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BIOLOGY OF THE PRIMARY SCREW WORM FLY, COCHLIOMYIA AMERICANA, AND A COMPARISON OF ITS STAGES WITH THOSE OF C. MACELLARIA

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INTRODUCTION

Screw worms have long been known to inflict serious injury to man and animals in the subtropical and tropical regions of North America and South America. The recent discovery [1] that at least two species of these flies have been confused heretofore under the name *Cochliomyia macellaria* Fab. raises a doubt as to which species was considered in the earlier published information relating to this subject. Because of the similarity of these two flies in their outward appearance, the fact that data concerning them are now questionable, and the ever-increasing importance of their activities, a newer knowledge of the economic status of each must be obtained.

While much remains to be determined concerning both species, the data here presented give the results of studies conducted by the Bureau of Entomology and Plant Quarantine to date on the biology and habits of *Cochliomyia americana* C. and P.[2]

[1] CUSHING, E. C., and PATTON, W. S. STUDIES ON THE HIGHER DIPTERA OF MEDICAL AND VETERINARY IMPORTANCE. COCHLIOMYIA AMERICANA SP. NOV., THE SCREW-WORM FLY OF THE NEW WORLD. Ann. Trop. Med. and Parasitol. 27: 539–551, illus. 1933.

[2] While it is possible that the primary screw worm fly may have been described by earlier workers under such names as *hominivorax, anthropophaga, fulvobarbata, infesta,* and others, an authentic name for this species can be assigned only after an examination of all type specimens has been made. For the present, it is deemed more appropriate to use the name *C. americana* to designate the primary screw worm fly of the New World, even though an older name may be adopted later.

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ECONOMIC IMPORTANCE

Apparently all warm-blooded animals are susceptible to infestation. Any type of wound, the navels of young animals, and the natural openings of the body, such as nostrils, mouth, eyes, ears, vagina, and anus, may become infested with the larvae of *Cochliomyia americana.* Infestation of the natural openings is usually the result of an injured, diseased, or unclean condition.

The evidence indicates that this fly is a primary, obligatory parasite and that it initiates the vast majority of cases of external myiasis, commonly called screw worm infestations, in man and animals in the United States and probably in the entire neotropical region. Not only is it important as a primary invader of wounds, but it will also continue to infest necrotic lesions. It is known to be the specific cause of a large number of cases of nasopharyngeal myiasis in man in the New World Tropics. Only one case of this type has been observed among domestic animals. a sheep on a ranch in southwestern Texas.

Table 1 gives the number and species of flies reared from each of 114 cases of myiasis occurring in domestic animals on one ranch in southwestern Texas during the year 1934. These animals became naturally infested on the range and were brought into the corrals for treatment. Most of the cases were found before the infestations became extensive and before the maggots first infesting the wound had matured. None of the cases recorded was a reinfestation; that is, the wound from which the maggots were taken had not been previously treated for an infestation.

TABLE 1.—*Number and species of flies reared from 114 cases of myiasis in all classes of range livestock on one ranch, Sonora, Tex., April to July 1934*

Species of flies bred from infested wounds	Cases	Percentage of total cases	Flies reared from cases	Percentage of each species in cases				
				Cochliomyia americana C. and P.	*Cochliomyia macellaria* Fab.	*Phormia regina* Meig.	*Sarcophaga plinthopyga* Wied.	*Lucilia sericata* Meig.
	Number	*Percent*	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
C. americana	91	79.8	1,430	100	0	0	0	0
C. americana and *C. macellaria*	3	2.6	110	90.9	9.1	0	0	0
C. americana and *S. plinthopyga*	4	3.5	169	34.3	0	0	65.7	0
C. americana and *P. regina*	1	.9	25	88.0	0	12.0	0	0
C. americana, C. macellaria, and *P. regina*	1	.9	7	42.9	14.2	42.9	0	0
C. americana, P. regina, and *S. plinthopyga*	2	1.8	126	56.3	0	7.1	36.6	0
C. americana, C. macellaria, P. regina, S. plinthopyga, and *L. sericata*	1	.9	788	16.8	66.1	15.8	.8	.5
C. macellaria	2	1.8	34	0	100	0	0	0
C. macellaria and *P. regina*	3	2.6	53	0	18.9	81.1	0	0
C. macellaria and *S. plinthopyga*	1	.9	55	0	47.3	0	52.7	0
C. macellaria, S. plinthopyga, and *L. sericata*	1	.9	110	0	69.1	0	17.3	13.6
P. regina	1	.9	11	0	0	100	0	0
S. plinthopyga	3	2.6	39	0	0	0	100	0

The history of the 11 cases from which no *Cochliomyia americana* were reared shows that in 2 cases the infestation occurred in a suppurative lesion containing pathogenic bacteria and in 3 cases it occurred in the soiled wool of sheep without involvement of the tissues.

Cochliomyia americana has been obtained in pure cultures from many other cases occurring in other parts of Texas and in Louisiana, Mississippi, Alabama, Georgia, Florida, and South Carolina, and from a few cases in Iowa and Indiana.

DISTRIBUTION

Normally the fly is confined to the tropical and subtropical sections of the United States and the countries to the south; it has, however, caused trouble in the Northern States. A list is given below of places from which authentic records of its occurrence have been obtained, although it is quite probable that the fly is present in several other States and countries.

North America: Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, Missouri, Iowa, Illinois, Indiana, Oklahoma, California, Arizona, New Mexico, Kentucky, Tennessee, and Kansas.

West Indies and Central America: Trinidad, St. Lucia, Dominican Republic, Puerto Rico, and Panama.

South America: Colombia, British Guiana, French Guiana, Brazil, Uruguay, Argentina, and Venezuela.

This fly is not a recent invader of the United States. The earliest authentic record known at present of the occurrence of screw worm cases caused by *Cochliomyia americana* in this country dates back to 1882.

SEASONAL ACTIVITY OF THE FLY

In the United States *Cochliomyia americana* usually begins its activities late in the spring or early in the summer, the exact time varying with the temperature of the season in a particular locality. The first authentic case in Georgia in 1934 occurred on May 15. During the same season at Menard and Sonora, Tex., the first cases were observed on April 16 and 19, respectively. Infestations occurred in Florida and southern Georgia during January and February of 1935. W. V. King of this Bureau recorded 17 infestations of animals in northern and central Florida during the winter of 1934–35, 15 of which occurred from January 8 to 19, inclusive, 1 on February 14, and 1 on February 22. The minimum temperature recorded in northern Florida during December 1934 was 16° F.

In Texas, R. A. Roberts reared *Cochliomyia americana* from an infested animal at Uvalde on January 19, 1935, and at Raymondville W. R. Hutchins collected larvae of this species from a wound on February 13, 1935.

DESCRIPTION OF STAGES, LIFE HISTORY, AND HABITS

Like most of the species of blowflies, *Cochliomyia americana* has five developmental stages in its life cycle.

THE EGG

DESCRIPTION

The egg of *Cochliomyia americana* (fig. 1) is approximately 1.04 mm in length and 0.22 mm in width (average of 10). It is glistening white with a very slight tinge of cream color, rounded at the

posterior and somewhat flattened at the micropylar end, and with a dorsal ridge or seam extending from the micropylar end almost to the opposite pole. As incubation proceeds the egg assumes a grayish color due to the development of numerous spines on the body of the encased larva. It is easily distinguished from the egg of the closely related species *C. macellaria*, having considerably less cream color. The dorsal seam divides at the anterior end and extends downward around the micropyle in a broad band, giving the appearance of a circular cap. In *C. macellaria* the extension of the dorsal seam around the micropyle forms a much narrower band and the cap therefore appears considerably smaller. Under high magnification the outer covering of an egg of *C. americana* has a reticulated or lacework appearance.

HATCHING

The process of hatching has been observed under the microscope in several instances. The eggs were placed on moist blotting paper in a glass dish and this was mounted on the microscope stage. The observations on the process of hatching described here were made in a room temperature that ranged from 101° F. at the time the eggs were laid to 90° at the moment the first larvae emerged. The total incubation period in this particular instance was 9 hours and 34 minutes. Under these conditions the first movements of the larvae could be seen through the eggshell 8 hours after the eggs were laid. It appears that the first-stage larvae are well developed some time before they emerge from the egg, approximately the last 1½ to 2 hours of the incubation period being devoted first to opening a hole in the micropylar end and then to splitting the egg shell along the dorsal seam. During the process of emerging the young larva opens a small slit along the dorsal seam at the anterior end of the egg. This slit is gradually increased in length by the activity of the encased larva, until at the time of emergence the eggshell is opened for two-thirds or more of its length. It frequently happens that the part of the seam which extends around the micropyle is split completely around and the entire micropylar end is pushed outward as a circular flap.

