid. In Europe, Zacher (27) reported Bruchus brachialis in lentils, Ervum lens Linn., of which Vicia lens Coss. and Germ. is a synonym. This is the only record of the vetch bruchid on any genus other than Vicia. Pinckney and Stitt found that roughpea Lathyrus hirsutus, was not susceptible to the bruchid.

A study of the literature indicates that both hairy and smooth varieties of Vicia villosa, and Vicia dasycarpa are susceptible to heavy infestations of the vetch bruchid. Vicia dasycarpa, Vicia caroliniana, Vicia cracca, and Vicia pannonica are susceptible to heavy or light infestations, but the remaining species of Vicia are relatively resistant to infestation.

TAXONOMIC POSITION

Bruchus brachialis was first described in 1839 by Fahraeus (20, p.79) from specimens collected by Chevrolat at Tours, France, and sent to Schonherr for description. No distinction was made between the male and female in this first description. The male was described in 1858 by Mulsant and Rey (14, p.33) as pallidicornis. They first described the distinctive sexual characters of this bruchid. Allard (1) unaccountably renamed _pallidicornis_ Mulsant and Rey as _ruficornis_ in 1867, and stated that this was the male of _brachialis_ Fahraeus. Baudi (3, p.13) redescribed the species in 1886 and gave _brachialis_ the new generic designation _Mylabris_. Bedel (4, p.357), in 1889, assigned the species to the genus _Laria_. In 1905, Schilsky (11, no.24) placed the species in _Bruchus_ as restricted by himself, and it has been referred to in this genus since that time, although there is still considerable controversy over the validity of this generic name.

Bruchus brachialis is a member of the family Bruchidae, order Coleoptera. As mentioned above, a great deal of controversy has existed and still exists as to the correct name of this family and its type genus, _Bruchus_. Synonyms of this genus are _Mylabris_ and _Laria_, and accordingly the family name Bruchidae is synonymous with Mylabridae and Lariidae. Adhering to the law of priority of the International Commission of Zoological Nomenclature, the generic names _Bruchus_ and _Laria_, as well as their family designations should be considered as synonyms of _Mylabris_. However the name _Bruchus_ has usage preference in the literature.

Bridwell (5, pp.52-53), in a plea for the suspension of the rules of the International Commission of Zoological Nomenclature in favor of the continuation of the use of Bruchus, summed up the situation as follows: In 1752, the pea bruchid and the oriental species now known as Callosobruchus chinensis (L.) were described in the new genus Bruchus by Baeckner. However, Linnaeus, in his tenth edition of Systema Naturae in 1758, included the pea bruchid in his genus Dermestes, thus making Bruchus a synonym. The rules of the International Commission of Zoological Nomenclature state that names prior to 1758 are not available, therefore the name Mylabris Geoffroy, 1762, has priority as the generic name of the bruchids. However, in 1775, Fabricius proposed the name Mylabris for a group of blister beetles, Meloidae, and it has since been widely used as such. Bridwell claimed that adherence to priority would result in great confusion and pleaded that the rules be suspended and the names Bruchus and Bruchidae be adopted. To the present no decidion had been reached, but since the insect concerned is referred to as Bruchus throughout the major portion of the literature, and since the American economic literature on this insect refers to it as Bruchus brachialis exclusively, that name shall be used in this study.

DESCRIPTION OF STAGES

DESCRIPTION OF ADULT

Female: Length, 2.5 to 3.5 mm. Black in color, ovate in shape. Head prognathous, appearing hypognathous in dead specimens; prolonged anteriorly into broad, short snout; finely punctate. Eyes emarginate anteriorly toward mouth parts. Antennae 12-segmented, clavate, inserted at emarginations of eyes; black, apical segment and basal three to five segments reddish-brown. Pronotum anteriorly as wide as head, broadening posteriorly to almost twice as wide; posterior angles acute; posterior margin dentate; patches of white pubescence irregularly distributed on surface; surface more coarsely punctate than head. Elytra short; truncate posteriorly with top of abdomen exposed; surface finely punctate, longitudinally striate with patches of irregularly distributed white pubescence. Metepisternum sparsely covered with fine white pubescence. Abdomen with five segments visible ventrally, covered with sparse, fine white pubescence. Posterior two pairs of legs black; fore legs reddish-brown, femora black at least basally; mid and hind femora and tibiae curved to fit against body; hind femora notched on apico-ventral margins.

Male: Similar to female except antennae and front femora entirely reddish-brown. Middle tibiae with short, truncate apical projections.

DESCRIPTION OF EGG

Length, 0.57 mm. Diameter, 0.22 mm. Oblong, tapering slightly to one end. Color, pale yellow. Surface finely reticulate.

When first laid, the egg is covered with a clear, viscous liquid which hardens shortly after oviposition and securely cements the egg to the pod. The freshly laid egg is translucent throughout, but after three days develops two dark transverse bands inside the chorion (see Figure 2). As the egg develops these two bands converge and move to the wider end of the egg. When development is complete, the dark area represents the location at which the head is situated. After hatching, the chorion is transparent, however, the hatching larva fills the egg with frass which gives the egg a whitish appearance.

DESCRIPTION OF LARVAL STAGES

The determination of larval instars was based on the measurement of the width of the head capsule at its widest point. In order to obtain the range of variability in head capsule size, 50 individuals of each instar were measured with an ocular micrometer. The head capsule was the only reliable character for separating instars, with the exception of the first instar, which could easily be distinguished by the presence of a prothoracic shield. The length and width of the larvae were extremely unreliable in instar determination, since a great deal of overlap occurred between and within instars. Therefore, in the larval descriptions which follow, the length is recorded only to note the maximum size attained. A summary of head capsule measurements for the four instars appears in Table I.

First instar: Head capsule width, 0.11 to 0.13 mm. Length on eclosion, 0.42 to 0.50 mm. Maximum length attained, 0.83 mm. Shape eruciform at first, becoming scarabaeiform later. Body color yellowish-white, head capsule and prothoracic shield pale brown, mandibles dark brown. Mouthparts hypognathous; mandibles opposed; maxillae and labium retracted, that is, basal sclerites of each located distinctly adjacent to neck region. Head with dorsum retracted into prothorax. Body 12-segmented, caudal segment very much reduced. Eight pairs of abdominal spiracles, located laterally, immediately dorsad of epipleural lobes of first eight abdominal segments. One pair of thoracic spiracles located laterally on mesothorax adjacent to the prothorax. Prothorax with H-shape sclerotized shield dorsally. Thoracic segments each with a pair of short, two-segmented, temporary legs.

<u>Second instar</u>: Head capsule width, 0.22 to 0.31 mm. Maximum length attained, 1.1 mm. Shape scarabaeiform. Similar to first instar except head capsule paler brown. Prothoracic shield absent. Thoracic legs reduced to fleshy protuberances with no visible segmentation.

<u>Third instar</u>: Head capsule width, 0.37 to 0.46 mm. Maximum length attained, 2.1 mm. Shape scarabaeiform. Similar to second instar except body color more yellowish, head capsule paler brown.

