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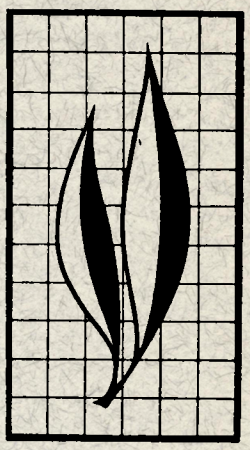
The Taxonomy, Life Histories, and Mating Behavior of the Green Lacewings of Strawberry Canyon (Neuroptera: Chrysopidae)

Catherine A. Toschi

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURAL SCIENCES



Six species of chrysopids belonging to three genera occur in Strawberry Canyon, University of California, Berkeley. They are *Chrysopa carnea* Stephens, *C. nigricornis* Burmeister, *C. quadripunctata* Burmeister, *Meleoma comata* Banks, *M. cavifrons* Banks, and *Nothochrysa californica* Banks. Keys are presented to aid in distinguishing the adults and larvae of the species. Taxonomic descriptions are given for stages which have not been described previously in literature.

Life history studies for the six species reveal many similarities; however, the differences are emphasized. The eggs, larvae, and cocoons are described. The adult food and prerequisites for mating are discussed. Detailed descriptions of the sequences of mating behavior for each species are given. Oviposition behavior is recorded for two genera as well as oviposition patterns for all the genera.

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THE AUTHOR:

Catherine A. Toschi is a graduate student in the Department of Entomology and Parasitology, Berkeley, and the holder of the Hilgard Scholarship for 1965.

Catherine A. Toschi

The Taxonomy, Life Histories, and Mating Behavior of the Green Lacewings of Strawberry Canyon (Neuroptera: Chrysopidae)[1]

INTRODUCTION and LITERATURE

SIX SPECIES of chrysopids belonging to three genera are known to occur in Strawberry Canyon, University of California, Berkeley. These are *Chrysopa carnea* Stephens, *C. nigricornis* Burmeister, *C. quadripunctata* Burmeister, *Meleoma comata* Banks, *M. cavifrons* Banks, and *Nothochrysa californica* Banks.

C. carnea and *C. nigricornis* are common species and their life histories are fairly well known. However, the *Meleoma* species and *N. californica* are rare, and their immature stages and life histories were previously unrecorded. Their mating and oviposition behavior also had never been reported.

The purpose of this paper is to (1) describe and distinguish the larvae of the species of green lacewings in Strawberry Canyon, (2) compare their life histories, and (3) record their mating and oviposition behavior.

Literature on *Chrysopa* is extensive, mainly because of the abundance of several species and their use as biological control agents. Balduf (1939) reviewed all of the major works on chrysopid biology in his discussion of the Chrysopidae. His work is the last major review on the subject.

Since 1939, however, considerable work has been done on more specific aspects of *Chrysopa* biology and behavior, for example: Chen and Young (1941) on the value of the egg pedicel, Clancy (1946) on parasites of *Chrysopa*, Finney (1950) on mass rearing techniques, Hagen (1950) on synthetic foods affecting *C. carnea* fecundity (as *C. californica* Coquillett), Fleschner (1950) on the searching capacity of *C. carnea* larvae (as *C. californica*), and Neumark (1952) on *C. carnea* biology.

In contrast to that on *Chrysopa*, literature on the genus *Meleoma* is fragmentary. Smith (1921) said that he could not keep *M. signoretti* Fitch adults alive for any length of time. In 1922 he mentioned the prominent frontal horn on the male of *M. signoretti* and its suggestion in *M. slossonae* Banks. He again reported that he was unable to keep adults of *Meleoma* alive for more than ten days. In the same paper he recorded a parasite, *Pseudoculicoides eques* Johannsen, on the wings of *M. signoretti*.

Putman (1932) discussed the possible roles of *M. signoretti* and *M. emuncta* Fitch in the control of Oriental fruit moth on peach. He reared

[1]Submitted for publication February 1, 1965.

two larvae of *M. signoretti* and one of *M. emuncta* and reported the lengths of time for their development. Putman's 1937 paper gives further biological data on the two species, along with brief descriptions of their eggs, larval instars, and cocoons. Knowlton (1946) captured *M. verticalis* Banks and *M. emuncta* adults in light traps at Logan, Utah.

Adams (1962) reported the occurrence of a stridulatory structure in both males and females of *M. schwarzi* (Banks). The males of this species do not have frontal horns as do those of other *Meleoma* species. However, Adams moved this species from the genus *Chrysopa* to *Meleoma* on the basis of male genitalia. He suggested that stridulation in this species may serve in the functions of attraction of the sexes and/or stimulation during courtship.

Literature on the life history of *Nothochrysa* also is fragmentary. Nothing has been reported on the American species, *N. californica*. Killington (1937) gave descriptions of the stages and some biological data on the European species *N. capitata* (Fabricius) and *N. fulviceps* (Stephens) as *Nathanica capitata* and *Nathanica fulviceps*.

METHODS

The collecting, rearing, and preserving techniques were similar for all species studied. Collections were made over a period of three years and most of the specimens have been deposited in the California Insect Survey collection at Berkeley.

Adults were occasionally collected at lights; however, the main collections of adults were made by tapping branches of trees, which caused the adults to fly. They could then be caught with a net. Adult lacewings were kept in 25 mm × 95 mm shell vials or in half-pint cartons with glass lids. They were supplied water, sugar or honey, and enzymatic protein hydrolysate of yeast.

Observations of mating and oviposition were made under laboratory lights or, where stated in the text, under red light. The red-light observations were made in a darkroom using red light bulbs and a Safelight filter.

Eggs were collected in the field as well as obtained from females in the laboratory. Both Smith (1922) and MacLeod (1960) report obtaining fertile eggs from females of Neuroptera confined in suitable containers.

Egg descriptions were made from living and slide-mounted specimens. Hatched eggs were used in making slide mounts. First, the egg shell was immersed in alcohol and the egg burster dissected out. Then the shell was cut and spread out so that there would be only one thickness on the slide. Both egg shell and egg burster were mounted in diaphane.

Larvae were collected mainly by beating *Quercus agrifolia* Nee and *Umbellularia californica* (Hooker and Arnott) Nuttall. They were confined in individual shell vials and fed various green aphids. All rearings were made in the laboratory under varying conditions of temperature, light and humidity.

Larvae were preserved by treating them with Peterson's K.A.A.D. solution (Peterson, 1953). The specimens were then transferred to 95 per cent ethyl alcohol. Slide mounts of the three larval instars were made for use in descriptions. Larvae first cleared in 10 per cent KOH solution were dehydrated with washes of 70, 95 and 100 per cent ethyl alcohol. The larvae were then mounted in diaphane. Larval descriptions were made using both slide mounts and alcohol-preserved specimens.

Drawings of larval heads and metathoraces were made with the aid of an ocular grid. Measurements were made with the grid calibrated with a stage micrometer. Measurements of head length were taken from the anterior margin of the clypeus to the posterior

margin of the head capsule. Width measurements were across the eyes and include the eyes. Body length was measured from the anterior margin of the clypeus to the end of the last abdominal segment. Measurements of setae on the large prothoracic tubercles indicate the length of these setae relative to the size of the body. These measurements are approximate due to curvature of setae.

TAXONOMY

KEY TO ADULT CHRYSOPIDS OF STRAWBERRY CANYON

1. Body mainly black . . . . . *N. californica*
   Body yellowish-green or reddish, with or without other markings 2
2. Scapes elongate, basally separated by at least one scape width; third antennal segment longer than fourth; males with prominent horn between scapes and with large frontal cavity . . . . . *Meleoma* 3
   Scapes rounded medially, basally separated by less than one scape width; third antennal segment same length as fourth; males and females without horn and frontal cavity . . . . . *Chrysopa* 4
3. Crossveins all green; pale reddish markings on prothorax, none on mesothorax; frontal cavity of male narrow, not reaching beyond antennal bases; third antennal segment of male enlarged and with long median hairs . . . . . *M. comata*
   Many crossveins black; red markings on pro- and mesothorax; frontal cavity of male broad, extending beyond antennal bases almost to eyes; third antennal segment of male not modified . . . . . *M. cavifrons*
4. Prothorax with four bright orange marks; head and mesothorax marked with bright orange . . . . . *C. quadripunctata*
   Thorax green or reddish, or with median yellow stripe, no orange markings . 5
5. Cheek markings red; cheeks with or without dark markings also; median yellow stripe; small species . . . . . *C. carnea*
   Cheek markings black only; body entirely green; large species . . *C. nigricornis*

KEY TO CHRYSOPID LARVAE OF STRAWBERRY CANYON

1. Large abdominal setae hooked; head almost entirely dark brown . *N. californica*
   Abdominal setae curved, not hooked; head with dark markings but not entirely dark 2
2. Head with only single pair dorsal longitudinal markings, not meeting posteriorly; lateral dark markings from eyes to cervix; no trash . . . *C. carnea*
   Head with more than only one pair dorsal markings, with or without lateral markings; some trash 3
3. Head dorsally with pair of posterior dark markings and median anterior dark marking; no lateral markings immediately posterior to eyes; body dark . . . . . *C. nigricornis*
   Head with more than three dorsal marks; lateral marks immediately posterior to eyes 4
4. Head dorsally with pair of median longitudinal marks curving outward anteriorly, pair of lateral longitudinal marks from base of antennae to cervix (first instar with single V-shaped mark) . . . . *C. quadripunctata*
   Head with at least three pairs dorsal longitudinal marks distinct anteriorly . 5
5. Marks from median base of antennae extending posteriorly and remaining distinct from marks from eyes; metathoraces of instars as in figures 5, 6, 7 . . . . . *M. comata*
   Markings from median base of antennae extending posteriorly and meeting marks from eyes; metathoraces of instars as in figures 11, 12, 13 . *M. cavifrons*

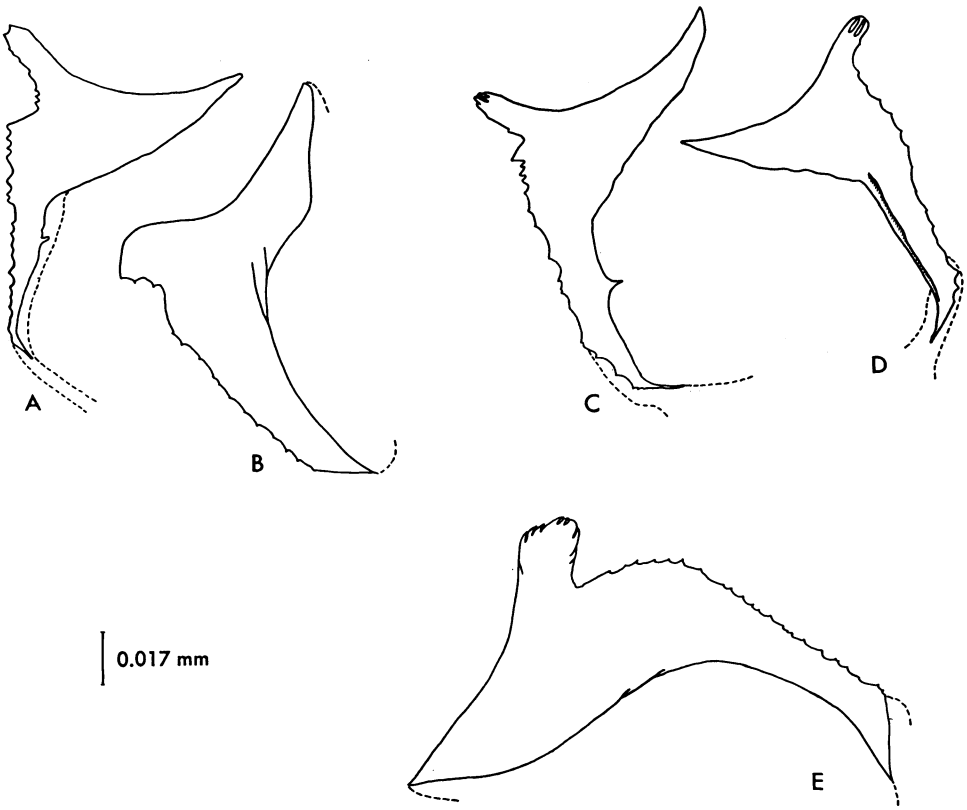

Fig. 1. Egg bursters. A. *Chrysopa carnea;* B. *C. nigricornis;* C. *Meleoma comata;* D. *M. cavifrons;* E. *Nothochrysa californica.*

Chrysopa carnea Stephens

C. carnea is the common California green lacewing. Adults are easily recognized by their fairly small size, green to yellowish-green color in summer and reddish color in winter, longitudinal yellow stripe, and red cheek markings. The genitalia of this species also are distinctive and have been figured (Killington, 1937; Neumark, 1952; Adams, 1963; and Bram and Bickley, 1963).

Previously this species has been referred to as *C. californica* Coquillett, *C. plorabunda* Fitch, and *C. plorabunda* var. *californica.* However, *C. californica* has been considered a synonym of *C. plorabunda* (Smith, 1932). *C. plorabunda* later was placed in synonymy with the Old World species *C. carnea* (Tjeder, 1960) so that now all the names are synonymous with *C. carnea.*

Egg

Smith (1932), Killington (1937), and Neumark (1952) briefly described the *C. carnea* egg; it is redescribed here for comparison. Egg when first laid, yellowish-green, becoming bluish-green later; stalked, ovoid, but slightly narrower at stalked end; stalk hyaline, flexible when first laid but becoming stiff after about a day; micropyle white, depressed in center, chorion elevated around its periphery; chorion finely reticulated with series of continuous raised ridges in irregular patterns; egg burster, figure 1A. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	0.89 mm	± 0.03 mm	0.84–0.96 mm
Width	0.39 mm	± 0.02 mm	0.36–0.43 mm
Stalk length	3.50 mm	± 1.03 mm	1.44–5.04 mm

Larva

The three larval instars of *C. carnea* have been adequately described and illustrated by Smith (1922), Killington (1937) and Neumark (1952) and will not be redescribed here. As in larvae of many species of chrysopids, coloration is frequently diagnostic, and most descriptions and illustrations emphasize this feature.

Cocoon

The cocoon is white, almost spherical, complete on all sides, thin walled and somewhat transparent; trash is sometimes incorporated very loosely into the outer layer of silk. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	3.29 mm	± 0.34 mm	2.78–3.70 mm
Width	2.64 mm	± 0.32 mm	2.22–3.16 mm

Chrysopa nigricornis Burmeister

C. nigricornis can be recognized by its green body, green crossveins and black cheek markings. Females may be difficult to distinguish from *M. comata* females; however, *C. nigricornis* can be recognized by its rounded scapes and its black cheek markings which do not reach the eyes. *C. nigricornis* also has four large setae on the clypeus which are absent from *Meleoma.*

C. nigricornis has previously been referred to as *C. majuscula* Banks in the western United States. However, Bram and Bickley (1963) considered the two names to be synonyms.

Egg

Smith (1922) only briefly described the egg of *C. nigricornis,* so it will be redescribed here. Egg, when first laid, uniformly yellowish-green, turning dark gray later; stalked, ovoid but slightly flattened at micropylar end; stalk hyaline, flexible throughout development of embryo, attached to egg slightly to side of posterior tip of egg; micropyle white, depressed in center, chorion elevated around its periphery; chorion finely reticulated with series of continuous raised ridges in irregular patterns; egg burster, figure 1B. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	0.96 mm	± 0.12 mm	0.79–1.22 mm
Width	0.46 mm	± 0.02 mm	0.43–0.50 mm
Stalk length	10.14 mm	± 0.53 mm	9.25–10.92 mm

Larva

The three larval instars have been described adequately by Smith (1922) and will not be repeated here.

Cocoon

The cocoon is white, rounded but longer than broad, thick-walled but not completely opaque; trash is sometimes loosely incorporated into outer layer of silk. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	4.56 mm	± 0.29 mm	4.08–4.89 mm
Width	3.80 mm	± 0.23 mm	3.35–4.15 mm

Chrysopa quadripunctata Burmeister

C. quadripunctata is extremely rare in Strawberry Canyon. Only one adult specimen was taken in the three years of collections. This was a male taken in September 1962. One first instar larva was taken from *Quercus agrifolia* on October 8, 1963. This larva was given aphids to feed on, but it did not survive beyond the first instar.

C. quadripunctata adults are very easy to recognize by their bright orange body markings. Smith (1922) described the egg, larval instars, and cocoon. Due

to lack of material no further studies were made on this species.

Meleoma comata Banks

According to Adams,[2] *M. comata* is very similar to *M. emuncta* Fitch and *M. verticalis* Banks. The only distinguishing characters are slight differences in antennae. He believes that since these forms are allopatric they probably represent clinal variations in a single species. However, he advised using the name *M. comata* Banks until this has been studied further.