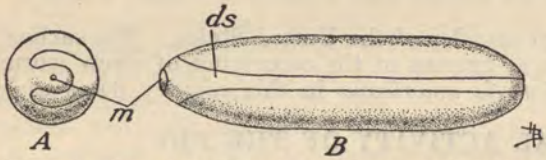

FIGURE 1.—Egg of *Cochliomyia americana*: *A*, End view; *B*, dorsal view; × 50; *m*, micropyle; *ds*, dorsal seam.

INCUBATION

The incubation period varies with the temperature and relative humidity. Under natural conditions (i. e., eggs on wounds in animals) the duration of the period ranged from 11 to 21.5 hours. Roy Melvin, at Dallas, Tex., has determined that under controlled laboratory conditions of 100 percent relative humidity the incubation period ranged from 9.2 hours at 99° F. to 13.9 hours at 84°, and that no hatching took place at 59°. He has shown also that the duration of the incubation period is almost twice that required for *Cochliomyia macellaria* under similar conditions.

W. E. Dove of this Bureau, working at the Savannah, Ga., laboratory, observed one instance in which eggs laid on a moist lanced abscess on a guinea pig had an incubation period as short as 6 hours.

EGG MASS

Eggs are usually deposited in regular, oval, shinglelike masses of from 10 to 393 each, on dry surfaces at the edge of both fresh and necrotic wounds. They may be laid also on dried blood clots, scabs, and exudate, even where a break in the skin is not apparent. In one case the eggs were deposited on the moist suppurating surface of a wound. In almost all cases the masses are glued tightly to the surface on which they are laid and the eggs are firmly cemented together. The egg masses are easily distinguished from those of *Cochliomyia macellaria*, which are laid in irregular groups in the hair or wool of the animal and only loosely or not at all attached to the surface of the skin, and the eggs are also less firmly cemented together than are those of *C. americana*.

THE LARVA OF COCHLIOMYIA AMERICANA AND THAT OF THE ASSOCIATED C. MACELLARIA[3]

There are the usual three larval instars in the development of *Cochliomyia americana* and *C. macellaria*. The first-instar larvae may be distinguished from those of the second and third instars by the absence of anterior spiracles, by the general structure of the cephalopharyngeal sclerites, and by the absence of a ring or peritreme which partly surrounds the spiracular slits in the second and third instars (figs. 2, 3, and 9). The second-instar larvae may be distinguished from those of the third instar by the structure of the cephalopharyngeal sclerites (fig. 6) and by the posterior spiracles; in the second instar there are two slits per spiracle, whereas in the third instar there are three.

The descriptions and figures here given are based on examinations of mounted and unmounted specimens.

The larvae of *C. americana* examined for the descriptions were collected at Sonora, Tex., and Ames, Iowa. In addition, third-instar larvae collected from wounds of animals from several points in the southern part of the United States and in Iowa were examined. The characteristics of the larvae as described appear to be the same in specimens examined from the various regions.

The larvae of *C. macellaria* were reared specimens collected at Ames, Iowa, and Dallas, Tex., and the characteristics checked with larvae obtained from one case of myiasis in Florida. As in *C. americana*, the characteristics appear to be the same in the specimens from the various localities.

COCHLIOMYIA AMERICANA CUSHING AND PATTON

FIRST INSTAR

Larva elongate, more or less cylindrical in shape, with 12 apparent segments, tapering anteriorly from the sixth segment; the last three segments slightly tapering posteriorly (fig. 2). Length and width

[3] By E. F. Knipling, assistant entomologist, Bureau of Entomology and Plant Quarantine.

at time of hatching 1.2 and 0.23 mm, respectively; fully developed first-instar larvae average 3.6 mm in length and 0.57 mm in width at the widest point.

Armed with large, dark, single-point, recurved spines, arranged in more or less irregular rows near the margin of the segments. Spines in anterior rows largest, the larger spines measuring approximately 20μ in length, as compared to 6μ, the length of similar spines of *Cochliomyia macellaria*.

Anterior margin of segments 2 to 9 completely encircled with a band of spines; on segment 10 the band interrupted for a short space on dorsum. On segment 11 the spines are absent on the dorsum and on the sides are reduced to two or three rows of small, more lightly pigmented spines. On segment 12 they are confined to the ventral and ventrolateral surfaces. On the ventral surface of segments 6 to 12 the band of spines is wider and transversely divided by a narrowed spineless area. Posterior margin of the segments devoid of spines except two or three rows of small spines on the ventral surfaces of segments 5 to 12. On segments 5 to 10, on the sides of each segment, is a small swollen area, the lateral fusiform area, which is provided with a group of spines.

The twelfth or last apparent segment is depressed behind, and in the depression nearer the upper end are located the two posterior spiracles. Each spiracle is comprised of two small, broadly oval apertures, each of which is encircled by a delicate ring of chitin from which fingerlike projections extend toward the center of the opening. Frequently the two openings are so closely appressed at the inner ventral border as to give the spiracle a bilobed appearance. The peritreme, so easily distinguished in second- and third-instar larvae, is not apparent. The anal protuberance, located on the ventral side of the last segment, bears two conical, fleshy projections, the anal tubercles. A group of spines is situated in front and behind on the anal protuberance. Two or three rows of spines are present also between the anal protuberance and the lower margin of the posterior cavity. The tubercles bordering the posterior cavity are poorly defined.

FIGURE 2.—Lateral view of first-instar larva (12 hours old) of *Cochliomyia americana*, × 22.

The cephalopharyngeal mechanism (fig. 3, *A*, *B*) is situated in the cephalic or first apparent segment and in a portion of segment 2. The structure consists of a pair of large pharyngeal sclerites (*phs*) composed of 2 dorsal (*dc*) and 2 ventral (*vc*) cornua and a rather short dorsoanterior projection. The pharyngeal sclerites are apparently not joined dorsoanteriorly as in the second- and third-instar larvae of *Cochliomyia americana* (fig. 6, *A*, *dps*) and in the three instars of *C. macellaria*. The ventral portion of the pharyngeal sclerites extends anteriorly and joins the hypostomal sclerites (*hs*), which in turn articulate with the ventral basal portion of the oral hooks (*oh*). The parastomal sclerites (*pss*), a pair of slender sclerites, extend anteriorly from the pharyngeal sclerites just above

the hypostomal sclerites. The oral hooks (*oh*) consist of 2 elongate sclerites to which are attached a group of about 6 small hooklets. Above and between the oral hooks is an unpaired structure, the hatching spine (*hsp*), which is present only in first-instar larvae. The degree of pigmentation of the cephalopharyngeal sclerites varies with the age of the larva. Length of cephalopharyngeal skeleton from tip of oral hooklets to posterior extremity of dorsal cornua ranging from 0.24 to 0.27 mm, the average of 10 being 0.26 mm; average width at widest point 0.07 mm.

SECOND INSTAR

Larva (fig. 4) more robust than in the first instar. Length and width of newly molted larvae approximately 3.5 and 0.6 mm, respectively; fully developed second-instar larvae measure from 6.3 to 7.4 mm in length and approximately 1.5 mm in width at the widest point.

Heavily armed with large dark spines; larger spines measuring approximately 55μ in length; spines with 1 to 3 points, more often 1 or 2. Anterior margin of segments 2 to 9 completely encircled with a band of spines, while on segment 10 the band is generally, but not always, interrupted by a narrow space on the dorsum. On segment 11 the band is reduced to 2 or 3 rows of smaller spines on the sides and never completely encircles the segment. On segment 12 the spines are confined to the ventral and ventrolateral surfaces. Ventral and lateral fusiform areas as in the first instar. Posterior margin of segment 11 completely encircled with a band of about 3 rows of smaller, anteriorly recurved spines. On segment 10 there are 2 irregular ventral and lateral rows, and a few scattered spines may extend to the dorsal surface but do not join to form a completely encircling band. A few scattered spines may be present on sides of segments 9 and 8 but are restricted to the venter on segments 7 and 6.

