

Life Histories of *Acanalonia bivittata* and *A. conica*¹ with Descriptions of Immature Stages²

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ABSTRACT

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The life histories of *Acanalonia bivittata* (Say) and *A. conica* (Say) were investigated in southern Illinois, and the immature stages were described. Both species were also reared in the laboratory.

A. bivittata and *A. conica* are univoltine, feed on a wide variety of woody and herbaceous plants, and overwinter as eggs inserted in woody vegetation.

A. bivittata was reared on green beans and walnut leaves, *A. conica* on green beans and redbud leaves. Total development time averaged 212.3 and 311.1 days for *A. bivittata* and *A. conica*, respectively.

Nymphs of both species are attacked by one or more unidentified species of Dryinidae. *A. conica* nymphs are parasitized by a mite, *Leptus* sp., and adults and nymphs are parasitized by an epipyropid moth, *Epipyrops barberiana* Dyar.

Field and laboratory investigations of *Acanalonia bivittata* (Say) and *A. conica* (Say) were conducted between April 1977 and November 1979 in southern Illinois.

A. bivittata ranges from Maine south to Florida, and west to Minnesota, Kansas, Texas, and Arizona (Metcalf 1954). It occurs on a wide variety of plants (summarized by Wilson and McPherson 1980). The only information on this insect's life cycle is that of Scammell (1917a). He reported that, in New Jersey, eggs overwintered in blueberry (*Vaccinium corymbosum* L.) and cranberry (*V. macrocarpon* Aiton) twigs, and were found from 19 August to 20 June; nymphs were collected from 21 May to 11 October, and adults were collected from 27 July to 20 October. He also reared this insect under unspecified conditions, described the egg, and provided photographs of the eggs and nymphs. Swezey (1903) described and illustrated the 5th instar.

A. conica ranges from New Jersey south to Florida, and west to Nebraska and Texas (Metcalf 1954), and occurs on a wide variety of plants (Wilson and McPherson 1980). The only information on this insect's life cycle is that of Hoffmann (1942), who found eggs in dead twigs of American elm, *Ulmus americana* L. Forbes and Hart (1900) described the eggs of what they considered to be *A. conica*. However, they included an illustration of an adult *Anormenis septentrionalis* (Spinola), erroneously identified as *A. conica*; thus, the eggs may actually have been those of *A. septentrionalis* or some other species. No descriptions of the nymphs have been published.

Materials and Methods

Field Studies

Observations and collections were made 3 to 4 days per week from 1 April to 1 November in 1977 through 1979 at various locations in southern Illinois (detailed in Wilson 1980). However, more than 90% of the data were collected at the following sites: Thompson Woods,

Southern Illinois University at Carbondale (SIUC) campus, Jackson County; La Rue-Pine Hills Ecological Area, Union County; Indian Creek walnut plantation, Jackson County; and Tree Improvement Center walnut plantation, Jackson County. The Indian Creek and Tree Improvement Center plantations were planted in 1965.

Nymphs and adults were hand-picked or swept from vegetation and placed in shell vials with a piece of vegetation for moisture, and the vials were plugged with cotton. Twigs or leaves that appeared to have oviposition punctures were clipped and placed in plastic bags.

Field data per trip included numbers of each developmental stage collected, host plants and feeding sites (e.g., leaf underside, stem, etc.), and when appropriate, overwintering stages and sites.

Nymphs were recorded as feeding if one of the following was observed: (1) many individuals on the same plant, (2) exoskeletons from previous molts with beaks inserted in the plant tissue, (3) a large amount of wax surrounding the nymphs, or (4) drops of liquid exuding from the anus. It was more difficult to determine if adults were feeding because their forewings generally obscured the anus. Adults were recorded as feeding if the beak was observed to be inserted in the plant tissue, or if the planthopper remained in the same position for at least 30 sec.

