

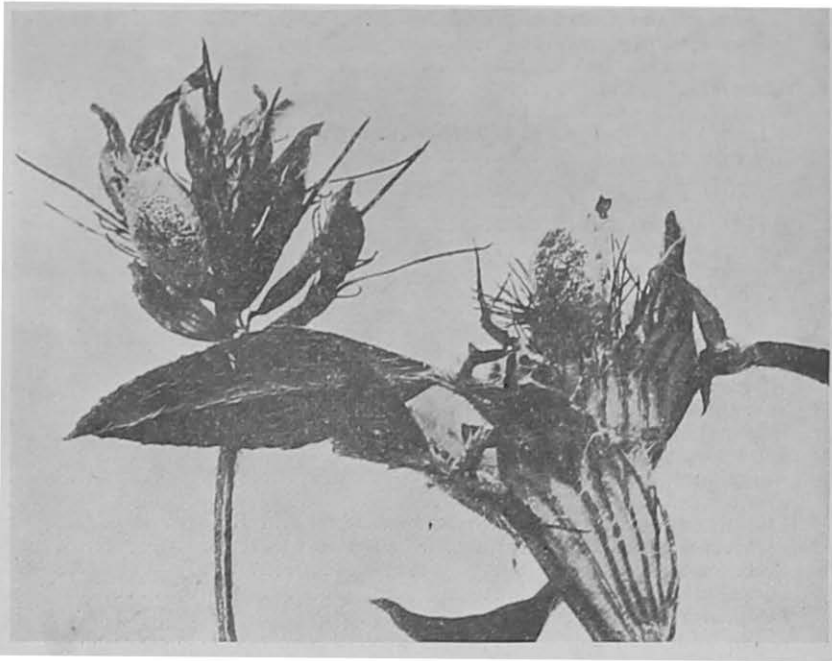
Three Little-Known Clover Insects

The Clover-Head Weevil (*Phytonomus meles* Fab.)

The Lesser Clover-Leaf Weevil (*Phytonomus nigrirostris* Fab.)

The Clover-Seed Weevil (*Tychius picirostris* Fab.)

John D. Detwiler



COCOONS IN CLOVER HEADS

Left, cocoon of *Phytonomus nigrirostris*; right, cocoons of *P. meles*

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THREE LITTLE-KNOWN CLOVER INSECTS

THE CLOVER-HEAD WEEVIL (*Phytonomus meles* Fab.)

THE LESSER CLOVER-LEAF WEEVIL (*Phytonomus nigrirostris* Fab.)

THE CLOVER-SEED WEEVIL (*Tychius picirostris* Fab.)

Order, *Coleoptera*

Family, *Curculionidae*

JOHN D. DETWILER

While engaged in general entomological work for the New York State College of Agriculture at Cornell University in the summer of 1918, the writer, at the suggestion of Professor Glenn W. Herrick, began a study of the beetles here described. During that summer some advance was made in the life histories of these pests and a general account was published (Herrick and Detwiler, 1919). The investigation was resumed by the writer in the following spring and was continued as a research problem.

The beetles were fairly abundant in the vicinity of the College, but could not be considered as serious pests. Since they all feed primarily on the red clover (*Trifolium pratense* L.), however, and since their attacks result in specific damage to both the stalk and the blossom, they constitute a standing menace by their presence, and a knowledge of their life history is a necessity.

THE CLOVER-HEAD WEEVIL

(*Phytonomus meles* Fab.)

The name *clover-head weevil*, which has been given popularly to the species *Phytonomus meles*, is not well established as yet, but is quite appropriate, as a study of the beetle's life history will show.

The species has long been known in Europe, but was first seen in America in 1907, near New York. In 1913 it was found at Albany, New York, and judging from its wide distribution in Europe it will probably become common throughout the greater part of this continent also wherever red clover is grown.

LIFE HISTORY

The life history of the clover-head weevil is not very well known, at least in America. In Europe some attention has been given to it. Laboulbène (1862) gives a good description of the larva of the variety *trifolii* Herbst, and also a short description of the pupa and the cocoon.

The adult

The beetle (figure 1) is rather small, measuring about 4.2 millimeters in length and approximately one-half as much in width. The general

color is either brown or black. The brown beetles are frequently tessellated with light brown or with dark spots; the black variety sometimes shows a greenish or grayish tinge.

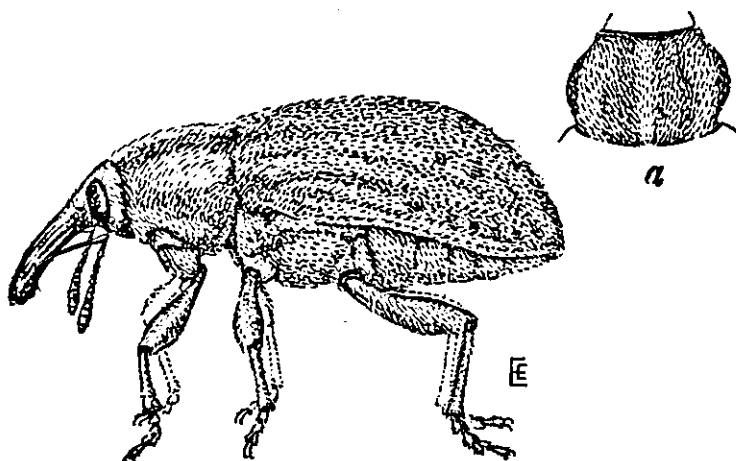


FIGURE 1. PHYTONOMUS MELES; a, DORSUM OF THORAX

The head is small and is narrow in front, considerably narrower than the eye. The beak is prominent, cylindrical, somewhat recurved, and a little longer than the prothorax.

The prothorax is wide, approximately one and one-half times as wide as its length, and the lateral margins are much rounded. In the brown variety the prothorax bears a median longitudinal pale stripe, and another pale but wider stripe along each side. These paler areas are due to scale effects.

The elytra are nearly rectangular in front and are noticeably wider than the widest part of the prothorax. The sides are nearly parallel to about one-third the distance from the caudal end, where they converge rather abruptly. Their surface is finely and striately punctate. The body is covered, though not densely, with small scales, some of which are deeply cleft while others are narrow and have the appearance of stout, metallic hairs.

Sex characters

In descriptive accounts of this species one finds a number of secondary sex characters given, most of which have been found of little or no real value. For example, it is stated that the beak of the female is more bent than that of the male. As neither shows much curvature, it would require rather a practiced eye to judge the difference with sufficient accuracy to make the character a dependable one. Equally valueless is it to state that the beak of the female is longer than the prothorax, for that of the male is also, though in neither sex is the beak much longer. Moreover, in the individuals measured the difference between the sexes in length of beak is slight.

Fortunately it is not necessary to depend on such characters as are based on slight comparative differences. In the last ventral segment of

the male one usually finds a fairly noticeable median depression, the appearance of the concavity being accentuated by the peculiar arrangement of the hairs there (figure 2). Besides this, there is an infallible and

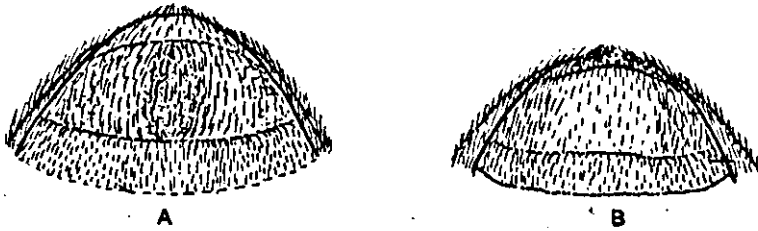


FIGURE 2. VENTER OF CAUDAL END (A) OF MALE, SHOWING DEPRESSION, (B) OF FEMALE

rather easily observed structural character in the division of the highly chitinized area constituting the dorsal wall of the last segment of the abdomen (figure 3); that is, the pygidium of the male shows two divisions

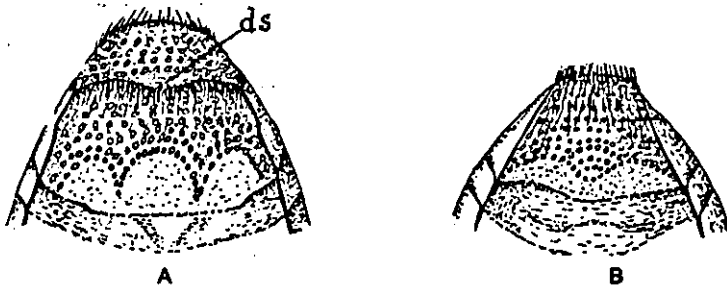


FIGURE 3. DORSUM OF CAUDAL END (A) OF MALE, (B) OF FEMALE
ds, Suture dividing pygidium

and that of the female only one. The extra suture in the male can sometimes be seen without lifting the elytra.