<u>Fourth instar</u>: Head capsule width, 0.55 to 0.68 mm. Maximum length attained, 3.7 mm. Shape scarabaeiform. Similar to third instar except body color with a distinct yellowish tinge. Head capsule almost completely opaque white, only mandibles remaining distinctly brown.

TABLE I

HEAD CAPSULE WIDTH FOR LARVAL INSTARS OF
BRUCHUS BRACHIALIS, IN MILLIMETERS

Instar	Minimum width	Maximum width	Average
I	.11	.13	.12
II	.22	.31	.25
III	.37	.46	.41
IV	.55	.68	.61

DESCRIPTION OF PUPA

Length, 2.5 to 3.5 mm. Width, 1.7 to 2.2 mm. Color, yellowish-white, newly formed pupa without pigmentation. Resembles adult in shape and structure except legs folded tightly against body, seven abdominal segments visible ventrally, hind wings protrude slightly past apex of elytra, which are folded ventro-laterally so that dorsal aspect of abdomen is visible from thorax to tip.

The first pigmentation occurs in the facets of the eyes, so that a mosaic, reddish-brown coloration appears several days after pupation. By the time the adult is formed the eyes have become solidly pigmented. The next pigmentation to appear is in the dark setae on the surface of the pronotum. Shortly before the adult emerges the tarsal claws become pigmented, along with the mandibles and the segments of the legs at their articulations. On the last day before adult emergence the remaining structures become uniformly black, except for the fore-legs and the antennae, which become uniformly reddish-brown in the male, and reddish-brown and black in the female.

SEASONAL HISTORY IN OREGON

During 1954 in the Willamette Valley the first adults of the vetch bruchid emerged from hibernation during April. Adults continued to emerge until field populations reached their peak on June 20 to June 25 (Figure 11). Shortly after emergence the adults mated and oviposition began when the first pods appeared on hairy vetch. In 1954 this was on June 10 at the higher and drier locations, and June 18 at the lower and more moist situations. Oviposition continued through July into the beginning of August, at which time most of the pods on hairy vetch were mature and unsuitable for egg deposition. The field populations of adults steadily declined from the time of peak abundance until early August when none were to be found. Toward the end of the egg laying period, from July 20 to the beginning of

August, many fields of hairy vetch matured, and neighboring fields, which were slower in development, showed an increase in bruchid populations. This indicated that adults which remained alive in the mature fields were able to migrate to fields that were more attractive to ovipositing females.

The eggs began hatching near the end of June, and new larvae continued emerging until early August. The larvae quickly penetrated the pod and larval development within the seed was evident until late September. Since hairy vetch was harvested during the first half of August, many of the seeds still contained developing larvae. The first pupae appeared in mid-August, and the first new generation adults at the beginning of September. Presumably the newly emerged adults in the field flew to their overwintering sites, since they were rarely ever collected in the field after the beginning of August. Many of the adults did not emerge from the seed in the fall, but remained alive within the stored seed until the following spring.

SEX RATIO

The actual ratio of females to males was determined by sexing 1100 individuals of the new generation in the fall of 1954. The resulting ratio was approximately one to one. This is then the ratio of females to males when the bruchids go into hibernation. From hibernation studies conducted during the winter of 1954-55, there was no difference in mortality between males and females. It is then assumed that the spring emergents will appear with a sex ratio of approximately one to one.

During the 1954 season periodical collections were made over a wide area. Fifteen fields were sampled at each collection date, and the per cent females and males was calculated. The results of this study indicated that the ratio of females to males was nearly equal at the beginning of the season, and steadily increased in favor of the females throughout the season (Table II). At the peak of the oviposition period, the sex ratio was approximately four to one in favor of the females. No males were collected in the field after mid-July, while females were collected as late as August 4, although their abundance had dropped considerably (Figure 11). Examination of the graphical presentation of the relative abundance of females and males (Figure 11), shows that the longevity of the males is shorter than the females.

TABLE II

PER CENT FEMALES AND MALES OF
BRUCHUS BRACHIALIS DURING 1954

Date of collection		Females	Males
Emergence		51.2	48.8
June	1	65.3	34.7
June	15	77.8	27.1
June	25	85.7	14.3
July	2	93.2	6.8
July	12	93.8	6.2
July	16	98.4	1.6
July	23	100.0	0.0
July	29	100.0	0.0
August	4	100.0	0.0
August	9	0.0	0.0

LIFE HISTORY AND HABITS

The life history studies of the vetch bruchid were conducted in the insectary at the Entomology Farm, Oregon State College, and in a field near the Entomology Farm. The insectary is a standard wooden structure with screen walls. A thermograph was maintained in the insectary during the course of the study. Seeds were dissected in the laboratory.

SPRING EMERGENCE

The emergence of adult vetch bruchids in the spring is dependent on the weather. Previous work in Oregon (19, p.1) showed that the bruchids usually began emerging in April. During 1954, spring emergence began in April. Observations and population counts showed that a peak in bruchid abundance was reached about the time that the pods were beginning to form on vetch, thus indicating that adults emerged from hibernation at least until that time.

MATING

Mating occurs in the spring before the pods are formed on hairy vetch. Attempts to force mating in the insectary were unsuccessful. Numbers of adults of both sexes were confined in lantern chimneys containing both flowers and pods of hairy vetch, and in no case was mating observed. Likewise, in the fall, after the new generation adults had emerged from the seed, large numbers of them were confined in small cartons, so that males and females could not possibly avoid contact, and again no mating was observed.

OVIPOSITION

Observations on adults, both in the field and in the insectary, indicated that ovipositing females exhibited a distinct pattern. Characteristically, the ovipositing female alighted directly on the pod or on the raceme. In the latter case, she would crawl up the raceme until a pod was contacted. The female then wandered about on the pod in search of a favorable ovipositing site. After a lengthy search, she stopped at a desired place, extended her abdomen, and by a series of rhythmic to and fro motions of her body deposited the egg. The length of time to actually deposit the egg varied slightly, usually requiring about one minute. It was noted that the female invariably oviposited while facing upward or toward the attached end of the pod.

The most frequent site on the pod for oviposition was along the margin of the valve, about one-eight of an inch in from the edge. Occasionally eggs were deposited anywhere on the pod, a few were even noted on the base of the pod as far up as the petiole. After a female laid one egg, she often laid one or two more on the same pod, each time going through the same lengthy search for a site. When she had laid one, two, or several eggs, she eventually flew off, presumably in search of another pod for egg deposition.

The number of eggs per pod depended more on the stage of development of the pods in relation to bruchid abundance than it did on any other factor. There seemed to be no ability on the part of the bruchids to determine the number of eggs on one pod for egg counts varied from none to 53 per pod. This is a distinct disadvantage to the insect, since at best there may only be seven or eight seeds in one pod, and more often only about four or five, and in no instance during the course of the study did more than one bruchid develop in one seed.

The daily trend in egg laying was established by placing several adults in lantern chimneys with a supply of vetch pods, which were changed at four hour intervals over a 24 hour period. The number of eggs laid during each period was counted. This study revealed that egg laying began early in the morning, increased until about mid-afternoon, and then decreased until night-fall, at which time oviposition ceased.