Egg

Egg, when first laid, greenish-gray, central portion slightly darker, later becoming bluish-gray; stalked, ovoid, not constricted near point of attachment as in *C. carnea;* stalk hyaline, flexible when laid and stiffening only slightly with age; micropyle white, slightly depressed in center, chorion elevated around its periphery; chorion finely reticulated with series of continuous raised ridges in irregular patterns; egg burster, figure 1C. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	0.97 mm	± 0.03 mm	0.92–1.01 mm
Width	0.39 mm	± 0.06 mm	0.36–0.42 mm
Stalk length	5.66 mm	± 0.98 mm	4.50–7.44 mm

Larva

Coloration of first instar. Whitish anteriorly, darker posteriorly, with red, brown and white areas as follows: *Head* dorsally with dark brown markings as indicated in figure 2, setae pale, anterior two corneal swellings of ocular area surrounded by brown mark which extends anteriorly to lateral base of mandibles, posterior four corneal swellings surrounded by white, area posterior to ocular area with large brown mark extending to cervical region. *Thorax* with white fat bodies showing beneath lateral and posterior margins of segments, setae pale, prothorax with pair of lateral elongate brown marks and broken pair of elongate red bands mesad to brown marks, four posterior tubercles brown, mesothorax with median pair of broken red bands twice as wide as prothoracic red bands, pair of small tubercles in center of posterior part of red bands brown, pair of small oval dark brown markings mesad and slightly posterior to large lateral tubercles, spiracles margined in dark brown, metathorax with pair of broken median red bands, two pairs of brown markings as in figure 5. *Abdomen* with white fat bodies visible medially beneath first four segments, segment 1 marked laterally by red, four posterior tubercles light brown, segment 2 with large lateral tubercles dark brown, pair of red markings extending medially from posterior part of brown tubercle markings, posterior tubercles light brown, segment 3 with base of large lateral tubercles marked posteriorly with brown and dorsally with red markings extending medially from posterior of tubercles, four small posterior tubercles brown-tipped, segment 4 with pair of red antero-lateral markings extending medially at posterior, four small posterior tubercles brown-tipped, segments 5, 6, and 7 with large lateral tubercles white, dorsal setal base of each tubercle brown, median red bands extending laterally at posterior, posterior tubercles dark brown, segment 8 with three transverse red bands connected medially, posterior transverse band laterally extending farther toward posterior, pair of elongate brown markings between lateral tips of first and second transverse bands, lateral tubercle brown-tipped, segment 9 brown laterally, anterior tubercles brown, posterior tubercles light brown, pair of red marks

[2] Personal communication by P. A. Adams, Orange State College, Fullerton, California, 1963.

behind posterior tubercles, segment 10 brown antero-laterally, elongate brown mark postero-medially, spiracles of abdomen margined in brown. *Legs* whitish, coxae brown, femora with two dark brown marks near apices, tarsal claws pale, empodia dark.

Structural characteristics. *Body* elongate, slightly wider than one-fifth length. Dorsal integument of each segment thinly covered with minute bristles.

Head shape and setation as in figure 2, length 0.26 to 0.35 mm, width 0.43 to 0.46 mm (N = 3); basal segment of labial palpus with one long mesal and one short lateral seta, second segment with annulation lengths in approximate ratio of 20:2:2:9, apical segment narrowed and annulated distally, with several short setae at very apex. *Thorax* with length slightly less than three-fourths width; prothorax with pair of large antero-lateral tubercles, each bearing two prominent setae, pair of long anterior setae between large tubercles, pair of small tubercles mesad to lateral brown marks, each with one seta, posteriorly three pairs of setae—median pair long and on small dark brown tubercles; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing spiracles laterally, posterior subsegment with pair of large lateral tubercles, each bearing three prominent setae, with pair of small anterior tubercles each with pair of large setae, two pairs of long setae near posterior margin; metathoracic setae as in figure 5. *Abdomen* with spiracles antero-lateral on segments 1 through 8; segment 1 with anterior row of two pairs setae, posterior row of six pairs setae mesad to

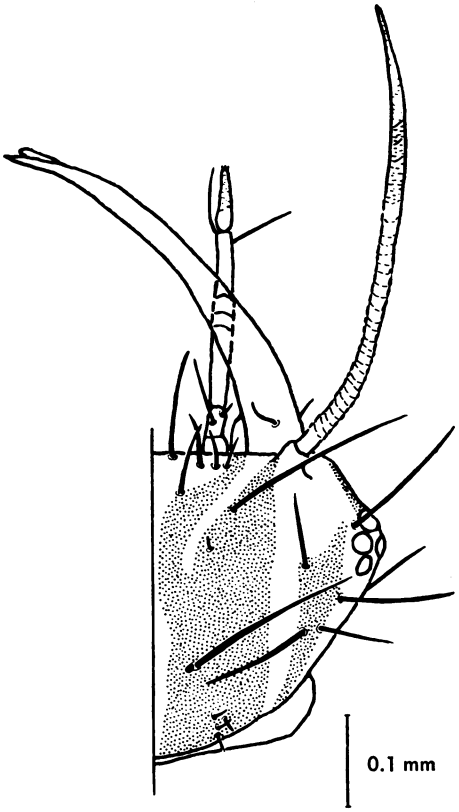

Fig. 2. First instar *Meleoma comata* head.

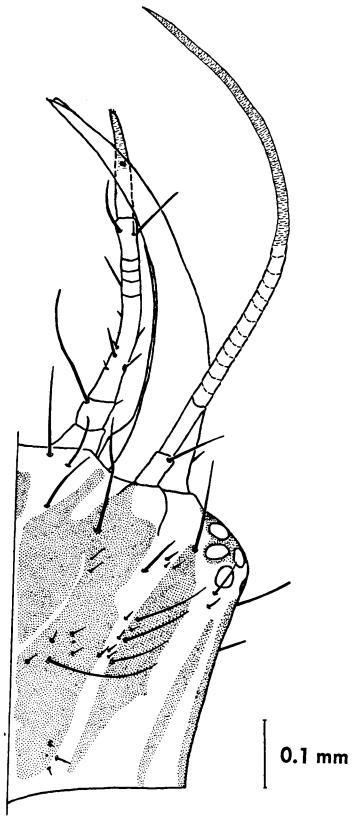

Fig. 3. Second instar *Meleoma comata* head.

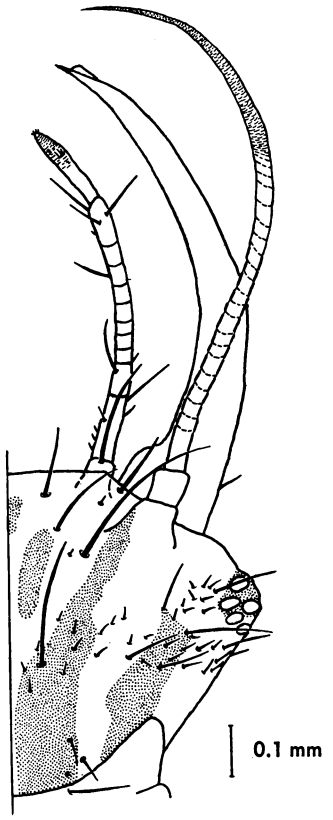

Fig. 4. Third instar *Meleoma comata* head.

spiracles—median two pairs long, next three pairs from pair of dark tubercles, lateral pair long; segments 2 through 7 with large lateral tubercles each bearing two prominent setae; segments 2, 3, and 4 each with one short seta immediately mesad to each spiracle, five pairs longer setae mesad and slightly posterior to short setae—postero-lateralmost two pairs from small tubercles; segments 5, 6, and 7 each with anterior row of three pairs of small setae, posterior row with four pairs of setae—median pair longer, next two pairs from pair dark tubercles, lateral pair smaller than median pair, on dark tubercles; segment 8 with pair of long lateral setae from small tubercles, posterior row of setae; segments 9 and 10 narrow; segment 9 with two pairs of setae from anterior tubercles, posterior row of many small setae. Body length 1.7 to 3.3 mm (N = 3); seta of prothoracic tubercle 0.5 mm (N = 1).

Coloration of second instar. Tan, with white, brown, and red marks as follows: *Head* dorsally with dark brown marks as in figure 3, setae pale, anterior three corneal swellings of ocular area surrounded by brown mark that extends slightly forward, other four swellings surrounded by white, area posterior to ocular area dark. *Thoracic* setae pale except tips of very long setae dark, prothorax with white fat bodies showing beneath anterior and lateral margins, pair of longitudinally elongate lateral brown marks, posterior tubercles dark brown, pair of antero-median reddish-brown marks, pair of broken bands of reddish-brown mesad to elongate brown marks, extending through two-thirds of mesothorax, mesothorax with white fat bodies visible beneath lateral and posterior margins, pair of dark brown marks posterior and slightly lateral to tips of reddish-brown bands, two pairs small anterior tubercles within reddish-brown bands brown, spiracles margined in dark brown, metathorax with white fat bodies visible beneath median, posterior, and lateral margins, median reddish-brown band extending from posterior region of mesothorax through two-thirds of metathorax, three pairs dark brown marks as in figure 6. *Abdominal* segments 1 through 5 marked laterally with broken reddish-brown bands which join at posterior margin of segment 5, segments 6 through 9 marked by median broken reddish-brown band, small lateral tubercles and four posterior tubercles of segment 1 light brown, large lateral tubercles of segment 2 dark brown, lateral tubercles of segments 3 through 7 pale, segments 5, 6, and 7 with posterior tubercles dark brown, segment 10 with brown marks antero-laterally and postero-medially, spiracles of abdomen margined by brown. *Legs* pale, coxae brown, femora with two dark brown marks near apices, tarsal claws and tips of empodia dark.

Structural characteristics. *Body* elongate, slightly wider than one-fifth length. Dorsal integument of thorax

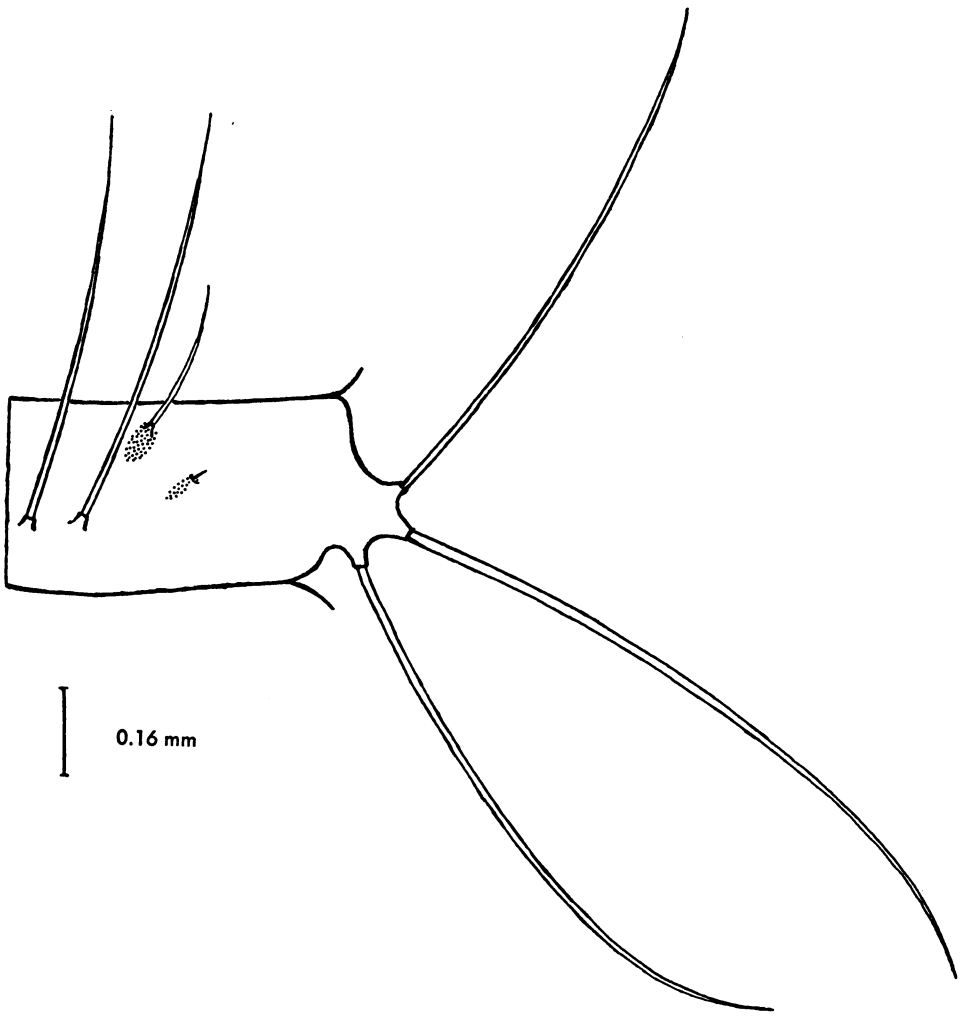

Fig. 5. First instar *Meleoma comata* metathorax dorsum.

thinly covered in wide median band with small slightly curved bristles, entire dorsum of remaining segments covered slightly more densely with bristles. *Head* shape narrower posteriorly than shown in figure 3; setation also as in figure; length 0.50 to 0.68 mm, width 0.77 mm (N = 3); basal segment of labial palpus with one long and one short seta distally and two very short ventral setae, second segment with annulation lengths in approximate ratio of 34:6:5:4:12, third segment narrowed and annulated apically, with several short setae at very apex. *Thorax* almost as long as broad; prothorax with large antero-lateral tubercles bearing many prominent setae, two pairs of anterior setae between large tubercles—lateral pair much smaller, three pairs setae posterior to anterior two pairs—antero-lateral pair small, other two pairs longer, four pairs of setae near posterior margin—median two pairs from small tubercles; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing spiracles laterally, two pairs of long setae from small tubercles medially, posterior subsegment bearing large lateral tubercles with many prom-

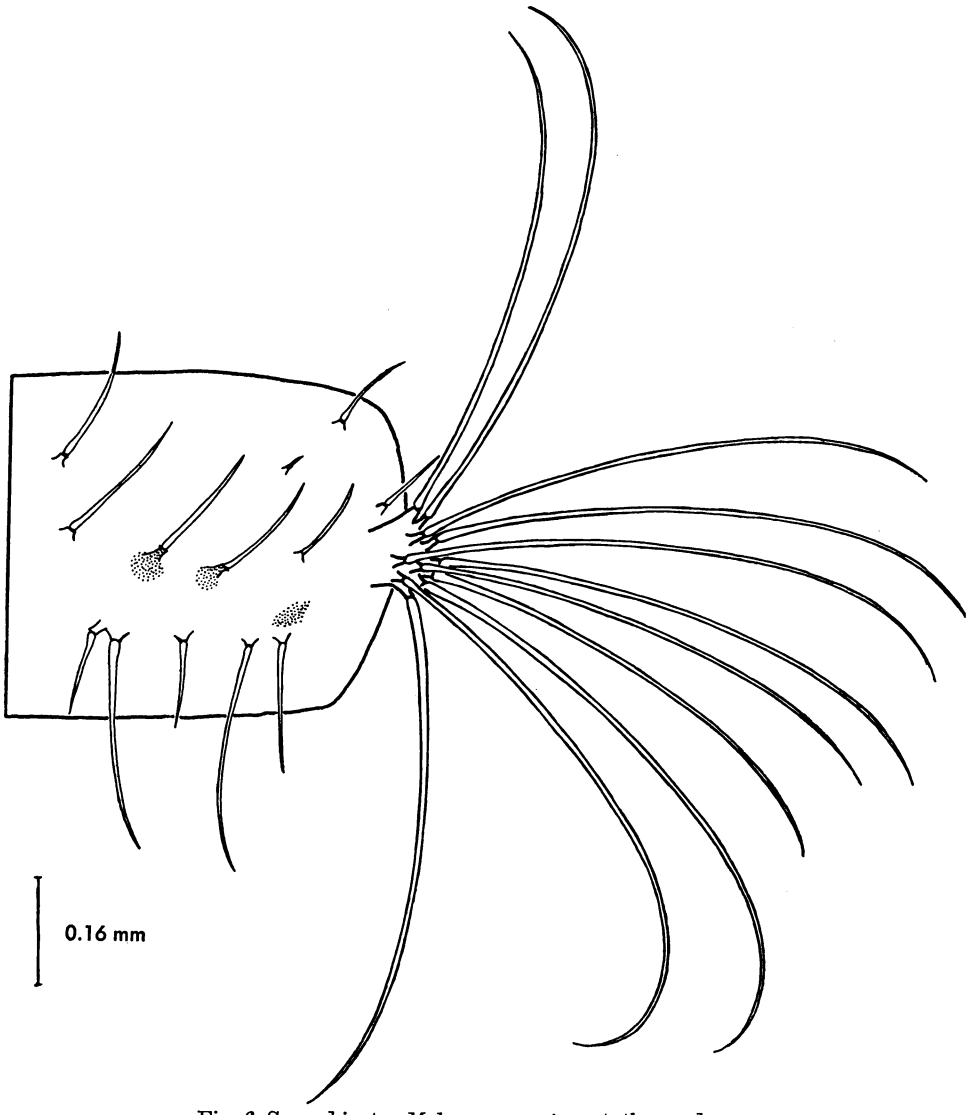

Fig. 6. Second instar *Meleoma comata* metathorax dorsum.

inent setae, two rows of setae—anterior row of four setae and posterior row of eight setae; metathorax with large lateral tubercles and setation as in figure 6. *Abdomen* with spiracles antero-lateral on segments 1 through 8; segment 1 with two transverse rows of setae—posterior row with four small dark tubercles; segments 2 through 7 with large lateral tubercles each bearing several prominent setae; segments 5, 6, and 7 each with two pairs long setae from small dark tubercles near posterior margin; segment 8 with long pair of setae from small lateral tubercles; segments 9 and 10 narrow; segment 9 with two rows of short setae. Body length 5.6 to 6.1 mm (N = 3); seta of prothoracic tubercle 0.6 mm (N = 1).

