

Life Histories of *Anormenis septentrionalis*, *Metcalfa pruinosa*, and *Ormenoides venusta*¹ with Descriptions of Immature Stages²

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ABSTRACT

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The life histories of *Anormenis septentrionalis* (Spinola), *Metcalfa pruinosa* (Say), and *Ormenoides venusta* (Melichar) were investigated in southern Illinois from 1977 to 1979, and the immature stages were described. The three species were also reared in the laboratory.

A. septentrionalis, *M. pruinosa*, and *O. venusta* are univoltine, and feed on a wide variety of woody and herbaceous plants. *A. septentrionalis*, *M. pruinosa* and, probably, *O. venusta* overwinter as eggs inserted in woody tissue.

The three species were reared on green beans. *M. pruinosa* was also reared on walnut leaves, and *O. venusta* was reared on walnut, pawpaw, and redbud leaves. Total development time averaged 178.4 days for *A. septentrionalis*; only partial rearing data were obtained for the other species.

Nymphs of the three species are attacked by one or more species of dryinid wasps. *M. pruinosa* and *O. venusta* nymphs are parasitized by a mite, *Leptus* sp., and *M. pruinosa* adults are parasitized by an epiphyropid moth, *Epipyrops barberiana* Dyar.

Field and laboratory investigations of *Anormenis septentrionalis* (Spinola), *Metcalfa pruinosa* (Say) and *Ormenoides venusta* (Melichar) were conducted between April 1977 and November 1979 in southern Illinois.

A. septentrionalis ranges from Connecticut south to Florida, and west to Iowa and Arizona (Metcalf 1957). It occurs on a wide variety of plants (summarized by Wilson and McPherson 1980). Little information is available on the life history of this insect. Wilson and McPherson (1979a) provided a brief summary of its life cycle in Illinois. *A. septentrionalis* has been noted "breeding" on hickory, *Carya* sp., sweetgum, *Liquidambar styraciflua* L., and oak, *Quercus* sp. (Dozier 1928), and has been reported to oviposit in the twigs of American elm, *Ulmus americana* L. (Hoffmann 1942), black cherry, *Prunus serotina* Ehrhart, redbud, *Cercis canadensis* L. (Wilson and McPherson 1979a), black walnut, *Juglans nigra* L. (Nixon and McPherson 1977, Wilson and McPherson 1979a), and sassafras, *Sassafras albidum* (Nuttall) (Uhler 1888). The eggs have been described, illustrated, and erroneously identified as those of *M. pruinosa*, by Dozier (1928), Forbes (1905), Forbes and Hart (1900), Lugger (1900), Uhler (1888), and Walden (1922). Swezey (1903) described and illustrated the 5th instar, and Surface (1907) provided an inaccurate illustration of a nymph. Line drawings of the nymphs were given by Wilson and McPherson (1979a).

M. pruinosa ranges from Quebec south to Florida, and west to Minnesota and California; it is also known from Bermuda, Cuba, Jamaica, Puerto Rico, Mexico, Central America, and Brazil (Metcalf 1957). This species has been recorded from a wide variety of plants (Wilson and McPherson 1980); nymphs can cause feeding damage to dahlias, *Dahlia* sp., salvia, *Salvia* sp. (Walden 1927), lime, *Citrus* sp. (Wene 1950), and amur privet, *Ligustrum amurense* Carriere (Wene and Riherd 1954). Generalized life history information was

provided by Phillips (1951) for Ontario, Dean and Bailey (1961) for Texas, and Mead (1969) for Florida. Phillips (1951) reported this planthopper "breeding" on sour cherry, *Prunus* sp., and found nymphs from May to late June and adults from late July to September. Dean and Bailey (1961) found overwintering eggs scattered singly in the bark of dead citrus, *Citrus* sp., twigs; hatching occurred in mid- to late March and the first adults were present in June, 69 days after hatching. Mead (1969) indicated that nymphs occur from April to June, and adults occur from May to October. As noted above, eggs of *A. septentrionalis* have been erroneously identified as those of *M. pruinosa* by several authors. Dean and Bailey (1961) provided photographs of eggs and nymphs; otherwise, no illustrations or descriptions of the immature stages are available.

O. venusta ranges from Maryland south to Florida and west to Missouri and Texas (Metcalf 1957), and it occurs on several plants (Wilson and McPherson 1980). The only information on this insect's life cycle is that of Dozier (1928), who stated that this planthopper was taken "breeding" on pecan, *Carya illinoensis* (Wangenheim), and on sweetgum and oak. No illustrations or descriptions of the immature stages are available.

Materials and Methods

Field Study

Observations and collections were made 3 to 4 days per week from 1 April to 1 November, 1977 through 1979, at various locations in southern Illinois (detailed in Wilson 1980). The dates of the study, field techniques, and primary study sites, were identical to those discussed by Wilson and McPherson (1981) for *Acanalonia bivittata* (Say) and *A. conica* (Say).

Laboratory Study

Field-collected and laboratory-reared *A. septentrionalis* adults were maintained, and nymphs were reared, on green beans, *Phaseolus vulgaris* L., which also served as oviposition sites. Field and laboratory *M. pruinosa* adults were maintained, and nymphs were reared,

¹ Homoptera: Fulgoroidea: Flatidae.

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on green beans, black walnut leaflets, and, for some adults, walnut twigs with attached leaves. Field and laboratory *O. venusta* adults were maintained, and nymphs were reared, on green beans, paw paw leaves, *Asimina triloba* (L.), redbud leaves, black walnut leaflets, and, for some adults, walnut twigs with attached leaves.

Adults were kept in 1-qt (ca. 0.95-liter) Mason jars, or round battery jars (ca. 16 cm diameter, 20 cm depth), with a disc of filter paper or paper towelling on the bottom. Each mason jar was closed with a disc of paper towelling and wire screening secured with the band of the two-piece Mason jar lid. Each battery jar was closed with a square of cheesecloth or plastic secured by an elastic band.

Of the three species, only *A. septentrionalis* females laid eggs in the laboratory; these eggs were inserted into green beans. Because the beans would eventually be covered with mold, the eggs were removed from the surrounding tissue with a fine needle and placed on cheesecloth strips. Each strip was placed in a petri dish (9 cm diameter, 2 cm depth) that was covered on the bottom with a disc of moistened filter paper. Each dish was covered with plastic secured by an elastic band and covered with the lid. The plastic prevented recently hatched nymphs from escaping between the dish and lid. Eggs of *A. septentrionalis* and *M. pruinosa*, but not of *O. venusta*, were found in the field inserted in twigs. These twigs were also placed in the dishes described above. Nymphs were reared individually in petri dishes prepared similarly to those used for eggs.

Eggs, nymphs, and adults were kept in incubators under a 16L:8D photoperiod at $23 \pm 1.1^\circ\text{C}$. Food was replaced every 3 to 4 days; filter paper was changed about once per week and, in petri dishes, moistened every 3 to 4 days.

Data on incubation and rearing were obtained, where possible, from laboratory cultures of eggs and nymphs, respectively. These specimens provided data on incubation periods and all nymphal stadia. Hatching of eggs was poor, and few nymphs reached adult stage. Thus, these data were supplemented with data from field-collected specimens. Since field specimens had already undergone some development before collection, data gathering began after hatching or after the nymphs had undergone one molt in the laboratory. Data were collected daily and included the number of eggs laid, the number hatched, and the number and instar of nymphal molts.