Oviposition in the field began with the development of the first vetch pods. At no time previous to this were any eggs found. From this observation it appears that egg laying is restricted to the pods, and that no oviposition occurs prior to their development. However, dissection of females collected in the field preceding pod appearance showed that females had fully formed eggs present in the oviducts. Female bruchids which were confined to a glass test tube, without any pods enclosed, laid eggs on the sides of the tube, which leads one to believe that eggs might be laid of necessity prior to the availability of pods. A close study of hairy vetch from the field where pods were not yet developed did not reveal any eggs on the vegetative parts of the plants or on the florets, so that if any eggs are laid in the field prior to pod development they were not found. Oviposition continues from the time of pod development until the adults disappear from the fields.

FECUNDITY

An experiment was conducted in the insectary to determine the fecundity of the female vetch bruchid. Racemes containing both florets and pods were inserted into vials of water to keep them fresh. These were then enclosed by lantern chimneys, the tops of which were covered with cheese cloth. Female bruchids were introduced, one per chimney, and a daily record of the number of eggs laid was kept. The female bruchids used were taken from a field in which the pods had not yet formed in order to reduce the possibility of eggs having already been laid. The racemes in the chimneys were also changed daily to provide fresh material for oviposition sites.

The number of eggs laid by each bruchid varied from none to 62 with an average of 24. Difficulty was encountered keeping the adults alive during confinement. Some died after only three days while others lived for 13 days. This experiment was conducted twice and the results were similar both times. The only conclusion that can be drawn from this is that the vetch bruchid is capable of laying as many as 62 eggs. This is undoubtedly below their ultimate potential, for dissected females contained as many as 20 mature eggs in the oviducts and a great many more developing. The fact that as many as 25 eggs were laid by one individual in one day bears out the above statement.

INCUBATION PERIOD

Two tests were conducted to determine the incubation period of the eggs of the vetch bruchid. The first, using eggs laid from June 24 to July 7, was conducted from June 24 to July 27. The second, using eggs laid on July 26, was conducted from July 26 to August 9. The major portion of the work was done in the insectary, although a record was also kept of eggs in the field. In the insectary, pods containing freshly laid eggs were isolated and observed daily in order to determine the time of eclosion. At the same time freshly laid eggs were marked in the field by tagging the pods on which they were laid and marking the individual eggs by scarring the pod directly above it. These too were observed daily to determine the time of eclosion. The data appears in Tables III and IV.

In both tests, the incubation periods in the insectary and the field were similar. However, the difference in incubation period between early and late deposited eggs was striking. Eggs laid between June 24 and July 27 required an average of 14.6 days to hatch, with extremes of 13 to 21 days. Those eggs laid on

TABLE III

INCUBATION PERIOD OF EGGS IN DAYS, JUNE AND JULY

Insectary		Field	
No. of eggs	Incubation pd.	No. of eggs	Incubation pd.
69	13	4	12
98	14	9	13
45	15	7	14
19	16	3	15
2	17	6	16
25	18	2	17
2	19	3	18
3	20	1	19
1	21		
Average	14.6	Average	15.1

TABLE IV

INCUBATION PERIOD OF EGGS IN DAYS, JULY AND AUGUST

Insectary		Field	
No. of eggs	Incubation pd.	No. of eggs	Incubation pd.
5	10	1	9
41	11	7	10
35	12	4	11
12	13	11	12
12	14	3	13
2	15	3	14
		2	15
		2	16
Average	11.9	Average	12.1

July 26 hatched in an average of 11.9 days, with extremes of 10 to 15 days. This time difference in the incubation period of the eggs corresponds closely to the rate of growth of the pods during these two periods. During the first period, from late June to mid-July, pod growth was slow, but in late July and early August pod growth accelerated considerably. Both of these factors, incubation period of the egg and pod development, can be partially attributed to temperature, although there are other factors involved. Temperature data recorded on a thermograph in the insectary indicated a distinct difference in average temperatures for the two periods concerned. For the period from June 24 to July 27 the average maximum temperature was 74.9°F, the average minimum temperature was 50.8°F, and the mean temperature was 62.9°F. For the period from July 26 to August 9 the average maximum temperature was 81.1°F, the average minimum temperature was 52.2°F, and the mean temperature was 66.7°F. It should be pointed out here that in a similar study by Pinckney (16, p.626) in North Carolina, the average incubation period of the egg was eight days, a considerable difference from conditions found in Oregon.

An interesting phase of the studies on the incubation period of the egg was the egg mortality. Hatching records were kept in the insectary and of 331 eggs laid, 60, or 18.1 per cent did not hatch. Although no similar records were kept of eggs in the field, as many as 50 per cent of the eggs on some pods dried up within the chorion a few days after being laid. This same condition did not occur in the insectary. Cheng (7), who worked with a bean weevil, Bruchus sp., attributed a high mortality of eggs to the direct rays of the sun. He made no distinction as to whether it was heat waves or ultraviolet rays which caused the mortality. Since sunlight was the only apparent variable between the insectary and the field, it may well contribute to egg mortality in the field.

EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF THE EGG

A study of the effect of temperature on the developmental time of the egg was made. Individual records of the incubation period of each egg were kept. From these records the mean temperature for the incubation period of each egg was calculated. With this information the average mean temperature was calculated for each group of eggs with the same length of incubation period (Table V). Examination of the data presented in Table V showed that these individuals fall into five groups on the basis of similar mean temperatures. This grouping of the data is not necessary, except that it simplifies the presentation of this material graphically (Figure 12). There are

TABLE V

LENGTH OF TIME FOR EGG DEVELOPMENT WITH THE CORRESPONDING MEAN TEMPERATURES °F.

Group no.	No. of eggs	Length of time for development	Mean temperature	Group mean temperature
	5	10 days	66.4	
I	41	11 days	66.3	66.3
	35	12 days	66.4	
II	81	13 days	62.3	62.2
	110	14 days	62.1	
	46	15 days	61.3	
III	19	16 days	61.5	61.4
	1	17 days	62.9	
IV	25	18 days	59.8	59.4
	2	19 days	63.3	
V	3	20 days	63.5	63.4
	1	21 days	63.4	

only four groups plotted on the graph in Figure 12, group V being eliminated because it contained only six individuals. The diameters of the circles plotted on the graph represent the relative number of individuals in each group. The resulting curve is a straight line and clearly illustrates the effect of the temperature on the development of the egg. An increase in the mean developmental temperature causes a decrease in the length of the incubation period.

HATCHING

When the larva is fully formed within the egg, it bores a tiny hole directly through the chorion and the valve of the pod thus entering the pod without being exposed. As it bores from the egg into the pod it leaves the egg filled with frass. The egg usually remains attached to the pod, but if it is removed or drops off, a tiny hole is visible in the pod through which the larva gained entrance.

LARVAL ACTIVITIES

After the larva hatches and bores into the pod, it crawls about until it contacts a seed. The tiny first instar larva then bores into the seed, leaving a small hole filled with frass which is barely visible to the naked eye. The insect then feeds within the seed until larval development is complete. A total of four instars are passed within the seed before the insect is ready for pupation.