Coloration of third instar. Pale with pink, brown, and red marks as follows: *Head* tan with dorsal brown marks as in figure 4, anterior median mark not always present, setae pale, anterior three corneal swellings of ocular area surrounded by brown, posterior three by

white, two elongate brown marks posterior to ocular area, antennae, mandibles, and palpi amber colored. *Thoracic* setae pale, prothorax with white fat bodies visible beneath lateral and anterior margins, with five longitudinally elongate marks—lateral pair mesad and posterior to large lateral tubercles very pale brown, median mark brown anteriorly and posteriorly, red between, pair of red bands between other three marks joining posteriorly, mesothorax with white fat bodies visible beneath lateral and posterior margins, pair of broken red bands anteriorly near midline, extending laterally to center of posterior subsegment, small pair of brown marks at postero-lateral tips of red bands, pair of postero-median red marks, pair of faint brown postero-lateral marks far posterior transverse band of pink, metathorax with white fat bodies visible laterally, posteriorly, and medially, broken median red band through anterior two-thirds of segment, pair of lateral marks very light brown, posterior transverse band of very pale pink. *Abdomen* with white fat bodies visible beneath cuticle dorsally except on midline and in scattered patches, pair of broken reddish-brown bands laterally on segments 1 through 5, joining in segment 6 and extending as a large single median broken band on segments 7 through 9, lateral tubercle of segment 2 pale with several brown setal bases, of segments 3 through 7 pale with all setal bases pale, segments 1 and 6 with two pale pink transverse bands each, segments 2, 3, 4, and 5 each with three pale pink transverse bands, segment 8 with pair of anterior brown marks, median elongate brown mark connected to transverse posterior brown mark, segment 9 with pair of anterior brown marks, segment 10 with antero-median brown mark, antero-lateral red marks, and posterior triangular brown mark, spiracles margined in brown. *Legs* pale, meso- and metathoracic coxae with some brown, femora with two pale brown marks near apices, tarsal claws and empodia dark.

Structural characteristics. *Body* elongate, four times as long as broad. Dorsal integument of thorax densely covered with small straight spines, of abdomen less densely covered except

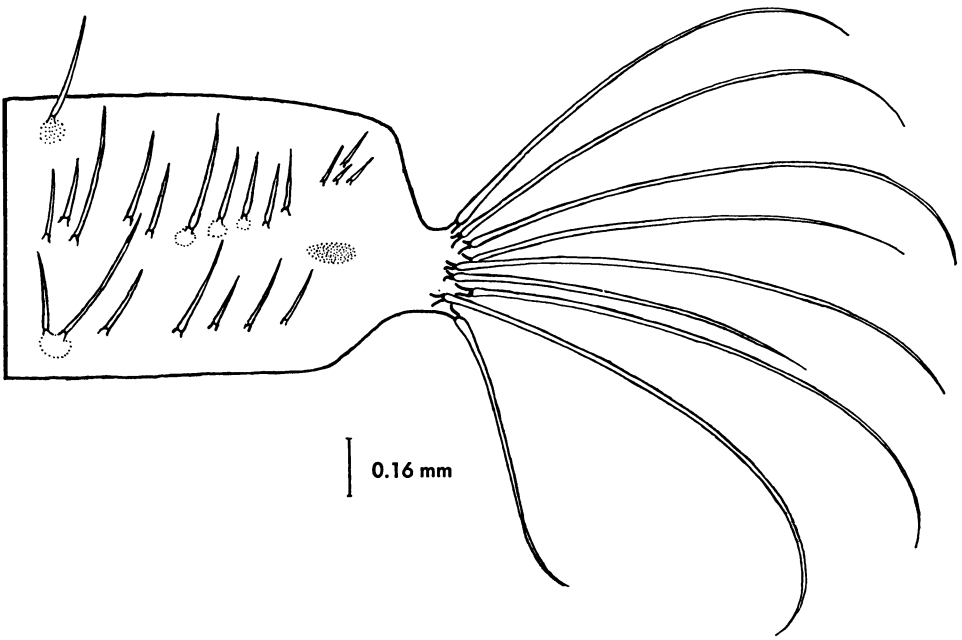

Fig. 7. Third instar *Meleoma comata* metathorax dorsum.

medially on segments 6 and 7. *Head* shape and setation as in figure 4; length 0.68 to 0.85 mm, width 1.11 to 1.19 mm (N = 3); basal segment of labial palpus with one long seta and five short setae, second segment with annulation lengths in approximate ratio of 16:5:2:3:2:3:3:4:4:9, third segment narrow and annulated distally, with several short setae at tip. *Thorax* three-fourths as long as broad; prothorax with large antero-lateral tubercles bearing many conspicuous setae, two pairs of long setae mesad to large lateral tubercles, two pairs of setae posterior to these but more widely separated, and four pairs setae near posterior margin—two pairs near midline and two far lateral pairs; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing spiracles laterally, row of setae medially, posterior subsegment with large lateral tubercles bearing numerous conspicuous setae, two rows setae—anterior row with eight pairs of pale setae, posterior row with four pairs long setae; metathorax with setation as in figure 7. *Abdomen* with spiracles antero-lateral on segments 1 through 8; segment 1 with two rows of setae; segments 2 through 7 with large lateral tubercles bearing numerous conspicuous setae, three rows of short setae each; segment 8 with small lateral tubercles bearing several short setae; segments 9 and 10 narrow; segment 9 with two rows of setae. Body length 8.7 to 9.9 mm (N=3); seta of prothoracic tubercle 0.7 mm (N = 1).

Cocoon

Cocoon white, rounded but slightly longer than broad; sometimes spun with very small surface immediately against substrate; silk walls thick, almost completely opaque; trash often incorporated into silk. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	3.70 mm	± 0.38 mm	3.51–4.34 mm
Width	3.17 mm	± 0.26 mm	2.80–3.50 mm

Meleoma cavifrons Banks

The population of *M. cavifrons* from the Berkeley area, according to Adams (see footnote on page 396), is a geographic variant of the population of *M. cavifrons* from Western Canada which resembles the type more closely. The type is from Pinecrest, Tuolumne County, California (Banks, 1950). The members of the Berkeley population have longer scapes and interantennal processes which may be linked with the greater size of the individuals in an allometric relationship (Adams, see footnote on page 396).

Egg

Egg when first laid yellowish-green, posterior end lighter, later becoming grayish; stalked, ovoid, slightly constricted near point of attachment; stalk hyaline, shorter and stiffer than *M. comata* stalk; micropyle white, circular, slightly depressed in center, chorion elevated around its periphery; chorion finely reticulated with series of continuous raised ridges in irregular patterns; egg burster, figure 1D. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	0.85 mm	± 0.04 mm	0.80–0.92 mm
Width	0.37 mm	± 0.02 mm	0.34–0.40 mm
Stalk length	3.51 mm	± 0.45 mm	2.94–4.38 mm

Larva

Coloration of first instar larva pale anteriorly, dark posteriorly, with dark and white markings as follows: *Head* pale with brown markings as in figure 8, setae pale, anterior halves of anterior

two corneal swellings of ocular area surrounded by a brown mark which extends slightly forward toward base of mandible, remaining swellings surrounded by white, two dark elongate marks extending posteriorly from ocular area, antennae, palpi, and mandibles amber-colored. *Prothorax* with white fat bodies visible beneath anterior, posterior, and lateral margins, pair of light brown marks mesad to large lateral tubercles, pair of elongate dark brown marks posterior and mesad to large lateral tubercles, one median mark and pair of brown marks posterior to elongate pair, mesothorax with white fat bodies visible beneath cuticle anteriorly, laterally, posteriorly, and medially, pair of reddish median broken bands, pair of small brown marks antero-mesad to large lateral tubercles, pair of dark brown marks mesad to large lateral tubercles, pair of small dark brown marks near posterior margin, spiracles dark brown, metathorax with white fat bodies visible beneath cuticle laterally and medially, wide reddish bands lateral to median fat bodies, pair of small brown antero-lateral red marks as in figure 11. *Abdomen* with white fat bodies visible beneath medially, marked by reddish-brown dorsally, segment 1 with four posterior tubercles dark, large lateral tubercles of segment 2 brown, of segments 3 and 4 marked by dark brown anteriorly, posteriorly and at tips, of segment 5 pale but faintly tipped by brown, of segments 6 and 7 pale, segment 8 with two longitudinally elongate brown marks, segment 9 with median and lateral pairs of elongate brown marks, segment 10 brown medially and laterally. *Legs* pale, coxae brown, tibiae with two brown marks near apices, femora and tarsi with brown apical bands, tarsal claws pale, empodia dark.

Structural characteristics. *Body* elongate, about three times as long as broad. Dorsal integument of head, prothorax, and mesothorax (except near anterior setae) without spines, of metathorax and abdominal segments 1 through 8 densely covered with straight or slightly curved spines—most dense and largest on metathorax and abdominal segments 1 and 2, of segment 9 with less dense and smaller spines medially, of segment 10 without spines. *Head* shape and setation as in figure 8; length 0.34 to 0.51 mm, width 0.43 to 0.59 mm (N = 3); basal segment of labial palpus with long median seta, short lateral seta, second segment with annulation lengths in approximate ratio of 26:6:5:6:4:6, distal annulation with two long setae near tip, third segment broad basally, narrower and annulated apically, with several short setae at apex. *Thorax* width about two-thirds length; prothorax with large antero-lateral tubercles each bearing two prominent setae, pair of anterior setae mesad to large antero-lateral tubercles, pair of setae

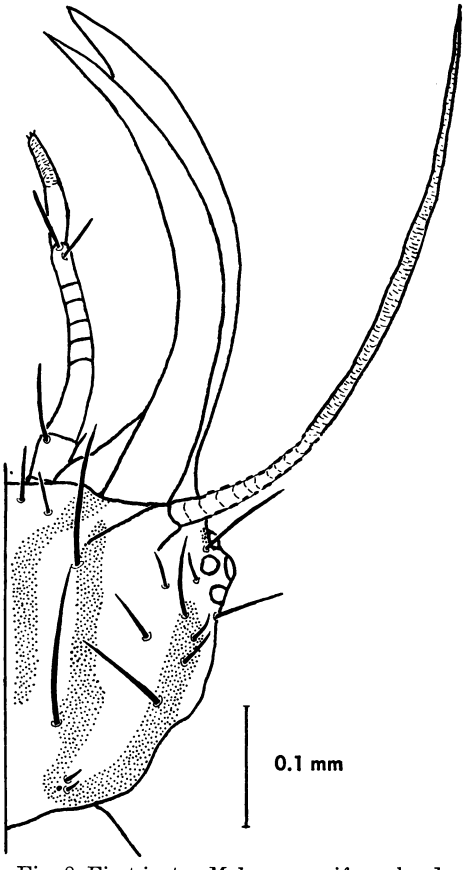

Fig. 8. First instar *Meleoma cavifrons* head.

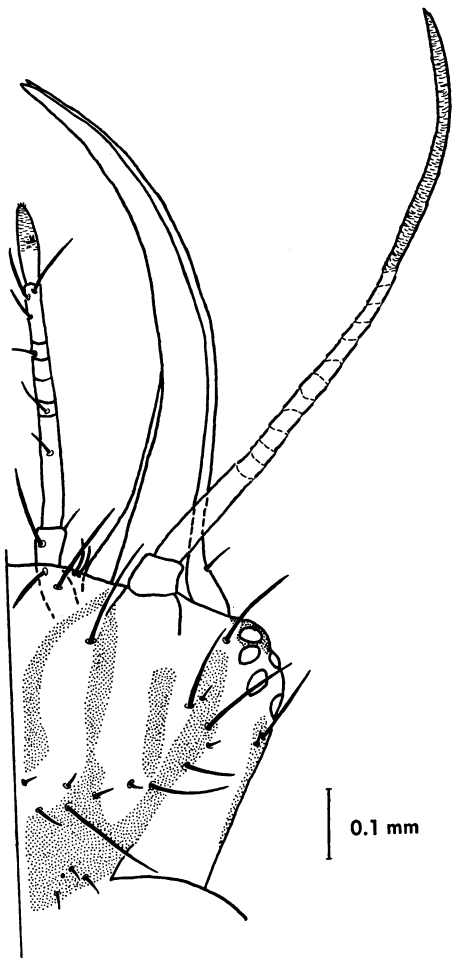

Fig. 9. Second instar *Meleoma cavifrons* head.

immediately postero-mesad to large antero-lateral tubercles, pair of long setae near posterior margin, two pairs of fairly long postero-lateral setae; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing spiracles and two pairs of very short setae, posterior subsegment bearing large lateral tubercles each with three prominent setae, pair of long setae mesad to large lateral tubercles, two pairs very long setae near posterior margin; metathorax with tubercles and setae as in figure 11. *Abdomen* with spiracles antero-lateral on segments 1 through 8, with pair of setae immediately mesad to spiracles; segment 1 with anterior row of four tubercles, each bearing a seta, posterior row with four pairs of tubercles—lateralmost smallest, next most lateral bearing two pairs long setae, median two pairs each bearing one long seta; segments 2 through 7 with large lateral tubercles each bearing two prominent setae; pair of dark tubercles mesad and slightly posterior to spiracles, each bearing two long setae, three pairs dark-based setae near midline; segments 8, 9, and 10 narrow; segments 8 and 9 each with two rows short setae. Body length 2.6 to 4.7 mm (N=3); seta of prothoracic tubercle 0.6 mm (N = 1).

Coloration of second instar. Whitish anteriorly, darker posteriorly, with brown and white markings as follows: *Head* dorsally whitish with brown markings as in figure 9, setae pale, an-

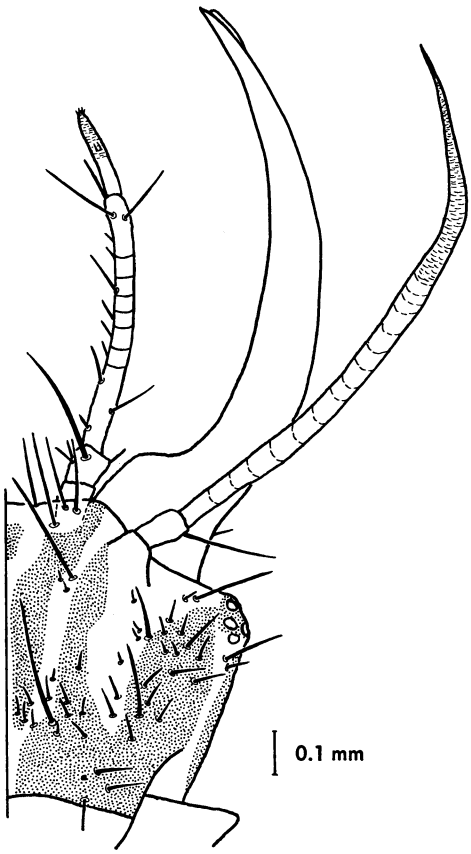

Fig. 10. Third instar *Meleoma cavifrons* head.

terior halves of anterior two corneal swellings of ocular area surrounded by brown mark which extends slightly forward, remaining corneal swellings surrounded by white, area posterior to ocular area with two elongate brown marks, antennae, palpi, and mandibles amber-colored. *Prothorax* whitish, with white fat bodies visible beneath margins, large antero-lateral tubercles pale with dark setal bases and dark setae, pair of anterior reddish-brown marks, pair of postero-median reddish-brown marks, pair of postero-lateral brown marks, mesothorax with white fat bodies visible beneath cuticle except at midline and antero-laterally, large lateral tubercle pale with several dark setal bases and setae, three anterior pairs of reddish-brown marks—one pair lateral to spiracles, two pairs mesad to spiracles, another three pairs of marks immediately posterior to anterior three pairs, pair dark brown marks mesad and posterior to large lateral tubercles, pair of median reddish-brown marks near posterior margin, extending farther posteriorly to bands of metathorax, pair of small tubercles antero-mesad to large lateral tubercles dark, spiracle margins dark brown, metathorax with white fat bodies visible beneath lateral and median margins, pair of wide reddish-brown median bands, pair of dark brown marks on lateral margins of bands mesad to large lateral tubercles, two pairs of small antero-lateral reddish-brown marks, brown tubercles as in figure 12. *Abdomen* with white fat bodies visible beneath all segments, anterior five segments marked by reddish-brown dorsally, segment 1 with several small tubercles brown, large lateral tubercles of segments 2, 3, and 4 marked by brown anteriorly and posteriorly, with several dark setal bases and dark setae, large lateral tubercles of other segments pale with several dark setal bases and setae, segments 5, 6, and 7 each with four tubercles mesad to large lateral tubercles dark-tipped, with dark setae, segment 6 with one pair of postero-median reddish-brown marks, segment 7 with three reddish-brown marks near posterior margin, segment 8 with pair of elongate lateral brown marks, one small median brown mark, segment 9 with five elongate brown marks. *Legs* pale, coxae brown, femora with two dark marks near apices, tibiae with dark band at apices, tarsal tips dark, empodia dark.