Laboratory Study

Field-collected and laboratory-reared *A. bivittata* adults were maintained, and nymphs were reared, on green beans, *Phaseolus vulgaris* L., and black walnut, *Juglans nigra* L., leaves; field and laboratory adults of *A. conica* were maintained, and nymphs were reared, on green beans and redbud, *Cercis canadensis* L. 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.

¹ Homoptera: Fulgoroidea: Acanaloniidae.

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Eggs were inserted into bean peduncles and walnut rachises. Because these peduncles and rachises 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 was covered with the lid. The plastic prevented recently hatched nymphs from escaping between the dish and lid. 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 became adults. 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 or died; they were then preserved in 95% ethyl alcohol.

Descriptions of Immature Stages

Specimens to be described were preserved in 95% ethyl alcohol. 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 ethyl alcohol due to relatively broad intersegmental membranous areas. Drawings of eggs and nymphs were made with the aid of a camera lucida.

Results and Discussion

A. bivittata (Say)

Field Study.—*A. bivittata*, a univoltine species, apparently overwinters as eggs (Scammell 1917a,b) although no eggs were found in the field during the present study. Field-collected females, however, laid eggs in

the laboratory from 11 August to 30 October (see laboratory study).

Scammell (1917a) reported that *A. bivittata* females laid from 1 to ca. 20 eggs in living and dead twigs of blueberry, *V. corymbosum*, and cranberry, *V. macrocarpon*, and that the eggs overwinter. Many of these twigs fell to the ground during the winter and became submersed in water, which the eggs were evidently able to survive. Phipps (1930) noted that oviposition injures blueberry twigs.

Most nymphs and adults were collected by sweeping, although several feeding records were obtained (Table 1). One 1st instar was collected on 20 June. No 2nd instars were collected. Third instars occurred from late May to early July, 4th instars were collected from early June to late July, 5th instars were collected from late June to mid-August, and adults were collected from mid-July to early October (Fig. 1).

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

Parasitoids of this species include *Hesperodryinus amphiscipae* Perkins, *Perodryinus amoenus* Perkins (Hymenoptera: Dryinidae) (Krombein et al. 1979), and *Pipunculus* sp. (Diptera: Pipunculidae) (Perkins 1907). Predators include the spiders *Argiope aurantia* Lucas (Araneidae) and *Agelenopsis naevia* (Walckenaer) (Agelenidae) (Bilsing 1920). *A. bivittata* has also been found in pitcher plants (*Sarracenia flava* L.) (Wray and Brimley 1943).

Laboratory Study.—Field-collected and laboratory-reared females inserted their eggs in the woody peduncles of beans and the rachises of walnut leaves; the presence of eggs was detected by a row of tufts of wood shavings on the peduncle or rachis. Females laid 149 eggs, 101 in 12 bean peduncles (mean \pm SE = 8.4 ± 1.29) and 48 in 6 walnut rachises (mean \pm SE = 8.0 ± 2.03). Six of the 48 eggs were subsequently destroyed during handling.

Table 1.—Southern Illinois food plants of *A. bivittata*

Host taxon	Stages collected ^a
Liliaceae	
<i>Allium vineale</i> L.	N
Juglandaceae	
<i>Juglans nigra</i> L.	N, A
Ulmaceae	
<i>Ulmus rubra</i> Muhlenberg	A
Polygonaceae	
<i>Rumex crispus</i> L.	N
Leguminosae	
<i>Melilotus alba</i> Desrousseaux	N
Eleagnaceae	
<i>Eleagnus angustifolia</i> L.	N
Plantaginaceae	
<i>Plantago lanceolata</i> L.	N
<i>P. rugelii</i> Decaisne	N
Compositae	
<i>Cacalia atriplicifolia</i> L.	A
<i>Solidago canadensis</i> L.	N
<i>Verbesina</i> sp.	N

^a N, collected as nymph; A, collected as adult.