The fourth instar larva deserves some comment here, since it makes certain preparations for pupation. When the larva is fully grown, it packs the frass, with which it has been surrounded during growth, tightly around the inside of the seed. At the time the larva reaches maturity, most of the seed content has been devoured. The larva then proceeds to chew almost through the outer seed coat forming a circular area at one end of the seed. This circular area, or disc, is usually visible to the naked eye, and serves as an exit site for the adult. After completing this task, the larva goes into a quiescent state just prior to pupation.

LARVAL DEVELOPMENT

In studying the larval development of the vetch bruchid, 200 pods with eggs already on them were tagged in the field. These pods were observed daily until the first egg had hatched on each pod, at which time the remaining unhatched eggs were removed. At intervals after hatching of the eggs (see Table VI), pods were removed from the field and taken into the laboratory where the seeds were dissected and the larvae within the seeds were examined to determine their stage of development. Instar determinations were based on head capsule measurements as previously outlined under description of the larvae. Dissection of the seeds continued until all the pods were dissected 75 days after hatching. Of the 200 tagged pods, 11 dropped from the racemes in the field, and of the remaining 189, only 103 individuals were recovered. The results of this study appear in Table VI.

From these data the minimum and maximum length of time from hatching until completion of the second, third, and fourth instars, and also the minimum length of time for the first instar can be determined. This is summarized in Table VII.

This does not correspond with work done by Pinckney (16, p.628) in North Carolina, where the average length of the entire larval stage was only two weeks.

TABLE VI

STAGE OF DEVELOPMENT AT DISSECTION

No. of days		No. of individuals in each stage				
after hatching	I	II	III	VI	Pupa	Adult
2-10	12					
13-20		9				
21		1				
22		2				
23		1				
24		1				
25		1	1			
26		1	3			
27			1			
30			3			
32			2			
33		3	6			
34			1			
35			4	1		
37			3			
39			1	2		
40			1			
41			3	1		
42				1		
45			2			
46					1	
47			2	2	1	
50			1	1		
52				2		
53			1			
54				1		
55					1	
57				1		
59				4		
60					1	
62				1	3	
67					1	1
68					1	1
69				1	1	
70						1
72				3		4
75						1

TABLE VII

MINIMUM AND MAXIMUM TIME FOR COMPLETION OF INSTARS, IN DAYS AFTER HATCHING

	Instars			
	I	II	III	IV
Minimum time	13	25	35	46
Maximum time		33	53	72

PUPATION

The first pupa was recovered 46 days after hatching of the egg (see Table VI). The latest date of pupation must have occurred after 72 days, since at that time fourth instar larvae were still present. The earliest record for completion of the pupal stage was 67 days after hatching of the egg. The latest recorded date for the completion of pupation was 75 days after hatching. However, these cannot be considered as the extreme time limits for pupation, since material became limited toward the end of the study on the developmental time of the bruchid. Further work is necessary to determine the maximum limits for completion of pupation.

ADULT EMERGENCE

The adults emerge by forcing through the disc-shaped cap at the end of the seed. If the seeds are still contained within the pod, the adults do not emerge until dehiscence, since they are unable to penetrate the dried pod. Upon emergence of the adults, they fly away, presumably to their hibernation quarters. The length of time required for development from hatching of the egg until emergence of the adult can be seen in Table VI. The minimum time required for emergence was 67 days, and maximum was 75 days. Here again, there is not sufficient data to establish the maximum time limit required for adult emergence because of insufficient material.

HIBERNATION

The vetch bruchid hibernates as an adult in protected places. During the course of this study adults were found to be hibernating in cracks in fence posts in the field, under lichens and loose bark on trees, and in trash and weeds at fence rows. A common hibernaculum is in grain storage bins and granaries. As hairy vetch has become a common weed in grain fields, much of the grain harvested contains infested vetch seeds. When the grain is stored the vetch bruchids emerge and hide in cracks and crevices in the bins, or in the seams of grain sacks, and if they do not emerge from the seed, they remain within the seed until the following spring.

The adults bruchids remain in hibernation until the weather warms up sufficiently to allow them to emerge. The hibernation of the bruchids is not a true quiescence or diapause, since they may be easily brought out of the hibernating state at any time throughout the winter by placing them in a warm room. However, they do not remain active for a very long period when confined to cages and soon return to the hibernating state.

PARASITES

An attempt was made during this study to rear and capture any parasites which might possibly be present. A total of 1808 individuals contained in seeds were kept in sealed cardboard cartons. A glass emergence tube was placed in the top of each carton to allow any parasites to be seen on emergence. Of the 1808 insects reared, 1645 completed their development and emerged as adults, the remainder died before maturing.

However, there were no parasites captured and the mortality was attributed to other causes.

Although no parasites were recovered during the course of this study, there are a number reported in the literature. Bridwell and Bottimer (6, p.747) reported six species of native American Chalcidoidea attacking the larvae and pupae of Bruchus brachialis. These six parasites are Eupelmus cyanips amicus Gir., Eupelminus saltator (Lindemann), Microdontomerus anthonomi (Crawford), Zatropus incertus (Ashm.), Habrocystus sp., and Eurytoma tylodermatus Ashm. None of these species are essentially bruchid parasites.

Pinckney (16, p.629) reared two additional Chalcicoidea from Bruchus brachialis. One of these, Lariophagus distinguendus (Foerst), is native to America, while the other, Bruchobius mayri (Masi), is a native European parasite of Bruchus brachialis. Strong (21, p.68) reported the establishment of an introduced European parasite, Triaspis thoracicus Curt., and two native parasites, Dibrachys cavus Wlk. and Habrolepoidea tarsalis Gir., both previously unrecorded from the vetch bruchid. Gahan (8, p.8) described a new species Chalcidoidea, Tetrastichus bruchivorus Gahan, which was found parasitizing the vetch bruchid.