Field-collected nymphs were examined daily for the emergence of parasitoids. Parasitoids emerged as larvae and were left in their hosts' petri dishes until they reached adult stage or died; they were then preserved in 95% ethyl alcohol (EtOH).

Descriptions of Immature Stages

Specimens to be described were preserved in 95% EtOH. The description of each stage is based on 10 specimens unless otherwise stated. For each species, the 1st instar is described in detail, but only major changes from previous instars are described for subsequent instars. Comparative statements refer to previous instars (e.g., "darker"). Dimensions of eggs and nymphs are expressed in millimeters as mean \pm SE. For nymphs,

length was measured from tip of vertex to tip of abdomen; width was measured across the widest part of the body. Thoracic length was measured along the midline from the anterior margin of the pronotum to the posterior margin of the metanotum; this measurement was included because total length measurements are affected by the various shapes of the head within and between species, and because the abdomen occasionally becomes bloated when preserved in EtOH due to relatively broad intersegmental membranous areas. Drawings of eggs and nymphs were made with the aid of a camera lucida.

Results and Discussion

Anormenis septentrionalis (Spinola)

Field Study—This species was found to feed and develop on several plant species (Table 1). It is univoltine and overwinters as eggs inserted in woody tissue. During fall 1977 and 1978, 843 eggs were found in 35 twigs of the following species: 524 eggs in 22 of black walnut (mean \pm SE = 23.8 ± 2.48), 257 eggs in 10 of pawpaw (mean \pm SE = 25.7 ± 3.43), 27 eggs in 1 of black cherry, 20 eggs in 1 of slippery elm, *Ulmus rubra* Muhlenberg, and 15 eggs in 1 of redbud. They were deposited in longitudinal rows in elongate slits in the outer bark of the twigs. The cephalic end of each egg slightly overlapped the base of the next posteriorly, giving the slit a zipper-like appearance (Fig. 1). Eggs were found only in the current year's growth, never in older twigs.

First instars occurred from early May to early June. Several were observed hatching from eggs inserted in pawpaw twigs on 17 May 1978. These nymphs dispersed and were found on the understory vegetation feeding on stems and leaves, including those of young pawpaw, within 4 days of hatching. Second instars occurred from mid-May to the third week of June, 3rd instars from mid-May to early July, 4th instars from late May to mid-July, 5th instars from early June to mid-August, and adults from late June to late September (Fig. 2).

One parasitoid was found. A larval dryinid (Hymenoptera) emerged from a field-collected *A. septentrionalis* nymph and pupated on the wall of the petri dish; however, the adult wasp never emerged and, thus, this parasitoid could not be identified further. No parasites or predators were collected.

The dryinids *Neodryinus arizonicus* Perkins and *N. ormenidis* are listed by Krombein et al. (1979) as parasitoids of *A. septentrionalis*. Bilising (1920) recorded the following spiders as predators of this planthopper: *Agelenopsis naevia* (Walckenaer) (Agelenidae); *Argiope aurantia* Lucas, *Leucauge venusta* (Walckenaer), *Neoscona arabesca* (Walckenaer), *N. domiciliorum* (Hentz), *Nuctenea cornuta* (Clerck) (Araneidae); and *Schizocosa avida* (Walckenaer) (Lycosidae).

Laboratory Study.—Field-collected and laboratory-reared females inserted eggs into the fleshy tissue of beans. From 5 to 98 eggs were laid (mean \pm SE = 23.9 ± 5.44) in 16 beans.

Of the 382 eggs laid in the laboratory, only 9 (2.4%) hatched. The incubation period averaged 135.3 days (Table 2). None of the nine nymphs survived to adult stage and, thus, these data were supplemented with data

Table 1.—Southern Illinois food plants of three species of Flatidae*

Host taxon	Stages collected ^b		
	As	Mp	Ov
Graminae			
<i>Digitaria sanguinalis</i> (L.)	—	—	A
Juglandaceae			
<i>Carya glabra</i> (Miller)	—	A	—
<i>C. ovata</i> (Miller)	—	A	—
<i>Juglans nigra</i> L.	N, A	N, A	N, A
Betulaceae			
<i>Alnus glutinosa</i> (L.)	—	N, A	—
<i>Betula nigra</i> L.	—	A	—
<i>Carpinus caroliniana</i> Walter	—	A	—
<i>Ostrya virginiana</i> (Miller)	N	—	—
Fagaceae			
<i>Quercus velutina</i> Lamarck	N, A	—	A
Ulmaceae			
<i>Celtis occidentalis</i> L.	—	A	—
<i>Ulmus americana</i> L.	—	A	A
<i>U. rubra</i> Muhlenberg	N, A	N, A	N, A
Moraceae			
<i>Maclura pomifera</i> (Rafinesque)	N	—	N
<i>Morus rubra</i> L.	N, A	A	N, A
Polygonaceae			
<i>Rumex crispus</i> L.	—	N	—
<i>R. obtusifolius</i> L.	N	—	N
Phytolaccaceae			
<i>Phytolacca americana</i> L.	A	—	A
Magnoliaceae			
<i>Liriodendron tulipifera</i> L.	A	—	N, A
Annonaceae			
<i>Asimina triloba</i> (L.)	A	N, A	N, A
Berberidaceae			
<i>Podophyllum peltatum</i> L.	—	N	—
Lauraceae			
<i>Sassafras albidum</i> (Nuttall)	N, A	A	N, A
Hamamelidaceae			
<i>Liquidambar styraciflua</i> L.	N, A	—	N, A
Platanaceae			
<i>Platanus occidentalis</i> L.	N, A	—	A
Rosaceae			
<i>Geum canadense</i> Jacquin	A	N	N
<i>Prunus serotina</i> Ehrhart	N	N, A	N, A
<i>Rosa multiflora</i> Thunberg	N	N	A
<i>Rubus</i> sp.	N	—	—
<i>R. alleghaniensis</i> Porter	—	A	—
Leguminosae			
<i>Cercis canadensis</i> L.	N, A	N	N, A
<i>Mellilotus alba</i> Desrousseau	N	A	—
<i>M. officinalis</i> L.	N	N	—
<i>Robinia pseudoacacia</i> L.	N, A	N	N
Celastraceae			
<i>Euonymus alatus</i> (Thunberg)	N	—	—
Anacardiaceae			
<i>Rhus copallina</i> L.	N	N	N
<i>R. glabra</i> L.	N, A	—	—
<i>R. radicans</i> L.	N, A	—	—
Aceraceae			
<i>Acer negundo</i> L.	A	N	—
<i>A. rubrum</i> L.	—	N	A
<i>A. saccharinum</i> L.	A	A	A
<i>A. saccharum</i> Marshall	N, A	N, A	A
Vitaceae			
<i>Parthenocissus quinquefolia</i> (L.)	—	N	—
<i>Vitis</i> sp.	N	N	N
Eleagnaceae			
<i>Eleagnus angustifolia</i> L.	—	N	—
Cornaceae			
<i>Cornus florida</i> L.	N, A	N	N
<i>Nyssa sylvatica</i> Marshall	—	A	—
Umbelliferae			
<i>Daucus carota</i> L.	—	N	—
Ebenaceae			
<i>Diospyros virginiana</i> L.	N, A	—	—
Oleaceae			
<i>Fraxinus americana</i> L.	A	N, A	A
<i>F. pennsylvanica</i> Marshall	—	A	—
Scrophulariaceae			
<i>Verbascum thapsus</i> L.	N	—	—
Bignoniaceae			
<i>Campsis radicans</i> (L.)	N	—	N, A
Plantaginaceae			
<i>Plantago lanceolata</i> L.	—	N	—
<i>P. rugelii</i> Decaisne	N	—	N
Caprifoliaceae			
<i>Lonicera japonica</i> Thunberg	N, A	N	A
<i>Sambucus canadensis</i> L.	A	—	—
Compositae			
<i>Ambrosia artemisiifolia</i> L.	A	—	—
<i>A. trifida</i> L.	N	A	A
<i>Erigeron canadensis</i> L.	N	N	N
<i>Lactuca canadensis</i> L.	N	—	—
<i>Solidago canadensis</i> L.	N	N	—
<i>Verbesina</i> sp.	N	N	A