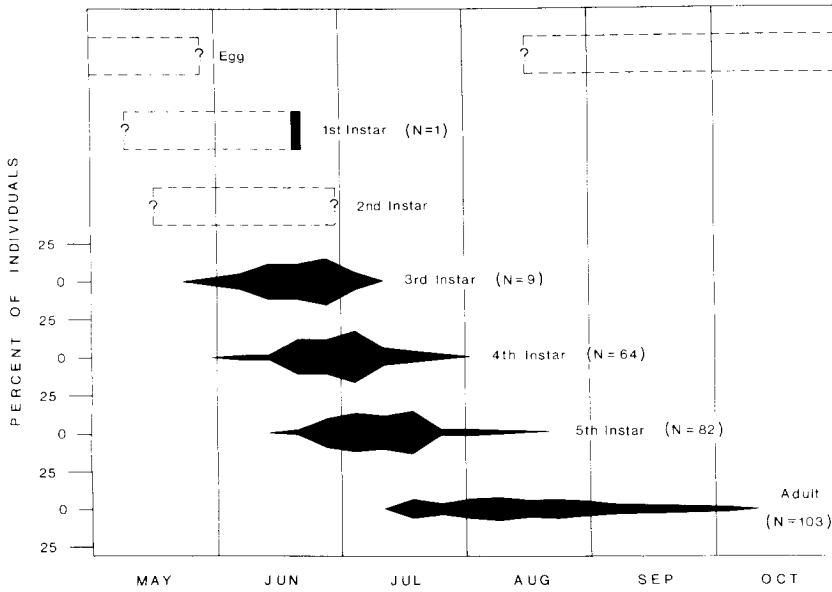


FIG. 1.—Seasonal occurrence of *A. bivittata* individuals in southern Illinois. Number of individuals of each stage is expressed as percentage of total observations of that stage.

One female was observed ovipositing. She straddled and grasped the peduncle with the third valvulae and excavated a cavity into the surface of the peduncle with the second pair. A conspicuous tuft of wood shavings was present at one end of the incision. After inserting the egg, the female moved along the peduncle and began a cavity for the next egg.

Of the 143 eggs, 41 (28.7%) hatched. The incubation period averaged 148.1 days (Table 2). Only three of the 1st instars reached the adult stage, and these data were supplemented with data from field-collected nymphs that had molted at least once in the laboratory. The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 12.7, 9.3, 12.0, 11.8, and 18.4 days, respectively (Table 2); total nymphal development averaged 64.2 days. Development from egg to adult averaged 212.3 days.

Descriptions of Immature Stages.—The following descriptions are based on laboratory specimens of the eggs, 1st and 2nd instars, and field specimens of the 3rd, 4th, and 5th instars. The white and light brown nymphs are usually found with waxy plumes, which are produced by the abdominal wax glands, on the posterior end.

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

Stage	No. beginning stadium	No. completing stadium	Days	
			Range	Mean ± SE
Egg	143	41	111–209	148.1 ± 3.96
Nymph				
1st instar	41	15	9–16	12.7 ± 0.55
2nd instar	18	10	6–15	9.3 ± 0.88
3rd instar	15	9	7–19	12.0 ± 1.27
4th instar	28	10	5–21	11.8 ± 1.47
5th instar	25	17	15–29	18.4 ± 1.05

^a Laboratory and field specimens combined.

Egg (Fig. 2A). Length 1.08 ± 0.011 ; width 0.48 ± 0.008 . Eggs laid singly; each elongate, oval; white when laid, turning orange ca. 6 weeks before hatching; chorion translucent, with a polygonal sculptured pattern, cephalic end with an elongate cylindrical process.

1st instar (Fig. 2B). Length 0.89 ± 0.037 ; thoracic length 0.45 ± 0.005 ; width 0.58 ± 0.007 .

Form elongate, subcylindrical. thoracic nota slightly humpbacked, widest across meso- and metathorax. Body white to yellowish brown with brown markings and many brown pits, lighter dorsally on head and thorax.