Hibernation

The beetle hibernates as an adult. It evidently finds shelter at or near the surface of the earth among the plants where it was feeding when fall overtook it, or among the débris collected there. Beetles have been found by the writer in such places in the early spring—that is, in March—but the number found was not large for the length of time spent in the search.

Oviposition

Oviposition begins fairly early in spring and extends over a long period, as is shown in the discussion of the seasonal history of the beetle. The act of ovipositing is very interesting. The beetle takes up her position, lengthwise, on the clover stalk or petiole, makes a crosswise cut of about 0.5 millimeter through the epidermis, and eats out a cavity beneath, frequently carefully preserving the epidermal covering. Sometimes she may be seen working her beak at different angles, as if anticipating the

need of considerable room in the plant tissue, for the cavity may have to hold a number of eggs ranging from one to a dozen or even more. After completing this operation she turns about, inserts her eggs, and then carefully combs the epidermis, which she preserved, back into place (figures 4 and 5) by catching it with the caudal end of the abdomen and

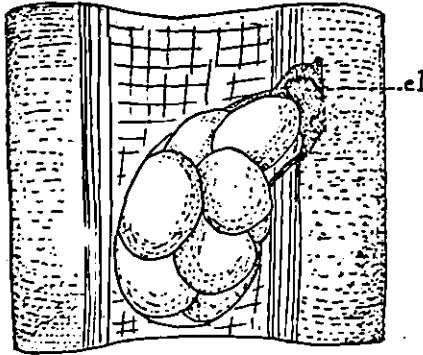


FIGURE 4. CAVITY WITH EGGS
el, Epidermal lid

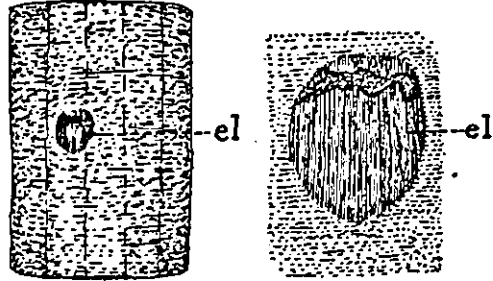


FIGURE 5. EGG PUNCTURE; ENLARGED VIEW
SHOWN AT RIGHT
el, Epidermal lid

pulling backward. This replacement of the epidermal lid is a deliberate process, for not only does it involve repeated action, but so much strength is put into it that the beetle's body may be seen to jerk as the hold is released. The covering soon dries, since it is severed from the underlying tissue, but until it dries it often excellently conceals the place of oviposition. It may be that the beetle's object is not one of concealment, but of protection against desiccation of the eggs.

The egg

The egg (figure 6) is small and ellipsoidal, and has a glossy surface. Its average size is approximately 0.55 millimeter long by 0.36 millimeter wide. Newly laid eggs have a whitish or a milky appearance, or in some cases are greenish.

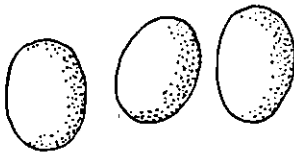


FIGURE 6. EGGS OF PHYTONOMUS MELES

The time of incubation varies considerably. This is true not only in a general way, but also of eggs of the same laying. The period of incubation, as shown from records kept, varies from eight and one-half to thirteen days.

As incubation proceeds, a dark spot begins to show in the egg. This may become very evident by the third or the fourth day, and it represents the head region of the developing embryo. Before the larva emerges, its small, black head can be distinctly seen. Aside from this the egg darkens but little during the process of hatching.

Eggs of the same laying often show considerable difference in the rate of hatching. In oviposition the beetle frequently leaves one or two eggs exposed in the opening of the cavity. These exposed eggs may be in the dark-spot stage while the deeply inserted ones show little, if any, signs of hatching. This variation in the rate of incubation is probably due to a difference in moisture conditions. The exposed eggs must be more or less

dried by their exposure to outside conditions, while those deeply imbedded are kept moist by the plant. A certain amount of moisture in excess of that found in the atmosphere, however, is necessary in the hatching of the egg; for eggs deposited entirely on the surface of the plant, as sometimes happens, invariably shrivel and dry up, although such eggs will hatch if they are placed artificially in a slit of the clover stem.

The larva

Newly hatched larvae are approximately 1 millimeter long and present a characteristically clean, white appearance. The head measures 0.2 millimeter across, is black, and bears a distinct Y-shaped, light-colored suture, the stem of the Y being in line with the median division of the dark-colored and somewhat narrow prothoracic shield. The body bears eight longitudinal rows of conspicuous hairs, four rows on each side, one pair on the dorsum and the other three ventrad of the spiracles. The hairs in each row are arranged segmentally, one hair to a segment.

The larvae reach maturity in about twenty days. The complete larval period thus approximates twenty-three days, a few days usually being spent within the cocoon before pupation takes place.

There are three molts, and the duration of the instars is, in general, four days for each of the first three, and eight days for the fourth, or last.

TABLE 1. HEAD MEASUREMENTS OF LARVAE MADE DURING REARING EXPERIMENTS

Specimen	First instar	Second instar	Third instar	Fourth instar
Larva 1....	13.0	16.0	25.0	33.5
Larva 2....	12.0	17.5	24.0	30.0
Larva 3....	11.0	17.0	24.0	30.0
Larva 4....	12.0	16.0	24.0	32.0
Average....	12.0 (=0.20 mm.)	16.6 (=0.28 mm.)	24.3 (=0.41 mm.)	31.4 (=0.53 mm.)

TABLE 2. HEAD MEASUREMENTS OF LARVAE COLLECTED, KILLED, AND THEN MEASURED

(Values arranged in four columns, or series)

	Series I	Series II	Series III	Series IV
	12.0	17.0	24.0	31.0
	12.0	17.5	23.6	30.0
	13.0	17.0	24.5	28.0
	13.0	16.0	24.0	32.0
	12.0	18.0	25.5	30.0
	12.5	17.5	24.0	31.0
	12.5	17.0	24.5	31.5
	13.0	18.0	23.0	30.5
	12.0	17.0	24.0	31.0
	13.0	17.0	22.0	32.0
Average....	12.5 (=0.20 mm.)	17.2 (=0.29 mm.)	23.9 (=0.41 mm.)	30.7 (=0.52 mm.)

The color of the head remains black until the final instar is reached, when it becomes a rusty brown. The variation in head measurements throughout the different instars is fairly uniform, sufficiently so to be used as a criterion of the stage of development, as is shown by tables 1 and 2. The measurements, which are given in micrometer readings, are for the head widths. The micrometer value is 0.017 millimeter.

Since accurate measurements of living larvae are difficult to make, the measurements given in table 2 must be considered the more nearly correct. It will be noticed that the results are remarkably similar. Incidentally it may be mentioned

that the variation in the head widths is practically that of a geometric progression. The width of the final instar, however, falls a little short of the required value.

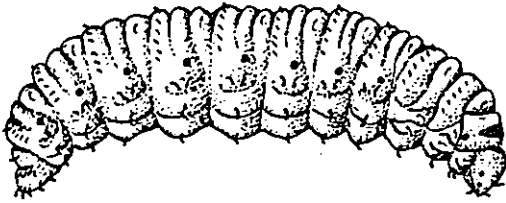


FIGURE 7. FINAL-INSTAR LARVA

the most striking feature of the final-instar larva (figure 7) is the development of the varied color markings. The color scheme appears as longitudinal stripes, and is confined mainly to the abdomen. The arrangement of the stripes can best be understood by reference to figure 8, together with the following notes:

Dorsal aspect: The ground color (thorax and venter generally) may be dark pearly white, grayish, greenish gray, greenish yellow, or yellow.

Stripe 1 (mid-dorsal, extending practically along the whole length of the abdomen and ending abruptly at the thorax): This may be pearly white, grayish, creamy, yellow, or even orange-yellow.

Stripe 2 (first dorso-lateral, extent practically that of stripe 1): The two stripes (one on each side) may be brown, bluish brown, or even blue-green.

Stripe 3 (second dorso-lateral): These stripes are very similar to the ground color and should probably be included with it.