Structural characteristics. *Body* elongate, width slightly more than one-fourth length. Dorsal integument of prothorax and mesothorax with small patches of minute bristles which become larger posteriorly, remaining dorsum covered with small straight bristles in wide median band between lateral tubercles. *Head* shape and setation as in figure 9; length 0.37 to 0.51 mm, width 0.59 to 0.60 mm (N = 3); basal segment of labial palpus with long median and short lateral seta, second segment with annulation lengths in approximate ratio of 24:4:7:5:12, with possible sixth annulation in approximate ratio of 20:4:4:7:5:12, third segment narrow and annulated apically, with several short setae at apex. *Thorax* almost as broad as long; prothorax with large antero-lateral tubercles bearing many prominent setae, pair anterior setae mesad to large antero-lateral tubercles, two pairs setae posterior to anterior pair, three pairs setae near posterior margin—median pair dark and long; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing spiracles laterally, two rows setae medially, posterior subsegment with large lateral tubercles bearing many prominent setae, anterior row of two pairs setae—lateralmost from small tubercles, posterior row of four pairs of setae—lateralmost pair longest; metathorax with large lateral tubercles and setation as in figure 12. *Abdomen* with spiracles antero-lateral on segments 1 through 8; segment 1 with two rows of setae—many setae from small tubercles; segments 2 through 7 with large lateral

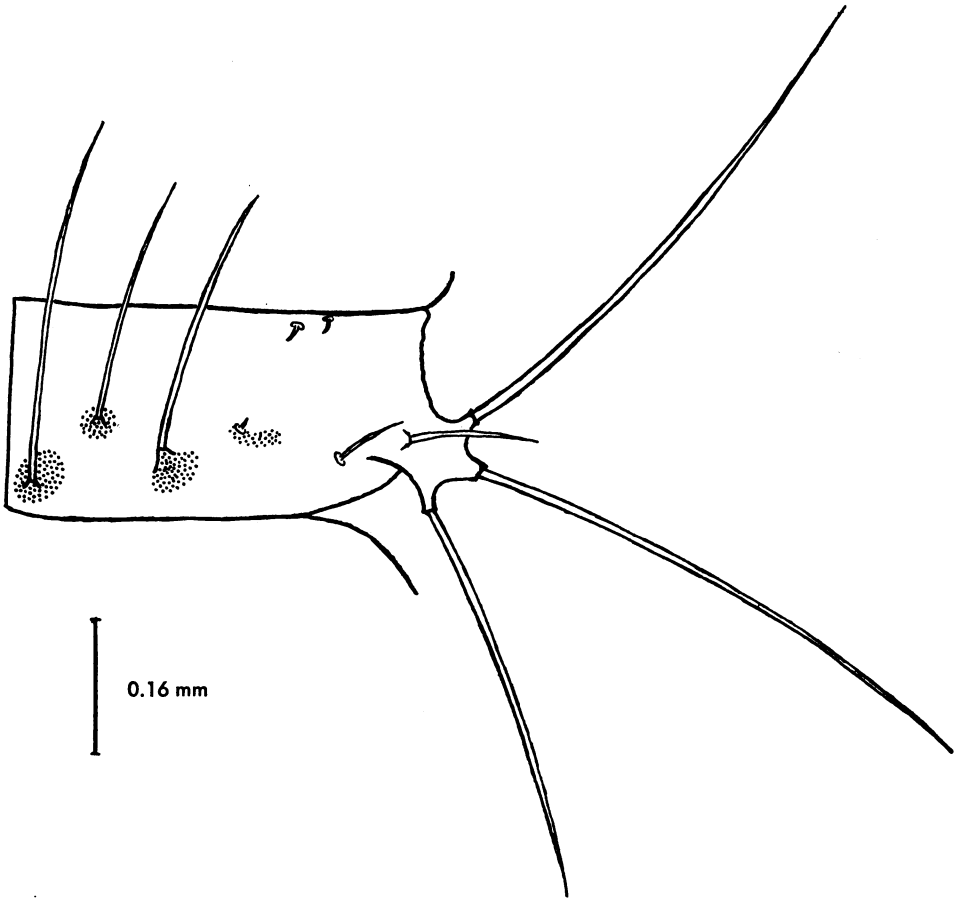

Fig. 11. First instar *Meleoma cavifrons* metathorax dorsum.

tubercles bearing several prominent setae; segments 5, 6, and 7 each with two pairs of long setae on small tubercles mesad to large lateral tubercles; segment 9 with two rows of setae. Body length 4.2 to 5.2 mm (N = 3); seta of prothoracic tubercle 0.6 mm (N = 1).

Coloration of third instar. Reddish, with markings as follows: *Head* pale with brown markings as in figure 10, anterior median mark may be absent, setae pale, anterior four corneal swellings surrounded by dark brown, remaining two surrounded by white, two elongate brown marks posterior to ocular area, antennae and palpi brownish, mandibles amber-colored. *Thorax.* Prothorax deep pink, with three small median brown marks—posterior one largest, pair of large kite-shaped lateral brown marks posterior to large antero-lateral tubercles, setae brown, mesothorax with two longitudinal pairs of broad deep pink broken bands with yellow and white fat bodies beneath, pair of small brown marks near anterior margin, pair of small brown marks anterior and mesad to large lateral tubercles, large pair of dark marks posterior and mesad to large lateral tubercles, spiracles dark brown, setae dark; metathorax with pair of broad median deep pink bands wider posteriorly, pair of deep pink antero-lateral marks, yellow and white fat bodies visible beneath margins of pink marks, pair of small dark marks mesad to large lateral tubercles, setae dark. *Abdomen* deep pink except yellowish fat bodies beneath midline, spiracles margined in dark brown,

setae light brown, segment 8 with pair of elongate meso-lateral brown marks, segment 9 with five elongate brown marks, few red marks, segment 10 with median and lateral brown marks, no red marks. *Legs* pale, coxae dark, femora with two brown marks near apices, tibiae and tarsi marked apically by brown, claws and empodia dark.

Structural characteristics. *Body* elongate, width slightly less than one-fourth length. Dorsal integument fairly densely covered with dark straight bristles—those of meso- and metathoraces darkest, largest, most dense. *Head* shape and setation as in figure 10; length 0.59 to 0.68 mm, width 0.85 to 0.94 mm (N = 3); basal segment of labial palpus with one long and two short median setae and one short lateral seta, second segment with annulation lengths in approximate ratio of 12:3:4:3:3:3:3:8, third segment narrowed and annulated distally, with several short setae at tip. *Thorax* slightly longer than broad; prothorax with large antero-

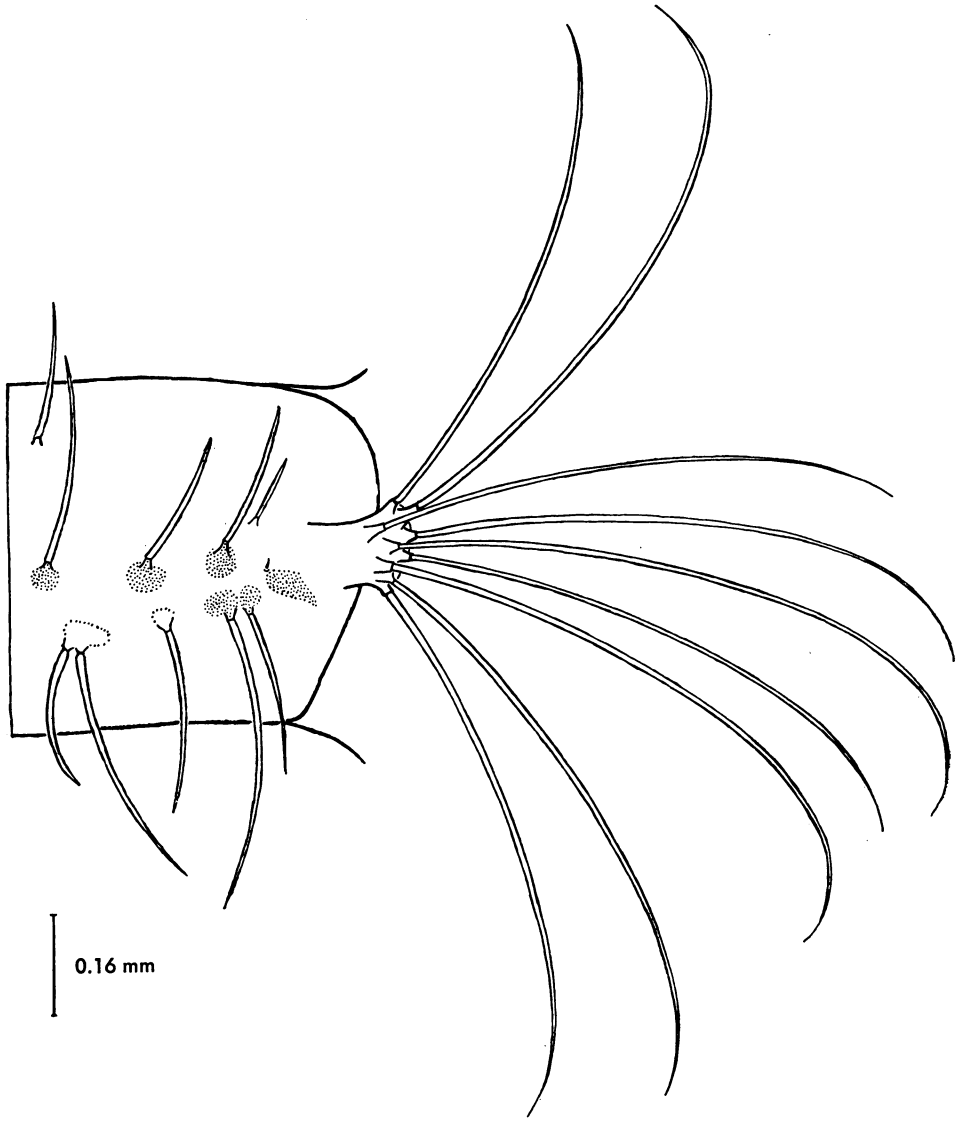

Fig. 12. Second instar *Meleoma cavifrons* metathorax dorsum.

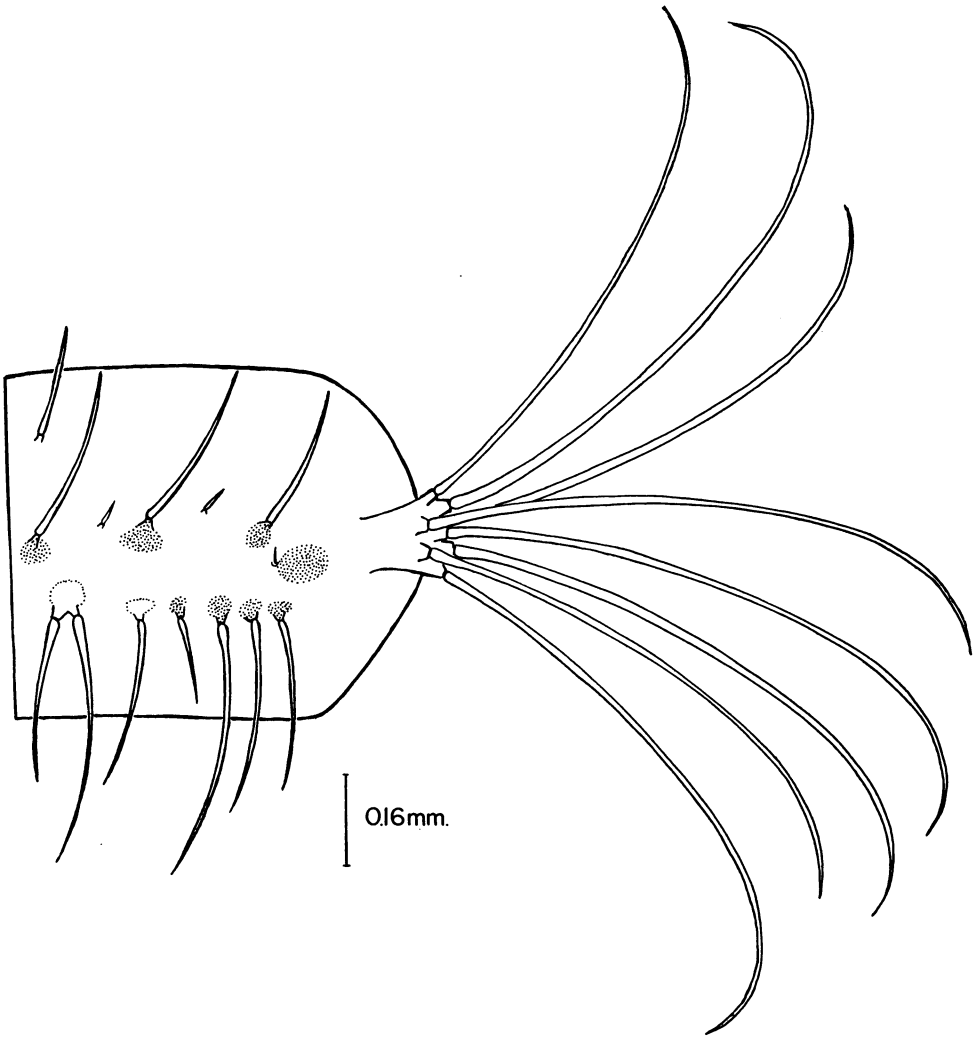

Fig. 13. Third instar *Meleoma cavifrons* metathorax dorsum.

lateral tubercles bearing many prominent setae, pair of long setae mesad to large lateral tubercles, two pairs of shorter setae posterior to long anterior setae, five pairs setae near posterior margin—two median pair longest, third pair immediately posterior to lateral brown marks, fourth and fifth pairs postero-lateral; mesothorax with anterior one-third separated by well-developed transverse fold, segment dorsally appearing as two subsegments, anterior subsegment bearing pair of spiracles laterally, row of six small dark setae medially, posterior subsegment with large lateral tubercle bearing many conspicuous setae, anterior row of four setae, posterior row of eight setae; metathoracic tubercles and setation as in figure 13. *Abdomen* with spiracles antero-lateral on segments 1 through 8; segment 1 with anterior single row of short setae, posterior double row of short setae, several longer lateral setae mesad to spiracles; segments 2 through 7 with large lateral tubercles bearing several long conspicuous setae, many short setae over dorsum; segments 5, 6, and 7 each with two pairs of long setae on posterior tubercles—medianmost

pair longer and darker, segment 8 with long lateral setae, short median setae; segments 9 and 10 narrow, with short setae. Body length 7.7 to 8.5 mm (N=3); seta of prothoracic tubercle 0.7 mm (N=1).