Head white to yellowish brown with brown markings and pits. Vertex approximately four times wider than long. Frons subrectangular, longer than wide, broadest dorsally, dorsal and lateral margins convex, ventral margin concave; each lateral margin carinate (outer carina) and paralleled by a second carina (inner carina) approximately midway between it and the midline of the frons, both carinae well defined; 10 to 12 pits between each inner and outer carina. Clypeus light brown; narrowing distally, consisting of a subconical, basal postclypeus and a beak like, cylindrical, distal anteclypeus. Beak three-segmented, gray to brown, black laterally and apically, extending beyond metacoxae; segment 1 covered by anteclypeus; segments 2 and 3 subequal. Eyes red. Antennae three-segmented, light brown; segment 1 short, cylindrical; segment 2 subcylindrical, pale apically; segment 3 bulbous basally, with an elongate bristle-like extension apically.

Thoracic nota white to yellowish brown with brown markings and pits; divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, extending to ventral level of antennae; each plate subtriangular, narrowing laterally with anterior and posterior margins arcuate, with a row of 11 pits which parallels the anterior margin (lateralmost pits not visible in

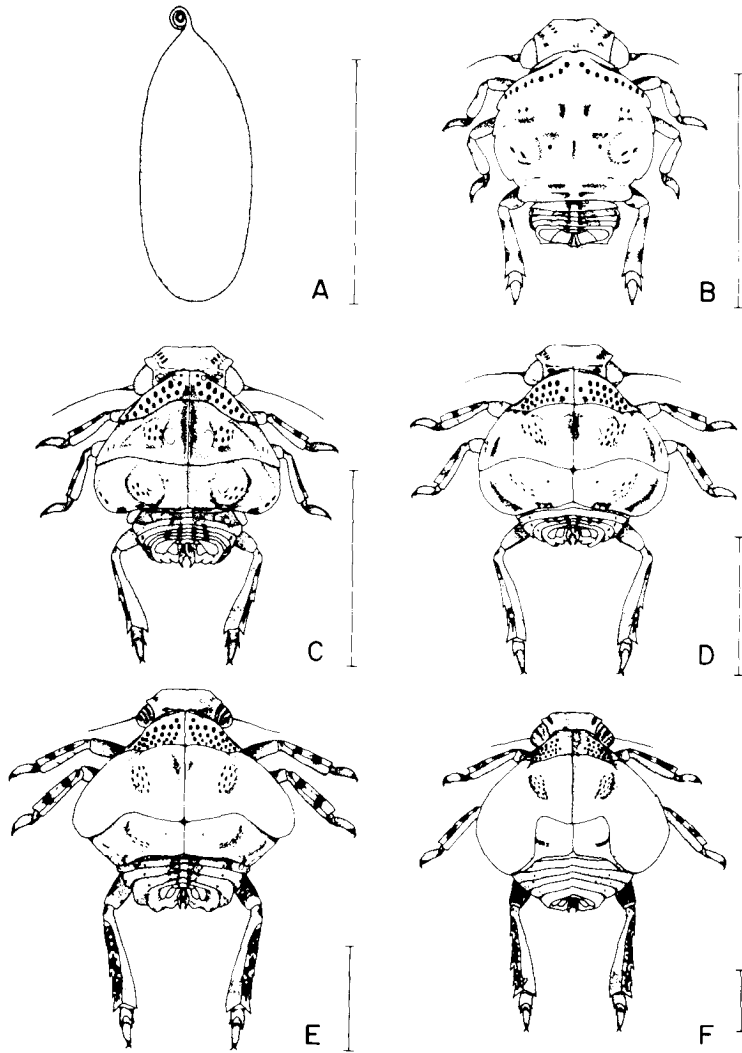


FIG. 2.—Immature stages of *A. bivittata*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