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APPENDIX

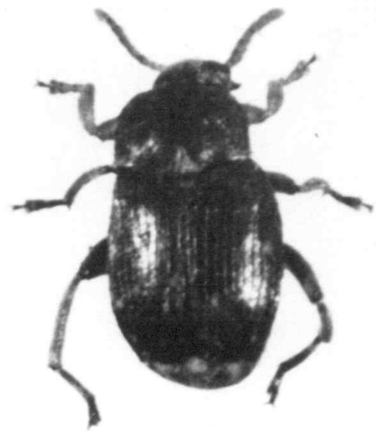

Fig. 1. Adult of the vetch bruchid, Bruchus brachialis

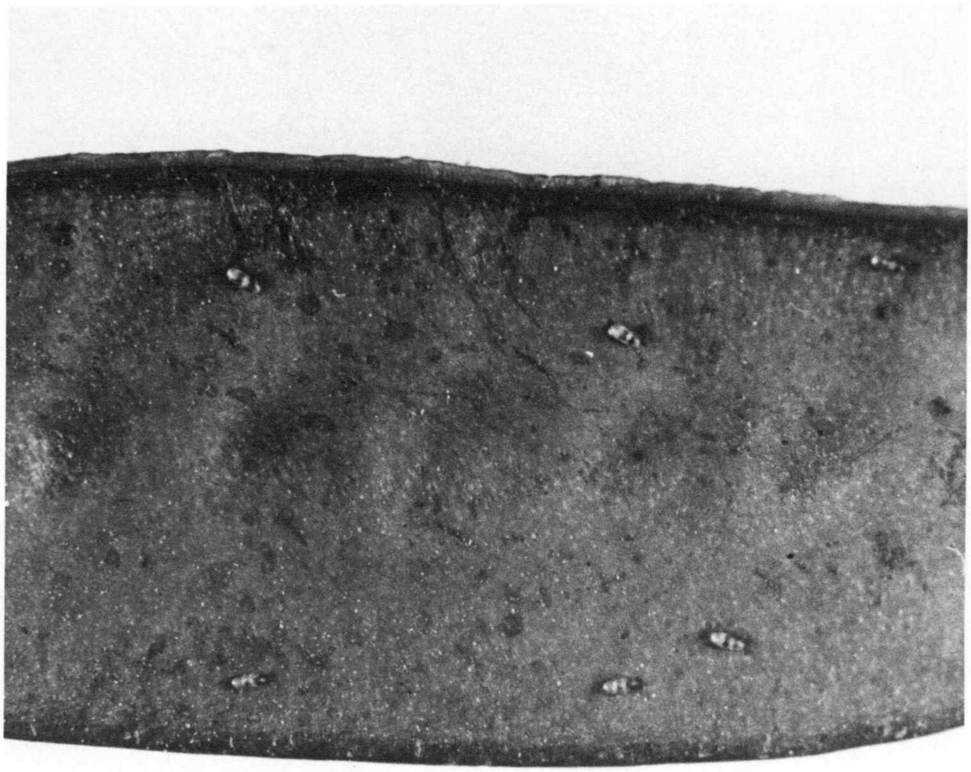

Fig. 2. Eggs of Bruchus brachialis
on a hairy vetch pod.

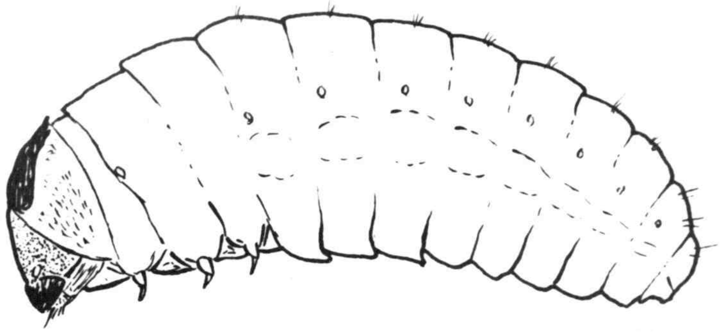

FIG. 3. FIRST INSTAR LARVA OF THE VETCH BRUCHID

ACTUAL LENGTH – .5 MM.

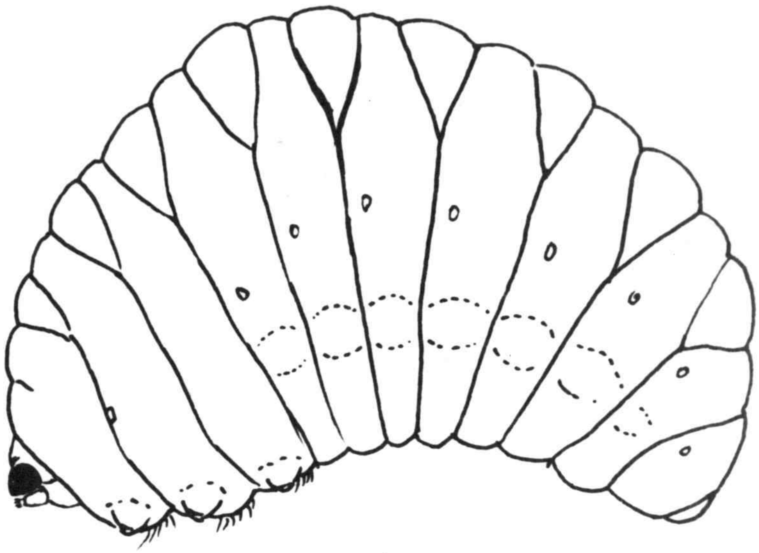

FIG. 4. FOURTH INSTAR LARVA OF THE VETCH BRUCHID

ACTUAL LENGTH — 3.7 MM.

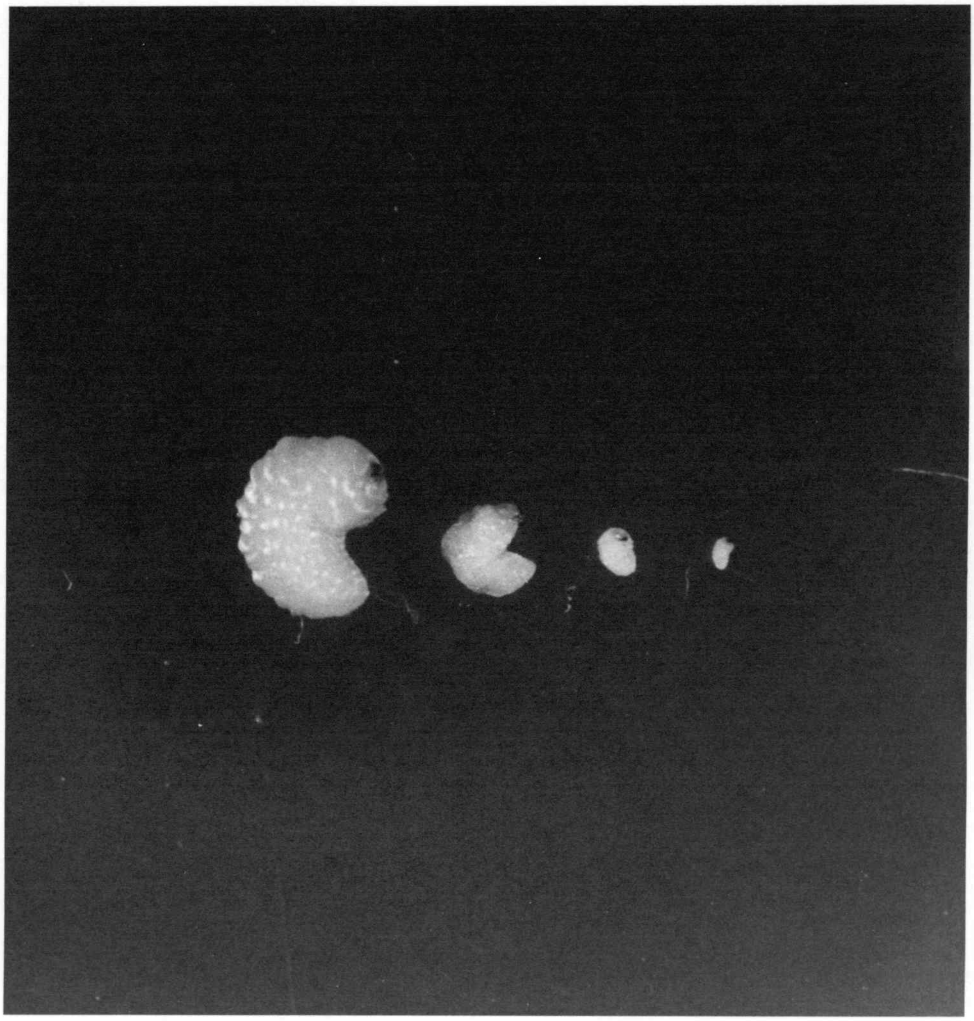

Fig. 5. The four instars of the larval stage of *Bruchus brachialis*.