Stripe 4 (lateral, lying along the line of the spiracles): These may be absent, faint, or well marked. The color, when present, resembles that of the first dorsals but is generally lighter. These stripes apparently never appear in the third instar.

Stripe 5 (ventro-lateral): These may appear in highly colored larvae, for the intensity of color varies considerably. When present, their color resembles that of the mid-dorsal and the second dorso-laterals, being less pearly than the ground color.

The larvae appearing later in the season seem to have a greater tendency to the dark brown stripes, accompanied, naturally, by a higher general coloration. They may be so dark as to give the general effect of brownish orange.

The last instar

The last-instar larva may attain a length of 7 millimeters. The general shape is elongate and

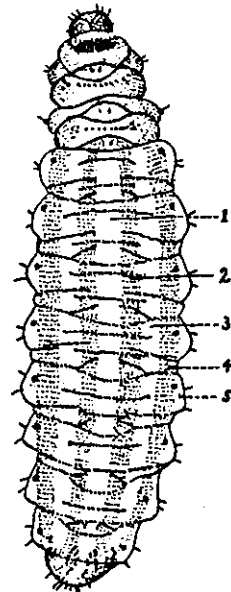


FIGURE 8. FINAL-INSTAR LARVA, SHOWING MARKINGS

1, Mid-dorsal stripe; 2, first dorso-lateral stripe; 3, second dorso-lateral stripe; 4, lateral stripe along line of spiracles; 5, ventro-lateral stripe

somewhat elliptical. The skin is everywhere finely papilliform. The head is a rusty brown, having changed from the black of the previous instars, and is small as compared with the size of the body. On the vertex may be seen the distinct Y-shaped suture already mentioned. The arms of this suture extend to the antero-lateral margin, where they terminate near the bases of the antennae. The antennae are very small and are situated on the frontal margin of the head, each just laterad of a conspicuous fronto-marginal hair. They are two-segmented, the proximal segment being relatively large and globular while the distal one is minute and awl-shaped. Immediately ventrad of each antenna, and across the suture mentioned above, is a small dark eye, and a short distance back is a second one, there being two to a side. The clypeus is trapezoidal, the shorter margin being at the front. The labrum is distinctly emarginate and bears a row of hairs. This sclerite and the lower part of the head are light-colored.

The thorax is relatively short and narrow. The prothoracic segment bears a brownish shield, which is more or less distinctly divided into lateral halves by a median line. With the exception of the prothorax, each segment is divided dorsally by a posteriorly curved groove. The anterior area thus becomes spindle-shaped. This area bears two hairs, while the posterior area has a distinct transverse row of hairs containing typically twelve hairs, six on each side.

The abdomen consists of nine segments, and the dorsum of each segment, except the eighth and the ninth, is divided into three areas, the extra groove appearing in what corresponds to the posterior area of the thoracic segment. This groove arises near the spiracle of its segment and passes over to the corresponding position on the other side. The foremost area here too is spindle-shaped and bears two hairs; the second area is smooth; the third area bears a transverse row of hairs similar to those described for the thorax. The last segment is truncated and bears a pair of stout, fleshy prolegs, or attachment disks.

The dorsal hairs referred to have a distinct tendency to be clavate. Those on the prothorax, which have not yet been described, do not possess this character. Their arrangement (figure 9), too, differs from those of the other segments. Roughly speaking, they may be said to border the cervical shield, converging to an apex just above the thoracic spiracle. In all there are eighteen distinct hairs, two of which form an anterior crosswise row.¹

The lateral margin of the body is rather conspicuously notched, due to a segmental series of swellings. These swellings are divided by two longitudinal grooves, thus forming, in all, three rows, or series, of somewhat angular protuberances. On the mid-ventral line there is another double row of swellings, but these are cuplike and not angular. All of these protuberances or swellings bear one or more hairs,

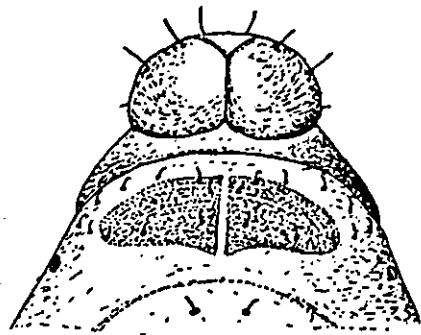


FIGURE 9. ARRANGEMENT OF DORSAL PROTHORACIC HAIRS

1 An indistinct pair may be seen behind the last pair mentioned.

or setae, the arrangement and number depending on the series and on the position, whether abdominal or thoracic. These larvae (in common with the larvae of weevils) have no legs and have to depend on the ventral swellings for locomotion.

There are nine pairs of spiracles, one pair in the thorax and eight in the abdomen. They are easily seen and appear as small dark spots, which on closer view prove to be small dark rings or peritremes.

The cocoon

The cocoon is a lacy, delicately formed, ellipsoidal structure. It is usually amber-colored, but may be greenish or even fairly white. It is often very symmetrical, its symmetry evidently being effected by the larva's habit of lying on its back while spinning, and reaching out only certain distances as it fastens the strands with its mouth. The head of the red clover offers a very convenient place in which to build this cocoon, for the spaces formed between the florets and those between the head and the involucre afford easy attachment places for the foundation strands. After a number of these foundation strands have been fastened, a small cavity is formed in which the larva curls up and walls itself in. The silk is obtained from a gland at the caudal end of the abdomen. In spinning, the larva reaches back, obtains a mouthful of the secretion by an action which resembles biting, attaches a bit of it to the foundation strands or to the wall of the developing cocoon, and then proceeds to another point, spinning the silk out, so to speak, as it moves from point to point. In this way a fairly uniform mesh is built up, though no definite method of procedure is apparent. From a few measurements made, the average mesh was calculated to be about 0.15 millimeter. The size of the cocoons varies somewhat, but ordinarily it is about 4.8 millimeters long by 3.4 millimeters wide.

The cocoon may require hours for building. One larva, for example, was observed spinning at 5.15 p. m., and at 11.40 the same night it was still busy. After spinning the cocoon the larva lies in it for a few days, usually two or three, before pupating.

Pupation and the pupa

Pupation may take place very suddenly. At the time of pupation great activity has been observed, the developing pupa throwing itself about very energetically. The old larval skin gives way at the head first, the recurved beak soon appears, and in a few minutes the whole pupa may be free.

The newly formed pupa is very light-colored, the freer parts, such as the beak, the antennae, the legs, and the wing covers, being a glassy white. The abdomen remains very larva-like, even the color markings persisting to a considerable degree. Within a day all but the abdomen begins to darken, and in a few days the most exposed parts may be dark brown. A white line (figure 10, b), however, which may persist throughout the entire pupal stage, remains along the median surface of the beak and extends over the head, through the prothorax, and into the mesothorax, where it ends at a median marginal flattened tubercle. The size of the pupa varies

considerably, ranging, in a few measurements made, from 4.3 to 5.4 millimeters in length. The prothorax bears a number of conspicuous hairs (figure 10, a and b)—ten on the venter, and typically an equal number on the dorsum though the number and position here may vary considerably.

The most interesting feature of the pupa is its great activity. It throws itself about in a revolving fashion around its long axis, first in one direction and then in the other.

Transformation and emergence

The newly transformed beetle is very light in color but it soon darkens. During the first day it may become fawn-colored, and in a day or so more it is a dark brown. It remains in the cocoon for about two days before emerging, and during that period it sometimes eats a considerable part of the cocoon.

Duration of stages and periods

In the discussion of the life history, the lengths of the different periods involved in the metamorphosis are not given. These can be readily obtained from the following tabulated life-history records, at least in so far as they apply to eggs laid in August.