* A. septentrionalis (As). M. pruinosa (Mp). O. venusta (Ov).
^b N, nymph; A, adult.

from field-collected eggs laid in pawpaw and black walnut twigs, and from field-collected nymphs which had molted at least once in the laboratory. Of the 491 field-collected eggs, in 18 twigs, 164 (30.0%) hatched. The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 11.6, 8.0, 8.2, 10.3, and 15.0 days, respectively (Table 2); total development averaged 43.1 days. Development from egg to adult averaged 178.4 days.

Descriptions of Immature Stages.—The following descriptions are based on field-collected specimens. The nymphs are usually surrounded by elongate filaments of white waxy exudate which may completely cover them.

Egg (Fig. 3A). Length 1.22 ± 0.009 ; width 0.53 ± 0.008 . Eggs laid singly in longitudinal rows; each elongate, oval; yellowish orange; chorion translucent, with a shallow sculptured pattern grading into elongated villi on the side of the egg not covered by plant tissue.

1st instar (Fig. 3B). Length 1.15 ± 0.042 ; thoracic length 0.60 ± 0.008 ; width 0.62 ± 0.009 .

Form elongate, subcylindrical, slightly flattened dorsoventrally, widest across metathorax. Body cream-colored with yellowish orange markings and many shallow pits.

Head cream-colored with yellowish orange markings. Vertex overlapped by anterior extension of pronotum. Frons subrectangular, longer than wide, broadest just beneath eyes, dorsal and lateral margins convex, ventral margin concave; each lateral margin carinate (outer carina) and paralleled by a second weak carina (inner carina) about two-thirds the distance from midline to outer carina; a longitudinal row of several pits between each inner and outer carina. Clypeus yellowish orange; narrowing distally, consisting of a subconical, basal postclypeus and a beaklike, cylindrical, distal anteclypeus. Beak three-segmented, extending slightly beyond metacoxae; segment 1 partially covered by anteclypeus, segments 2 and 3 subequal. Eyes red. Antennae three-segmented, yellowish orange; segment 1 short, cylindrical; segment 2 subcylindrical; segment 3 subcylindrical basally, with a bristle-like extension apically.



FIG. 1.—Black walnut twig containing three rows of *A. septentrionalis* eggs (one row indicated by arrow).

Thoracic nota cream-colored with yellowish orange markings and concolorous pits; divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, overlapping vertex, extending laterally to ventral level of antennae; each plate subtriangular, narrowing laterally, anterior border arcuate forming a ridge extending from midline of pronotum posterolaterally to just beyond level of lateral border of eye, posterior border sinuate, with a row of 12 obscure pits which parallels the anterior margin (lateralmost pits not visible in dorsal view). Mesonotum longest medially, median length ca. 2.5 times that of pronotum; each plate subtrapezoidal, posterior margin slightly sinuate with one large orange spot bearing two pits about midway between midline and lateral margin of mesonotum and one small orange spot bearing two pits near lateral margin of mesonotum (lateralmost pits often not visible in dorsal view). Metanotum longest medially, median length about three-fourths that of mesonotum, often with a posteromedial triangular piece visible which falsely appears to be a metanotal tergite; each plate subrectangular, posterior margin slightly curved, with one small

orange spot in posterolateral corner of metanotum (not visible dorsally). Legs yellow, infused with orange. Pro- and mesocoxae elongate, subcylindrical, posteromedially directed; metacoxae subrectangular, transverse; remaining segments of legs with very fine setae (not illustrated). Metatibiae bearing an apical row of four black-tipped spines ventrally. Tarsi two-segmented, pro- and mesotarsi with segment 1 wedge-shaped; metatarsi with segment 1 cylindrical and bearing an apical row of four black-tipped spines ventrally; all tarsi with segment 2 subconical and curved, with a pair of brown claws and a white pulvillus apically.

Abdomen nine-segmented, subcylindrical, widest across segments 2 through 4; segments 8 and 9 telescoped anteriorly giving abdomen a truncate flattened appearance caudally; segment 9 elongate vertically, surrounding anus, with a small finger-like process on either side of midline. Segments 3 through 7 with tergites curving around lateral margin to ventral side, segment 7 with tergite slightly notched on posterior margin; segments 8 and 9 with dorsum not visible because of telescoping. Each segment with the following number of pits and wax pads on either side of midline (lateralmost, ventral, and caudal pits often not visible in dorsal view); segments 4 through 6 each with 2 obscure lateral pits on tergite, segment 7 with one obscure lateral pit on tergite, segments 8 and 9 apparently without pits; segment 6 with an obscure transverse dorsal J-shaped orange wax pad on tergite, segment 7 with an elongate caudal C-shaped orange wax pad, segment 8 with an oval caudal orange wax pad, segment 9 without pads.

2nd instar (Fig. 3C). Length 1.57 ± 0.059 ; thoracic length 0.81 ± 0.009 ; width 0.86 ± 0.021 .

Body cream-colored to white with yellowish orange markings on head, thorax, and abdomen.

Frons apparently without a median carina.

Each plate of pronotum with two rows of ca. 20 obscure pits which parallel anterior margin (lateralmost pits not visible in dorsal view). Mesonotum with median length 2 to 2.5 times that of pronotum; each plate with five obscure pits in large orange spot and two obscure pits in small orange spot. Each plate of metanotum with small posterolateral orange spot bearing two obscure pits. Metatibiae bearing one black-tipped spine on lateral margin and an apical row of five black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of five black-tipped spines ventrally.

Abdominal segments with pits generally more numerous than previous instar. Segment 6 with one well-defined dorsal, J-shaped (as in previous instar), and one lateral, ovoid orange wax pad on tergite on either side of midline.

Otherwise, similar to 1st instar.

3rd instar (Fig. 3D). Length 2.28 ± 0.079 ; thoracic length 1.18 ± 0.011 ; width 1.39 ± 0.018 .

Body white with fewer yellowish orange markings and with pits on sides of pronotum and mesonotum pale to brown.