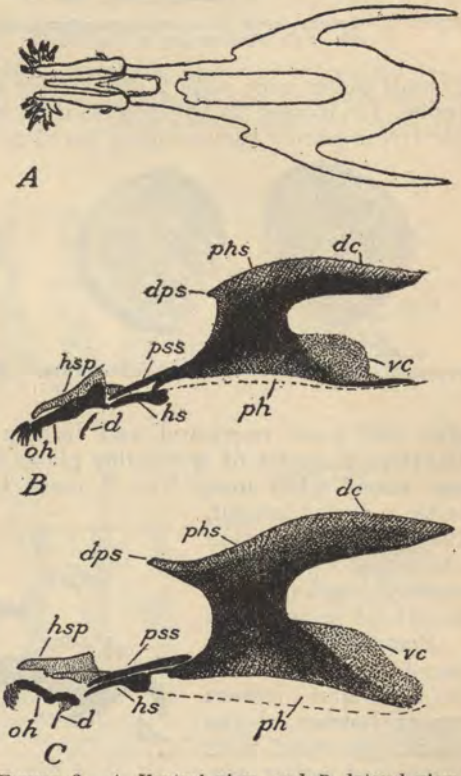

FIGURE 3.—*A*, Ventral view, and *B*, lateral view, of cephalopharyngeal sclerites of first-instar larva (12 hours old) of *Cochliomyia americana*, × 222; *C*, cephalopharyngeal sclerites (lateral view) of first-instar larva (almost fully developed) of *C. macellaria*, × 194; *d*, dental sclerite; *dc*, dorsal cornu; *dps*, dorsopharyngeal sclerite; *hs*, hypostomal sclerite; *hsp*, hatching spine; *oh*, oral hook; *ph*, pharynx; *phs*, pharyngeal sclerite; *pss*, parastomal sclerite; *vc*, ventral cornu.

The anterior spiracles, 2 small fan-shaped structures generally with 7 to 9 fingerlike processes or branches on each, are situated 1 on each side near the base of segment 2. The structure, except for the smaller size, is similar to that of the third instar (fig. 7, *A*). Posterior spiracles (fig. 5, *A*), 2 small plates each with 2 slits partly surrounded by a ring or peritreme, are located in the posterior cavity on the last segment. The peritreme partly surrounding the slits is incomplete ventrad of the slits and quite narrowed and lightly pigmented dorsad of them. Greatest diameter of spiracular plates from 0.134 to 0.168 mm, average about 0.150 mm. The 2 main tracheal trunks are provided with a dark pigment, the pigmented portion extending approximately one-half the length of segment 12.

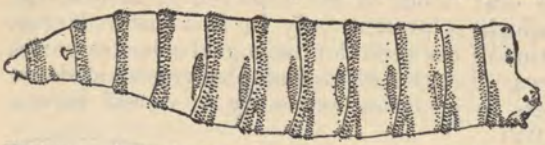

FIGURE 4.—Lateral view of second-instar larva (48 hours old) of *Cochliomyia americana*, × 12.

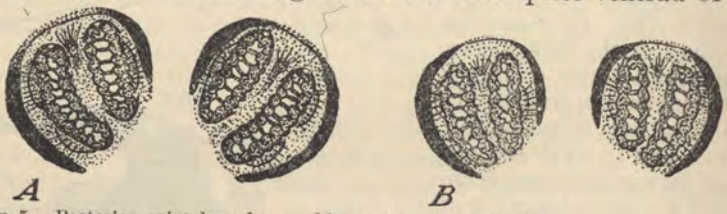

FIGURE 5.—Posterior spiracles of second-instar larva: *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 148.

Posterior cavity more depressed than in the first instar; upper border of the cavity provided with 3 pairs of rather low, broadly rounded, fleshy processes; the inner and outer pair equal, the median pair poorly defined. On the lower border of the cavity the median pair somewhat the largest and the outer pair larger than the inner, which is poorly defined. Relative positions similar to those in the third instar (fig. 8, *A*). Anal protuberance rather small, with 2 prominent anal tubercles. Spines on anal protuberance similar to those in the third instar (fig. 8, *A*).

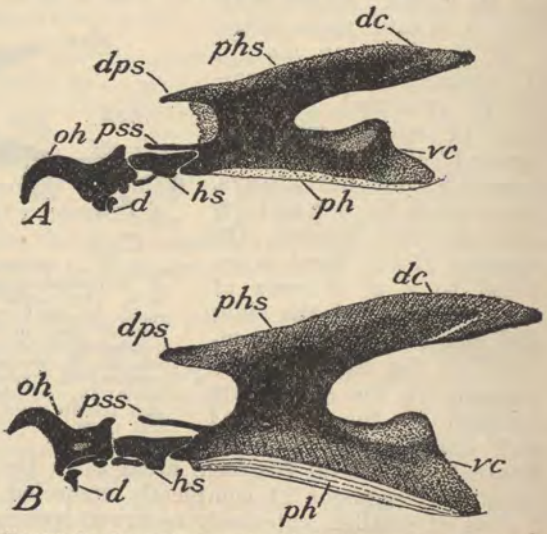

FIGURE 6.—Lateral view of cephalopharyngeal sclerites of second-instar larva: *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 94; see explanation of symbols under figure 3.

Cephalopharyngeal mechanism as in figure 6, *A*. The oral hooks are 2 prominent sclerites with a more or less rectangular basal portion with 2 long, broadly curved hooks. The pharyngeal sclerites are produced dorsoanteriorly and are connected by the dorsopharyngeal sclerites (*dps*). The cephalopharyngeal sclerites become darker as the larvae grow older. Length of cephalopharyngeal skeleton from 0.670 to 0.688 mm; average of 10, 0.674 mm.

THIRD INSTAR

Form rather robust, tapering toward the anterior extremity from the sixth segment and slightly tapering toward the posterior end on the last three segments (fig. 7, *A*). Length from 6.4 to 17 mm and

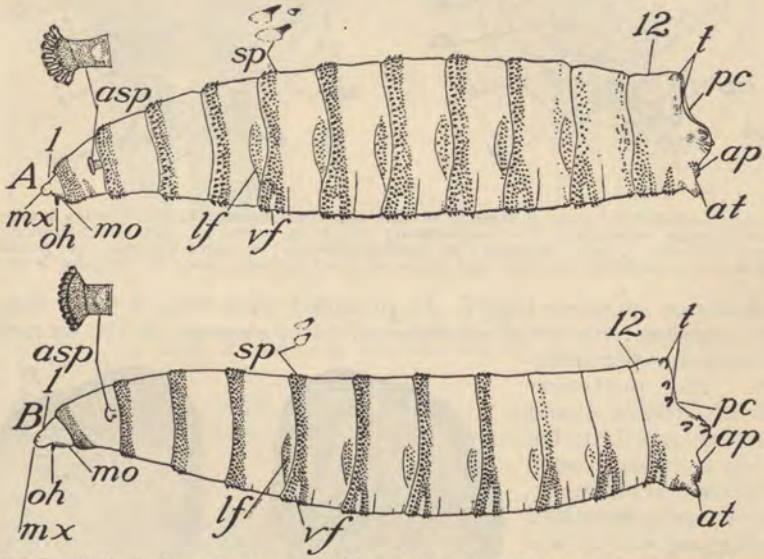

FIGURE 7.—Lateral view of mature third-instar larva: *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 6; anterior spiracles and some spines are shown more enlarged; *ap*, anal protuberance; *asp*, anterior spiracle; *at*, anal tubercle; *lf*, lateral fusiform area; *mo*, mouth; *mx*, maxillary lobe; *oh*, oral hook; *pc*, posterior cavity; *sp*, spines; *t*, tubercles; *vf*, ventral fusiform area; *1*, first (or cephalic) segment; *12*, twelfth segment.

width from 1.6 to 3.5 mm. Fully matured larvae are generally 15 to 16 mm in length. Newly molted larvae are creamy white in color; mature larvae have a slight reddish tinge.

Heavily armed with large 1- to 3-pointed spines; more often there are 1 or 2 points to each. Anterior margin of segments 2 to 9 completely encircled with a band of spines. Spines arranged in irregular rows, those in the anterior rows the largest. On segment 10 the anterior band of spines is somewhat narrowed and generally interrupted on the dorsum as in the second instar. On segment 11 the anterior band never completely encircles the segment and the spines on the sides are smaller and greatly reduced in numbers. Spines on segment 12 are restricted to the ventral and ventrolateral surfaces. The posterior margin of segment 11 is provided with a loose band of 2 or 3 rows of anteriorly curved spines. On segment 10 a few scattered spines may be present laterally and dorsolaterally

but are always present ventrally and ventrolaterally. On segments 7 to 9 the spines at the posterior margin are reduced to 1 or 2 rows and confined to the ventral surfaces.