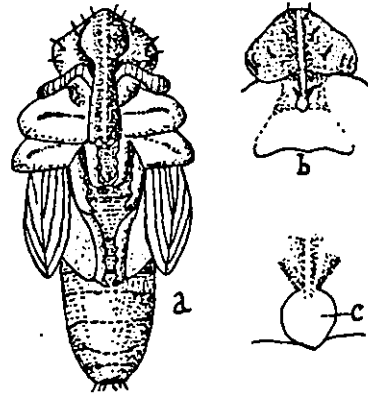


FIGURE 10. PUPA OF PHYTNOMUS MELES

b, Thorax, showing mid-dorsal line.
c, Tubercle at end of mid-dorsal line (enlarged from b)

Life-history dates

Experiment	Eggs laid	Hatched	Spun up	Pupated	Trans- formed	Emerged
(a).....	Aug. 21	Aug. 30	Sept. 22	Sept. 25	Oct. 2	Oct. 5
(b).....	Aug. 22	Aug. 30	Sept. 22	Sept. 24	Sept. 29	Oct. 3
(c).....	Aug. 22	Aug. 31	Sept. 23	Sept. 26	Oct. 4	Oct. 6
(d).....	Aug. 23	Sept. 1	Sept. 25	Sept. 27	Oct. 6	Oct. 8
(e).....	Aug. 25	Sept. 2	Sept. 22	Sept. 25	Oct. 3	Oct. 6
(f).....	Aug. 26	Sept. 4	Sept. 23	Sept. 26	Oct. 4	Oct. 4

Life-history periods

Experiment	Incubation	Larval	Prepupal	Pupal	Emergent	Total
(a).....	9 days	23 days	3 days	7 days	3 days	45 days
(b).....	8	23	2	5	4	42
(c).....	9	23	3	8	2	45
(d).....	9	24	2	9	2	46
(e).....	8	20	3	8	3	42
(f).....	9	19	3	8	0	39

From these records it is seen that adult beetles may appear from thirty-nine to forty-six days after the eggs are laid.

SEASONAL HISTORY

In 1921 eggs were found in considerable abundance in the petioles of red clover leaves on April 25. These were believed to be eggs of the species under discussion, and an early appearance of the larvae was expected. In this, however, the writer was disappointed, and it is not known what happened to the eggs. The season was very early. In a normal season, similar activity in egg-laying would probably not have taken place until May. As a matter of fact, eggs were plentiful in the same locality on May 26, as many as 25 having been found in a petiole of red clover $2\frac{3}{4}$ inches long. Assuming that active egg-laying takes place about the middle of May in a normal season, and allowing forty-five days for the new generation to complete its life history, the adults would begin to appear early in July. In 1918 a number of larvae brought in from the field emerged during July, and on July 1, 1920, great numbers of final-instar larvae were observed on the clover heads. On July 29 of the same year, eggs were found on the second-growth clover; some of these had evidently been laid recently, while others showed signs of hatching. In the latter part of August numerous beetles were collected, and these laid actively; in fact, eggs were found as late as September 15. From these records it appears that there is at least a partial second generation in a summer. It may be mentioned that a considerable number of the beetles caught during August were black instead of the usual brown. Both the black and the brown beetles laid actively.

FOOD PLANTS AND FEEDING HABITS

Titus (1911:441) reports eggs deposited on clover and alfalfa. (The article cited contains an extensive bibliography.) European observers report the following food plants: *Medicago sativa*, *M. falcata*, *M. lupulina*, *M. media*, *Trifolium pratense*, *T. incarnatum*. In the vicinity of Ithaca the writer has found the eggs laid in the petioles and stems of the red clover (*Trifolium pratense*), and on alsike (*T. hybridum*).

The feeding habits of the larvae have been observed in the field and in the laboratory. Rearing experiments proved unsuccessful until clover florets were given to the newly hatched larvae; after that, little difficulty was experienced in starting them feeding and in rearing them. Perhaps this dependence on the clover head for food would account for the non-appearance of the larvae on clover early in the spring of 1921. In the field also the larvae attack the blossoms. There they may be observed headforemost in the calyx, devouring the whole of the floret contents. The writer has never seen the adults in sufficient numbers in the field to notice their doing any appreciable damage. In the laboratory they have rather a characteristic habit of attacking the clover leaflet at its base, thus severing it more or less completely from the petiole. When the clover comes into bloom, the beetles may be seen on the blossoms, presumably feeding on the pollen.

ABUNDANCE AND INJURY

In 1920 the larvae were abundant in a field of red clover on the agricultural college farm at Cornell. This field had been seeded down the preceding year. On July 1 a number of clover heads were examined, and

84 out of 100 were either infested with larvae or bore cocoons; the remaining 16 heads were mature and may have been previously infested. As many as eight larvae were found on one head. Some of the larvae, however, may have been *Phytonomus nigrirostris*, since the two species are difficult to distinguish in their early instars. Many of the final-instar larvae (of *P. meles*) were lying rather freely on the clover head, but no sign of disease was noticed. On returning to the field on July 8, the writer expected to find many cocoons; but for some reason, not understood, they were conspicuously scarce.

These larvae seemed to have done the clover little if any harm. The clover showed a very good stand; the plants were tall and appeared thrifty. It would thus seem that as far as the hay crop is concerned little damage is done by the larvae. If this crop had been grown for seed, the problem would have been much more serious; but as the seed is harvested from the second growth, the injury is not liable to be great, since the larvae are not nearly so abundant at that time.

CONTROL

Judging from the marked scarcity of pupating larvae after the heavy infestation of 1920, referred to above, there must be a very effective natural control. This is probably a fungous disease. Laboulbène (1862) states that he has found direct parasites which, as well as he was able to make out, were ichneumon flies. The question of hymenopterous parasites is discussed further in connection with *P. nigrirostris*.

Should this species become a serious pest, it seems reasonable to believe that if the clover were cut a little early, that is, at a time when the striped larvae are beginning to be abundant, effectual control would result. The larvae seem to be very dependent on the clover head for food, and, as the heads would dry up directly, starvation would follow.

A short summary of this species is given in connection with that of *P. nigrirostris*, in which the two species are compared (page 20).

THE LESSER CLOVER-LEAF WEEVIL

(*Phytonomus nigrirostris* Fab.)

The species *Phytonomus nigrirostris* is commonly known by the name *lesser clover-leaf weevil*, in contradistinction to the *clover-leaf weevil*, *Hypera punctata* Fab.

Like the species previously discussed, this one also has a general European distribution. Its discovery in America antedates that of *P. meles* by at least twenty-five years. It probably gained its first foothold in the maritime provinces of eastern Canada, and from there gradually worked its way westward. In 1916 Cooley (1916) reported it as appearing in great numbers in western Montana.

LIFE HISTORY

The adult

The beetle (figure 11) is somewhat smaller and noticeably more slender than that of *P. meles*. It averages about 3.7 millimeters in length, and is not quite half as wide as long. Dorsally it is green or blue-green, the color being due to the scales covering the dorsum of the prothorax and the elytra.

The head is small, black, closely punctured, and covered with brownish, scale-like hairs which give it a pitchy brown effect. The eyes are large, black, and elongate. The front is narrow, not so wide as the eye. The beak is conspicuous, glossy black, recurved, somewhat slender, and approximately as long as the prothorax. The antennae are reddish brown and are inserted toward the distal end of the beak. The club is elongate ovate and is covered with a white pubescence.

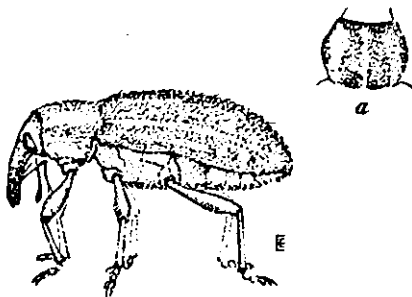


FIGURE 11. PHYTONOMUS NIGRIROSTRIS;
a, DORSUM OF THORAX

The prothorax is wider than long — about one-fifth to one-sixth wider — and the sides are gently, though not markedly, rounded. They do not bulge as in *P. meles*. The relationship here given between the width and the length of the prothorax as determined by measurements is not the one usually given. Capiomont (1868) states that in the male the prothorax is a little longer than wide, and in the female it is much more so. Titus (1911:445) says that it is one-third longer than wide. Since this is one of the characters used in separating the species under discussion, the diversity is likely to lead to a little confusion.² The dorsal surface of the prothorax is coarsely and closely punctate, and from these punctures there arise either deeply cleft or uncleft narrow scales. These scales impart a greenish color to the dorsum, particularly to three longitudinal stripes, which are dark green. One of these is a narrow median stripe and the other two are wider laterals. Ventrally the scales are light-colored. The elytra are elongate and the humeri gently rounded. The upper surface is black, striated, and densely covered with deeply cleft, green scales. On the lateral margins the scales are brownish.

The legs are reddish brown and are clothed with whitish, scale-like hairs except on the coxae, where the bifurcated scales persist. The tarsi show distinct white hair-pads.