Each plate of pronotum with three irregular rows of ca. 25 pits which parallel anterior margin (lateralmost pits not visible in dorsal view). Mesonotum with median length 2.5 to 3 times that of pronotum; each plate with about eight obscure pits within weekly defined large

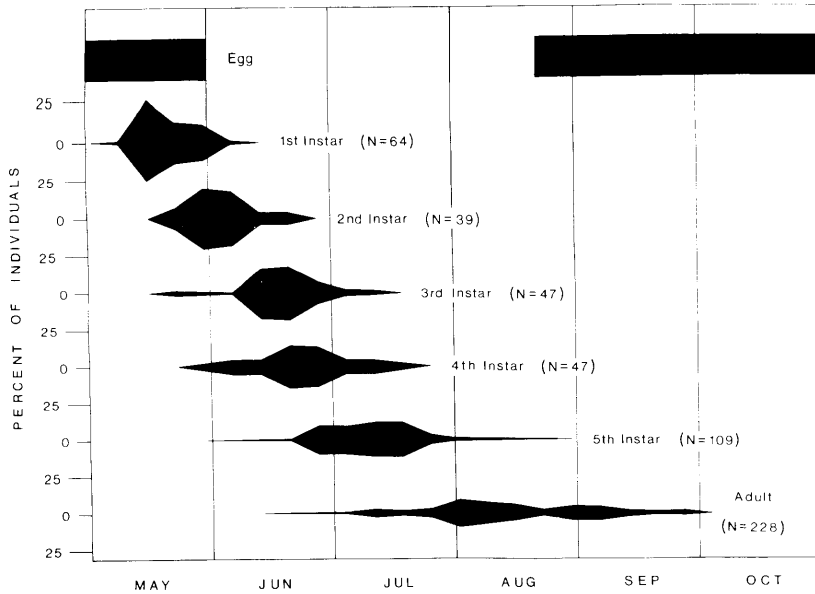


FIG. 2.—Seasonal occurrence of *A. septentrionalis* instars in southern Illinois. Number of individuals of each stage is expressed as percentage of total observations of that stage.

orange spot. Metanotum apparently without pits in posterolateral corners. Metatibiae bearing two to four black-tipped spines on lateral margin and an apical row of six black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of six black-tipped spines ventrally.

Abdominal segments with pits weakly developed and generally more numerous than previous instar. Segment 6 with one dorsal, J-shaped and two lateral, ovoid orange wax pads on tergite on either side of midline.

Otherwise, similar to 2nd instar.

4th instar (Fig. 3E). Length 2.64 ± 0.054 ; thoracic length 1.44 ± 0.022 ; width 1.94 ± 0.048 .

Body white without orange markings and with thoracic pits brown to black.

Frons with a weakly developed median carina.

Each plate of pronotum with ca. 30 pits (lateralmost pits not visible in dorsal view). Each plate of mesonotum with 12 to 17 pits about one-third the distance from midline of mesonotum to lateral margin of mesonotum (this region contained the large orange spot present in previous instars), and three to four pits near lateral margin of mesonotum; each wingpad broadly expanded laterally, covering about half of metanotal plate. Each plate

of metanotum with one pit in distal third; wingpad extending to third abdominal tergite, usually with a dark brown crescent-shaped mark on the posterior margin. Metatibiae bearing three to four black-tipped spines on lateral margin and an apical row of six to seven black-tipped spines ventrally. Pro- and mesotarsi two-segmented; metatarsi three-segmented, segment 1 bearing an apical row of seven black-tipped spines ventrally, segment 2 bearing one apical black-tipped spine ventrally, segment 3 similar to segment two of previous instars.

Abdominal segments with pits generally more numerous, wax pads light cream-colored to orange. Segment 6 with one dorsal, J-shaped, and three lateral, ovoid wax pads on tergite on either side of midline.

Otherwise, similar to 3rd instar.

5th Instar (Fig. 3F). Length 4.03 ± 0.177 ; thoracic length 2.01 ± 0.038 ; width 3.03 ± 0.075 .

Body often with dark brown to black marks on thorax. Frons with median carina more strongly developed.

Each plate of pronotum with ca. 35 pits (lateralmost pits not visible in dorsal view). Each plate of mesonotum with 21 to 31 pits about one-third the distance from midline of mesonotum to lateral margin of mesonotum and 4 to 11 obscure pits near lateral margin of mesonotum; often with one to three brown markings; each wingpad broadly expanded, subtruncate apically, extending to apex of metanotal wingpad. Each plate of metanotum usually with one large dark mark on apical half; wingpad extending to 3rd, 4th, or 5th abdominal tergites. Metatibiae bearing two to four black-tipped spines on lateral margin and an apical row of seven to eight black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of seven to eight black-tipped spines ventrally, segment 2 bearing two apical black-tipped spines ventrally.

Abdominal segments with pits generally more numerous, wax pads cream-colored. Segment 6 with one

Table 2.—Duration (in days) of each immature stage of *A. septentrionalis*^a

Stage	No. beginning stadium	No. completing stadium	Days	
			Range	Mean \pm SE
Egg	382	9	80-169	135.3 \pm 9.08
Nymph				
1st instar	173	46	7-24	11.6 \pm 0.52
2nd instar	60	41	6-13	8.0 \pm 0.26
3rd instar	72	45	5-14	8.2 \pm 0.29
4th instar	101	57	6-24	10.3 \pm 0.41
5th instar	140	61	5-27	15.0 \pm 0.54

^a Laboratory and field specimens combined.