dorsal view). Mesonotum longest medially, median length ca. 1.5 times that of pronotum; each plate subrectangular, posterior margin slightly arcuate, with a raised white area bearing a crater-like depression near midline of mesonotum, two pits between raised area and lateral margin of mesonotum, and two pits (not visible in dorsal view in this instar) in posterolateral corner of mesonotum. Metanotum longest laterally, median length ca. three-fourths that of mesonotum; each plate subrectangular, posterior margin almost straight, with a raised white area bearing a crater-like depression approximately midway between midline and lateral margin of metanotum, one pit between midline and raised area, 3 to 4 pits on and just lateral to raised area, and one pit in posterolateral corner of metanotum (not visible in dorsal view in this instar). Coxae light brown with brown markings; pro- and mesocoxae elongate, subcylindrical posteroventrally directed; metacoxae subrectangular, transverse; remaining segments of legs with

very fine setae (not illustrated). Femora yellowish brown. Tibiae yellowish brown, each with a pair of brown incomplete transverse bands; metatibiae bearing an apical row of four black-tipped spines ventrally. Tarsi two-segmented, brown; 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 dark claws and a pale pulvillus apically.

Abdomen nine-segmented, subcylindrical, widest across segments 2 through 4; segments 7 through 9 partially 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 8 with tergites curving around lateral margin to ventral side, segment 9 with tergite short and bearing a median carina. Each segment with the following num-

ber of pits and wax pads on either side of midline (lateralmost, ventral and caudal pits often not visible in dorsal view): segments 4 through 7 each with two lateral pits on tergite, segment 8 with one ventral pit, segment 9 with three caudal pits; segments 4 through 6 each with one small lateral circular yellow wax pad near lateral margin, segments 7 and 8 each with one caudal oval yellow wax pad, segment 9 without pads.

2nd instar (Fig. 2C). Length 1.01 ± 0.042 ; thoracic length 0.66 ± 0.019 ; width 0.92 ± 0.028 ; seven specimens examined.

Body white dorsally with light brown markings and brown ventrally with pale markings; pits light brown.

Vertex obscured medially by anterior extension of pronotum; a shallow oval crater-like depression present on either side of midline. Frons with 13 pits between each inner and outer carina. Clypeus pale to brown, often darker than frons.

Thoracic nota more strongly humpbacked. Each plate of pronotum with posterior margin more arcuate, with a shallow crater-like depression at anterior margin near midline of pronotum, and two rows of pits which parallel the anterior margin (and an additional pit anteromedial to anterior row), anterior row with 12 to 14 pits, (lateralmost pits not visible in dorsal view), posterior row with 5 to 6 pits. Each plate of mesonotum with posterior margin more arcuate, raised area bearing 6 to 8 pits, and with 4 pits (not all visible in dorsal view) near lateral margin of mesonotum. Each plate of metanotum with posterior margin slightly arcuate, raised area bearing one to two shallow crater-like depressions and five to six pits, and one obscure shallow crater-like depression and two well-defined pits near lateral margin of metanotum. Metatibiae with 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 7 and 9 with same number of pits as previous instar; other segments with following number of pits on either side of midline (lateralmost, ventral, and caudal pits often not visible in dorsal view): segment 3 with one lateral pit on tergite, segments 4 through 6 each with three lateral pits on tergite, segment 8 with two ventral pits.

Otherwise, similar to 1st instar.

3rd instar (Fig. 2D). Length 2.01 ± 0.156 ; thoracic length 1.19 ± 0.030 ; width 1.51 ± 0.029 ; six specimens examined.

Body white dorsally with fewer light brown markings; darker ventrally, light grayish brown to brown with pale markings; pits light brown to white.

Frons occasionally with three shallow, crater-like depressions just median to each inner carina and with 13 to 16 pits between each inner and outer carina; inner and outer carinae weakly defined, inner carinae sometimes absent.

Thoracic nota more strongly humpbacked. Each plate of pronotum with three rows of pits which parallel anterior margin, anterior row with 14 to 15 pits (lateralmost pits not visible in dorsal view), middle row with 6 to 7 pits, posterior row with 4 to 5 pits. Mesonotum with median length approximately two times that of pronotum; each plate with raised area bearing 10 to 11

pits, and with seven pits (lateralmost pits often not visible in dorsal view) near lateral margin of mesonotum. Metanotum with median length half to three-fourths that of mesonotum; each plate with raised area bearing two shallow crater-like depressions and eight pits, and with one well-defined shallow crater-like depression and three obscure pits near lateral margin of metanotum. Metatibiae heavily marked with brown, transverse bands less apparent; with one to two black-tipped spines on lateral margin and an apical row of six black-tipped spines ventrally.