Sex characters

The male of this species, like that of *P. meles*, shows a distinctly chitinized extra dorsal sclerite on the caudal end of the abdomen (figure 12, A). The depression in the venter of the last caudal segment of the

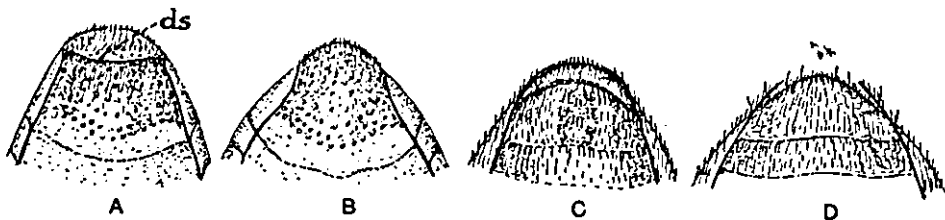


FIGURE 12. CAUDAL END IN PHYTONOMUS NIGRIROSTRIS

A, Dorsum of caudal end of male; ds, dividing suture of pygidium. B, Dorsum of caudal end of female.
C, Venter of caudal end of male. D, Venter of caudal end of female

² According to Capiomont (1868) the species is very variable, variations occurring in size, color, dimensions of scales, and hairs, and, up to a certain point, in the form of pronotum and elytra.

male (figure 12, c) as noted by Titus (1911) is a fairly good character. Here, too, the hair arrangement resembles that of *P. meles*, but the curvature of the rows is not so marked. The beak of the male, in the specimens measured, is of the same length as the prothorax. In some females, also, the beak is of the same length as the prothorax, while in others it tends to be slightly longer.

Hibernation

During March of 1919 and 1920, search was made for these beetles among the clover plants in the field. They were rather easily located, though scattered about. The best results were obtained from a small hollow, about twelve square yards in area, on the top of a high hill, where fourteen beetles were found. Here there was opportunity for debris to collect and lodge, thus affording some protection to the insects.

Oviposition

Egg-laying begins early in the spring. In 1920 eggs were found inter-epidermally on leaves in the field on April 29, and in 1921 they were found sub-epidermally on the basal sheaths of the petiole on April 26. Those of 1920 were black when found, indicating that they were not newly laid. Some of those of 1921 were brought into the laboratory, and the larvae emerged on April 28 and 29.

Observations on oviposition were made on beetles in captivity. The eggs were placed inter-epidermally in the clover leaflet after a slit had been cut into the epidermis and a cavity excavated with the beak. The operation is very similar to that described under *P. meles*, except that there is no attempt made to close up the opening — which, of course, would be unnecessary, since it remains slit-like. The eggs are usually laid singly, though cavities containing a few are common also.

Fecundity

The beetles are very prolific layers. One under observation laid 294 eggs, at least, from April 14 to May 27, averaging nearly seven a day. Another began laying on April 10 and laid approximately 200 eggs by May 28, averaging about four a day and laying as many as fifteen in one day. The first-named beetle laid as many as twenty-one eggs in a little less than one day, and no doubt she laid more than the sum total given (294), for whenever there was any uncertainty about a record it was discarded.

The egg

When the egg is viewed in place, under the epidermis, it appears green, but when dissected out it has a distinct whitish color. There may be a trace of green, as some think, but, if there is, it is very slight. As incubation proceeds the color deepens, until finally it becomes very dark. The shape tends to be regularly ellipsoidal (figure 13), and the surface is finely sculptured. The average length as calculated from a number of measurements made was 0.56 millimeter, and the width 0.36 millimeter.

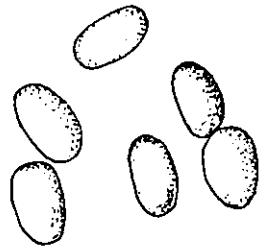


FIGURE 13. EGGS OF
*PHYTOMUS NIGRI-
ROSTRIS*

In the spring, when the weather is still cool, the incubation period is considerably prolonged, as the following records show. Later on this period decreases by at least one-half.

Experiment	Date of oviposition	Date of hatching	Incubation period
(a).....	May 4	May 23	19 days
	May 4	May 25	21
(b).....	May 4	May 23	19
(c).....	May 5	May 25	20
	May 5	May 26	21
(d).....	May 6	May 26	20
(e).....	May 7	May 24	17
	May 7	May 26	19
(f).....	May 15	May 27	12
(g).....	May 18	June 1	14
(h).....	May 19	May 30	11
	May 19	May 31	12
(i).....	May 26	June 7	12

Eggs laid on the same day as those of experiment (a) and kept inside, hatched in eleven days, and, similarly, eggs laid on the same day as those in experiment (c) hatched in eleven and twelve days. According to Wildermuth (Webster, 1909), the egg period varied from seven days and twenty hours to eight days and twelve hours. This is probably the average time during the hot days of summer only.

The larva

When newly hatched, the larva is approximately 1 millimeter long. Its body is whitish in color, and its head is black. The head shows the distinct Y-shaped epicranial suture as described for *P. meles*. The cervical shield is not quite so dark as the head, and is divided medially by a narrow white mark. The body bears eight longitudinal rows of conspicuous dark hairs, arranged segmentally. Four rows can be readily seen from a dorsal view, two being dorsal and the other two lateral. The other four rows are situated ventro-laterally, two rows to a side, and somewhat close together. The lateral and the ventro lateral rows are arranged along an equal number of rows of segmental swellings, a hair adorning the apex of each swelling.

The larva soon acquires a somewhat dirty white color, a character which helps to distinguish it from the larva of *P. meles*. But no really good character has yet been found to distinguish the larva of one species from that of the other in the earlier stages.

In this species also there is an interesting relationship between the instars and the head widths, as the following records from a number of rearing experiments show. In this larval life-history record, the head widths are given in micrometer readings. In the column of averages both the micrometer-reading average and the equivalent in millimeters are given, the micrometer value being 0.017 millimeter.

Larval life-history record

	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Exp. 8	Average
Date of hatching.....	April 29	April 29	May 1	May 10	May 11	May 11	May 11	May 11	12
Head width..	12-13	12	12	12	12	12	12	12	(=0.20 mm.)
First molt...	May 4	May 4	May 6	May 15	May 18	May 15	May 16	May 15	16.3
Head width..	16-17	16-17	16	16	16	17	16	16	(=0.28 mm.)
Second molt..	May 8	May 8	May 9	May 18	May 21	May 19	May 19	May 18	22.4
Head width..	23	23	21	22	23	22	22	23	(=0.38 mm.)
Third molt...	May 10	May 11	May 13	May 21	May 24	May 23	May 21	May 21	29.4
Head width..	29-30	29-30	30	29	29-30	29	29	30	(=0.50 mm.)
Spun up.....	May 15	May 15	May 17	May 26	.....	May 28	May 26	May 26	.....
Pupation....	May 18	May 19	May 20	May 28	.....	May 31	May 30	May 28	.....
Total time...	19 days	20 days	19 days	18 days	.....	20 days	19 days	17 days	.....

From these data it appears that there is considerable uniformity in the length of each stadium: five days in the first, three in the second, three in the third, and eight in the fourth. The constancy of the head widths in each instar may be noted, the average values for the different instars forming practically a geometric progression as in the case of *P. meles*. The length of the larval period as shown in this record (about nineteen days) represents, no doubt, the time required during the late spring or the early summer, since the data were obtained from larvae reared indoors.

The full-grown larva (figure 14) may attain a length of 7.5 millimeters. The body is fusiform and the head relatively very small. With the last molt the head becomes a light rusty brown, instead of remaining black as in the previous molts. The body color may be dirty white, dark straw, or yellowish green; rarely it appears as a bluish green. A faint stripe, which is always somewhat lighter than the body color, extends along the mid-dorsal line of the body. The position of the antennae and the eyes, the divisions and swellings of the thorax and the abdomen, the number of hairs and their distribution, all are similar to the corresponding characters in *P. meles*.



FIGURE 14. FINAL-INSTAR LARVA

The cocoon

The cocoon is a delicately formed, lacy structure. It is ellipsoidal and often very symmetrical. The average length is about 4.5 millimeters and the width 2.6 millimeters. On close examination the fine strands of silk, which give the cocoon its lacy appearance, are seen to pass in all directions without any evidence of system. At the same time no large openings are left. The strands are often fusions of two or more strands. The substance composing the cocoon is clear and transparent, but appears to be white or nearly so because of the diffusion of light.

These cocoons are commonly spun on the head of the clover, but they may appear elsewhere, as, for example, in the axils of the plant.

In spinning the cocoon the larva first stretches a few foundation strands across the position chosen. These serve more or less as anchorage points in which to build the structure. During the spinning, the larva, which lies curled up in the developing cocoon, reaches out and attaches the strands of silk to other strands, chewing the fiber out, so to speak, as it passes from point to point. By reaching out on both sides and by moving around headforemost, the larva gradually builds up the symmetrical structure. At intervals it will poke its mouth against the wall and through the openings, as if examining the size of the mesh. This apparently is its method of determining the fineness and uniformity of its weaving. It will even mend a puncture. The building of a cocoon may take several hours.