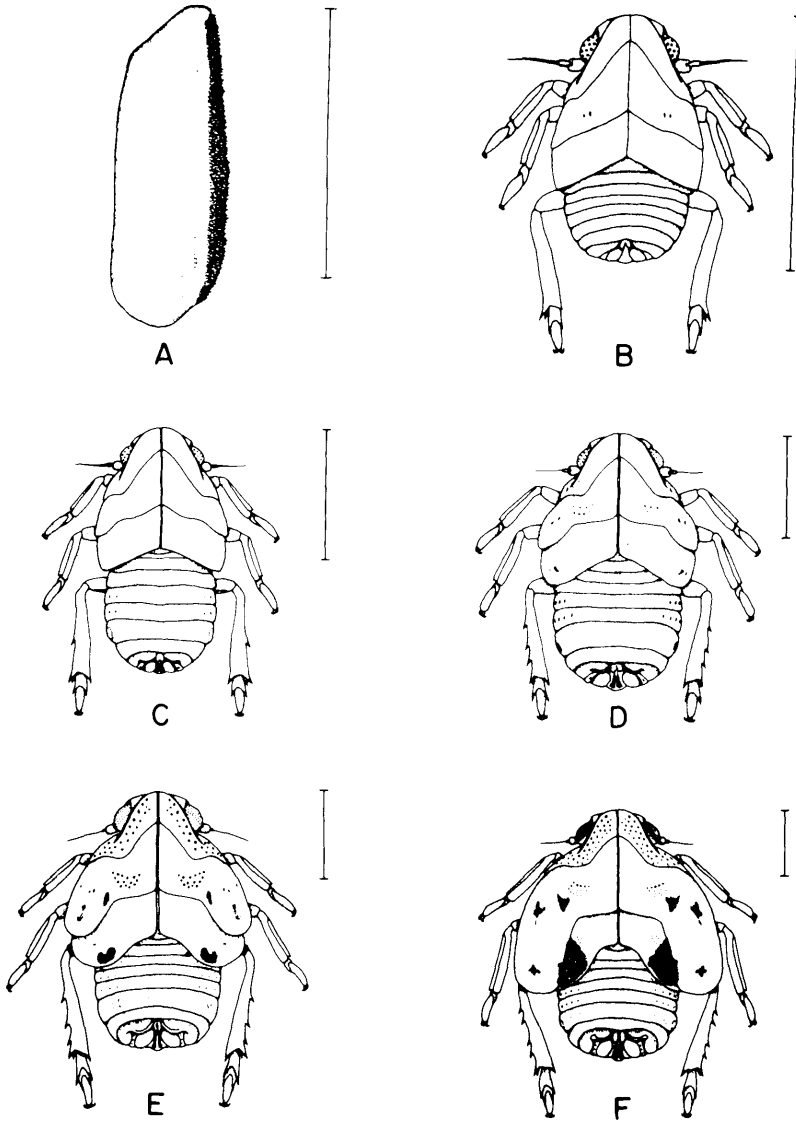


FIG. 3.—Immature stages of *A. septentrionalis*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

dorsal, J-shaped and four lateral, ovoid wax pads on tergite on either side of midline.

Otherwise, similar to 4th instar.

Metcalfa pruinosa (Say)

Field Study—This species was found to feed and develop on several plant species (Table 1) and although it has been reported to cause feeding damage to several plants (see above), no feeding damage was observed during the present study. It is univoltine, and overwinters as eggs inserted in woody tissue (Dean and Bailey 1961). Three eggs of this species were found in the bark of a live slippery elm twig on 13 August 1979 and three, one, and one eggs were found in the bark, bud, and leaf scar, respectively, of two live black walnut twigs on 28 September 1979. Eggs were found scattered singly, each

inserted into a shallow concavity partially covered by bark (Fig. 4).

Four 1st instars were found on 30 May. Second instars occurred from early to late June, 3rd instars from early June to early August, 4th instars from mid-June to early August, 5th instars from late June to early August, and adults from early July to early October (Fig. 5).

One parasitoid and two parasites were found during this study. Six larval dryinids emerged from field-collected nymphs and pupated on the walls of the petri dishes; only one developed to adult, emerging after 29 days, and was identified as a female *Neodryinus* sp., probably *ormenidis* (Ashmead) (P. H. Freytag, personal communication). Krombein et al. (1979) list *M. pruinosa* as a host of *N. ormenidis*. Adults were attacked by the moth *Epixyrops barberiana* (see Wilson and McPherson



FIG. 4.—Slippery elm twig showing oviposition site of *M. pruinosa* (indicated by arrow).

1979b). Larval mites, *Leptus* sp., were found attached to the thorax and abdomen of nymphs. No predators were collected during this study.

Laboratory Study—*M. pruinosa* proved difficult to rear. Of the field-collected females, many of them gravid, none laid eggs in the laboratory. The eggs found in the field (see above) were returned to the laboratory and placed in petri dishes, but none hatched. Rearing data are from field-collected nymphs that had molted at

least once in the laboratory. The 3rd, 4th, and 5th stadia averaged 11.3, 14.1, and 19.5 days, respectively (Table 3).

Descriptions of Immature Stages.—The following descriptions are based on field collections; the eggs were extracted from field-collected females. The white nymphs are usually found surrounded by elongate filaments of white waxy exudate, which may completely cover them.

Egg (Fig. 6A). Length 0.84 ± 0.007 ; width 0.37 ± 0.005 . Eggs laid singly; each elongate, oval; white; chorion translucent, with a shallow sculptured pattern; two sinuate grooves bordering an unpatterned area which faces interior of twig in which egg is laid.

1st Instar (Fig. 6B). Length 1.02 ± 0.063 ; thoracic length 0.46 ± 0.009 ; width 0.48 ± 0.027 ; two specimens examined.

Form elongate, subcylindrical, slightly flattened dorsoventrally, widest across metathorax. Body white with many shallow concolorous pits.

Vertex overlapped by anterior extension of pronotum. Frons subrectangular, longer than wide, broadest just beneath eyes, dorsal and lateral margins convex, ventral margin concave; with a longitudinal median carina; each lateral margin carinate (outer carina) and paralleled by a second carina (inner carina) about two-thirds the distance from midline to outer carina; with a longitudinal row of several pits between each inner and outer carina. Clypeus narrowing distally; consisting of a subconical, basal postclypeus and a beaklike cylindrical, distal anteclypeus. Beak three-segmented, extending slightly beyond metacoxae; segment 1 almost completely obscured by anteclypeus; segments 2 and 3 subequal. Eyes red. Antennae three-segmented; segment 1 short, cylindrical; segment 2 elongate, cylindrical; segment 3 subcylindrical basally, with an elongate bristle-like extension apically.

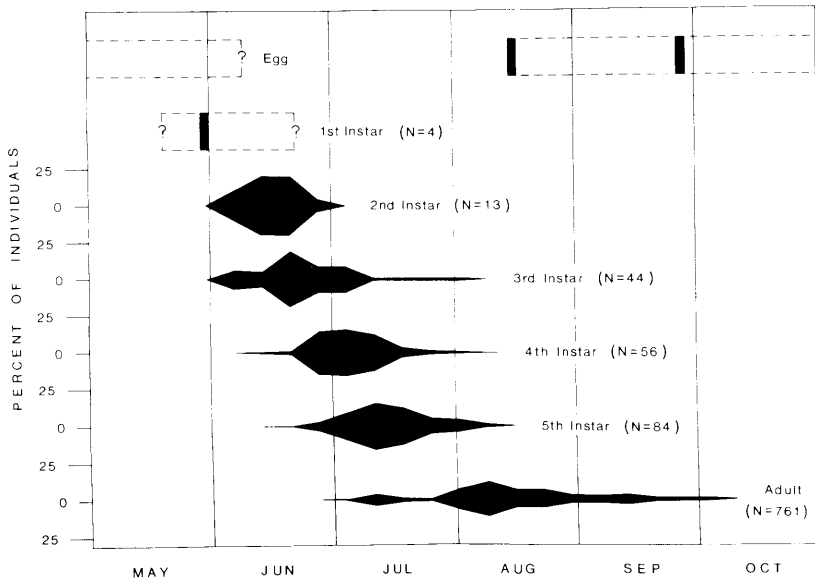


FIG. 5.—Seasonal occurrence of *M. pruinosa* instars in southern Illinois. Number of individuals of each stage is expressed as percentage of total observations of that stage.

Table 3.—Duration (in days) of the 3rd, 4th, and 5th instars of *M. pruinosa*^a

Nymphal stage	No. beginning stadium	No. completing stadium	Days	
			Range	Mean ± SE
3rd instar	18	7	5–24	11.3 ± 2.36
4th instar	48	23	6–36	14.1 ± 1.58
5th instar	50	28	9–31	19.5 ± 1.15

^a Laboratory and field specimens combined.