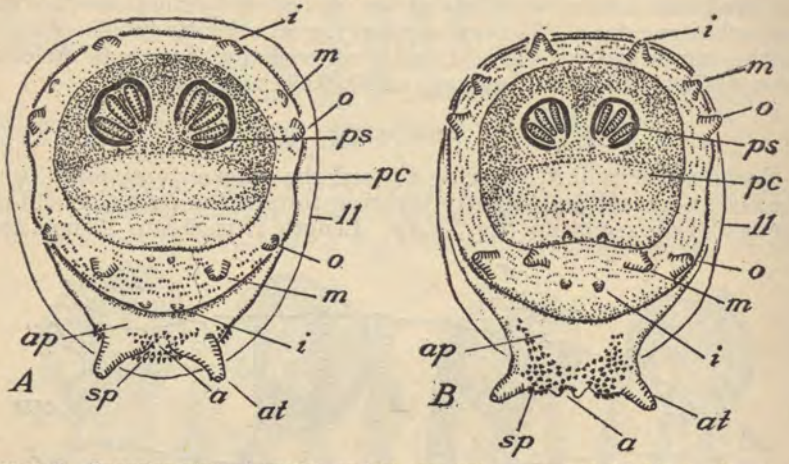

FIGURE 8.—Posterior view of twelfth or last apparent segment of third-instar larva: *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 16; *a*, anus; *ap*, anal protuberance; *at*, anal tubercle; *i*, inner tubercle; *m*, median tubercle; *o*, outer tubercle; *pc*, posterior cavity; *ps*, posterior spiracle; *sp*, spines on anal protuberance; *11*, eleventh segment.

Anterior spiracles (fig. 7, *A*) provided with from 6 to 11 finger-like branches; the usual number is 7 to 9; average of 120 spiracles, 8.3 branches per spiracle. The posterior spiracles (fig. 8, *A*, and more enlarged in fig. 9, *A*) are large, each with a prominent, dark, pigmented peritreme which apparently does not completely surround the 3 more or less oval slits. Greatest diameter of spiracular plate from 0.39 to 0.46 mm; average of 10, 0.43 mm. The 2 main tracheal trunks are darkly pigmented, the pigmented portion extending anteriorly to the tenth or ninth segment (fig. 10, *A*).

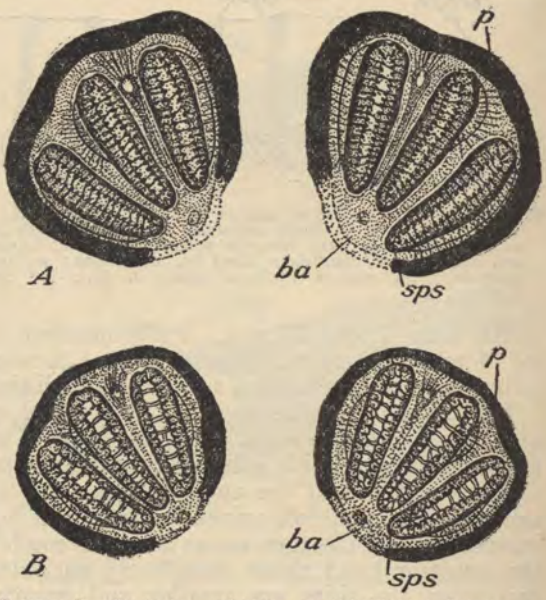

FIGURE 9.—Posterior spiracles of third-instar larva: *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 84; *ba*, button area; *p*, peritreme; *sps*, spiracular slits.

Upper border of posterior cavity (fig. 8, *A*) bearing 3 pairs of low, broadly rounded tubercles; inner and outer pairs approximately equal; median pair greatly reduced and closely approximated to the outer tubercle.

Lower border of cavity provided with similar tubercles; the median pair the largest and the outer pair larger than the inner pair. An

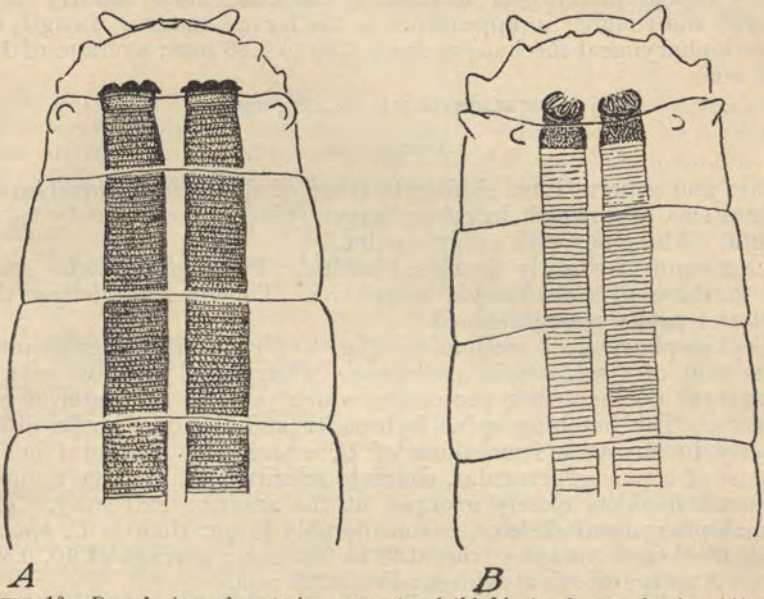

FIGURE 10.—Dorsal view of posterior segments of third-instar larvae showing (*A*) pigmented tracheal trunks of *Cochliomyia americana* and (*B*) unpigmented tracheal trunks of *C. macellaria*; × 13.

additional pair of small tubercles situated medially near the lower margin of the posterior cavity. Anal protuberance (fig. 8, *A*) comparatively small, with 2 prominent, conical anal tubercles. Rather prominent spines located on the anal protuberance in front and behind. Short rows of 3 to 4 minute spines situated on the lower portion of the depressed area and on lower margin of posterior cavity (fig. 8, *A*).

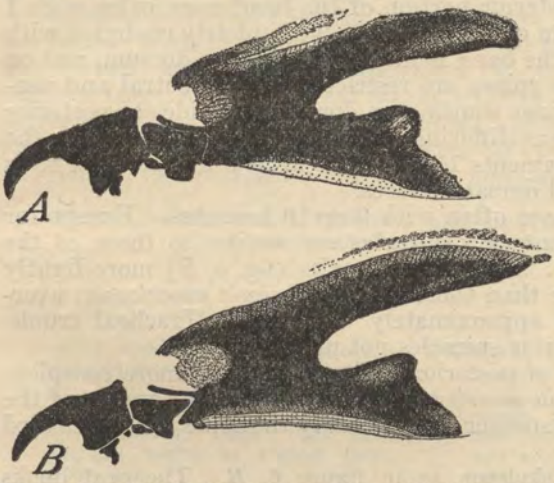

FIGURE 11.—Cephalopharyngeal sclerites of mature third-instar larva (lateral view): *A*, *Cochliomyia americana*; *B*, *C. macellaria*; × 49.

Cephalopharyngeal mechanism as in figure 11, *A*. Although larger and quite different in appearance, the parts are essentially the same as in the second instar. The narrow pigmented strip arising at the dorsoanterior margin of the pharyngeal sclerites and extend-

ing posteriorly is not seen in younger third-instar larvae, but as the larvae mature this part gradually becomes more distinct. The entire cephalopharyngeal mechanism becomes more heavily pigmented and rougher in appearance as the larvae mature. Length of cephalopharyngeal mechanism from 1.40 to 1.56 mm; average of 10, 1.49 mm.

COCHLIOMYIA MACELLARIA FAB.

FIRST INSTAR

Size and general form similar to those of *Cochliomyia americana*. Spines small, brownish in color; larger spines approximately 6μ in length. All spines with a single point.

Last segment slightly depressed behind. Posterior spiracles similar to those of *Cochliomyia americana*. Tubercles bordering the posterior cavity poorly defined.

Cephalopharyngeal mechanism (fig. 3, *C*) differing significantly from that of *Cochliomyia americana*. Pharyngeal sclerites with a prominent dorsoanterior projection which joins at the anterior extremity. The hatching spine is broader and the oral hooks differ greatly in structure from those of *C. americana*. The oral hooks consist of a pair of irregular, elongate sclerites with a large number of small hooklets closely grouped at the anterior extremity. The cephalopharyngeal skeleton is considerably larger than in *C. americana*, the length ranging from 0.33 to 0.34 mm; average of 10, 0.336 mm. Average width at widest point 0.125 mm.

SECOND INSTAR

Larva slightly less robust than in *Cochliomyia americana*. Spines small; length of larger spines approximately 20μ. Spines in the anterior rows of each band generally with 2 and occasionally 3 points; those in the posterior portion of the band more often with 1 point. Anterior margin of segments 2 to 9 completely encircled with spines; on segment 10 the band is interrupted on the dorsum, and on segments 11 and 12 the spines are restricted to the ventral and ventrolateral regions. Spines wanting on dorsum and sides at posterior margin of segments, thus differing from *C. americana*, in which the posterior margin of segments 11 and 10 is armed with several rows of spines on lateral and dorsal surfaces.