Fig. 6. Pupa of <u>Bruchus</u> <u>brachialis</u>.

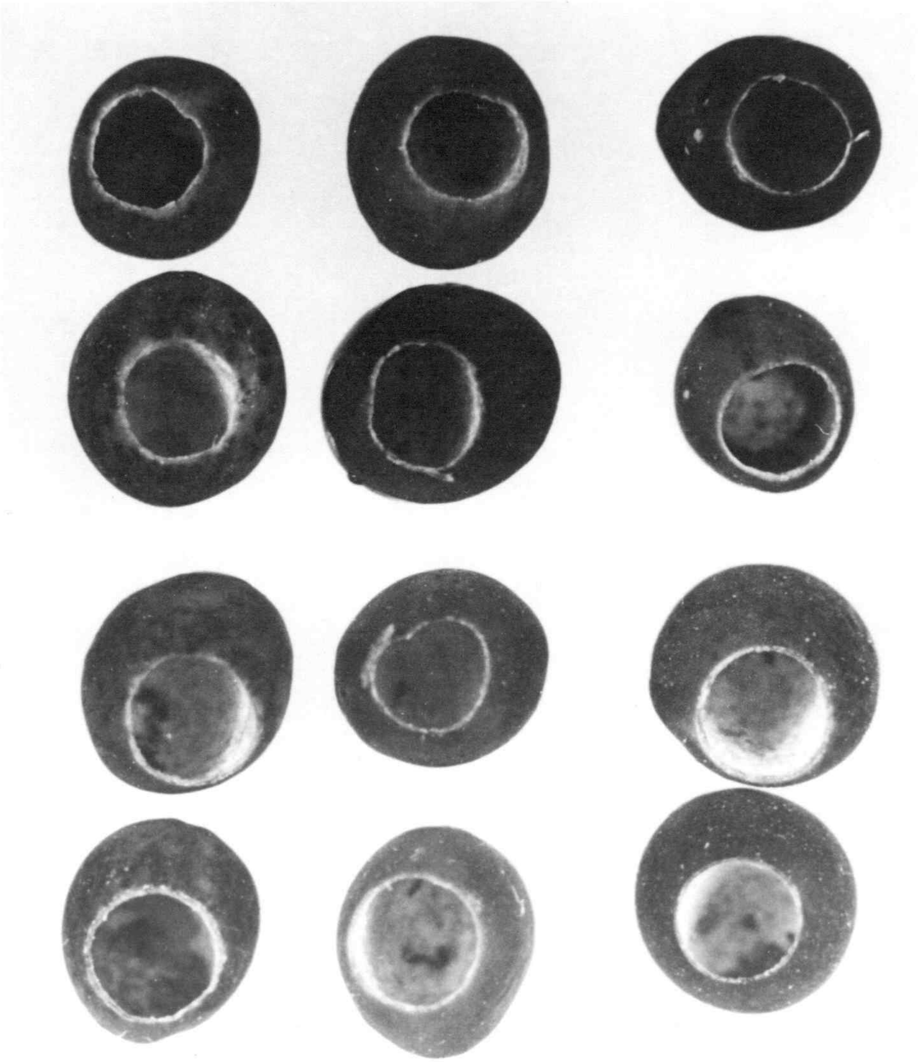

Fig. 7. Hairy vetch seed after emergence of adult vetch bruchids.

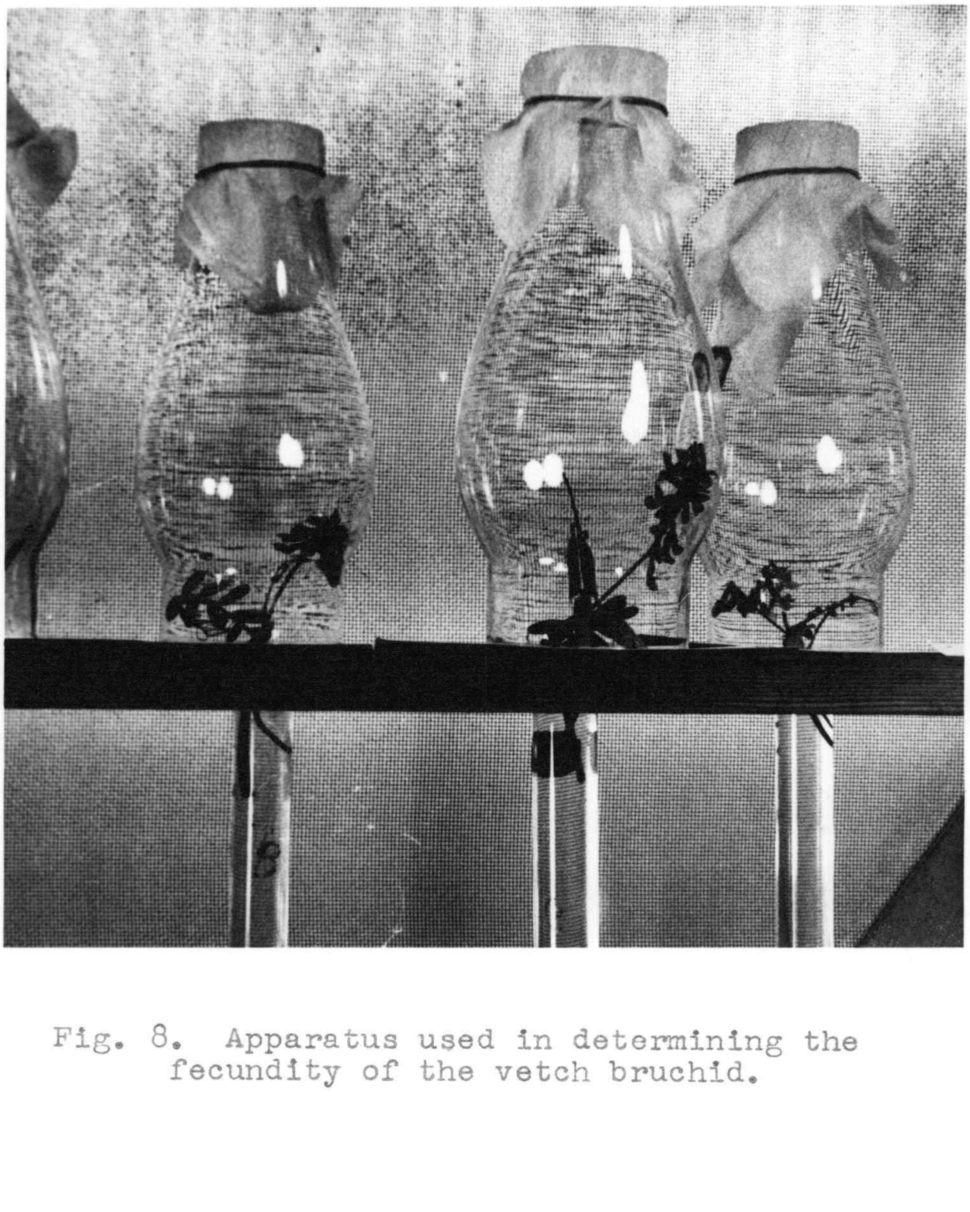

Fig. 8. Apparatus used in determining the fecundity of the vetch bruchid.