Thoracic nota divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, overlapping vertex, extending laterally to ventral level of antennae; each plate subtriangular, narrowing laterally, anterior margin sinuate, forming a ridge extending from anterior midline of pronotum posterolaterally to just beyond level of lateral border of eye, pos-

terior margin sinuate, with a row of obscure pits which parallels the anterior margin. Mesonotum longest medially, median length about two times that of pronotum; each plate subtrapezoidal, posterior margin slightly sinuate, with two obscure pits between midline of mesonotum and lateral margin of mesonotum. Metanotum longest medially, median length about three-fourths that of mesonotum, often with a posteromedial triangular piece visible which falsely appears to be a metanotal abdominal tergite; each plate subrectangular, posterior margin slightly curved. Pro- and mesocoxae elongate, subcylindrical, posteromedially directed; metacoxae subrectangular, transverse; remaining segments of legs with very fine setae (not illustrated). Metatibiae bearing an apical row of four black-tipped spines ventrally. Tarsi two-segmented; pro- and mesotarsi with segment 1 wedge-shaped; metatarsi with segment 1 cylindrical and bearing an apical row of four black-tipped spines ventrally; all tarsi with segment 2 subconical and curved,

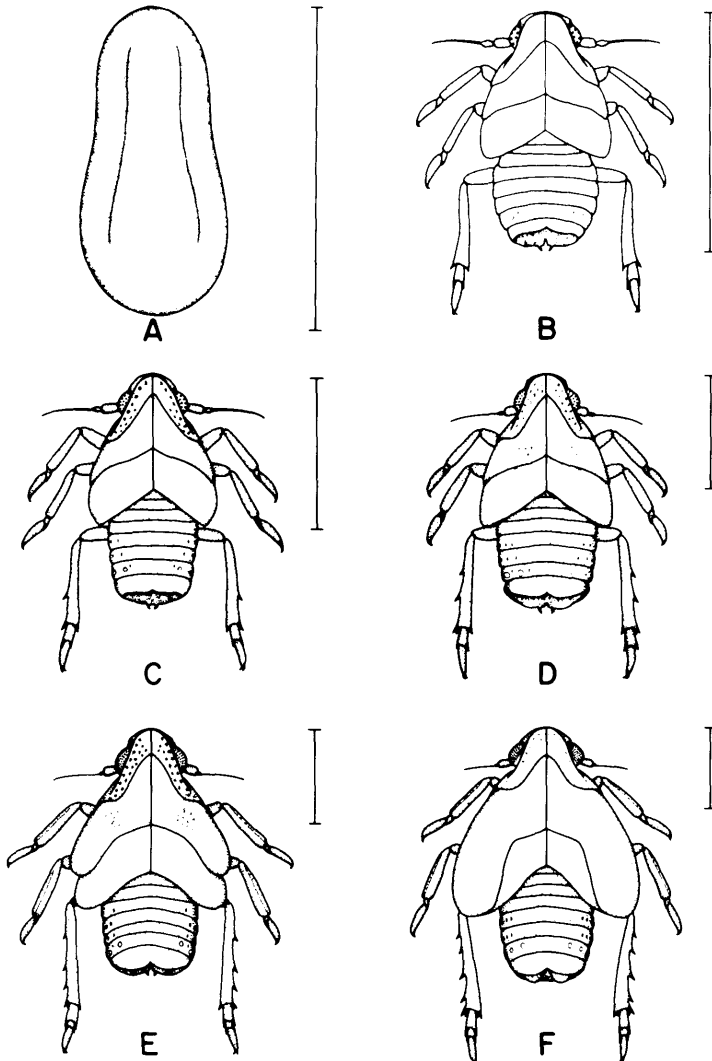


FIG. 6.—Immature stages of *M. pruinosa*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

with a pair of brown claws and a white pulvillus apically.

Abdomen nine-segmented, subcylindrical, widest across segment 3; segments 8 and 9 telescoped anteriorly giving abdomen a truncate flattened appearance caudally; segment 9 elongate vertically, surrounding anus, with a small ventral finger-like process on either side of midline; segments 3 through 7 with tergites curving around lateral margin to ventral side, segment 7 with tergite notched medially on posterior margin; segments 8 and 9 with dorsum not visible because of telescoping. Very obscure pits present on some tergites. Each segment with the following number of wax pads on either side of midline: segment 6 with one small lateral yellow oval wax pad on tergite, segments 7 and 8 each with one oval caudal elongate yellow wax pad, segment 9 without pads.

2nd Instar (Fig. 6C). Length 1.27 ± 0.111 ; thoracic length 0.67 ± 0.010 ; width 0.69 ± 0.033 ; three specimens examined.

Each plate of pronotum with two rows of obscure pits which parallel anterior margin. Mesonotum with median length ca. 2.5 times that of pronotum. Metatibia bearing one to two black-tipped spines on lateral margin and an apical row of five black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of five black-tipped spines ventrally.

Abdomen with tergite 7 overhanging and obscuring caudal wax pads (posterior portion of abdomen in Fig. 6C slightly upturned to illustrate wax pads). Segment 6 with two small lateral yellow to white oval wax pads on tergite on either side of midline.

Otherwise, similar to 1st instar.

3rd Instar (Fig. 6D). Length 2.02 ± 0.075 ; thoracic length 1.08 ± 0.010 ; width 1.04 ± 0.013 .

Metatibiae bearing one to three black-tipped spines on lateral margin and an apical row of six black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of six black-tipped spines ventrally.

Abdominal segment 6 with three small lateral pale yellow to white oval wax pads (lateralmost wax pad not visible in dorsal view) on tergite on either side of midline.

Otherwise, similar to 2nd instar.

4th Instar (Fig. 6E). Length 2.48 ± 0.053 ; thoracic length 1.48 ± 0.017 ; width 1.50 ± 0.020 .

Mesonotum with each wingpad lobate laterally, covering about half of each metanotal plate. Metatibiae bearing three to four black-tipped spines on lateral margin and an apical row of 7 black-tipped spines ventrally. Pro- and mesotarsi two-segmented; metatarsi three-segmented, segment 1 bearing an apical row of seven black-tipped spines ventrally, segment 2 bearing one to two apical black-tipped spines ventrally, segment 3 similar to segment 2 of previous instars.

Abdominal segment 6 with four small lateral yellow to white oval wax pads (lateralmost wax pads not visible in dorsal view) on tergite on either side of midline.

Otherwise, similar to 3rd instar.

5th Instar (Fig. 6F). Length 3.21 ± 0.089 ; thoracic length 1.78 ± 0.025 ; width 2.40 ± 0.054 .

Mesonotum with each wingpad broadly expanded, extending to apex of metanotal wingpad. Metanotum

with median length about half that of mesonotum, wingpad extending to 3rd or 4th abdominal tergite. Metatibiae bearing three to four black-tipped spines ventrally. Metatarsi with segment 2 bearing two apical black-tipped spines ventrally.

Abdominal segment 6 with five small lateral yellow to white oval wax pads (lateralmost wax pads not visible in dorsal view) on tergite on either side of midline.

Otherwise, similar to 4th instar.