Cocoon

Cocoon white, spherical, sometimes spun directly against substrate so side against substrate with very thin layer silk; trash often incorporated into silk. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	3.19 mm	± 0.32 mm	3.01–3.71 mm
Width	2.60 mm	± 0.25 mm	2.31–3.08 mm

Nothochrysa californica Banks

N. californica was described by Banks (1892) and is the only known species of the genus from North America. Principi (1946) moved *N. italica* Rossi to the new genus *Italochrysa,* thus leaving the European species *N. capitata* and *N. fulviceps* and the North American *N. californica* as the three species in the genus *Nothochrysa.*

Egg

Egg when first laid yellowish-green with stalked end slightly lighter, becoming grayish-green then brownish-gray before hatching; ovoid, very slightly narrower at stalked end; stalk hyaline, stiff throughout development of embryo; micropyle white, slightly depressed in center, chorion elevated around its periphery; chorion finely granulated; egg burster, figure 1E. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	1.32 mm	± 0.04 mm	1.27–1.38 mm
Width	0.60 mm	± 0.03 mm	0.55–0.64 mm
Stalk length	6.48 mm	± 0.55 mm	5.49–7.50 mm

Larva

Coloration of first instar. Pale with markings as follows: *Head* dorsum entirely brown except white at base of antennae, mesad and postero-mesad to eyes, as in figure 14, scapes mainly tan, white distally, flagella tan laterally, pale mesally, mandibles amber-colored, palpigers and basal segment of labial palpi mainly tan, white distally, second palpal segment pale except tan distally and laterally, third segment pale ventrally, brown dorsally, cardo and stipes brown, with rectangular-shaped median mark visible ventrally, eyes dark brown to black, white beneath five corneal swellings, dark beneath central corneal swelling, area postero-ventral to eyes brown, cervical region pinkish, large lateral brown mark anterior to fore-coxae. *Prothorax* pinkish to pale, antero-lateral tubercle brown, bases of large anterior and posterior median bristles brown, pair of large brown marks in shape of right triangles with long sides medially, short sides postero-mesad to antero-lateral tubercles, sclerite dorsal to base of coxa brown, mesothorax white to pink, spiracles immediately surrounded by pale brown, fading anteriorly, large lateral tubercle brown with brown mark extending anteriorly toward spiracle, irregularly shaped brown mark posterior and mesad to large lateral tubercle, base of postero-median bristle brown, metathorax pale to pinkish, lateral tubercle brown, brown mark extending slightly anterior, small round brown mark mesad to lateral tubercle, bases of four large posterior bristles brown, sclerite at base of coxae dark brown. *Abdomen* pale to pink, segment 1 with spiracles immediately surrounded by dark brown, tubercles lateral to spiracles tipped by brown, three pairs of anterior setae with dark bases, four pairs posterior setae with dark bases, segments 2 through 5 pale, large lateral tubercles brown, spiracles surrounded by dark brown, small tuber-

cles anterior to spiracles brown, bases of three pairs anterior setae brown, three pairs small posterior tubercles brown, small tubercles ventral to large lateral tubercles brown, segments 6 and 7 pale, lateral tubercles brown, spiracles surrounded by dark brown, anterior three pairs bristles with brown bases, posterior two pairs tubercles brown, tubercles ventral to lateral tubercles brown, two pairs ventral setae with brown bases, segment 8 pale, lateral tubercles tipped by brown, spiracles margined by brown, anterior three pairs bristle bases brown, two pairs small posterior tubercles brown, four pairs setae ventral to lateral tubercles with brown bases, segment 9 pale, transverse brown mark at base of anterior bristles, pair of brown marks at base of posterior bristles, four pairs lateral setae brown-based, segment 10 brown antero-laterally and postero-medially, ventral surface with inverted V-shaped brown mark, vertex of V immediately anterior to midpoint of segment. *Legs* with dorsum of coxae dark brown, trochanters pale, brown basally, femora tannish dorsally, tibiae tan, tarsi, claws, empodia brown.

Structural characteristics. *Body* elongate. *Head* shape and setation as in figure 14; length 0.51 to 0.57 mm, width 0.57 to 0.63 mm (N = 2); venter with pair long setae postero-mesad to palpal bases, shorter pair setae directly posterior to palpi, long pair setae postero-mesad to base of mandibles, pair very short setae immediately posterior to mandibles, pair short setae mesad to eyes; dorsal surface of mandibles with minute setae; ventral surface of maxillae with minute setae, four longer setae on midventral surface; second segment of palpi annulated laterally, ventral surface with apical, median pair long setae and two pairs shorter apical, lateral setae; antennae annulated. Cervical area with two median spots of minute bristles. *Prothorax* with pair of large antero-lateral tubercles each bearing two setae slightly longer than longest seta on head; two pairs setae in antero-median corners of large dark brown marks about one-half length of setae on tubercles, two pairs posterior setae—one mesad to posterior corners of large brown marks, one on lateral margins of brown marks, large brown marks surrounded anteriorly, laterally, posteriorly by minute bristles; mesothorax divided by transverse fold into two subsegments, anterior subsegment about one-half size of posterior subsegment, bearing round spiracles laterally, two pairs short setae antero-mesad to spiracles, broad transverse band of minute bristles, posterior subsegment with pair of large lateral tubercles each bearing two very long setae and two median setae, one about one-fifth length of long setae, other about one-sixth length, two pairs very small setae antero-mesad to large tubercles, three pairs setae mesad to large tubercles—two median pairs about four times length of lateral pair, lateral setae at anterior margins of lateral brown marks, posterior row of four long setae on tubercles, two transverse bands of minute bristles; metathorax with pair of large lateral tubercles each bearing two very long setae and two anterior setae about one-fifth length of setae on lateral tubercles, very small anterior setae, three pairs larger setae postero-mesad, two pairs long posterior setae on tubercles, dorsal surface covered generally with minute bristles. *Abdomen.* Dorsal surface of abdomen generally covered with minute bristles; first abdominal segment with anterior row of four pairs of setae—lateral pair short, at median margin of small brown marks, three median pairs longer, slightly hooked, on small tubercles, lateral round spiracles, long pair setae ventro-lateral to spiracles, seven pairs setae mesad to spiracles—first pair very small, immediately mesad to spiracles, second pair short, at base of small tubercles, third pair very small, posterior to tubercles, four median pairs very long, hooked, on tubercles; segments 2, 3, 4, and 5 each with large lateral tubercles

each bearing two very long curved setae, pair of round spiracles mesad to tubercles, pair of long hooked setae on small tubercles antero-mesad to spiracles, three pairs long hooked anterior setae, three longer hooked posterior pairs setae on tubercles, ventral surface with pair of long setae on large tubercles immediately ventral to large lateral tubercles, smaller pair postero-median setae on smaller tubercles; segment 6 with large lateral tubercles each bearing two very long hooked setae, round spiracles anterior to tubercles, pair of small setae mesad to spiracles, row of four pairs median setae—lateral pair small, second and fourth pairs very long, hooked, on tubercles, third pair minute, ventral surface with pair of long lateral setae on protuberances, two pair smaller median setae—medianmost pair very small; segment 7 with large lateral tubercles each bearing two very long setae, round spiracles anterior to tubercles, row of three pairs small setae mesad to spiracles, two pairs setae mesad to large lateral tubercles—lateral pair very long, curved, on tubercles, median pair about one-fourth length, on smaller tubercles; segment 8 with pair of small lateral swellings each bearing long seta at apex and smaller seta anteriorly, pair of round spiracles anterior to swellings, two rows setae—one mesad to spiracles with four pairs short setae, other mesad to swellings with three pairs setae, ven-

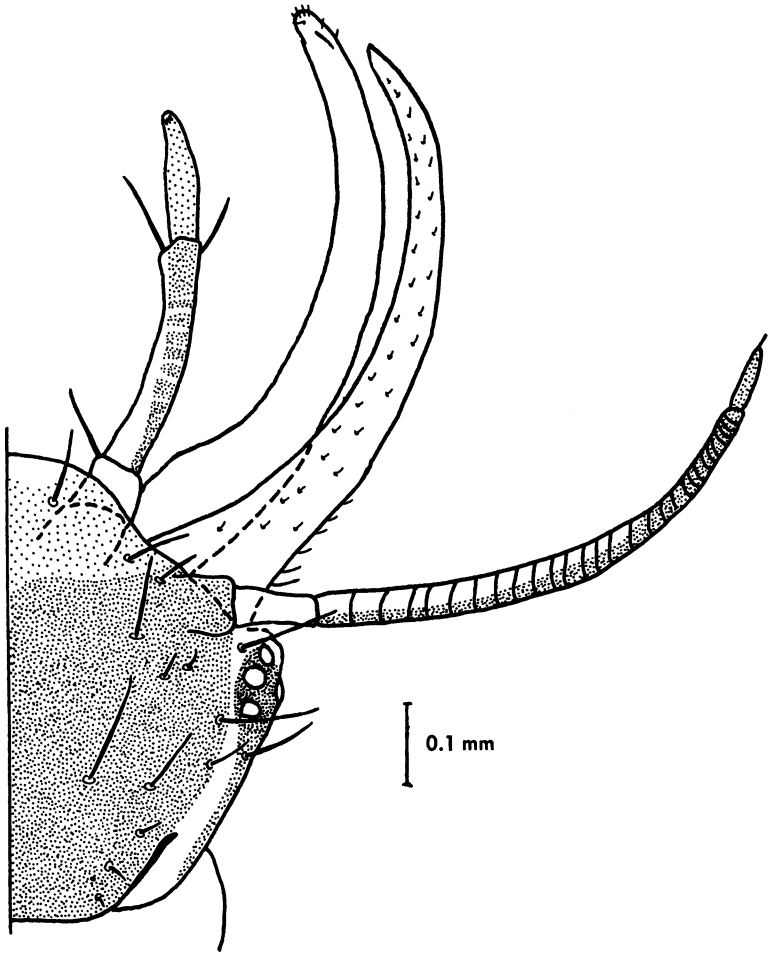

Fig. 14. First instar *Nothochrysa californica* head.

tral surface with three pairs setae—small antero-median pair, two pairs longer and posterior; segment 9 with pair very small anterior setae, two pairs long setae slightly posterior, on small tubercles, three pairs far posterior setae—medianmost very small, two pairs lateral setae, ventral surface with four pairs setae, posterior two pairs long, on small tubercles, anterior two pairs small; segment 10 with minute pair anterior setae, four pairs short setae in circle near posterior tip, two pairs short lateral setae, ventral surface with pair of small antero-lateral setae, pair of meso-lateral short setae, five pairs short postero-median setae. Coxae with four pairs posterior setae, three pairs anterior setae; trochanters with nine pairs setae; femora and tibiae with six longitudinal rows setae; tarsi with two long setae at apex. Body length 3.1 to 3.8 mm (N = 2); seta of prothoracic tubercles 0.1 mm (N = 1).

Coloration of second instar. *Head* dorsally marked with brown, as in figure 15, small irregular red marks immediately mesad to base of antennae, scapes tan, flagella tan dorsally, white ventrally, mandibles amber-colored, basal segment of labial palpi tan basally, pale apically, apical segment of labial palpus tan, second segment tan laterally and apically, pale postero-medially, middle corneal swelling dark gray, others pale distally, reddish proximally,

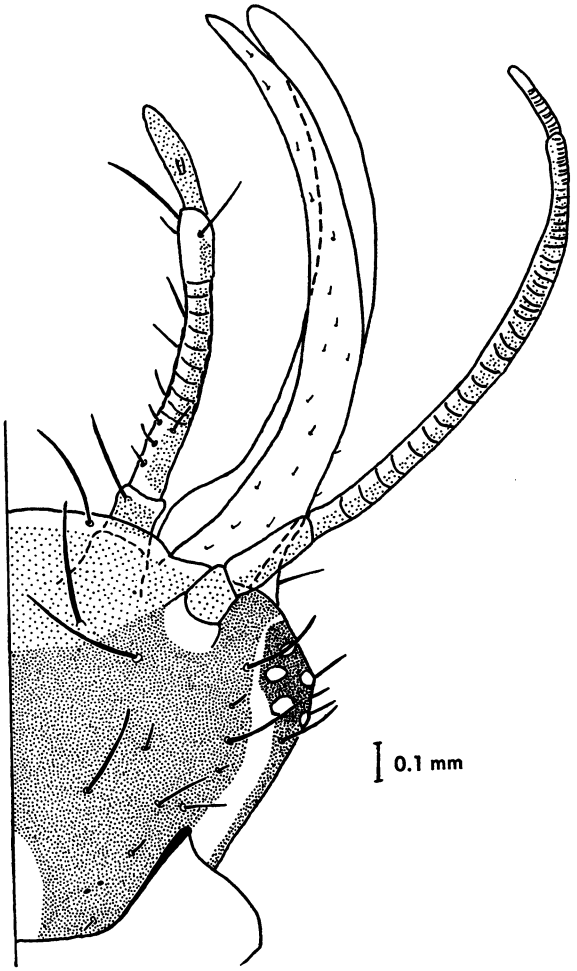

Fig. 15. Second instar *Nothochrysa californica* head.

swellings surrounded by dark brown, area posterior and ventral to eyes dark brown, stipes and cardo dark brown, cervical region pale dorsally, marked by diffuse transverse bands of red, red laterally, pale ventrally. *Prothorax* with pair of antero-mesad, triangular red marks, posterior transverse band of red, large lateral triangular brown marks—base of triangle medially, rectangular median light brown mark mesad to posterior part of triangular brown mark, reddish-brown lateral band over dorsal part of coxae, extending posteriorly below large lateral tubercles of all segments to abdominal segment 9, prothorax ventral surface pale, diffuse pale red mark anteriorly, meso- and metathoraces marked dorsally by diffuse reddish marks, each with pair of irregularly shaped brown marks mesad to large lateral tubercles, ventral surfaces pale, very few small light red marks. *Abdominal* segment 1 with two transverse bands of small diffuse red markings, segments 2 to 6 each with three similar transverse bands, segments 7 and 8 with dark red irregular dorsal marks, segment 9 dorsally with pair of anterior elongate light brown marks, small postero-median light brown mark, scattered red marks, red bands laterally, light brown mark antero-ventral to red band, pale ventrally, segment 10 dorsally with triangular brown mark, brown antero-ventrally, inverted V-shaped red mark above posterior triangular brown mark, ventral surface of abdominal segments 1 through 8 pale, with very few scattered red marks; coxae dark red dorsally, pale ventrally, trochanters pale, brown dorso-apically, femora and tibiae tan dorsally, pale ventrally, tarsi and empodia dark.

Structural characteristics. *Body* elongate; abdomen humped dorsally. *Head* shape slightly narrower posteriorly than in figure 15, setation as in figure 15; length 0.65 to 0.77 mm, width 0.87 to 1.11 mm (N = 3); venter with two pairs long setae posterior to labial palpi, pair of shorter setae posterior to preceding two pairs, two pairs setae ventral to eyes, palpiger with median pair setae, dorsal mandible surface and ventral maxillary surface with scattered minute bristles, four minute circular marks near dorsal base of mandibles. Cervical area with pair of short lateral setae, covered dorsally by minute bristles, eight pairs ventro-lateral short setae. *Prothorax* with pair of antero-lateral tubercles each with two long setae and four shorter setae, three pairs small setae anterior to tubercles, pair small setae mesad to three pairs, five pairs setae immediately mesad to tubercles, two pairs setae postero-mesad to tubercles, transverse row of six posterior setae, four pairs ventral setae mesad to coxae, four pairs postero-ventral setae, dorsal surface anteriorly, laterally, and posteriorly covered with minute spinules; mesothorax divided by transverse fold into two very distinct subsegments, anterior subsegment one-half length posterior subsegment, bearing round spiracles laterally, pair of setae antero-lateral to spiracles, transverse row of five pairs small setae mesad to spiracles, posterior subsegment with pair of large lateral tubercles each bearing six very long setae and three shorter setae, two pairs small setae antero-lateral to tubercles, two pairs small setae postero-lateral to tubercles, three pairs short setae antero-mesad to tubercles, three pairs longer setae mesad to tubercles, small pair setae on antero-median margin of small brown marks, transverse row of four pairs posterior setae—lateralmost long, next short, third long, medianmost short, dorsal surface covered by minute bristles, two pairs long ventral setae anteriorly, two pairs short ventral setae posteriorly; metathorax with pair of large lateral tubercles each bearing six large setae and two shorter setae, two indistinct transverse rows setae—anterior row mesad and slightly anterior to small brown mark, with seven pairs curved setae, posterior row mesad and slightly posterior to brown mark, with six pairs

long hooked setae, dorsal surface covered by minute spinules, venter with three pairs anterior setae, small pair posterior setae. *Abdominal* segment 1 laterally with pair of round spiracles, double transverse row of numerous long hooked setae, joining laterally, segments 2 to 5 with large lateral tubercles each bearing many long hooked setae and some shorter setae, pair round spiracles mesad to tubercles, anterior raised area bearing single transverse row of hooked setae, posterior raised area with double row of long hooked setae, dorsal surface covered with minute spinules; segments 6 and 7 with pair of large lateral tubercles each bearing four large hooked setae and four pairs smaller setae, pair of round spiracles antero-lateral to lateral tubercles, two transverse rows of setae mesad to tubercles, dorsal surface covered with minute spinules; segment 8 with two pairs long lateral setae on slight swellings, pair of spiracles anterior to swelling, pair of setae mesad to spiracles, two transverse rows of short setae—three pairs in anterior row, four pairs in posterior row, two indistinct rows of short setae on venter; segment 9 with small anterior pair setae, two transverse rows setae—anterior row with four pairs setae—medianmost two pairs long, next pair short, lateral pair long, posterior row with six pairs setae—medianmost, third, fourth, and fifth pairs long, second medianmost and lateralmost short, venter with two pairs long setae in posterior row, numerous shorter setae; segment 10 with pair of long lateral setae, numerous shorter setae in triangular brown area, venter with two rows short setae in figure of inverted V—postero-lateral pair setae long, numerous setae in triangular brown area. Coxae and trochanter setation irregular, femora and tibiae with six longitudinal rows of setae. Body length 5.3 to 6.2 mm (N = 3); seta of prothoracic tubercle 0.6 mm (N = 1).