Abdominal segment 9 with the same number of pits as previous instar, other segments with pits generally more numerous.

Otherwise, similar to 2nd instar.

4th instar (Fig. 2E). Length 2.11 ± 0.086 ; thoracic length 1.47 ± 0.040 ; width 1.97 ± 0.040 .

Body white dorsally with fewer light brown markings, clypeus and ventral side of thorax usually darker.

Frons with three to four shallow, crater-like depressions and with 18 to 21 pits near each lateral margin.

Each plate of pronotum with four poorly defined rows of pits which parallel anterior margin, pits more numerous. Each plate of mesonotum with an obscure, shallow, crater-like depression near anterior border just lateral to midline of mesonotum, with raised area bearing 12 to 15 pits, and with 9 to 11 obscure pits between raised area and lateral margin of mesonotum; each wingpad broadly rounded posterolaterally and covering one-third to one-half of each metanotal plate laterally. Metanotum with median length approximately half that of mesonotum; each plate with one shallow, crater-like depression near midline of metanotum, with raised area bearing 10 to 12 obscure pits, and with 3 to 4 pits near lateral margin of metanotum; wingpad extending to fourth abdominal tergite. Legs with brown markings darker. Metatibiae with two to three 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 five to six black-tipped spines ventrally, segment 2 bearing two small apical black-tipped spines ventrally, segment 3 similar to segment two of previous instars.

Abdominal segment 9 with the same number of pits as previous instar, other segments with pits generally more numerous.

Otherwise, similar to 3rd instar.

5th instar (Fig. 2F). Length 3.31 ± 0.116 ; thoracic length 2.09 ± 0.023 ; width 2.78 ± 0.047 .

Body white dorsally, heavily marked with light brown mottled with white; clypeus, ventral side of thorax, and legs darker.

Frons with many small obscure pits near lateral margins.

Pronotum with pits more numerous. Each plate of mesonotum with raised area bearing 14 to 18 pits; wingpad broadly expanded, extending to apex of metanotal wingpad. Each plate of metanotum with raised area bearing 12 to 16 pits; wingpad extending to third or fourth abdominal tergite. Metatibiae bearing three black-tipped spines on lateral margin and an apical row of six to seven black-tipped spines ventrally.

Abdominal segment 9 with the same number of pits

as previous instar, other segments with pits generally more numerous; segment 3 with a shallow, crater-like depression on either side of midline, near lateral margin of tergite.

Otherwise, similar to 4th instar.

A. conica (Say)

Field study.—*A. conica* feeds and develops on several plant species (Table 3) and is univoltine. It inserts its eggs in woody tissue and apparently overwinters in this stage. A female was observed on 12 September 1978 inserting eggs in the live stem of a grape vine (*Vitis* sp.) in Thompson Woods. The vine was tagged with a piece of red plastic flagging so that hatching could be observed, and the eggs counted the following spring. However, the vine was destroyed in pruning operations before the eggs hatched. A second vine containing seven eggs was found on 20 September 1978. Field-collected females laid eggs in the laboratory from 29 August to 5 October (see laboratory study below).

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

One parasitoid and two parasites were found. A larval dryinid emerged from a field-collected *A. conica* nymph and pupated on the wall of the petri dish; however, the adult wasp never emerged, and this parasitoid could not be identified further. Adult and nymphal *A. conica* were attacked by *Epipyrops barberiana* Dyar (Lepidoptera: Epipyropidae) (Wilson and McPherson 1979). Larval mites, (*Leptus* sp., Acari: Erythraeidae) were found attached to the abdomen of nymphs. No predators were collected.