After spinning up, the larva remains in the cocoon for two or three days before pupating. During this time it shows little activity, merely flexing its body now and then.

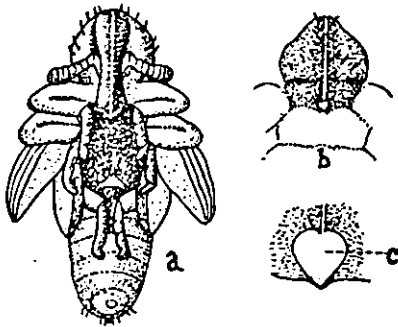


FIGURE 15. PUPA OF PHYTOMOMUS NIGRIROSTRIS

b, Thorax, showing mid-dorsal line. c, Tubercle at end of mid-dorsal line (enlarged from b)

The pupa

The changes in color during the early part of the pupal period are marked. It is rather typical of the early-formed pupa to be a beautiful glossy lemon-yellow in color, except the abdomen, which in this species, as in *P. meles*, is larva-like. A median white line extends from the beak over the head and dorsally on through the thorax to a tubercle on the caudal margin of the mesothorax (figure 15, b and c). The more exposed parts, such as the beak, the antennae, the head, the knees, and the wing covers, soon begin to darken, and by the third day they

may be of a dark, dingy gray color. The head and the thorax finally become brownish or brownish gray, with the median white line persisting; but the abdomen remains larva-like, even in color. The pupa flexes its body and turns about, but is not so active as the pupa of *P. meles*. The pupal period has been observed to last from five to eight days.

The newly transformed beetle

The newly transformed beetle is light in color but very soon turns fawn-colored. It remains in the cocoon for two or three days, frequently eating a considerable part of it. When it emerges it is brown, but in a few days (usually two or three) a little green begins to show along the sides of the elytra. The three green dorsal thoracic stripes also appear early. In from four to six days the beetle is usually of a pronounced green.

Summary of duration of stages

Allowing eighteen days for hatching, twenty-three days for the larval period, eight days for the pupal period, and three days for emergence, the beetles would appear in fifty-two days after egg-laying had begun.

Thus, in a normal season they would appear during the first half of June. In 1921, final-instar larvae were found in the field on May 20.

SEASONAL HISTORY

There evidently is a partial second generation in a season. In 1920 some beetles were brought into the laboratory in the latter part of August, and oviposition took place. A few beetles were reared from these eggs, pupation taking place on September 28 and October 3. Some eggs, apparently newly laid, were found as late as October 7.

FOOD PLANTS AND FEEDING HABITS

The adults and the larvae commonly feed on red clover (*Trifolium pratense*), although from observations made they evidently attack alsike (*T. hybridum*) also. Titus (1911:451) lists the following food plants for this species in America: *T. pratense*, *T. repens*, *T. incarnatum*, *T. medium*, *T. hybridum*, *Medicago sativa*. The larvae will attack newly forming buds both in the axils and in the heads. These buds may be blasted and the early-forming heads fail to develop. Besides attacking these buds, the larvae have been observed to eat into the stalk and even partially tunnel into it. The adults feed on the leaves, riddling them.

ABUNDANCE AND INJURY

In 1920 this species was so abundant in a field on the agricultural college farm that the clover crop seemed to be rather seriously endangered. Examination on May 29 showed the larvae to be present in large numbers. They were then rather small and seemed to be working upward toward the clover heads, which were just forming. Strangely, however, but few cocoons were found later, indicating that the larvae did not reach maturity. As fodder, the clover did not appear to suffer very seriously from the infestation, except that the early heads were very poorly formed. If a sufficient number of larvae had survived to produce a strong second generation, they might have caused serious damage to a second crop grown for seed. In 1884 Fletcher (1884) found this species doing great damage to clover at Dalhousie, New Brunswick, Canada. In 1916 it was reported as having caused great damage, as usual, to lucern and clover in Denmark (Lind, Rostrup, and Ravn, 1916).

CONTROL

A small ichneumonoid parasite, *Bathyplectes exigua* Gravenhorst,³ has been found to be rather abundant here. It attacks the larvae, and pupates in the cocoon, of its host. Its cocoon is reddish brown and bears a median crosswise white band. This parasite appears to have at least two generations in a season. In 1920 an adult which was reared from a larva of the current spring emerged on June 19, while others emerged from overwintering cocoons.

From observations made during a part of the summer of 1921, it would appear that another parasite, a species of *Microbracon*,⁴ is a very important

³ Determined by R. A. Cushman, through the kindness of C. F. W. Muesebeck.

⁴ Determined by C. F. W. Muesebeck.

factor in the control of the lesser clover-leaf weevil. In the early part of the season this parasite was fairly abundant, and later the writer had considerable difficulty in getting sufficient larvae to enable him to continue his study efficiently. It is probable that this parasite attacks the larvae of *P. meles* also. Life-history studies of the species proved very interesting and an account will be published later.

Webster (1909) states that two parasites have been reared from the larvae of *P. nigrirostris*: one was a small fly determined by C. H. T. Townsend as *Anisia* sp., near *variabilis* Coq.; the other was determined by J. C. Crawford as *Bracon* sp. Webster says also that the pupae are destroyed by a fungus, *Empusa* [*Entomophthora*] *sphaerosperma*.

LIFE-HISTORY COMPARISON OF PHYTONOMUS MELES AND *P. NIGRIROSTRIS*

The beetles of the two species *Phytonomus meles* and *P. nigrirostris* have rather similar habits and life histories, and during certain stages are so similar that they are somewhat confusing. Both hibernate as adults only. Both begin oviposition in spring, *nigrirostris* beginning very early. *P. meles* lays its eggs in punctures made in the petioles or the stalks, while *nigrirostris* oviposits sub-epidermally in the sheaths of the basal leaves or in the leaflets. The eggs of *meles* are a little longer than those of *nigrirostris*.

The newly hatched larvae are so similar that it is very difficult to distinguish them; in fact, no trustworthy distinguishing character has yet been found. The larvae of *meles*, however, tend to remain a clear white, while those of *nigrirostris* soon become a dirty white. Furthermore, *meles* larvae found in the vicinity of Ithaca become striped at the end of the third instar or in the beginning of the fourth, and are thus usually rather easily distinguished from the dirty white or creamy-colored *nigrirostris* larvae. The larvae of *meles* appear to depend on the clover head for food, while those of *nigrirostris* feed elsewhere as well.

The pupa of *meles* is somewhat more robust than that of *nigrirostris*. In the former the disposition of the dorsal hairs of the prothorax shows less regularity than in the latter.

Both beetles on their emergence from the cocoon are brown, but *meles* is the stouter. *P. nigrirostris* soon turns green or bluish green. Black or grayish black *meles* were plentiful in the fall of 1920, but their previous history was not known; all *meles* as yet reared have been brown.

In this vicinity the injury caused by *nigrirostris* exceeds that caused by *meles*.

THE CLOVER-SEED WEEVIL

(*Tychius picirostris* Fab.)

The species *Tychius picirostris* is a European species first described by Fabricius (1787). After its introduction into America it was redescribed by Schaeffer (1908:217-218) under the name *Tychius griseus*. It has been called *Miccotrogus picirostris* by various authors, but not by Schoenherr, who established the genus *Miccotrogus* (Blatchley and Leng, 1916:246, and Leng, 1920).

COMMON NAME

DuPorte (1916) gave this species the common name *clover-head weevil*. It will be recalled that this name has been given also to *Phytonomus meles*,

and that it is very suitable for that species because it suggests a life-history characteristic. In studying the life history of the species under discussion, the writer found that the larva lives entirely in the developing seed of the clover. Hence it was thought advisable to call this species the *clover-seed weevil*, and retain the name *clover-head weevil* for *P. meles*.

It may be mentioned that in the preliminary paper on these beetles, referred to in the general introduction, *Tychius picirostris* is called the *clover Tychius*. This name, however, must be abandoned, since it is contrary to the ruling of nomenclature adopted by the American Association of Economic Entomologists.

DISTRIBUTION

The type species evidently came from Copenhagen, Denmark, or its vicinity. In the original description Fabricius gives its habitat as "Hafniae." Paykull (1792) described it from southern Sweden; Marsham (1802) gives its habitat as England; Gyllenhal (1827) gives it as Germania and Gallia; and Calwer (1883) states that the species occurs over the whole of Europe.