Anterior spiracles more often with 9 or 10 branches. Except for the smaller size, the anterior spiracles are similar to those of the third instar (fig. 7, *B*). Posterior spiracles (fig. 5, *B*) more lightly pigmented and smaller than those of *Cochliomyia americana*; average greatest diameter approximately 0.120 mm. Tracheal trunks leading from the posterior spiracles not pigmented.

Tubercles on border of posterior cavity larger and more conspicuous than in *Cochliomyia americana*. The general appearance of the last segment, although smaller, is essentially the same as in the third instar (fig. 8, *B*).

Cephalopharyngeal skeleton as in figure 6, *B*. The oral hooks are comparatively short and not so broadly curved as in *Cochliomyia*

americana. Other differences are readily apparent by comparing the figures. Length of cephalopharyngeal skeleton from 0.73 to 0.80 mm; average of 10, 0.78 mm. Average width approximately 0.3 mm.

THIRD INSTAR

Form (fig. 7, *B*) less robust and slightly smaller than *Cochliomyia americana.* Spines comparatively small, with from 1 to 3 points, more often with 2. Anterior margin of segments 2 to 9 completely encircled with bands of spines arranged in more regular rows than in *C. americana.* On segment 10 the band is interrupted on dorsum, and on segments 11 and 12 the spinose area is restricted to the ventral and ventrolateral regions. Spines wanting on posterior margin of segments, except for 1 or 2 rows of small spines on venter of segments 7 to 12. Anterior spiracles short, with rather short branches (fig. 7, *B*), the number of branches varying from 8 to 12, more often 9 to 11, average of 120 spiracles 9.81 branches per spiracle. Posterior spiracles (figs. 8, *B*, and 9, *B*) smaller and more rounded than in *C. americana.* Greatest diameter of spiracles from 0.342 to 0.370 mm; average of 10, 0.356 mm. Tracheal trunks leading from the posterior spiracles not pigmented (fig. 10, *B*).

Posterior cavity outlined with conspicuous conical tubercles (fig. 8, *B*); the inner and outer pairs on upper margin equal in size, the median pair smaller. On the lower margin the outer pair slightly larger than the median; the inner pair smaller than the median. An additional pair of small tubercles is situated medially near the lower margin of the posterior cavity. Anal protuberance (fig. 8, *B*) large, with the two prominent, conical anal tubercles. Spines on anal protuberance as shown in the figures. A more or less V-shaped group extending upward on the outer side. Border of the posterior cavity armed with numerous rows of 3 or 4 minute spines.

Cephalopharyngeal mechanism as in figure 11, *B*. The oral hooks are smaller than in *Cochliomyia americana*; the pharynx is more or less ribbed, whereas in *C. americana* it is smooth. Pharyngeal sclerites large, with the dorsal cornua slightly elevated. The strip of pigmented material just above the dorsal cornua is present in varying amounts only in the older third-instar larvae. Length of cephalopharyngeal skeleton from 1.43 to 1.63 mm; average of 10, 1.56 mm.

SUMMARY OF THE CHARACTERISTICS DIFFERENTIATING THE LARVAE OF C. AMERICANA AND C. MACELLARIA

FIRST INSTAR

C. americana	*C. macellaria*
1. General appearance of cephalopharyngeal sclerites as in figure 3, *A*, *B*.	1. General appearance of cephalopharyngeal sclerites as in figure 3, *C*.
2. Smaller cephalopharyngeal mechanism; average length 0.260 mm, average width at widest point 0.069 mm.	2. Average length of cephalopharyngeal mechanism 0.336 mm, average width at widest point 0.125 mm.
3. Spines large; larger spines approximately 20μ in length. Spines generally heavily pigmented.	3. Spines smaller; larger spines approximately 6μ in length. Spines generally lighter in color.

SECOND INSTAR

C. americana	*C. macellaria*
1. General appearance of cephalopharyngeal sclerites as in figure 6, *A*.	1. General appearance of cephalopharyngeal sclerites as in figure 6, *B*.
2. Average length of cephalopharyngeal mechanism 0.674 mm.	2. Average length of cephalopharyngeal mechanism 0.780 mm.
3. Posterior margin of segment 11 provided with a completely encircling band of spines; on segment 10, spines wanting only on dorsum.	3. Posterior margin of segments devoid of spines except on ventral surface.
4. Tracheal trunks leading from posterior spiracles dark in color from junction with spiracles through approximately one-half length of last segment.	4. Tracheal trunks leading from posterior spiracles not pigmented.
5. General appearance of last segment, except for the smaller size, closely resembling that of the third instar, which see (fig. 8, *A*).	5. General appearance of last segment, except for the smaller size, closely resembling that of the third instar, which see (fig. 8, *B*).
6. Ventral wall of pharynx smooth.	6. Ventral wall of pharynx ribbed.
7. Spines large; larger spines approximately 55μ in length. Spines generally dark brown to black.	7. Spines smaller; larger spines approximately 20μ in length. Spines brownish.
8. General appearance of posterior spiracles as in figure 5, *A*. Comparatively large, average greatest diameter 0.150 mm.	8. General appearance of posterior spiracles as in figure 5, *B*. Comparatively small, average greatest diameter 0.120 mm.
9. Anterior spiracles more often with 7 to 9 branches.	9. Anterior spiracles more often with 9 to 11 branches.

THIRD INSTAR

C. americana	*C. macellaria*
1. General appearance of cephalopharyngeal sclerites as in figure 11, *A*.	1. General appearance of cephalopharyngeal sclerites as in figure 11, *B*.
2. Tracheal trunks leading from posterior spiracles dark in color at junction with posterior spiracles and extending to tenth or ninth segment (fig. 10, *A*).	2. Tracheal trunks not pigmented (fig. 10, *B*).
3. Posterior margin of segment 11 provided with a completely encircling band of spines.	3. Posterior margin of segments devoid of spines except on ventral surface.
4. Appearance of posterior spiracles as in figure 9, *A*. Average greatest diameter of posterior spiracles 0.427 mm.	4. Appearance of posterior spiracles as in figure 9, *B*. Average greatest diameter of posterior spiracles 0.356 mm.
5. Structure of last segment as in figure 8, *A*.	5. Structure of last segment as in figure 8, *B*.
6. Spines large; larger spines approximately 130μ in length.	6. Spines smaller; larger spines approximately 80μ in length.
7. Anterior spiracles more often with 7 to 9 branches. Branches longer and more widely separated (fig. 7, *A*.)	7. Anterior spiracles more often with 9 to 11 branches. Branches comparatively shorter and closer together (fig. 7, *B*).
8. Ventral wall of pharynx smooth.	8. Ventral wall of pharynx ribbed.

DURATION OF LARVAL INSTARS OF COCHLIOMYIA AMERICANA

Experiments to determine the duration of each instar indicate that this is considerably influenced by the size and nature of the

wound and the number of larvae present. The weighted mean larval feeding period for 551 larvae reared in a large wound was 149.8 hours, while that for 485 larvae reared in a small wound on the opposite side of the same animal and infested at the same time was 214.2 hours.

The weighted means of the duration of the total larval stage in each of six cases in sheep at Sonora, Tex., during May and June of 1934, were 174.5, 107.5, 103.8, 139.3, 141.2, and 164.1 hours. At Menard, Tex., observations on cattle infested in nature showed that the larvae continue to feed for 82 to 239 hours before they leave the wound.

H. O. Schroeder and C. N. Smith, of this Bureau, working with an infested sheep at Washington, D. C., during March 1935, obtained the results shown in table 2 on the duration of the various instars.

TABLE 2.—*Duration of the larval instars of Cochliomyia americana in sheep, Washington, D. C., Mar. 1, 1935*

Age (hours)	Larvae removed from wounds					
	First instar		Second instar		Third instar	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
24	17	100	0	0	0	0
30	10	58.8	7	41.2	0	0
42	1	5.3	18	94.7	0	0
48	0	0	19	100	0	0
54	0	0	49	100	0	0
60	0	0	20	100	0	0
66	0	0	43	97.7	1	2.3
72	0	0	59	93.6	4	6.4
78	0	0	35	72.9	13	27.1
84	0	0	24	55.8	19	44.2
90	0	0	6	50	6	50.
96	0	0	3	50	3	50.
102	0	0	1	16.7	5	83.3
117	0	0	2	40	3	60.
132	0	0	0	0	10	100
183 [1]	0	0	0	0	12	100
195 [2]	0	0	0	0	6	100

[1] Age at which first mature larvae left wound.
[2] Age at which last mature larvae left wound.