Coloration of third instar. *Head* pale, marked anteriorly with red and posteriorly with brown as in figure 16, antennae and labial palpi pale with tips and ventral surfaces tan, mandibles amber-colored, central corneal swelling surrounded by black, anterior three surrounded by brown, posterior two pale, proximal area red beneath five swellings surrounding central swelling, area posterior to eyes brown, ventral surface marked with brown and purple, cervical region pale, marked with brown laterally and light red dorsally. *Prothorax* marked anteriorly by two large rectangular red marks which extend posteriorly and medially in irregular spots, medially by two elongate brown marks posterior to red spots and anterior to far posterior transverse dark red marks, dorso-laterally by large triangular brown mark with long side medially and apex directly dorso-mesad to coxae, lateral margins and dorsal coxae marked by very dark brown band extending laterally down whole length of larva, mesothorax marked dorsally by three blotchy transverse red bands, roundish dark brown mark laterally between second and third bands, spiracle tan, metathorax marked dorsally by three transverse blotchy red bands. *Abdominal* segments 1 to 9 marked dorsally with blotchy transverse bands of red, segment 10 with diamond-shaped brown mark, venter with anterior triangular brown mark; coxae dark dorsally, pale ventrally, trochanters pale, dark dorso-ventrally, femora tan, pale baso-ventrally, tibiae tan dorsally, pale ventrally, tarsi and empodia tan.

Structural characteristics. *Body* elongate, abdomen slightly raised antero-dorsally. *Head* shape and setation as in figure 16; length 0.85 to 1.04 mm, width 1.28 to 1.40 mm (N = 3); ventral surface with three pairs long setae—anterior pair immediately posterior to antennae, second pair lateral and posterior, third pair mesad and posterior to first pair; anterior surface of clypeus with minute bristles; dorsal surface of mandibles and ventral surface of maxillae with few scattered minute setae;

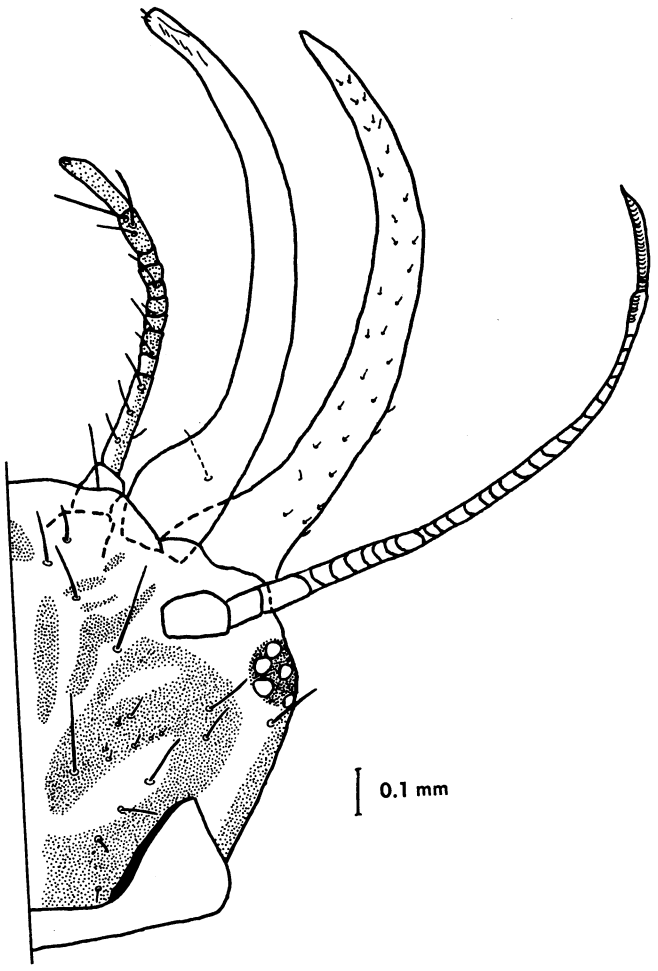

Fig. 16. Third instar *Nothochrysa californica* head.

second segment of palpus annulated entirely; ventral surface of basal segment of palpus with long seta. Cervical region covered dorsally with minute bristles, eight pairs short setae on lateral and ventro-lateral brown mark. *Prothorax* with pair of antero-lateral tubercles each bearing two very long setae and nine pairs shorter setae, three pairs small setae anterior to tubercles, three pairs small setae mesad to previous three pairs setae, four pairs setae mesad to antero-lateral tubercles—lateral pair small, next lateral pair long, next pair small and slightly posterior, median pair long, four pairs long setae posterior to previous four pairs, mesad to large triangular brown mark, row of four pairs long setae posterior to large brown mark, pair of long lateral setae posterior to coxae, ventral surface with five pairs fairly long anterior setae, two pairs long posterior setae, dorsal surface covered anteriorly and posteriorly by minute round bumps; mesothorax divided by transverse fold into two subsegments, anterior subsegment about one-half length of posterior subsegment, bearing spiracles laterally, two pairs short setae anterior to spiracles, two pairs small setae anterior to previous setae, row of eight pairs small setae mesad to spiracles, dorsal surface covered by minute round bumps, posterior

subsegment antero-laterally bearing pair of large tubercles each with six very large setae and seven shorter setae, two pairs small setae immediately anterior to large tubercles, four pairs short setae antero-lateral to large tubercles, four pairs short setae postero-lateral to tubercles, transverse row of six pairs setae—antero-lateralmost two pairs small, third lateral pair longest, two pairs short setae immediately posterior to anterior row, small pair setae on antero-median margin of small round brown mark, far posterior transverse double row of ten pairs of setae—antero-median three pairs longest, dorsal surface covered by minute round bumps; metathorax with pair of large lateral tubercles each bearing six long setae and eleven shorter setae, two irregular transverse rows of numerous curved and hooked setae—one row anterior to lateral tubercles, other posterior, dorsal surface covered with minute round bumps. *Abdominal* segment 1 with pair of lateral spiracles, three pairs curved setae antero-lateral to spiracles, transverse row of long hooked setae—row separating medially, dorsal surface covered with minute round bumps; segments 2 to 6 with large lateral tubercles each bearing many long setae and numerous shorter setae, pair of round spiracles mesad to large lateral tubercles, transverse irregular row of long hooked setae on raised anterior fold, double row of long hooked setae on raised posterior double fold, joining laterally into single fold and single row setae, dorsal surface covered by minute round bumps; segment 7 with large postero-lateral tubercles each bearing three long setae and eight shorter setae, pair of round spiracles anterior to lateral tubercles, pair of short setae immediately mesad to spiracles, four pairs short setae antero-mesad to spiracles, pair of very long setae mesad to lateral tubercles surrounded by ten pairs shorter setae, pair of long median setae, dorsal surface with minute round bumps; segment 8 with lateral tubercles each bearing about fifteen setae, pair round spiracles immediately anterior to lateral tubercles, two transverse rows fairly short setae, dorsal surface with minute round bumps, venter with single median transverse row setae; segment 9 with pair of anterior short setae, median and posterior rows of short setae, antero-lateral corners covered by minute bristles, ventral surface with median transverse row setae; segment 10 with seven pairs short lateral setae, numerous short setae and bristles in diamond-shaped dark area, ventral surface with ten pairs short setae from antero-median margin to meso-lateral margin, numerous very small setae medially. Coxae and trochanters with irregular setation; femora and tibiae with six longitudinal rows setae. Body length 7.1 to 10.4 mm (N = 3); seta of prothoracic tubercle 0.4 mm (N = 1).

Cocoon

Cocoon white, oval, with one side directly against substrate covered by very thin layer transparent silk; two very distinct layers silk, outer layer thin, mixed with trash, inner layer thick. Measurements: N = 10.

	$\bar{X}$	s.d.	range
Length	4.32 mm	± 0.24 mm	4.02–4.69 mm
Width	3.49 mm	± 0.35 mm	3.02–4.02 mm

BIONOMICS

Chrysopa carnea Stephens

C. carnea adults were collected in all months in Strawberry Canyon. Overwintering occurred in the adult stage. About the first of October the adults assumed a yellowish or yellowish-brown color. The abdomen became prominently marked with median red spots.

The sex ratio was approximately 1:1 (N = 150). The number of generations

per year was variable for this species. In Strawberry Canyon there were from three to five generations a year. Adults of *C. carnea* were kept alive as long as seven months in the laboratory during winter months. However, the maximum life span during summer in the laboratory was about one month. The adults of this species were not predaceous, nor did they feed on their own eggs. Cleaning activities were observed for this species; however, there was little other activity during the day. Adults were frequently collected at lights during the night. No unpleasant odor was noticed with *C. carnea* as there has been with some other chrysopids. The only predator records obtained for *C. carnea* adults during this study were two male empids, *Empimorpha barbata* Loew (det. F. R. Cole), which were using the lacewings as prey for females.

Mating was observed on two occasions in the laboratory. The first mating occurred in the evening under subdued light. Several times the female with antennae waving approached the male head-on until their mouthparts were almost touching. The male held his antennae back and to the sides of his body; the female held hers forward near his. The male began vibrating his abdomen up and down. The vibration began slowly and became faster within a few seconds. Then he stopped vibrating his abdomen, and the female began vibrating hers in a similar manner. They alternated vibrating their abdomens several times, and then both began vibrating at the same time. The male then moved away. The above pattern of approach, vibrations, and separation occurred several times. At the final time, while both the male and female were facing each other and vibrating their abdomens, the male raised his left wings and began turning his body toward hers. He extended his abdomen far toward hers and then she toward his. While doing this their bodies were parallel to each other, and their heads were turned toward each other. Their genital openings were open. The abdomen of the male stopped vibrating and began following and reaching for the vibrating abdomen of the female. The male then grasped the tip of her abdomen with the tip of his. The female immediately curled ventrally. She was swung around so that she was on the dorsum of the male beneath his wings, facing in the same direction as he. Her head was extended forward with her mouthparts anterior-most. Her mouthparts did not touch the male, but the top of her head occasionally touched his slightly raised wings. Her fore- and midlegs held onto about the fifth to seventh abdominal segments of the male; her hindlegs were completely free. Her wings were held in normal position. Her antennae were held back toward her body, and the male's antennae were held out and spread apart. The only movement during the 10½ minutes of copulation was a slow movement of the abdomens. Then the female's legs let go of the male's abdomen and came into contact with his wings. After this she let go of his wings and hung down from him, venter up and supported only by the genital connection. The pair almost immediately separated. Both then remained quiet on the sides of the vial.

The second observation of mating occurred in the afternoon. The preliminary actions were essentially the same as described above. However, once the genital connection had been made, the female retained her hold on the substrate. She was not elevated onto the back of the male. Copulation lasted approximately 15 minutes. Soon after mating the lacewings applied the tips of their abdomens to their mouths in apparent cleaning activities.

The preoviposition period for *C. carnea* from Strawberry Canyon was not studied. However, Neumark (1952) reported the minimum time to be four days for the species under his laboratory conditions. Eggs were laid singly on stalks. Rarely was more than one

egg found on a leaf in nature. Figure 89 in Essig (1958) which pictures 20 "*C. californica*" eggs with long, bending stalks on one leaf is in error. They are probably eggs of *C. nigricornis*.

The *C. carnea* egg was yellowish-green when first laid. As the embryo developed the pigmentation of the larval abdominal segments was evident. It appeared as lateral alternating red and pale transverse marks separated medially by a bluish-green area. The micropylar end remained yellowish-green until just a few days before hatching.

The incubation period in the laboratory under varying conditions averaged five days (table 1). Hatching was by means of an egg burster; the process was described by Smith (1922). After pulling itself free from the embryonic membrane the larva remained attached to the egg by the tip of the abdomen. The larva then bent ventrally and grasped onto the egg shell with its legs. It remained on the egg from 15 minutes to several hours. During this time pigmentation of the larva increased. The larva descended from the egg by crawling down the stalk using the legs and abdominal apex.

After descending the larva fed immediately. If some food was not ob-

TABLE 1

REARING DATA

Laboratory conditions: T = 24 ± 4° C

Stage	Range	Mean ± s.d.	N
	Days		
Chrysopa carnea			
Egg	3–7	5.3 ± 1.4	97
First Instar	3–10	5.8 ± 1.1	109
Second Instar	2–7	3.5 ± 1.0	84
Third Instar (until spinning)	2–8	5.2 ± 1.4	66
Third Instar (within cocoon)	2–7	3.8 ± 1.3	72
Pupal	6–14	9.6 ± 2.0	44
Chrysopa nigricornis			
Egg	3–6	4.7 ± 0.9	256
First Instar	3–6	5.5 ± 1.4	77
Second Instar	3–8	3.6 ± 1.1	69
Third Instar (until spinning)	3–9	5.5 ± 1.4	59
Third Instar (within cocoon)	11–19	13.7 ± 1.4	58
Pupal	9–18	14.5 ± 1.7	56
Meleoma comata			
Egg	6–9	7.7 ± 0.6	81
First Instar	5–10	7.5 ± 1.1	46
Second Instar	2–11	4.9 ± 1.6	51
Third Instar (until spinning)	3–20	9.1 ± 4.7	45
Third Instar (within cocoon)	169–245	216.4 ± 21.3	19
Pupal	7–20	13.2 ± 4.3	11
Meleoma cavifrons			
Egg	5–8	6.3 ± 0.6	32
First Instar	5–11	6.7 ± 1.7	11
Second Instar	3–10	6.0 ± 2.5	9
Third Instar (until spinning)	5–18	11.1 ± 3.4	14
Third Instar (within cocoon)	140–233	188.1 ± 31.6	15
Pupal	5–17	10.5 ± 3.3	13
Nothochrysa californica			
Egg	6–10	7.3 ± 0.8	176
First Instar	3–9	6.3 ± 1.2	87
Second Instar	4–7	4.8 ± 0.8	34
Third Instar (until spinning)	13–32	19.0 ± 4.5	17
Third Instar (within cocoon)	approximately 200 days		7
Pupal	60–74	69.0 ± 5.5	5

tained within 24 hours the larva did not survive. Larvae were often seen to crawl up the stalks of other eggs in the vial and to attack unhatched eggs. One larva was also seen to attack another, but it was probable that larvae would not have attacked if there had been sufficient other food present. Fleshner (1950) stated that larvae do not perceive the presence of prey until actual physical contact has been made.

The feeding process as described by Smith (1922) for *C. oculata* Say was similar for *C. carnea*. Food was sucked up through a groove between the maxillae and mandibles. Wildermuth (1916) determined the number of aphids eaten by *C. carnea* larvae (as *C. californica*). Based on the results of his laboratory rearings he estimated that the three larval instars may eat 300 to 400 aphids in the field. In the present study larval development was completed with fewer aphids, and normal-sized adults were obtained. The larvae in this study were reared only on aphids; however, it is known that other soft-bodied insects can be used as food under rearing conditions (Finney, 1950). Psocids, mites, scale insects, and aphids were present where collections of larvae were made and could have served as food in nature.

One to two days before ecdysis the larva was sluggish and did not feed. A large amount of anal secretion was produced. The cervical region became swollen, and the ommatidial areas withdrew from the corneae. The complete process of ecdysis by *C. carnea* was not observed. However, observations made after the thoracic split had begun indicate that the ecdysis by *C. carnea* was similar to that described by Smith (1922) for *C. oculata*. The post-moult period was also as Smith described it—the larva was inactive for several hours during which pigmentation increased.

The average length of time between ecdyses for *C. carnea* in the laboratory under varying conditions of light, temperature, and humidity was six days for the first stage, four days for the second stage, and five days for the third stage until spinning. See table 1 for detailed data.

Larvae of *C. carnea* were commonly collected during spring, summer, and fall in Strawberry Canyon from the foliage of *Quercus agrifolia* and *Umbellularia californica*. Slightly more were taken from *Umbellularia californica*. Larvae were taken infrequently from shrubs and grass. In other areas numerous specimens have been collected on herbaceous plants and shrubs (Smith 1922). A few larvae were taken during the winter in Strawberry Canyon. When brought into the laboratory these larvae immediately were reared through to adults.

The *C. carnea* larvae did not carry trash on their backs. When they were disturbed some exhibited a "defense position." The body was contracted and the head elevated with jaws spread. Although no odor has been noticed with it, Kennett (1948) suggested that anal secretion is probably another means of defense. The *C. carnea* larvae also were very fast moving.

Clancy (1946) did a major study of the parasites of *C. carnea* (as *C. californica*) and *C. nigricornis* (as *C. majuscula*). He also gave a complete review of the literature on all chrysopid parasites. Two larvae collected in the summer of 1962 spun cocoons from which the parasite *Isodromus iceryae* Howard emerged (det. R. L. Doutt). Five emerged from one cocoon on August 10, 21 days after it was spun, and two emerged from the other cocoon on September 21, 28 days after it was spun. In 1963 two *Perilampus chrysopae* Crawford were obtained from two cocoons (det. R. L. Doutt). One emerged on September 19, 20 days after the cocoon was spun. The other emerged by October 2 from a cocoon collected September 2. Six undetermined pteromalid wasps emerged by October 4 from one cocoon collected September 2.