Ormenoides venusta (Melichar)

Field Study.—This species feeds on several plant species (Table 1) and is univoltine. Adults and nymphs were observed feeding on pawpaw leaves in Thompson Woods on the campus of Southern Illinois University, Carbondale. During fall 1979, 100 living and dead twigs were clipped, brought back to the laboratory and inspected for eggs; none was found. However, since *O. venusta* females have a sawlike ovipositor similar to those of *A. septentrionalis* and *M. pruinosa*, and because the three life cycles are similar, *O. venusta* probably inserts its eggs into plant tissue as do the other two species.

First instars occurred from mid-May to early June, 2nd instars from the 3rd week in May to mid-June, 3rd instars from late May to late June, 4th instars from early June to mid-July, 5th instars from the 3rd week in June to late July, and adults from early July to late September (Fig. 7).

One parasitoid and one parasite were found during this study. A larval dryinid emerged from a field-collected *O. venusta* nymph and pupated on the wall of the petri dish; however, the adult never emerged and, thus, this parasitoid could not be identified further. Larval mites, *Lep-tus* sp., were found attached to the abdomen of *O. venusta* nymphs. No predators were collected.

Laboratory Study.—*O. venusta* proved difficult to rear. Of the field-collected females, many of them gravid, none laid eggs in the laboratory. Rearing data are from field-collected nymphs that had molted at least once in the laboratory. The 2nd, 3rd, 4th, and 5th stadia averaged 18.9, 18.5, 13.8, and 20.0 days, respectively (Table 4).

Descriptions of Immature Stages.—The following descriptions are based on field collections; the eggs were extracted from field-collected females. The green nymphs are usually found with a pair of elongate white waxy filaments, which are produced by the abdominal wax glands, on the posterior end.

Egg (Fig. 8A). Length 0.88 ± 0.007 ; width 0.34 ± 0.004 . Eggs elongate, oval; white; chorion translucent, with a shallow sculptured pattern.

1st Instar (Fig. 8B). Length 1.13 ± 0.189 ; thoracic length 0.55 ± 0.009 ; width 0.47 ± 0.018 ; one specimen examined.

Form elongate, subcylindrical, slightly flattened dorsoventrally, widest across metathorax. Body green in life; white, sometimes infused with greenish, rose, or orange, when preserved in EtOH; with many shallow concolorous pits.

Vertex broadly rounded anteriorly, partially overlapped by anterior extension of pronotum. Frons subrectangular, longer than wide, broadest at level of an-

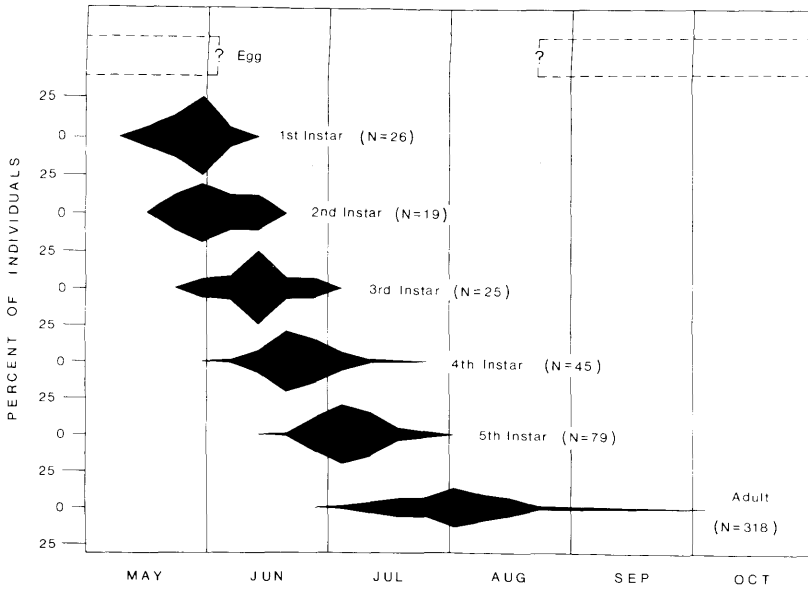


FIG. 7.—Seasonal occurrence of *O. venusta* instars in southern Illinois. Number of individuals of each stage is expressed as percentage of total observations of that stage.

tennae, dorsal and lateral margins convex, ventral margin concave; with a longitudinal median carina; each lateral margin carinate (outer carina) and paralleled by a second carina (inner carina) about two-thirds the distance from midline to outer carina; with a longitudinal row of several pits between each inner and outer carina. Clypeus narrowing distally; consisting of a subconical, basal postclypeus and a beaklike cylindrical, distal antclypeus. Beak three-segmented, extending slightly beyond metacoxae; segment 1 partially obscured by antclypeus; segments 2 and 3 subequal. Eyes red. Antennae three-segmented; segment 1 short, cylindrical; segment 2 subcylindrical; segment 3 bulbous basally, with an elongate, bristlelike extension apically.

Thoracic nota divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, overlapping vertex, extending laterally to ventral level of antennae; each plate subtriangular, narrowing laterally, anterior margin sinuate forming a ridge extending from anterior midline of pronotum posterolaterally to just beyond level of lateral border of eye, posterior margin sinuate, with a row of obscure pits which parallels the anterior margin. Mesonotum longest medially, median length ca. 1.5 times that of pronotum; each plate subtrapezoidal, posterior margin slightly sinuate, with two obscure pits (often not visible in dorsal

view) in posterolateral corner of mesonotum. Metanotum longest medially, median length subequal to that of mesonotum; each plate subrectangular, posterior margin slightly curved. Pro- and mesocoxae elongate, subcylindrical, posteromedially directed; metacoxae subrectangular, transverse; remaining segments of legs with very fine setae (not illustrated). Metatibiae bearing an apical row of four black-tipped spines ventrally. Tarsi two-segmented; pro- and mesotarsi with segment 1 wedge-shaped; metatarsi with segment 1 cylindrical and bearing an apical row of four black-tipped spines ventrally; all tarsi with segment 2 subconical and curved, with a pair of brown claws and a white pulvillus apically.

Abdomen nine-segmented, subcylindrical, widest across segment 3; segments 8 and 9 telescoped anteriorly giving abdomen a truncate flattened appearance caudally; segment 9 elongate vertically, surrounding anus, with a small ventral finger-like process on either side of midline; segments 3 through 7 with tergites curving around lateral margin to ventral side; segment 7 with tergite notched medially on posterior margin; segments 8 and 9 with dorsum not visible because of telescoping. Very obscure pits present on some tergites. Each segment with the following number of black marks and wax pads on either side of midline: segments 4 and 5 each with two, and segment 6 with one, small black mark ventrolaterally (not visible in dorsal view), segments 6 and 7 each with one black crescent-shaped mark dorsally on tergite; segment 6 with one small lateral white oval wax pad (may be obscure) on tergite, segments 7 and 8 each with one caudal elongate white oval wax pad on tergite.

2nd Instar (Fig. 8C). Length 1.69 ± 0.080 ; thoracic length 0.84 ± 0.012 ; width 0.76 ± 0.015 .