Data obtained on the duration of larval instars in six infestations of sheep at Sonora, Tex., during the summer of 1934 are given in table 3.

TABLE 3.—*Variations in the duration of larval instars of Cochliomyia americana in sheep, Sonora, Tex., May and June 1934*

Case no.	Age of larvae when removed from wound		Larvae removed from wound			Larvae leaving wound to pupate				Larvae maturing in wound
			First instar	Second instar	Third instar	First larvae leaving wound		Last larvae leaving wound		
	Hours	*Minutes*	*Number*	*Number*	*Number*	*Numoer*	*Age in hours*	*Number*	*Age in hours*	*Number*
6	1	45	10	--------	--------	21	99.5	1	124.5	81
	28	0	--------	7	--------					
	50	30	--------	1	6					
	73	45	--------	--------	9					
	98	45	--------	--------	9					
8	25	20	16	--------	--------	--------	--------	--------	--------	--------
	49	20	--------	11	--------	--------	--------	--------	--------	--------
	55	0	--------	7	2	--------	--------	--------	--------	--------
	69	40	--------	--------	5	--------	--------	--------	--------	--------
	75	40	--------	--------	8	--------	--------	--------	--------	--------
	94	40	--------	--------	5	--------	--------	--------	--------	--------
	100	40	--------	--------	5	--------	--------	--------	--------	--------
9	3	0	11	--------	--------	--------	--------	--------	--------	--------
	24	0	7	--------	--------	--------	--------	--------	--------	--------
	49	30	--------	9	--------	--------	--------	--------	--------	--------
	54	30	--------	17	--------	--------	--------	--------	--------	--------
	73	30	--------	9	4	--------	--------	--------	--------	--------
	121	30	--------	--------	3	--------	--------	--------	--------	--------
12	36	0	--------	7	--------	50	130	2	155	138
	48	0	--------	8	--------					
	54	0	--------	2	6					
	60	0	--------	2	5					
	66	0	--------	--------	6					
	78	0	--------	--------	5					
13	32	50	--------	12	--------	6	126	1	154	51
	44	50	--------	18	--------					
	50	50	--------	5	5					
	56	50	--------	3	7					
	62	50	--------	1	6					
	74	50	--------	1	2					
14	32	50	23	10	--------	1	129	3	198	863
	44	50	--------	44	--------					
	50	50	--------	50	--------					
	56	50	--------	42	--------					
	62	50	--------	34	3					
	74	50	--------	2	23					
	80	50	--------	10	--------					

In one case in a sheep, where the wound was infested with less than 100 larvae, it was observed that some of the larvae changed to the second instar in 18 hours.

The results of observations to determine at what time of day mature larvae leave the wound are shown in table 4. The animals used in this experiment were kept in a screened insectary and watched constantly until all maggots had left the wounds.

TABLE 4.—*Observations on time of day larvae of Cochliomyia americana leave wounds in sheep, Sonora, Tex., May and June 1934*

Time of day	Case 3			Case 6		Case 6a		Case 12		Case 13		Case 14				Total
	May—			June—		June—		June—		June—		June—				
	15	16	17	4	5	15	16	26	27	26	27	26	27	28	29	
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
12 to 4 a. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	2	5
4 to 5 a. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	-----	3
5 to 6 a. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	-----	3
6 to 7 a. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	8	-----	9
7 to 8 a. m.	-----	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----	-----	11	-----	12
8 to 9 a. m.	-----	-----	-----	-----	5	-----	-----	-----	10	-----	-----	-----	19	90	1	125
9 to 10 a. m.	-----	4	-----	-----	5	-----	-----	-----	19	-----	10	-----	38	159	2	237
10 to 11 a. m.	1	4	-----	-----	9	22	3	50	21	6	12	-----	38	99	3	268
11 to 12 a. m.	1	19	1	21	4	36	16	18	2	8	4	-----	94	69	-----	293
12 to 1 p. m.	5	10	-----	6	1	15	3	8	-----	-----	-----	-----	31	20	-----	99
1 to 2 p. m.	6	6	-----	13	-----	11	-----	6	-----	-----	3	1	36	34	-----	116
2 to 3 p. m.	7	1	-----	11	-----	11	2	1	-----	-----	1	2	36	4	-----	76
3 to 4 p. m.	6	-----	-----	3	-----	4	-----	2	-----	5	-----	4	25	1	-----	50
4 to 5 p. m.	-----	-----	-----	1	-----	-----	-----	1	-----	2	-----	4	11	1	-----	20
5 to 6 p. m.	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----	1	1	1	-----	4
6 to 7 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7 to 8 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	-----	-----	2
8 to 10 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4	-----	-----	4
10 to 12 p. m.	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1	-----	-----	1
Total	26	44	1	56	25	99	24	86	52	21	30	12	337	506	8	1,327

Larvae begin feeding on the tissues of the wound as soon as they hatch. Melvin has demonstrated experimentally that newly hatched larvae are capable of penetrating the unbroken skin of rabbits and guinea pigs. This has never been observed to take place in nature, but numerous infestations occur among range sheep in the external lachrymal fossae of the eyes in which there is no evidence of skin abrasions.

After the larvae penetrate the tissues, they assume the characteristic head-downward position, with the posterior end bearing the spiracles remaining in contact with the air. In cases where the wound is so located that the exudate collects in the cavity, the larvae periodically extrude the posterior tips of their abdomens above the surface of the liquid for the purpose of obtaining air. When once the larvae of *Cochliomyia americana* become embedded in the flesh, they do not move about in the wound as do *C. macellaria* and other wound-inhabiting species.

THE PREPUPA

The length of the prepupal period varies considerably and is apparently dependent to some extent upon the environment in which the mature larvae find themselves at the time they drop from the wound. It has been noted to range from 7 to 76 hours. The weighted mean prepupal period for all mature larvae which had dropped naturally from five cases in sheep at Sonora, Tex., during June 1935 is given in the following tabulation:

Number of mature larvae dropping from wound	*Weighted mean prepupal periods, hours*
81	20.7
120	18.7
135	17.3
50	15.3
863	20.0

As soon as the larvae observed in this test dropped from the wound they were placed in a pint mason jar half full of slightly moistened sand. The jars were kept in an open insectary.

Upon leaving the wound, the larvae immediately seek some sheltered place in which to pupate. They either crawl under some object or burrow into the soil. The results of experiments conducted by Melvin to ascertain how deeply the larvae would penetrate into several types of soil are given in table 5. These tests were conducted by placing each type of soil in a wooden container 6 inches square and 38 inches high, waterproofed at the sides and open at each end, and standing the container upright in 3 inches of water. The depth of penetration by *Cochliomyia macellaria* is also given for comparison.

TABLE 5.—*Depth of penetration by Cochliomyia americana and C. macellaria larvae in soil of different types*

Species	Clay		Heavy black soil		Sand		Gravel	
	Weighted mean depth	Maximum depth	Weighted mean depth	Maximum depth	Weighted mean depth	Maximum depth	Weighted mean depth	Maximum depth
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
C. americana	7.77	17	2.48	13	2.25	6	1.87	3
C. macellaria	1.35	5	1.41	4	1.76	3	----------	----------

In another experiment, heavy black loam was tightly packed in a glass cylinder 5½ inches in diameter and 5 inches high by tamping the soil with a heavy stick. Larvae of *Cochliomyia americana* penetrated into this medium to depths ranging from five-sixteenths of an inch to 1½ inches, the weighted average being fifteen-sixteenths of an inch. When the cylinder was loosely filled with the same kind of soil, the depth of penetration ranged from six-sixteenths of an inch to 3 inches, the weighted average being $1\frac{5}{16}$ inches.

The first experiment was conducted in the laboratory at a fairly constant temperature (86° F.) during February 1935, at Dallas, Tex. The second experiment, by H. O. Schroeder and C. N. Smith, was made on April 1, 1935, in a room temperature of about 80°. It must be remembered that these tests were made under purely artificial conditions and give only an indication of the ability and tendency of the larvae to penetrate soil.

THE PUPA

The pupa of *Cochliomyia americana* is shown in figure 12. Normally it is of a dark brown color and is much larger and more barrel-shaped than that of *C. macellaria*. Ten specimens averaged 10.2 mm in length and 4.3 mm in width.

The duration of the pupal stage is subject to considerable variation. Under conditions in which the pupae were exposed to the influence of outside weather factors, the length of this period ranged from 167 hours (about 7 days) during the summer to 54 days during the winter; under controlled laboratory conditions of 100 percent relative humidity, Melvin determined that the period ranged from 142.2 hours at 94° F. to 760.4 hours at 59°.