Cocoon spinning was observed several times and was similar to that described

by Smith (1922) for *C. oculata* except in the final part. *C. oculata* near the end of its spinning covered the inside of the cocoon with thick silk which rendered it opaque. However, in *C. carnea* this last step was not present, and the larva was visible through the silk. The cocoons, even when spun against a hard surface, were complete on all sides.

On an average, four days after the cocoon was spun, the last larval skin was shed. It could be seen as a dark disc at one end of the cocoon. In time the greenish color of the developing adult lacewing could be seen through the cocoon. Also the eyes and median yellow stripe became visible. After an average of ten days a circular slit was made in one end of the cocoon through which the pharate adult emerged. Emergence occurred in the evening and in the morning, and the pharate adult crawled around for a short time before undergoing ecdysis to the imago. Smith (1922) described the ecdysis for *C. oculata,* and it appeared similar for *C. carnea.* This final ecdysis was one of the most critical stages in laboratory rearing of lacewings. Many specimens were unable to complete it. The meconial pellet was eliminated by the adult either during or shortly after expansion of its wings. Until this time the dark pellet could be seen within the abdomen.

Chrysopa nigricornis Burmeister

C. nigricornis adults have been taken during the spring and summer months in Strawberry Canyon. There were probably two to three generations per year in that area. Both sexes of *C. nigricornis* when disturbed emitted an odor foul smelling to humans. Killington (1936) discusses the odor and its origin in the prothoracic glands. *C. nigricornis* adults were active mainly at night and have been collected at lights. One adult of this species was kept alive in the laboratory for 50 days.

C. nigricornis was the only chrysopid species in Strawberry Canyon whose adults were predaceous. In the laboratory they fed on a variety of aphids and on their own eggs. Whether feeding was necessary for mating or oviposition is not known. However, it was observed that when aphids were scarce the rate of oviposition slowed down and the amount of feeding on eggs increased. *C. nigricornis* adults also fed on sugar and honey. Excretion by this species was copious. Liquid droplets or solid pellets were eliminated several times during the day. The abdomen was bent to one side and the wings were raised; then the pellet was released. This species was active under room lights; however, cleaning activities were not common.

Mating by *C. nigricornis* was observed. Each of three pairs were kept in individual cartons all afternoon in the laboratory under room lights. The females all had been laboratory reared and were about one month old; two of the males were laboratory reared, two days old and unmated. One male was field-collected. During the afternoon two pairs showed little activity. One pair showed some sexual activity; however, copulation was not completed. The male of this pair frequently approached the female with his antennae waving and his abdomen vibrating. At this time a clear, amber-colored spermatophore appeared at the tip of his abdomen. However, when copulation was not completed it was withdrawn back into the abdomen.

Observations of mating were made in a darkroom using a 25 watt red light bulb and slight natural twilight. Six minutes after the room lights had been turned off a male with antennae waving and abdomen vibrating approached a female toward her head. He then came alongside of her so that their bodies were parallel. Their heads were turned toward each other. He vibrated his abdomen. Both then raised their wings slightly and bent their abdomens sideways toward each other. A connection was made, and the male moved or was

pulled so that the longitudinal axis of his body was at a 90° angle to that of the female. To do this his left wings were raised. The ventral surface of the left hindwing was in contact with the top of the female's right wings. The genital connection was such that the abdomen of the male was twisted. The venter of his abdomen was aligned with the dorsum of hers. Both had all pairs of legs in contact with the substrate. The pair remained quiet for four and one-half minutes, and then the female began pulling and walking. The male remained connected to her abdomen, and the pair became stretched linearly so that they were facing in opposite directions. The female continued pulling and dragging the male which attempted to keep his legs in contact with the substrate. After one minute and 50 seconds the pair separated. They had been in copulation a total of six minutes and 15 seconds. Immediately after separation both applied the tips of their abdomens to their mouthparts in what appeared as cleaning activities.

The second observed mating was similar to the first. The pair was in copulation eleven minutes after being put under dark conditions. They remained still in copulation for two minutes and 45 seconds. Then the female began dragging the male. She carried him onto the lid of the container, at which time he released his hold on the substrate and was supported only by the abdominal connection. After one minute and ten seconds of movement the pair was separated—total of three minutes and 55 seconds after initiating copulation. After separation the female was prevented from putting her abdomen to her mouthparts. Microscopic examination of the external genital area of the female immediately after separation from the male showed no visible spermatophore.

The amount of time after mating until oviposition was one and two days for the two females. Oviposition of a batch of eggs was observed and timed. Although the process can occur under normal room light, it usually occurs in the dark. The observations were made under a 25 watt red light. The behavior began by the female arching her abdomen and tapping the substrate with the tip several times. Then her abdomen was raised so that her whole body was parallel with the substrate. Waves of contraction passed down the abdomen. Then the abdomen was moved from side to side in a rocking motion. The abdomen was arched again, and the tip of it tapped the substrate. After several taps the tip was applied to the substrate and a small amount of clear liquid was emitted. The abdomen was raised slowly and smoothly, drawing out the stalk. When the stalk was at maximum length an egg appeared from the genital chamber. The egg was then held at the end of the stalk by extreme corners of the gonapophyses laterales. Only a very small part of the sides of the egg was in contact with the lateral plates. The average holding time was 39 seconds. The egg was released with a slight springing motion when the female abdomen was moved back. The abdomen of the female then remained raised for only a few seconds before arching again. See table 2 for timings.

Approximately 40 eggs were laid in the batch which was observed. The batch covered an area 25 mm long and 7 mm wide at the widest spot. The female began by laying an egg in line with the direction she was facing. Then she moved forward and laid four or five eggs across in a rank. To do this she stretched her abdomen and laid an egg to the far right. Next she laid one slightly to her right, then one immediately behind her, and then two to her left. She moved slightly forward during the time the eggs were laid, but she remained facing in approximately the same direction. Her wings often touched the tips of the eggs, but she held her wings raised during the whole procedure.

The maximum number of eggs obtained from one female was 225 over

TABLE 2

OVIPOSITION TIMINGS

Period	Range	Mean ± s.d.	N
	Seconds		
Length of time from appearance of egg until its release by ovipositor (period of stalk drying)			
Chrysopa nigricornis	28–73	38.7 ± 9.8	44
Nothochrysa californica	10–87	55.8 ± 27.2	10
Length of time abdomen held raised after release of egg			
Chrysopa nigricornis	2–10	5.0 ± 1.3	41
Nothochrysa californica	4–75	25.3 ± 24.6	10
Length of time from release of egg until appearance of next egg			
Chrysopa nigricornis	30–78	46.7 ± 6.2	41
Nothochrysa californica	66–177	95.2 ± 36.9	9

nine days. The average number of eggs per batch was 27 (N = 9; s.d. = 13). A batch of eggs was collected in the field only once. This collection was on July 24, 1963 from the underside of an *Umbellularia californica* leaf. In the laboratory eggs were laid mainly on the glass lids of the containers.

The *C. nigricornis* egg when first laid was yellowish-green. After two days it was bluish-green at the stalked end and pale green at the micropylar end. Laterally there was a slight tinge of the embryonic red. Later the dark reddish brown bands of the embryo were distinct. Immediately before hatching the egg was very dark. It had a grayish hue due to the white chorion. The incubation period under laboratory conditions averaged five days (table 1).

Hatching by this species was similar to that by *C. carnea.* One hatching was timed. The larva pulled itself free from the egg, and then moved about while attached to the egg by the tip of the abdomen. This movement lasted three minutes. Then the larva hung quietly with head down from the egg for 18 minutes and 40 seconds. The larva was attached by the tip of the abdomen only; the legs were free and held out from the body. The larva then bent ventrally until its legs contacted the egg shell. It then remained on the egg shell with head facing down the stalk for about nine hours.

Larvae descended egg stalks in a manner similar to that of *C. carnea.* Once down the stalk the larvae would feed immediately. The newly hatched larvae could survive in the laboratory only slightly more than 24 hours without food. Some climbed the stalks of other eggs to feed on them. In the laboratory this species was fed a variety of green aphids. The feeding process by this species was similar to that by *C. carnea.*

Ecdysis by *C. nigricornis* was similar to that by *C. carnea.* The average length of time between ecdyses was six days for the first stage, four days for the second, and six days for the third until spinning. Larvae of this species were dark colored. They also occasionally carried a small amount of trash on their backs. Their anal secretion and large jaws possibly were utilized for escaping predation. Larvae of *C. nigricornis* were collected in Strawberry Canyon from the end of July in 1963 (first, second and third instars) until mid-October (third instar). Plant association records were 19 larvae from *Umbellularia californica* and two from *Quercus agrifolia.*

Cocoon spinning by this species was similar to that described by Smith (1922) for *C. oculata.* Trash was rarely incorporated into the cocoon, and the cocoon was always complete on all sides. The third instar larva overwintered within the cocoon, presumably in dia-

pause. The factors affecting this diapause were not studied.

Pupation by the overwintering larvae occurred from February to early June. In summer-reared generations, pupation occurred 14 days after spinning. The cast larval skin could be seen as a dark disc within one end of the cocoon. As the pupa developed, the green color of the adult could be seen within the cocoon. The pupal stage lasted an average of 15 days before the pharate adult emerged from the cocoon through a circular slit. The adult *C. nigricornis* emerged from the pupal skin by a longitudinal dorsal slit. The wings were expanded and the large meconial pellet was voided.

Meleoma comata Banks

Fresh adults of *M. comata* were taken in Strawberry Canyon only during late June, July and early August. One worn female was taken late in August. There was only one main generation per year. A few of the early adults probably produced a small second generation.

Both sexes of *M. comata* when disturbed emitted an odor which was foul smelling to humans. This odor was very similar to the one given off by *C. nigricornis*. The origin of the odor, however, as well as its effect on enemies and other *M. comata* was not studied. This species was active at night and was collected at lights.

Field-collected and laboratory-reared adults were kept alive for slightly more than a month in the laboratory. *M. comata* adults, like those of *C. carnea*, were never seen to feed on other insects or on their own eggs. Protein hydrolysate, sugar, and water were the foods supplied to adults. These foods were able to support life; however, one or more additional nutrients were necessary to induce complete coloration and mating by the adults. Aphid honeydew may contain the necessary nutrients. There was little activity by this species under room lights. However, feeding and cleaning activities were common for this species when it was observed under red light.

Mating was observed for *M. comata* on one occasion with a female taken at Inverness, Marin County, and a male taken 23 miles southwest of Quincy, Plumas County, California. The male was at least 13 days old; and the female was at least nine days old and had not laid eggs in the laboratory. The pair had been together all afternoon in the light. However, they remained inactive until they were put into the darkroom under red light only.

The male stood on the side of the jar. His antennae waved in front of his head and his forewings were held high above the hindwings. The female approached him several times from the front seemingly toward his thorax. As soon as the female touched him his antennae were pulled back next to his body, and his forewings were lowered to his hindwings. He turned, and she followed so that both were facing in the same direction about one-half inch apart as they moved. They then moved apart and turned several circles individually. Just prior to the fourth and final approach by the female, the male jerked his abdomen and wings up and down vigorously, causing a rustling sound. The female then approached and put her mouthparts into the frontal cavity of the male. After this position was assumed the male quickly swung his abdomen toward hers. She moved her abdomen away while keeping her mouthparts in his frontal cavity. His abdomen touched her wings. These movements were repeated a second time. On the third movement by the male their abdomens met. Their genitalia were connected in such a manner that the venter of the male was associated with the dorsum of the female. Then the female was swung around and elevated with her venter uppermost and supported only by the abdominal connection. Her body curved ventrally toward the male, and she began antennating the wings of the male which were

simultaneously raised. The male fore- and hindwings were not separated. Antennation stopped, and the only motion seen was a slight jerking movement of the pair. Within one or two minutes the female arched forward still farther until her mouthparts and legs contacted the tips of the left fore- and hindwings of the male. The male, still in copulation, then began walking toward the other side of the jar. After he had walked about six inches the female dropped off. Then both insects moved around the jar rapidly. The male applied his mouthparts to the tip of his abdomen in what appeared to be a cleaning activity. When the room lights were turned on, both became inactive.

Two days later the female began laying fertile stalked eggs. Oviposition behavior by *M. comata* was not observed. However, as in *C. carnea,* stalked eggs were laid in the laboratory on the sides of the vial or on leaves. Eggs collected in the field were found on the surfaces of leaves. No more than one egg was found on a leaf. The maximum number of eggs obtained from one female in the laboratory was 43 over a period of 15 days.

During embryological development, the ventral portion of the egg turned bluish-gray. The brown and white transverse bands of the embryo were visible through the chorion of the other half of the egg. Just prior to hatching, the whole egg was colored by the transverse bands of the larva within.

The incubation period averaged eight days in the laboratory (table 1). Hatching was similar to that in *C. carnea.* The young larvae remained on the egg stalk for some time after hatching. They descended from the egg and were cannibalistic like *C. carnea.*

The feeding process in *M. comata* larvae was similar to that of *C. carnea* and *C. nigricornis.* In the laboratory the larvae were fed mainly pea aphids. However, in the field they probably fed on various aphids and soft-bodied insects. The mature *Euthoracaphis umbellulariae* Essig (det. D. Hille Ris Lambers), which were common on *Umbellularia californica,* were too hard for the larvae to pierce. However, the crawlers were seen to be preyed on by *Meleoma* larvae.

Larvae of *M. comata* were collected in the field from August 20 (first instar) to October 31 (third instar) in 1962 and as early as July 28 (first instar) in 1963. Plant association for the three seasons' collections showed 29 collected on *Umbellularia californica* and 14 on *Quercus agrifolia.* Two other larvae were taken on unidentified shrubs.

The *M. comata* larvae were debris carriers. Small pieces of leaves, moss, and aphid skins were found loosely arranged on their backs. However, they did not form dense packets of trash as some chrysopid larvae do. Larvae of this species were slower moving than *C. carnea* larvae and were also more difficult to observe in nature. Their jaws and anal secretion may also have served in defense. The only predator record obtained was a syrphid larva which accidentally got into a rearing vial during feeding and ate a first instar larva. Whether syrphids normally attack chrysopids in nature is not known, but several syrphid larvae were seen on *Umbellularia californica* in Strawberry Canyon.

Ecdysis was observed on several occasions and appeared to be similar to that by *C. carnea.* Debris which was carried on the backs of larvae was shed with each moult. In the laboratory it was usually not replaced, or only a small part of it was replaced. However, in the field it was replaced very soon after each moult. The average time in the laboratory between moults was eight days for the first stage, six days for the second, and 11 for the third until spinning (table 1).

Spinning of the cocoon was observed on one occasion. Although the cocoon was never finished, the beginning was similar to that described by Smith (1922) for *C. oculata.* The third instar

larvae overwintered within their cocoons. During this time they were in diapause. In the laboratory, diapause terminated and the third instars moulted to pupae from the end of March through May. This moult appeared earlier in the laboratory than in the field where it probably occurred from the end of May through June. In many specimens the shed larval skin was visible at one end of the cocoon as a dark disc. This ecdysis under laboratory conditions was a particularly critical period in the development of the lacewings. Many of the cocoons subsequently dissected contained insects which apparently had died in the course of this ecdysis.

Attempts were made to find the factor or factors which break the diapause of the third instar. Twenty overwintering larvae were exposed to a cold temperature of 5° C in the dark for four weeks. When not under treatment these larvae were held under the laboratory conditions of variable light and temperature. Unlike a report of eastern species of *Meleoma* (E. G. MacLeod, 1962, personal communication), this treatment had no effect on breaking diapause. The treated larvae pupated at the same time as the untreated controls which were kept under laboratory conditions.

Additional experiments were made to determine whether day length was a factor controlling the diapause. Overwintering larvae in their cocoons were exposed to various light periods, while others were held under laboratory conditions as controls. The small numbers of larvae available prevented replicating experiments or obtaining statistically significant results. Also there were numerous deaths in the cocoons which decreased the numbers in each group. Thus, the experiments will not be described here. However, the results obtained, while not definitive, indicated that a long day length was probably effective in breaking the diapause.

During pupal development the green color could be seen through the cocoon walls. However, this was a more faint color than that in *C. carnea* because of the thickness of the cocoon walls. Only occasionally could the median yellow stripe or the eyes be seen through the cocoon. The pupa emerged from the cocoon an average of 13 days after becoming a pupa. Emergence was through a circular slit as in other chrysopids. When observed, emergence was always in the evening between 5:30 and 8:00 p.m. The pharate adult remained active for only a short time before beginning the ecdysis to an adult. However, many of the laboratory-reared insects were unable to begin this ecdysis, and of those which did begin many were unable to complete it. *M. comata* adults voided the larval excrement immediately after the wings were expanded.