Each plate of pronotum with two rows of pits which parallel anterior margin. Mesonotum with median length

Table 4.—Duration (in days) of the 2nd to 5th instars of *O. venusta*^a

Nymphal stage	No. beginning stadium	No. completing stadium	Days	
			Range	Mean \pm SE
2nd instar	29	12	5–43	18.9 \pm 3.96
3rd instar	35	10	6–41	18.5 \pm 3.66
4th instar	45	5	6–29	13.8 \pm 3.94
5th instar	33	6	6–37	20.0 \pm 3.48

^a Laboratory and field specimens combined.

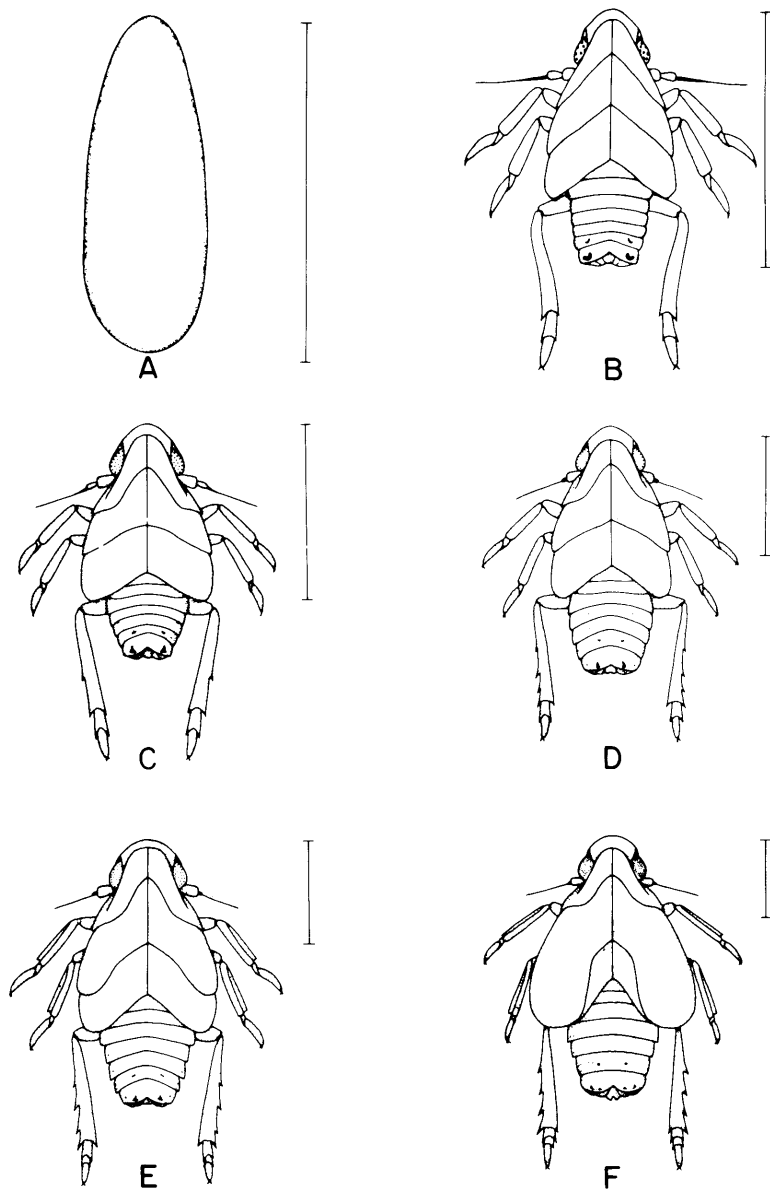


FIG. 8.—Immature stages of *O. venusta*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

1.5 to 2 times that of pronotum; each plate apparently without pits in posterolateral corner of mesonotum but with one to two small orange spots (in specimens preserved in EtOH) about midway between midline of mesonotum and lateral margin of mesonotum. Metatibiae bearing one black-tipped spine on lateral margin and an apical row of five black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of four to five black-tipped spines ventrally.

Abdominal segment 6 with two small shallow lateral white oval wax pads (may be obscure) on tergite on either side of midline.

Otherwise, similar to 1st instar.

3rd Instar (Fig. 8D). Length 2.39 ± 0.086 ; thoracic length 1.15 ± 0.013 ; width 1.08 ± 0.016 .

Each plate of mesonotum with several pits and two orange spots (in specimens preserved in EtOH) about midway between midline of mesonotum and lateral margin of mesonotum. Metanotum with median length three-fourths to equal that of mesonotum; each plate usually with one orange spot anteriorly and one posteriorly, near midline of metanotum (in specimens preserved in EtOH). Metatibiae bearing three black-tipped spines on lateral margin and an apical row of five to six black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of five to six black-tipped spines ventrally.

Abdomen with an obscure mid-dorsal longitudinal pale stripe; segment 6 with three small shallow lateral white oval wax pads (may be obscure) on tergite on either side of midline.

Otherwise, similar to 2nd instar.

4th Instar (Fig. 8E). Length 2.81 ± 0.110 ; thoracic length 1.44 ± 0.022 ; width 1.35 ± 0.027 .

Mesonotum with median length about twice that of pronotum; each plate with a weak longitudinal incomplete carina one-fourth to one-third the distance from midline of mesonotum to lateral margin of mesonotum; several obscure pits about midway between midline of mesonotum and lateral margin of mesonotum; each wingpad broadly expanded laterally, covering about half of each metanotal plate. Metanotum with median length about three-fourths that of mesonotum; posterior border usually faintly marked with orange (in specimens preserved in EtOH). Metatibiae bearing three black-tipped spines on lateral margin and an apical row of five to six black-tipped spines ventrally. Pro- and mesotarsi two-segmented; metatarsi three-segmented, segment 1 bearing an apical row of six to seven black-tipped spines ventrally, segment 2 bearing one apical black-tipped spine ventrally, segment 3 similar to segment 2 of previous instars.

Abdominal segments with tergites slightly tinged with orange (in specimens preserved in EtOH) and with a longitudinal white stripe one-half to two-thirds the distance from midline to lateral edge on either side of midline, and extending from tergite 3 to 6; segment 6 with four small shallow lateral white oval wax pads (may be obscure) on tergite on either side of midline.

Otherwise, similar to 3rd instar.

5th Instar (Fig. 8F). Length 3.97 ± 0.114 ; thoracic length 1.83 ± 0.037 ; width 2.35 ± 0.079 .

Pronotum with small orange markings (in specimens preserved in EtOH). Mesonotum with median length ca. 2.5 times that of pronotum; each plate with several obscure pits on a slightly raised area one-third to one-fourth the distance from midline of mesonotum to lateral margin of mesonotum; wingpad broadly expanded, extending to apex of metanotal wingpad. Metanotum with more prominent orange markings (in specimens preserved in EtOH); wingpad extending to fourth abdominal tergite. Metatibiae bearing three to four black-tipped spines on lateral margin and an apical row of 6 black-tipped spines ventrally. Metatarsi with segment 1 bearing an apical row of seven to eight black-tipped spines, segment 2 bearing two apical black-tipped spines ventrally.

Abdominal segments with tergites more heavily marked with orange (in specimens preserved in EtOH); segments 6 and 7 with smaller black markings on tergites; segment 6 with five shallow lateral oval wax pads (may be obscure) on tergite on either side of midline.

Otherwise, similar to 4th instar.

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