The introduction of this weevil into America is evidently one of recent date. According to reports, however, it has become well established. DuPorte (1916) states that he has collected it every year since 1912, but that not until 1915 was it present in sufficient numbers to be regarded as injurious. Felt (1916) reports it from a number of points in the State of New York. The earliest record for this State, and probably for North America, is that of 1908, when Dr. J. C. Bradley, of Cornell University, sent specimens to Schaeffer who described them as a new species (*T. griseus*). The weevil has been reported also from Maine, New Hampshire, and Massachusetts.

LIFE HISTORY

The following life history of this species, with the exception of the description of the adult in part, has been obtained entirely by the writer through studies carried on at Cornell University.

The adult

The beetle (figure 16) is small, robust, elongate oval in form, and grayish brown in color. Its average length is approximately 2.4 millimeters, and the width across the elytra is 1 millimeter.

The head is short, dark reddish brown, and rather coarsely punctate. It is fairly well covered with silvery, hairlike scales. The eyes are black, large, and wide. The beak is long and narrow, and inclined to taper toward the tip. The antennae, which are reddish brown, are inserted near the distal third of the beak. The club is ovoid and fairly broad, and bears a fine pubescence.

The prothorax is slightly wider than long, and comprises about one-third the length of the whole beetle. The sides are moderately curved and the anterior margin is considerably shorter than the posterior one. The surface is pitchy black, rather coarsely punctate, and well covered with silvery, finely ribbed, flattened, narrow scales.



FIGURE 16. TYCHIUS PICIROSTRIS

The elytra are oblong ovoid, and rather narrow as compared with the prothorax. They are striately punctate, and in each stria is a row of recumbent, backward-pointing, white hairs. In the interspaces are two or more rows of silvery white, elongated scales, which do not touch along the striae but leave them plainly exposed. These scales give the beetle a grayish color. When they are rubbed off, the body color becomes more prominent and a darkening of the color results. This accounts for the brownish effect. The scales are of two kinds, the narrow dorsal scales and the wide ones of the venter. The dorsal scales are finely ribbed longitudinally, while the ventral ones are densely and finely spiculate.



FIGURE 17. DORSUM OF CAUDAL END (A) OF MALE, (B) OF FEMALE

ds, Suture dividing pygidium

Spiculate scales appear also on the bases of the legs; more distally these are replaced by narrow, ribbed scales, which in their turn are replaced still more distally by narrow, white, scale-like hairs.

Sex characters

The most reliable sex character in this species, as in the others here discussed, is the extra dorsal suture in the pygidium of the male (figure 17, A).

Hibernation

As these beetles are approximately only 2.5 millimeters long and somewhat ground-colored, they are very difficult to find in their winter quarters. A small number were found in the clover field in the early spring. To facilitate the search, some debris and plants were brought in on March 16 and 19 (1921) and placed in a tub. This was then tightly covered except for a small opening, in which was placed a glass jar to catch the beetles as they emerged. This material yielded, in all, twenty-four beetles, a sufficient number to show that they winter in the field where they feed.⁵

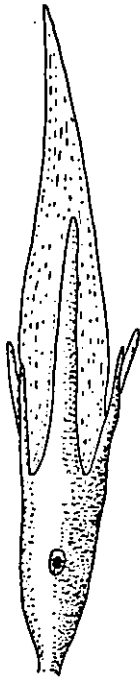


FIGURE 18. CLOVER FLORET, SHOWING PUNCTURE AND DEADENED TISSUE AROUND IT

Oviposition

Oviposition takes place in the clover head. The beetle makes her way toward the base of a floret, prying the florets apart, if necessary, with her beak. She then punctures the calyx and the corolla (figure 18) with her

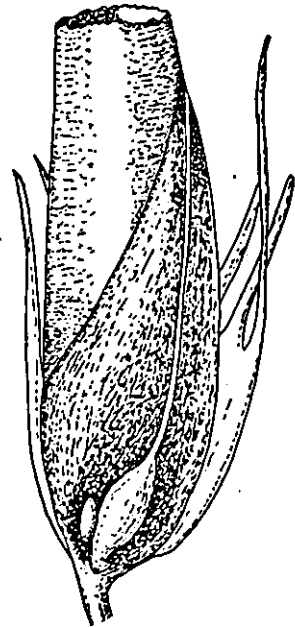


FIGURE 19. CLOVER FLORET OPENED, SHOWING EGG ON OVARY

⁵DuPorte (1916) states that this species winters in the adult stage in lumps of manure and vegetable matter beneath the soil.

beak, turns about, and places her egg on the ovary of the floret (figure 19). Sometimes a beetle has considerable difficulty in finding the puncture after turning around. She locates it chiefly by means of a relatively long, claw-like appendage at the caudal end of the abdomen, apparently using also the hind tarsi. The long ovipositor, noticeable after laying has taken place, is very different from the claw-like seeker just mentioned. The extensibility of the ovipositor may be judged from the following measurement, made after observing a beetle laying. The puncture was made near the distal end of the floret, and the egg was conducted downward so that it lay in contact with the ovary of the floret. The distance from the puncture to the egg was 1.35 millimeters.

The egg

The egg (figure 20) is shiny white. Its shape varies considerably, some eggs being rather ellipsoidal and blunt at both ends, and others being decidedly ovoidal. In the ovoidal egg the smaller end may be rather sharp. The average egg is about 0.5 millimeter long by 0.25 millimeter in cross section. The variation in size, however, is rather great; in twenty-two eggs measured, the lengths ranged from 0.46 to 0.66 millimeter, the corresponding shorter diameters being 0.30 and 0.34 millimeter, respectively.

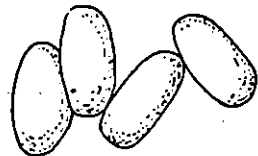


FIGURE 20. EGGS OF TYCHIUS PICIROSTRIS

The period of incubation was ascertained by first examining clover heads as to infestation, then exposing them to beetles for a day, and after that keeping them isolated to prevent later infestation. Dissection of the florets showed that the eggs began to hatch in from seven to nine days, inclusive. In these experiments it was found that if the eggs were nearly hatched they could be retained in the florets for later hatching provided the florets remained fresh. A few were hatched in this way.

The larva

The larva is a small, white, plump, footless grub. When mature and well-developed it measures from 2.7 to 3 millimeters in length. It is always partly curled, and from a lateral aspect presents a somewhat humped appearance (figure 21). The surface of the body is smooth except for the many transverse wrinkles common to coleopterous larvae. The head is light brown, and bears, though somewhat indistinctly, the Y-shaped suture described for the larvae of the two previously discussed species. Here, too, the arms of the suture extend forward and laterad to the anterior margin, where they pass between the eye and the minute, light-colored antenna. In this species there is only one eye to a side. It is black and relatively large, and hence is easily seen. The mandibles are toothed. The clypeus is emarginate, and comparatively wide but short.

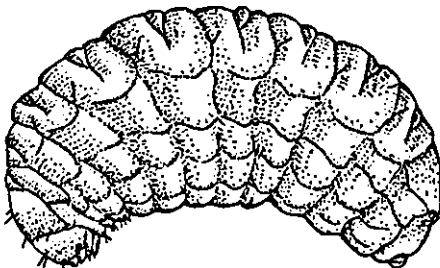


FIGURE 21. LARVA OF TYCHIUS PICIROSTRIS

The labrum is fleshy and bears a row of fine bristles on its ventro-cephalic margin; another row may be seen between the labrum and the clypeus. The width of the head in newly hatched larvae is approximately 0.45 millimeter. The number of instars has not been well worked out, but there appear to be only three. The larvae live within the floret, and when mature drop to the ground to pupate.

To ascertain the length of the larval period, clover heads were treated in much the same way as described for the incubation period. In this case, however, they were left inclosed in cages and the time of the emergence of the larvae from the clover head was noted. The results of these experiments were not so satisfactory as might have been expected, for the beetles did not oviposit freely in captivity. However, the results indicated the sum of the incubation and larval periods to be from eighteen to twenty-seven days. The experiments were carried on during the latter half of August and the early part of September, and the shortest periods occurred during the earlier experiments. Deducting eight days for the time required to hatch, leaves a larval period of ten days for the early-maturing larvae, and this probably is approximately the time required during the earlier part of the summer when reproduction is actively going on.