Under controlled temperature and humidity the pupal period is almost twice as long as that of *Cochliomyia macellaria*, as determined by Melvin's experiments.

The relation between air and soil temperatures and their effect on the duration of the pupal stage were studied by R. A. Roberts at Uvalde, Tex., during January, February, and March 1935. On January 19, pupae were buried 4 inches below the surface of the soil. Maximum and minimum temperatures of air and soil were recorded daily until either the flies emerged or the pupae had died. On March 1, 3, and 4, or 41, 43, and 44 days later, from the pupae placed in the soil, 9.1, 4.5, and 22.7 percent, respectively, of flies emerged. The remainder (63.7 percent) of the pupae were dead. The highest and lowest daily maximum and minimum air and soil temperatures recorded during the period from the time the pupae were placed in the soil until the adults emerged are as follows:

FIGURE 12.—Pupa of *Cochliomyia americana*, × 10.

	° F.
Highest daily maximum air temperature	83
Lowest daily maximum air temperature	37
Highest daily minimum air temperature	58
Lowest daily minimum air temperature	18
Highest daily maximum soil temperature	70
Lowest daily maximum soil temperature	48
Highest daily minimum soil temperature	62
Lowest daily minimum soil temperature	40

THE ADULT

The adult of *Cochliomyia americana* has a deep greenish-blue metallic color and may be readily distinguished from species belonging to other genera of blowflies in the United States by the characteristic yellow, orange, or reddish face, and the the three dark

stripes on the dorsal surface of the thorax (pl. 1). Because of the similarity in external characters between *C. macellaria* and *C. americana*, however, it is much more difficult for the inexperienced observer to separate these two species. Females of *C. macellaria* may usually be distinguished from those of *C. americana* by the fact that the basicostal scale (a small sclerite at the base of the wing) of the former is of a yellowish color whereas in the latter this part is black. Also, in *C. macellaria* the underside of the abdomen along the mid-line is covered by a dense whitish pruinosity which, on the last visible segment of the abdomen, appears as two lateral whitish spots when the specimen is viewed from above. This character is absent in *C. americana*.

FIGURE 13.—Male genitalia of *Cochliomyia americana*.

The most reliable means of telling the males of the two species apart is by an examination of the genital apparatus. The difference between them is shown in figures 13 and 14.

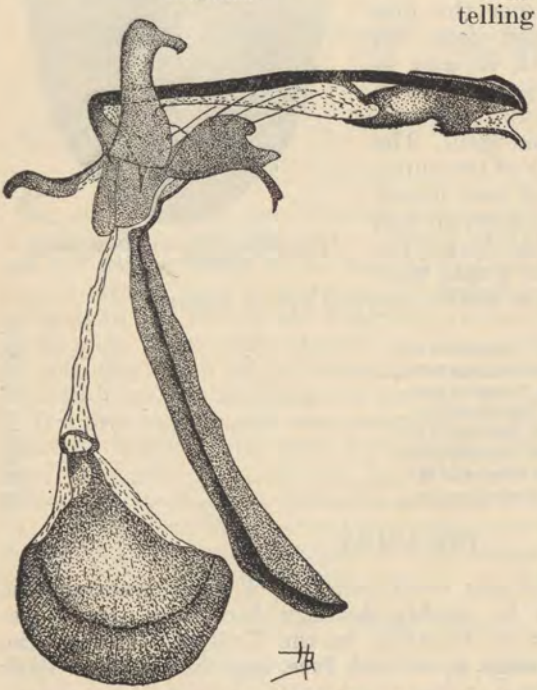

FIGURE 14.—Male genitalia of *Cochliomyia macellaria*.

In most cases it has been observed that the flies emerge from the puparia early in the morning between the hours of 4 and 7 o'clock, and are ready to take wing a few hours later. Generally from 5 to 10 days must elapse after emergence before the female is capable of depositing fertile eggs.

As previously stated, the eggs, according to the records, are deposited in batches of 10 to 393. The female is able to deposit as many as 300 eggs in 4 to 6 minutes. Tests have been made to determine the total number of fertile eggs a female is capable of

laying. The maximum number laid by a single female kept in captivity and fed on meat, sugar water, and banana under an average room temperature of 80° F., as determined by H. O. Schroeder and C. N. Smith, is shown in table 6. This fly lived for a period of 65 days, which is the greatest longevity record so far obtained on flies of this species kept in captivity. When this fly died, its abdomen was dissected and found to contain approximately 250 almost fully developed eggs. As a rule, when the flies are kept in cages they are short-lived. A large number die within 7 days and few of them live longer than 30.

TABLE 6.—*Oviposition record of one female of Cochliomyia americana*

Batch no.	Eggs in batch [1]	Age of fly at time of laying each batch	Batch no.	Eggs in batch [1]	Age of fly at time of laying each batch	Batch no.	Eggs in batch [1]	Age of fly at time of laying each batch
	Number	*Days*		*Number*	*Days*		*Number*	*Days*
1	336	13	6	234	42	11	183	56
2	283	17	7	229	46	12	194	60
3	264	22	8	286	49			
4	294	31	9	4	52	Total	2,853	
5	329	39	10	217	53			

[1] Each batch contained a high percentage of fertile eggs.

When kept in cages in insectaries or out of doors, adults are not so active as other species of flies under like conditions. They prefer to remain motionless, resting on the walls or top of the cage the greater part of the time; in nature, however, they appear to be strong fliers. During the hot months of summer and early fall the flies are more numerous and active about animals, and it is during these seasons that the largest number of infestations usually occur. The lowest temperature at which females have been observed ovipositing in nature was 65° F., but it is quite possible that some of them will infest animals at temperatures lower than this.

Adults kept in captivity feed readily on sweets of various kinds, blood, meat, bananas, and the nectar from flowers growing in the cage; in nature, they have been observed to feed on wounds, fresh manure, and fresh meat.

According to records obtained by Melvin, the total life cycle of *Cochliomyia americana*, that is, from the time the eggs are laid until females developing from these eggs are ready to oviposit, is about 24 days at an average air temperature of 72° F. during September and October at Dallas, Tex. This is nearly twice the time required for *C. macellaria* to complete its life cycle.

The comparative abundance of *Cochliomyia americana* and *C. macellaria* in nature is 1 of the former to 590 of the latter, as determined by the attractiveness of fresh uninfested and infested necrotic wounds in cattle at Menard, Tex., by H. E. Parish, during the summer and fall of 1934. This ratio is based on a total of 66,155 of the two species visiting 6 wounds which were exposed for a period of 2 days each. The ratio of the species taken in a standard meat-baited flytrap during a 7-day test in which 80,159 *Cochliomyia* were caught, was 1 *C. americana* to 2,427 *C. macellaria*.

EFFECT OF COLD UPON EGGS, PREPUPAE, PUPAE, AND ADULTS

The results of experiments by H. O. Schroeder and C. N. Smith to determine the effect of cold on the various stages of *Cochliomyia americana* are given in tables 7 and 8. In the tests shown in table 7, specimens were placed in an electric refrigerator and the temperature was run down to the desired point; then the current was cut off and the refrigerator allowed to warm gradually. When the temperature had risen to 50° F., the specimens were removed and kept at a room temperature of about 80°. In some instances a few of the specimens were held at 40° for a number of hours before being kept at room temperature. The time required to run the temperature in the refrigerator down to the desired point ranged from 3 to 5½ hours. One-half of each egg mass listed in table 7 was kept at room temperature for a check on the viability of each batch. All the check eggs hatched. Similarly, an equal number of prepupae and pupae which had spent their larval stage in the same wound as those used in the test served as check specimens. These all produced normal adults. Adults from the same source as those used in the test were all normal specimens.