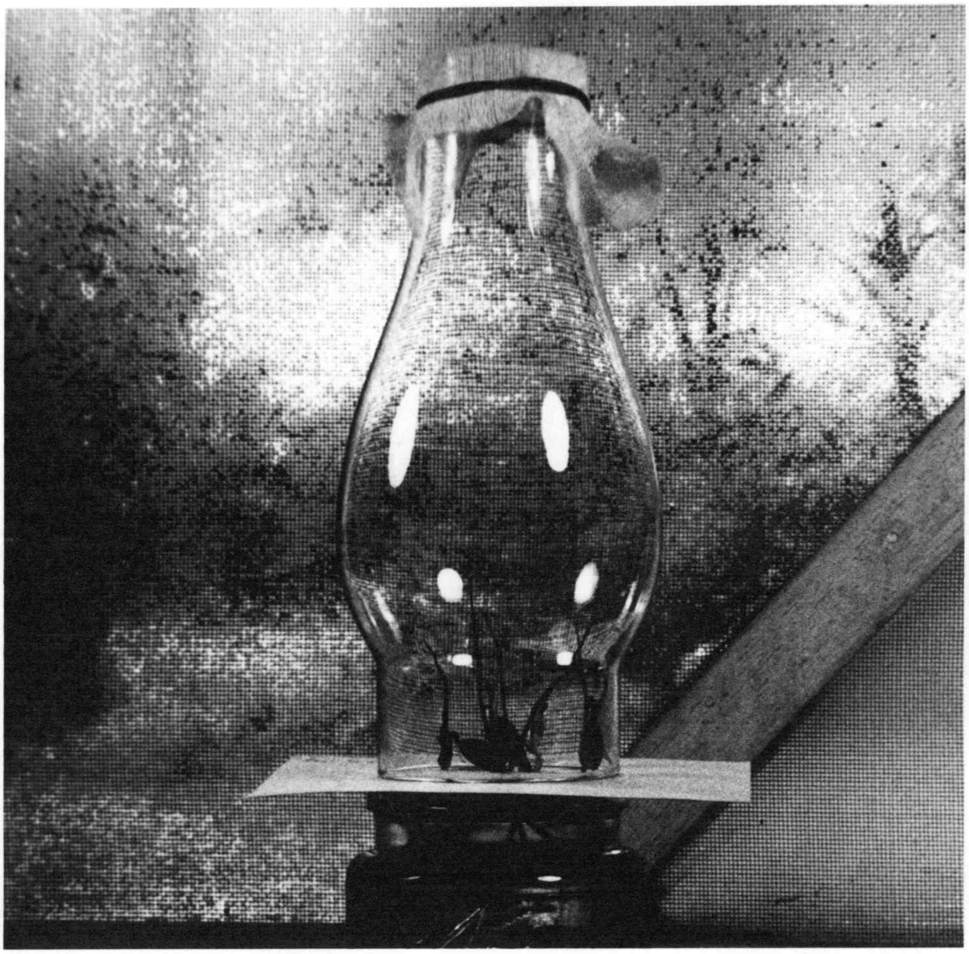

Fig. 9. Apparatus used in studies of the incubation period of the eggs of the vetch bruchid.