Meleoma cavifrons Banks

M. cavifrons adults occurred during July and early August concurrently with *M. comata* in Strawberry Canyon. However, they were also taken during late August and September when *M. comata* adults were not present or were rare. The main part of the population probably occurred somewhat later than that of *M. comata.* Some of the early adults probably produced a small second generation, as in *M. comata.*

One *M. cavifrons* adult was kept alive in the laboratory for 51 days. It was fed protein hydrolysate, sugar and water. However, this species appeared to require an additional nutrient or nutrients as *M. comata* did before becoming fully colored or mating. This species was never seen to feed on other insects or on its own eggs. The adults were inactive under room lights, but they became active when observed under red light only.

Unlike *M. comata, M. cavifrons* was never noticed to give off an odor when disturbed. This species also was nocturnal and was collected at lights.

As in *M. comata,* mating by *M. cavifrons* occurred in the dark; observations were made under red light. The court-

ship behavior of *M. cavifrons* was very similar to that of *M. comata.* The male with antennae waving and forewings held high was approached by a female. As soon as a contact was made the male lowered his forewings and pulled his antennae back. The female inserted her mouthparts into the frontal cavity of the male. Connection was made similarly to *M. comata.* The mating position, with the female arched forward on the dorsum of the male, was also similar to that in *M. comata.*

Oviposition by this species was not observed. However, like *M. comata* and *C. carnea,* stalked eggs were laid on leaves—rarely more than one egg per leaf in the field. However, *M. cavifrons* eggs were more often found on the margins of leaves than on the surface as in *M. comata.* The maximum number of eggs obtained from one female was 49 over a period of two weeks.

When first laid, the egg was a uniform yellowish-green color. As the embryo developed the dorsal portion of the egg turned more yellow, and the other half of the egg turned bluish-green. Later the red and white transverse bands of the larva appeared on the dorsum, and the ventral portion became darker bluish-green or grayish-blue. The micropylar end remained green until just before hatching. The incubation period averaged six days in the laboratory.

Hatching, as in other chrysopids, was by means of an egg burster. The newly hatched larva remained on the egg for a while before crawling down the stalk. *M. cavifrons* larvae were very similar to *M. comata* in appearance. Their feeding habits, trash carrying habits, and ecdyses, as far as were observed, were identical with those of *M. comata.* These larvae were also reared mainly on pea aphid. However, they probably fed on a variety of soft-bodied insects in nature. The average length of time between ecdyses was seven days for the first stage, six days for the second stage, and 11 days for the third stage until spinning.

The earliest *M. cavifrons* larva obtained in Strawberry Canyon hatched on July 23, 1963, from an egg taken on July 16. The next earliest record was a third instar larva taken on August 24, 1963. The latest record was October 31, 1962. Records of plant association for the three seasons' collections showed 19 collected on *Umbellularia californica* and 27 on *Quercus agrifolia.* Three others were taken in Berkeley on birch (*Betula* sp.).

M. cavifrons overwintered in the cocoon as diapausing third instars. Larvae of this species were treated with conditions of light and temperature similar to those of *M. comata* in an attempt to break diapause. The results, also inconclusive, indicated that long day length was one of the critical factors in breaking the diapause.

Pupation and emergence from the cocoon were similar to that in *M. comata.* The pupal stage averaged eleven days in length. All the pupae which were observed emerged in the evening, as did *M. comata.* The ecdysis to the adult was also very critical. Many failed to undergo the ecdysis at all, and many others did not complete it. The meconial pellet was voided soon after emergence of the adult.

Nothochrysa californica Banks

N. californica adults were taken in Strawberry Canyon from the end of March through the end of May. There was only one generation of this species per year.

The adults readily fed on honey, sugar, protein hydrolysate, and oak pollen. They were not predaceous; however, one female was seen feeding on her own unlaid eggs. She did this by bending her abdomen ventrally to her mouth. Excretion was observed on one occasion. The abdomen was bent to one side, and a dark brown droplet was eliminated. Cleaning activities were common, especially after feeding and before mating. One female was kept alive in the laboratory for almost two months.

Mating by adults reared in the laboratory was observed on three occasions. Mating did not occur until after the adults had fed on oak pollen. How specific this requirement was for mating is not known because other nutrients were not tested. Unlike many chrysopids, mating by this species occurred under both lighted and dark conditions.

The male, with antennae waving vigorously, approached the female toward her head. The female was standing on the undersurface of the transparent top of the container. When the male approached she began waving her antennae, and their antennae touched. The male during the approach stopped several times and with his wings slightly raised vibrated his abdomen up and down. The male continued coming toward her head until his mouthparts made contact with hers. No exchange of material was noticed, but their palpi did make contact. The female abdomen was lowered toward the bottom of the container, and the tip of it was arched dorsally during palpitation. The male then started to turn his body so that it was parallel with hers. Their heads were bent toward each other. He then raised his wings and vibrated his abdomen toward hers. She raised her wings slightly. The tip of the male abdomen then tapped the side of the female abdomen at about the sixth segment. He turned his abdomen and moved the tip of it down hers. She moved the tip of hers up, and a connection was made. The female was immediately lifted onto the male so that her ventral surface was above the dorsum of the male. Her fore- and midlegs held onto the sides of his fourth and fifth abdominal segments. Her hindlegs touched the sides of about his sixth segment. The wings of the male were raised. The female after one minute moved up the abdomen of the male until her head touched the base of his wings. She applied her mouthparts to the dorsum of the male immediately behind the base of the wings. Both had their wings raised high. The connection of the abdomens was such that the tip of the female abdomen curved ventrally toward the male abdomen. The dorsal surface of the tip of her abdomen was aligned with the venter of his. One minute and 45 seconds after the connection was made, a small amount of white material was secreted from the sides of the male near the genital connection. This white material was followed immediately by a secretion of yellow and white materials in the shape of a pair of horns. The secretion continued issuing and then wrapped around the fourth to seventh segments of the female abdomen. The pair in this case remained in copulation for six minutes; another pair remained together for 12 minutes.

After separation of the pair a spermatophore remained protruding from the genital opening of the female. The spermatophore was round in shape, almost as wide as the abdomen itself, and it extended anteriorly just beyond the sixth segment. Anterior-most the spermatophore was clear; closest to the genital opening it contained pale and amber-colored material. Immediately after the pair had separated, the abdomen of the female began to contract and relax in wave-like motions. The motions consisted of the tip of the abdomen bending ventrally and a wave of contraction passing anteriorly up the abdomen. During this time the segments with the secretion on the sides (segments 4 to 7) were very widely separated from each other. The rate of the pulsations immediately after mating was approximately 30 per minute. The pulsations continued but with decreasing intensity and rate for one hour. At that time the spermatophore was shriveled and opaque. All of the pale and amber-colored material was gone from it.

The female then began eating what was left of the spermatophore. She did this by curving her abdomen ventrally to her mouthparts. She continued to eat for 14 minutes until the spermatophore was gone and the genital pore exposed.

She continued cleaning the genital area for another five minutes and then she became inactive.

The male, immediately after separating from the female, remained with his wings raised and his dorsum pressed against the side of the container. He appeared almost as if paralyzed. This position persisted for about one minute before he fell to the floor of the carton. He then became active. He was later observed with the tip of his abdomen applied to his mouthparts, apparently in cleaning activity.

The spermatophore and secretion on the sides of one female were removed immediately after copulation. These were mounted in saline solution on slides for microscopic examination. A phase contrast microscope was used to examine the slides. The spermatophore slide showed numerous elongate spermatozoa that had a slight, stiff movement. It also showed cells similar to the cyst cells described by Landa (1961) for *Melolantha melolantha* L. The wall of the spermatophore appeared thick and opaque. The material secreted onto the sides of the female appeared as hyaline globules under microscopic examination.

The amount of time after mating before oviposition ranged from one to three days. The length of this period probably partially depended on how well the eggs were developed when mating occurred. Females whose abdomens were swollen and colored by eggs at the time of mating laid eggs sooner than others whose abdomens were not swollen or colored with eggs.

Oviposition by *N. californica* was observed on several occasions under laboratory lights. The behavior began by the female curving her abdomen ventrally and giving the substrate several taps with the tip of her abdomen. She then raised her abdomen so that it was in a horizontal line with the rest of her body. A single wave of contraction then passed down the abdomen. She curved her abdomen ventrally again and tapped the substrate approximately ten to 20 times. The tip of the abdomen was then applied to the substrate, and a droplet of clear liquid issued out onto the substrate. The abdomen was raised up immediately with a smooth and quick movement which drew out the stalk. When the stalk was full length, an egg issued from the genital chamber. The egg was held in place at the end of the stalk by the tips of the gonapophysis laterales. This position, with the egg held by the lateral plates and with the abdomen stretched high, was held until the stalk dried (an average of 56 seconds; table 2). The position was interrupted once after the egg had been held for only a few seconds. The stalk collapsed beneath the weight of the egg, and it fell to the substrate.

After the stalk was dried the egg was released from the hold by the lateral plates with a slight springing motion. The abdomen of the female remained high for varying lengths of time. See table 2. It was generally observed that the shorter the time the egg was supported the longer the abdomen remained raised after the egg was released.

N. californica eggs were deposited in batches mainly on the edges of leaves or on twigs. At the very beginning of their ovipositional period females laid batches of about 12 to 16 eggs. One batch was laid every day for about three to five days. For the next four or five days the number decreased to between two and six eggs. Finally single eggs were only occasionally laid, and they were usually unstalked and inviable. In two cases near the end of the egg laying period the female deposited five or six stalked eggs onto a single egg. Only a few of these were viable.

It is not known if females will mate more than once. However, many females lived and contained eggs for a few weeks after they had stopped laying eggs. Perhaps these eggs would have been laid if later matings had occurred. The maximum number of eggs obtained from one female was 62 over a period of five days. The average number of eggs

laid by laboratory-raised females was 52 (N = 4; s.d. = 8.8). Eggs were laid in the laboratory in 1964 from March 28 to April 23. A large batch was collected on May 25, 1963, in Strawberry Canyon. Other batches of old egg shells were also collected on that day.

When first laid the egg was bright yellowish-green. There were lighter yellow areas at the tip, at the stalked end, and in a strip running longitudinally up one side of the egg. As the embryo developed the yellow-green area turned a dark grayish-green while the tips and strip remained light. Later the stalked end of the egg became bluish-gray, and the reddish pigment of the embryo could be seen within the tips and down one side of the egg. The incubation period under laboratory conditions averaged seven days (table 1).

Hatching was similar to that in other chrysopids. Seven to ten minutes were required for the larva to free itself from the egg. Upon freeing itself the young larva hung connected to the egg shell by the tip of the abdomen with head down for about 25 minutes. After this the larva bent ventrally until its legs grasped the egg. It was then facing down the stalk. There was considerable movement of the abdomen and legs while the larva was on the stalk. Larvae were seen to remain on the egg for over 12 hours, during which time their color darkened.

Descent from the egg was accomplished by crawling down the stalk, as in other chrysopids. Once down, the larva was active and ready to feed. Larvae of this species were cannibalistic and would climb the stalks of other eggs for a meal. In the laboratory this species was fed various green aphids. In nature they probably fed on a variety of soft-bodied insects. The feeding process by this species was similar to that of other species.

Ecdysis was similar to that of other species. The average length of time between ecdyses was six days for the first stage, five days for the second, and 19 days for the third until spinning. The anal secretion, large jaws, dark color, and trash carrying habit of *N. californica* probably all contributed to avoidance of predation. This species carried more trash than any other species studied from Strawberry Canyon. The hooked setae on the dorsum probably accounted for the large amount of trash. No predator or parasite records were obtained for this species.

Larvae were collected in Strawberry Canyon from May 25, 1963 (first and second instar) to July 28, 1963 (third instar). The plant associations were ten larvae from *Quercus agrifolia* and 14 from *Umbellularia californica.*

Cocoon spinning by this species began by the larva laying down a layer of matted silk into which was often incorporated trash. Then a very distinct inner layer of silk was spun around the larva. The period of cocoon spinning was very critical in laboratory-reared specimens. Many did not complete their cocoons and subsequently died. The third instar larva persisted within the cocoon until approximately January when pupation occurred. The pupa remained in the cocoon until March or April. Emergence was through a circular slit in the cocoon. It usually followed a few days of warm weather. Laboratory-reared insects always emerged in the morning. The pharate adult remained outside of the cocoon approximately four hours.

Emergence of the adult was through a large dorsal, longitudinal slit in the pupal skin. About one hour was required for the wings to expand fully. In two to three hours the lacewing was fully darkened. The meconial pellet was discharged after the wings were expanded—in one case one-half hour after they were expanded. The meconial pellet was black and solid as in other chrysopids.

CONCLUSIONS

The biologies of the three genera of chrysopids in Strawberry Canyon show many similarities, for example, stalked eggs laid on leaves or twigs, method of hatching, carnivorous larvae with three instars, etc. However, many differences were discovered during this study. A comparison of characteristics among the species of lacewings studied is given in Appendix table 1A, pages 432–433.

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APPENDIX TABLE 1A

COMPARISON OF CHARACTERISTICS AMONG THE CHRYSOPID SPECIES STUDIED

	C. carnea	*C. nigricornis*	*M. comata*	*M. cavifrons*	*N. californica*
EGG					
size	L. 0.89 mm ± 0.03 mm W. 0.39 mm ± 0.02 mm	L. 0.96 mm ± 0.12 mm W. 0.46 mm ± 0.02 mm	L. 0.97 mm ± 0.03 mm W. 0.39 mm ± 0.06 mm	L. 0.85 mm ± 0.04 mm W. 0.37 mm ± 0.02 mm	L. 1.32 mm ± 0.04 mm W. 0.60 mm ± 0.03 mm
stalk length	3.50 mm ± 1.03 mm	10.14 mm ± 0.53 mm	5.66 mm ± 0.98 mm	3.51 mm ± 0.45 mm	6.48 mm ± 0.55 mm
stalk	stiff	bending	bending	stiff	thick, stiff
LARVAE					
setae	short	long, curved	long, curved	long, curved	hooked
dorsal head marks	one longitudinal pair	one longitudinal pair, single antero-median mark	3 pairs; pair from base of antennae not meeting pair from eyes at cervix	3 pairs; pair from base of antennae meeting pair from eyes at cervix	head almost entirely dark
trash	none	loose pieces	loose pieces	loose pieces	dense packet
COCOON					
density	thin transparent walls	opaque	opaque	opaque thick walls	very thick opaque walls
sides	complete	sometimes small clear surface against substrate	sometimes small clear surface against substrate	large clear surface sometimes against substrate	one side always against substrate and clear
trash	very little	sometimes in outer layer of silk	sometimes in outer layer of silk	often in outer layer of silk	always in outer layer of silk
ADULT					
color	green, yellow stripe, red cheek marks	green, black cheek marks	green, yellow stripe, black cheek marks	green, yellow stripe, red on thorax, black cheek marks	black

time of emergence	morning or evening	?	evening	evening	morning
feeding habits in laboratory	sugar, protein hydrolysate, honeydew	small insects, sugar, protein hydrolysate, honeydew	sugar, protein hydrolysate, honeydew	sugar, protein hydrolysate, honeydew	sugar, protein hydrolysate, pollen
prerequisites for mating	?	nutrients (?), darkness	nutrients, darkness	nutrients, darkness	nutrients (oak pollen?)
mating behavior	♂ and ♀ heads held toward each other during turn	♂ and ♀ heads held toward each other during turn	♀ mouthparts in ♂ frontal cavity during turn	♀ mouthparts in ♂ frontal cavity during turn	♂ and ♀ heads held toward each other during turn
copulatory position	♀-above position or on substrate next to ♂	♀ on substrate at 90° angle to body of ♂	♀-above position	♀-above position	♀-above position, yellowish and white fluid flows from ♂ onto abdomen of ♀
external spermatophore	none	none	none	none	visible after mating
oviposition	eggs laid singly	eggs in batches	eggs laid singly	eggs laid singly	eggs in batches
oviposition behavior	eggs held for short time while stalk hardens	eggs held for short time while stalk hardens	?	?	similar to *Chrysopa* but holds eggs longer time
site of oviposition	leaf surface	leaf surface	leaf surface	leaf margin mainly	leaf margin, twigs
GENERAL					
generations per year	variable, 3–5	probable 2, at most 3	probably 1 and some second	probably 1 and some second	1
overwintering	adult (discolored), some continuous development all year	diapausing 3rd instar larva in cocoon	diapausing 3rd instar larva in cocoon	diapausing 3rd instar larva in cocoon	diapausing 3rd instar larva in cocoon
adult occurrence	all year	spring and summer	summer	summer and fall	spring
larval occurrence	all year, mostly in spring, summer and fall	spring, summer and fall	summer to late fall	late summer to late fall	spring and early summer

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