TABLE 7.—*Effect of cold on eggs, prepupae, pupae, and adults of Cochliomyia americana*

Stage of fly exposed	Specimens in test	Lowest temperature to which specimens were exposed	Total time required for temperatures to reach lowest point and to rise to 50° F.	Results
	Number	*° F.*	*Hours*	
Eggs	450 (3 lots [1])	32	7½	2 lots hatched; 1 did not.
	450 (3 lots)	28	9	3 lots did not hatch.
	600 (4 lots)	26	10	2 lots hatched; 2 did not.
	450 (3 lots)	24	7½	1 lot hatched; 2 did not.
	300 (2 lots)	20	9	2 lots did not hatch.
Prepupae	6	[2] 20	[3] 3	1 died; 5 lived to adult stage (all males).
	10	[2] 15	7½	3 died; 7 lived to adult stage; females laid fertile eggs.
	6	15	7½	3 died; 3 pupated but died later; no adults.
	10	[2] 13	9	2 died; 8 pupated; 4 adults emerged.
	10	13	9	3 died; 7 pupated but died later; no adults.
	10	[2] 12	12	4 died; 6 pupated but died later; no adults.
	10	[2] 12	12	1 died; 9 pupated; 1 male emerged.
	10	12	12	5 died; 5 pupated but died later; no adults.
	10	[2] 11	13	3 died; 7 pupated but died later; no adults.
	10	11	13	9 died; 1 pupated but died later; no adults.
	6	16	15	6 died.
	6	10	20	Do.
	6	[2] 10	24	Do.
Pupae	6	[2] 20	8	6 adults emerged and laid eggs.
	10	[2] 15	12	4 adults emerged and laid fertile eggs; 6 died.
	6	[2] 13	5	2 adults emerged and laid eggs; 4 died.
	6	[2] 13	8	6 died.
	10	[2] 11	14	10 died.
	10	[2] 11	[4] 27	Do.
Adults	6	20	7	3 males lived; 2 females died; 1 lived and laid eggs.
	10	18	8	10 died.
	6	18	8	6 died.
	10	15	10	10 died.
	10	10	[5] 22½	Do.
	10	10	[5] 22½	Do.
	10	10	17½	Do.

[1] Each lot consisted of one-half of an egg mass and contained about 150 eggs.
[2] Specimens placed in half-pint paper cup containing sawdust; all others in open cups.
[3] Specimens held at 40° F. for 15 hours.
[4] Specimens held at lowest temperature 16 hours.
[5] Specimens held at lowest temperature 4 hours and at 40° F. for 13 hours.

By using a thermocouple and galvanometer, the temperatures at which the body fluids of the different stages of *C. americana* freeze was determined. These temperatures are given in table 8.

TABLE 8.—*Undercooling and freezing points of eggs, prepupae, and adults of Cochliomyia americana*

Stage and number of specimens	Average undercooling point	Average freezing point	Effect on specimens
	° F.	° F.	
1 egg mass	16	17	All failed to hatch.
7 prepupae	13	23	All died.
8 pupae	18	20	3 adults emerged.
3 male adults	19	21	All lived.
3 female adults	21	23	All lived and laid fertile eggs.

BREEDING PLACES

At the present time all the evidence at hand indicates that in nature *Cochliomyia americana* larvae begin their development only in the tissues of live animals.

Of approximately 67,000 flies of the genus *Cochliomyia* reared by H. E. Parish from carcasses of cattle, sheep, and rabbits exposed in nature at Menard, Tex., when adults of *C. americana* were active, all were *C. macellaria*. At Sonora, Tex., no adults of *C. americana* were found in samples of 2,000 flies reared from each of 5 rabbit carcasses that were exposed for 3 days after the animal had been dead for the following periods: 10 minutes and 12, 36, 60, and 84 hours.

While it is possible under laboratory conditions, by a method developed by Melvin, to rear the flies from the egg to the adult stage on such media as hard-boiled eggs and raw lean beef kept at a constant temperature of 94° F., under natural conditions oviposition has never been observed to take place on carcasses, pieces of meat, or other materials. Females kept in cages in the laboratory under room temperatures of 80° have deposited eggs on fresh lean meat, and they oviposit readily on this medium at a temperature of 95°.

Numerous observations have shown that larvae which have begun their development in live animals are able to complete their growth in dead tissue. Results of three tests conducted by Melvin, in which guinea pigs were killed at 24-hour intervals after becoming infested, showed that the minimum ages of the larvae at which they continued development in the carcass were 36, 48, and 96 hours; during these periods the average daily mean temperatures were 75.6°, 86.0°, and 52.4° F., and the average daily maximum temperatures were 88°, 86°, and 64°, respectively. Observations indicate that under such conditions the larvae must molt to the second instar before they can complete their development.

SUMMARY

Cochliomyia americana and *C. macellaria* are two species of screw worms which infest wounds in man and animals. The former, because of its close similarity in outward appearance to the latter and more common species, remained unrecognized for a number of years. Its discovery necessitated a restudy of the biology, habits, and relative economic importance of the two species.

Present data indicate that in nature *Cochliomyia americana* is a primary, obligatory parasite and initiates the majority of screw worm infestations in warm-blooded animals in the tropical and subtropical regions of the New World. Its known normal distribution extends from Argentina, South America, to the southern part of the United States; it has been found in a few instances in several of the more

northern States. The earliest authentic record of its occurrence in the United States dates back to 1882.

The activity of the adults of *Cochliomyia americana* is considerably influenced by seasonal variations in temperature. In the southern part of the United States, the fly begins its attacks late in the spring or early in the summer. As a rule, the first killing frosts in the fall mark the cessation of the fly's activity throughout the winter; during the milder winters, however, temperatures are not low enough to kill the adults.

Studies on the duration of the different stages of *Cochliomyia americana* reveal the following facts: (1) The incubation period of eggs on wounds in animals ranges from 11 to 21.5 hours under natural conditions; in one instance, in an animal in a laboratory, eggs hatched in 6 hours, and under controlled conditions of temperature and 100 percent relative humidity the incubation period ranged from 9.2 hours at 99° F. to 13.9 hours at 84°; no hatching takes place at 59°. (2) The duration of all larval instars in cattle infested in nature ranges from 82 to 239 hours; in sheep the weighted mean range of this stage was from 103.8 to 174.5 hours. The length of the different instars appears to be influenced by the size of the wound and the number of larvae that infest it. (3) The prepupal stage lasts from 7 to 76 hours and the pupal stage from about 7 days in the summer to 54 days during the winter. The duration of both these stages is considerably influenced by temperature and moisture. (4) The longevity of adults in captivity is usually short (about 7 to 30 days), but in one instance a female lived 65 days.

Eggs, larvae, and adults of *Cochliomyia americana* can be distinguished from those of *C. macellaria;* the eggs, by the wider band which encircles the micropyle; the larvae, by differences in the structure of the cephalopharyngeal mechanism, the size and arrangement of spines on the segments, the posterior spiracles, and the size of the tubercles on the last segment; the adults, by the form of the genitalia and differences in coloration of certain parts of the body.

Larvae of *Cochliomyia americana* appear to penetrate more deeply into soil to pupate than do those of *C. macellaria.*

Individual females of *Cochliomyia americana* may lay as many as 2,853 eggs. The eggs are deposited in characteristic batches of 10 to 393 eggs each, and the oviposition of as many as 300 eggs may be completed in from 4 to 6 minutes.

Eggs of *Cochliomyia americana* are killed at temperatures near the freezing point, but prepupae, pupae, and adults are able to withstand temperatures considerably below this point.

The evidence indicates that under natural conditions *Cochliomyia americana* breeds only in live animals, but in the laboratory it has been possible to rear it from the egg to the adult stage on dead tissue.

The comparative abundance of *Cochliomyia americana* and *C. macellaria* in nature, as determined by the number of each species attracted to fresh and necrotic wounds, is 1 of the former to 590 of the latter; as determined by the number taken in meat-baited flytraps, the ratio is 1 to 2,427.

Under controlled laboratory conditions the length of the life cycle of *Cochliomyia americana* is about twice that of *C. macellaria.*

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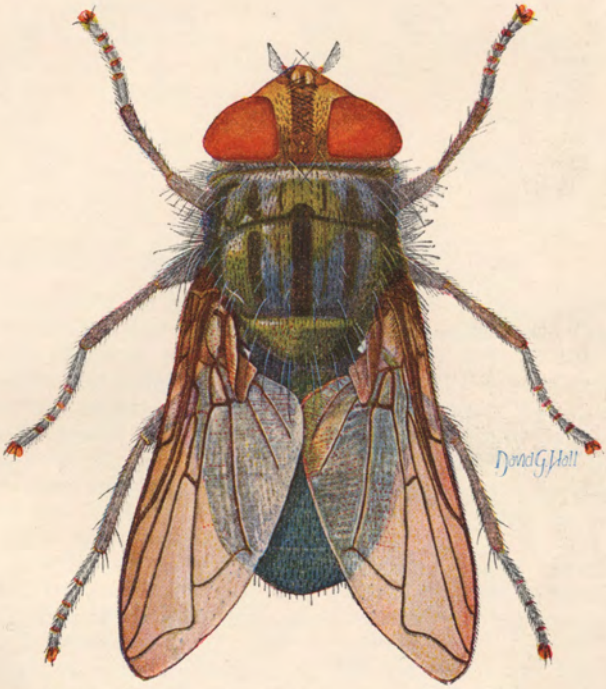

Negatives furnished through courtesy of M. S. Yeomans.

ADULT SCREW WORM FLY (COCHLIOMYIA AMERICANA).