The cocoon

When mature larvae are placed on loose soil they quickly work their way down into it. Their habit of flexing the body in crawling evidently stands them in good stead as they go headfirst into the ground. When they are well in, they begin forming their cocoons (figure 22), and in this species, as in *Phytonomus meles*, the silk is obtained from a caudal gland. The inner wall of the cocoon is made of particles of earth incorporated in the silky secretion, and is leathery in texture. There are no strands lining the walls.



FIGURE 22. COCOON OF
TYCHIUS PICIROSTRIS

Great activity is shown during the process of cocoon building; the larva turns about in its cell, takes mouthfuls of the secretion, and chews this out, so to speak, as it builds up the wall. One larva was observed taking three mouthfuls of the silk in one minute. After the cocoon has been apparently finished and the larva has quieted down, exposure to light or the addition of water will awaken it, and it will then show an active interest in the cell wall. This has been seen to take place even on the third day after spinning up. The larva lies in the cocoon in a partly curled position, swells up somewhat, and at the end of about a week, or a little over, pupates.

Pupation and the pupa

In pupation the head of the pupa appears first as the larval skin slips down. A bending and working

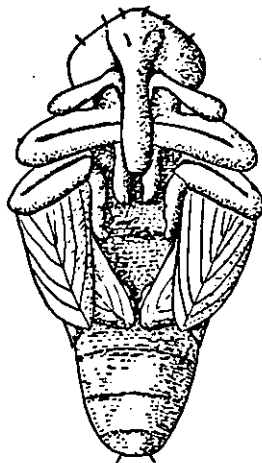


FIGURE 23. PUPA OF
TYCHIUS PICIROSTRIS

of the body accompanies this action and seems to aid in the process. The pupa is not nearly so active as those of the other species described herein. The color remains white until about the ninth day, when it turns creamy. Before transformation into the beetle the color becomes rusty. The form (figure 23) is that common to rhynchophorous pupae.

Transformation and emergence

As the pupa emerges from the thin, transparent, pupal skin, the wing covers, which were lying on the venter, gradually move back into place. By dint of squirming, and finally by use of the legs, the pupa sloughs off the whole covering. The antennae at first appear stretched out between the legs.

The newly transformed beetle is rusty white or light fawn in color. The whitish scales are very evident. By the second day it assumes the normal appearance of the adult. It remains inactive in the cocoon for a day or two, and then begins to struggle to get out of the ground.

Duration of post-larval periods

The duration of the post-larval periods can be most easily shown by the following data derived from rearing experiments:

Experiment	Date of spinning	Date of pupating	Number of pupae	Date of transforming	Number of beetles
1.....	Aug. 26	Sept. 3	23	Sept. 17	12
		Sept. 4	1	Sept. 18	12
2.....	Aug. 26	Sept. 3	9	Sept. 17	12
		Sept. 4	6	Sept. 18	3
3.....	(Sept. 6)*	Sept. 14	3	Sept. 27	2
		Sept. 15	1	Sept. 28	2
		Sept. 16	1	Sept. 29	1
4.....	Sept. 9	Sept. 18	5	Oct. 2	1
		Sept. 19	3	Oct. 3	4
		Sept. 20	2	Oct. 5	5

* Spinning was not noted here, but the larvae normally work their way into the ground directly after they are put on it, and then begin spinning almost at once. These larvae were placed on the ground on the date given.

From these data it will be observed that the majority of the larvae remained in the cocoon eight days before pupating; others required nine days, some ten, and a few, later in the season, even eleven. This distinct period might reasonably be called the prepupal stage. It will be seen also that the pupal stage consists of from thirteen to fifteen days. The data on the period of emergence were not very satisfactory, for, under the conditions of the experiments, the larvae seemed to have buried themselves too deeply and hence experienced great difficulty in getting out; some, in fact, did not get out at all. However, by putting larvae in pots and watching for the emergence of the adults, it seemed to be fairly conclusively shown that at least a week is spent in the soil after transformation.

It may be of interest to note the method by which the post-larval activities and development were watched. Small pupating cases were made from

two glass slides with just sufficient space between them to permit the larvae to pass down readily, and yet not enough room to allow them to construct an earthen wall next to the glass as they built their cocoons. The cases could then be buried and the larvae thus provided with an approximately normal environment. This method proved most convenient for close study, as the cases could be examined, even with the binocular, without disturbing the insects.

Summary of duration of stages

From a review of the data thus far obtained, the following summary is given as constituting the duration of the complete life cycle: incubation, from seven to eleven days; active larval, from eleven to eighteen days; inactive larval (prepupal), from eight to eleven days; pupal, from thirteen to fifteen days; emergence, seven days (partly estimated); total, from forty-six to sixty-two days.

SEASONAL HISTORY

The beetles begin laying as soon as the clover heads begin to turn purple. In 1920, beetles were observed in the act of laying on July 1, 13, 15, and 17. In 1921, however, eggs were dissected out on May 23. In 1920, rearing experiments involving egg-laying were carried on during August and into September (September 3). This shows that reproduction goes on practically throughout the summer. Assuming that oviposition begins in the first week of June, and allowing forty-six days (a month and a half) for the complete life cycle, the new generation should begin to appear by the middle of July. It is probable that the late eggs included in the life-history experiments were laid by the beetles of the new generation, and that there is thus a partial second generation in a season. At any rate, clover brought in from the field yielded larvae until after the middle of September.

FOOD PLANTS AND FEEDING HABITS

In Europe this species is said to attack red clover, plantain, and Genista. In America it has apparently confined itself to red clover. Knight (Blatchley and Leng, 1916) reported it as found abundantly on pear trees. At the time when Dr. Knight collected the beetles, however, the orchard had been plowed on both sides and there was little else above ground on which they could settle.

Both the adult and the larva attack the clover head. The larva, on hatching, begins eating its way into the developing seed, and lives in the seed until ready to pupate. The adult feeds actively on the pollen grains, puncturing the keel of the floral envelope to get at the stamens. DuPorte (1916) reported the destruction of red-clover leaves by the beetles' feeding gregariously on them. This habit has not been observed by the writer. Beetles have been kept for a long time on clover leaves, with no damage resulting beyond a yellowing of the bases of the leaflets where the beetles were in the habit of congregating.

ABUNDANCE, INJURY, AND CONTROL

The beetles were fairly abundant on the agricultural college farm. On July 3, 1918, nineteen adults were collected from one clover head. In

1920 experiments were conducted to determine the degree of infestation in second-crop clover. Green clover heads in which the corollas had just turned brown or were just turning, were selected and their stems placed in water. These yielded final-instar larvae. The first larvae to appear from the bunches of clover heads were well developed; the later ones were often very small, yet their head measurements showed them to be in the last stadium. As these clover heads frequently yielded larvae in considerable numbers on the day after they were brought in, there remained the possibility that some larvae had already dropped out in the field. However, in nearly all of the experiments the maximum number of larvae appeared later. The clover was taken from two fields; one had been seeded down the year preceding, while the other had been left standing for a number of years. In the new field the crop had been heavy, and the clover had been cut in sections on different dates as follows: June 15, June 28, July 8, and a later date in July. In the old field the clover was good only in spots, and cutting had been done during the fore part of July. The experiments were carried on from August 18 to September 18. In all, 1609 clover heads were examined and 1852 larvae obtained. The results showed that the infestation in the old field was decidedly heavier than in the new, from two to five times heavier for clover taken at the same date; that early cutting is not to be recommended when the second crop is to be harvested for seed, for the larvae decrease in numbers as the season advances⁶; and that the degree of infestation in plots cut at different times is practically the same at the same time.

As already mentioned, these results are based only on experiments with second-growth clover. If a similar study were made of the infestation of first-growth clover, it might be found that early cutting on a large scale would destroy great numbers of the larvae when reproduction is actively going on, and so very materially reduce the number of beetles attacking the second crop.

From the study of the life history it will be seen that the actual damage caused by the beetles to the clover as a fodder is negligible, unless the failure of the seeds to set and partly develop is to be considered as a loss to the food value of the hay. In the raising of clover seed in the second crop, however, the problem is quite different. In the clover experimented with, the loss was estimated at about 4 per cent. This did not take into account the damage done by the adults' feeding on the anthers. In an examination of a clover head in the early part of July of 1918, it was estimated that about 85 per cent of the anthers had been damaged.

⁶Clover heads taken on August 18 from the section cut on June 15 gave an average of three larvae to the head; those of August 23 gave one larva to the head; and those of August 28 and September 2 each gave 0.5 larva to the head.

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