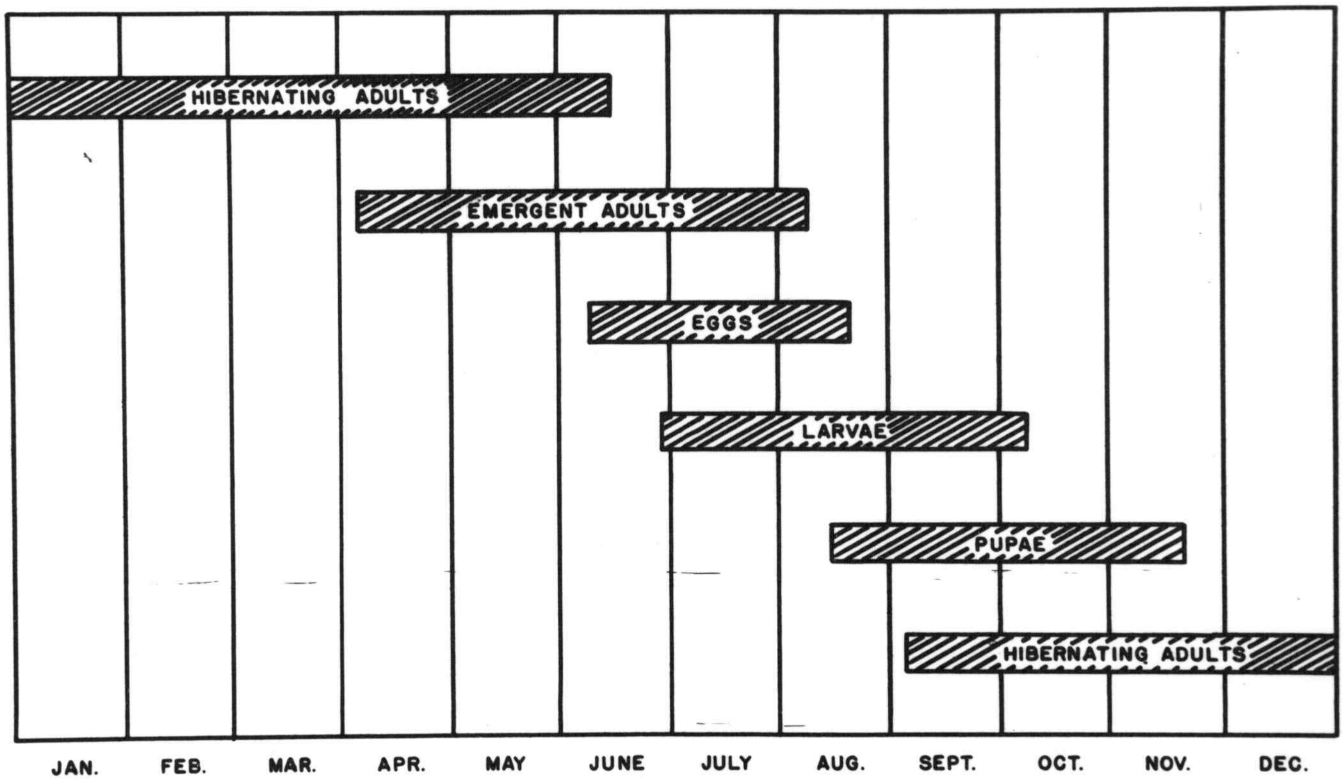

FIG. 10. SEASONAL LIFE HISTORY OF BRUCHUS BRACHIALIS IN OREGON

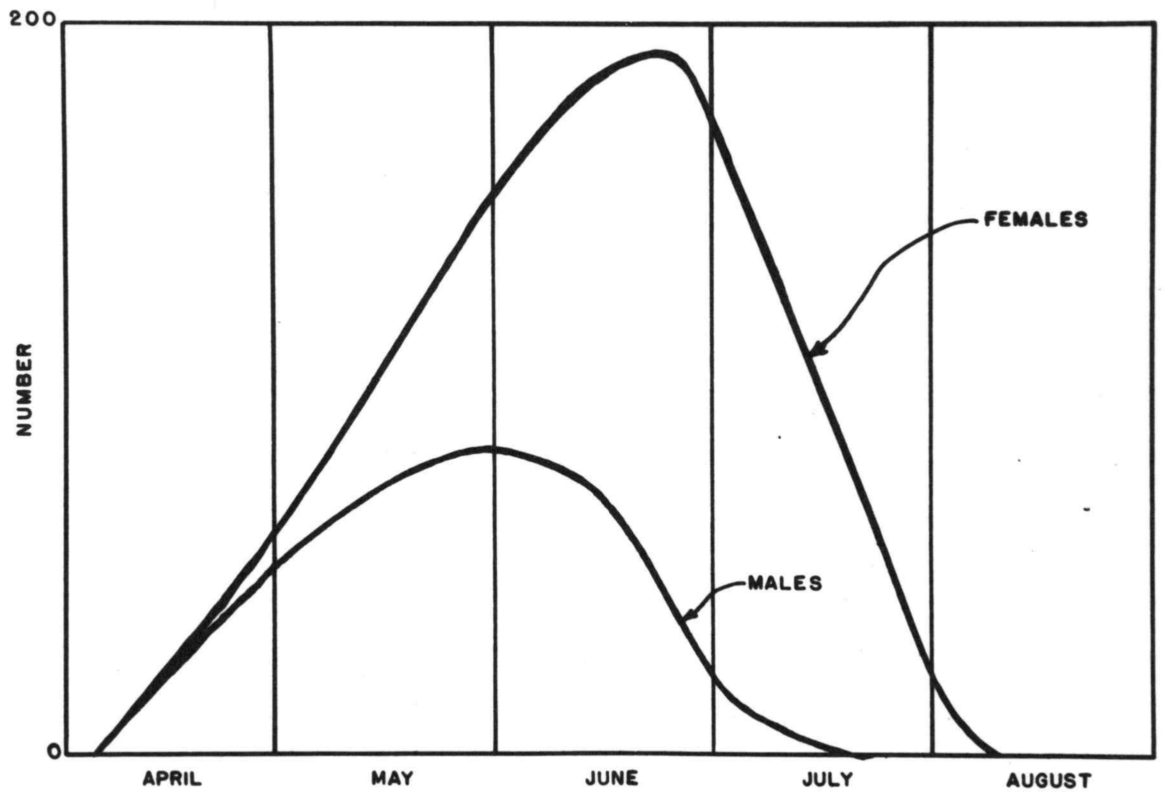

FIG. 11. RELATIVE ABUNDANCE OF FEMALES AND MALES DURING 1954 SEASON

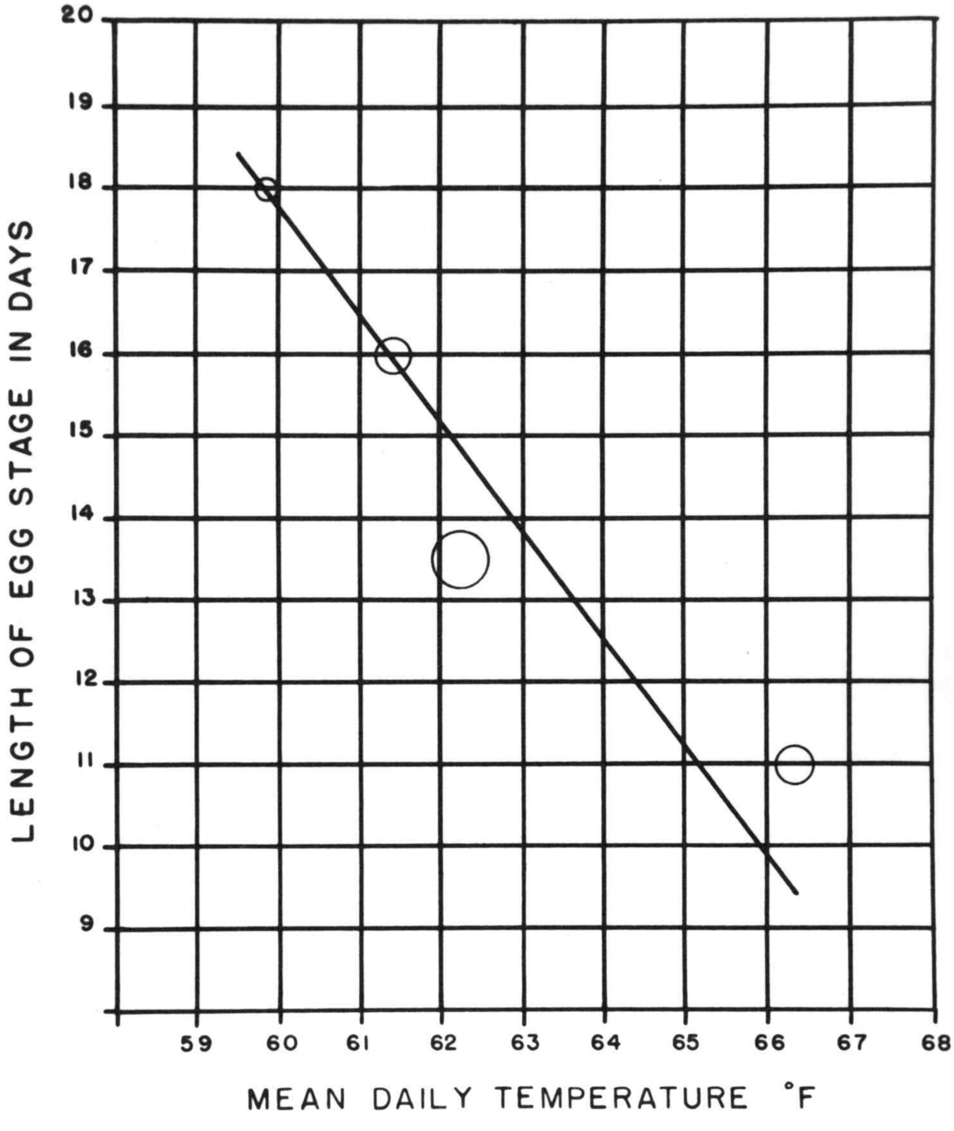

FIG. 12. EFFECT OF TEMPERATURE ON DEVELOPMENT OF THE EGG