Laboratory Study.—Field-collected and laboratory-reared females inserted eggs into the woody peduncles of beans (Fig. 4). Oviposition is similar to that of *A. bivittata*. From 1 to 25 eggs were laid in 33 bean peduncles (mean \pm SE = 7.7 \pm 0.92).

Of the 155 eggs laid in the laboratory, only 23 (14.8%) hatched. The incubation period averaged 218.5 days (Table 4). Only 1 of the 23 nymphs molted to the 2nd instar, and thus, these rearing data were supplemented with data from field-collected nymphs that had molted at least once in the laboratory. The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 24, 14.2, 16.9, 17.4, and 20.1 days, respectively (Table 4); total nymphal development averaged 92.6 days. Development from egg to adult averaged 311.1 days.

Descriptions of Immature Stages.—The following descriptions were based on laboratory specimens of eggs and field specimens of nymphs. The brownish nymphs are usually found with waxy plumes, which are produced from the abdominal wax glands, on the posterior end.

Egg (Fig. 5A). Length 1.31 \pm 0.016; width 0.48 \pm 0.006. Eggs laid singly; each elongate, oval; white when laid, turning orange ca. 6 weeks before hatching; chorion translucent, with a polygonal sculptured pattern, cephalic end with an elongate cylindrical process.

1st instar (Fig. 5B). Length 0.90 \pm 0.044; thoracic length 0.52 \pm 0.009; width 0.67 \pm 0.013.

Form elongate, subcylindrical, thoracic nota greatly humpbacked, widest across metathorax. Body white to light brown, with brown markings and many brown pits.

Head white to light brown with brown markings and pits. Vertex wider than long, obscured medially 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

Table 3.—Southern Illinois food plants of *A. conica*

Host taxon	Stages collected ^a
Graminae	
<i>Chasmanthium latifolium</i> (Michaux) . . .	N
<i>Festuca pratensis</i> Hudson	N
<i>Panicum</i> sp.	N
Commelinaceae	
<i>Commelina communis</i> L.	N
Juglandaceae	
<i>Juglans nigra</i> L.	N, A
Betulaceae	
<i>Alnus glutinosa</i> (L.)	N
Ulmaceae	
<i>Ulmus rubra</i> Muhlenberg	N
Moraceae	
<i>Maclura pomifera</i> (Rafinesque)	N, A
<i>Morus rubra</i> L.	N, A
Polygonaceae	
<i>Rumex crispus</i> L.	N, A
<i>R. obtusifolius</i> L.	N
Phytolaccaceae	
<i>Phytolacca americana</i> L.	A
Annonaceae	
<i>Asimina triloba</i> (L.)	N, A
Lauraceae	
<i>Sassafras albidum</i> (Nuttall)	N, A
Hamamelidaceae	
<i>Liquidambar styraciflua</i> L.	N
Rosaceae	
<i>Geum canadense</i> Jacquin	N
<i>Prunus serotina</i> Ehrhart	N
<i>Rosa multiflora</i> Thunberg	N
Leguminosae	
<i>Cercis canadensis</i> L.	N
<i>Melilotus alba</i> Desrousseaux	N
<i>M. officinalis</i> (L.)	N
<i>Robinia pseudoacacia</i> L.	N, A
Anacardiaceae	
<i>Rhus radicans</i> L.	N
Aceraceae	
<i>Acer negundo</i> L.	A
<i>A. saccharinum</i> L.	N
Vitaceae	
<i>Vitis</i> sp.	N
Cornaceae	
<i>Cornus florida</i> L.	N, A
Oleaceae	
<i>Fraxinus americana</i> L.	N, A
Bignoniaceae	
<i>Campsis radicans</i> (L.)	N, A
Plantaginaceae	
<i>Plantago rugelii</i> Decaisne	N
Caprifoliaceae	
<i>Lonicera japonica</i> Thunberg	N
Compositae	
<i>Ambrosia artemisiifolia</i> L.	N, A
<i>A. trifida</i> L.	N, A
<i>Solidago canadensis</i> L.	N

^a N, collected as nymph; A, collected as adult.

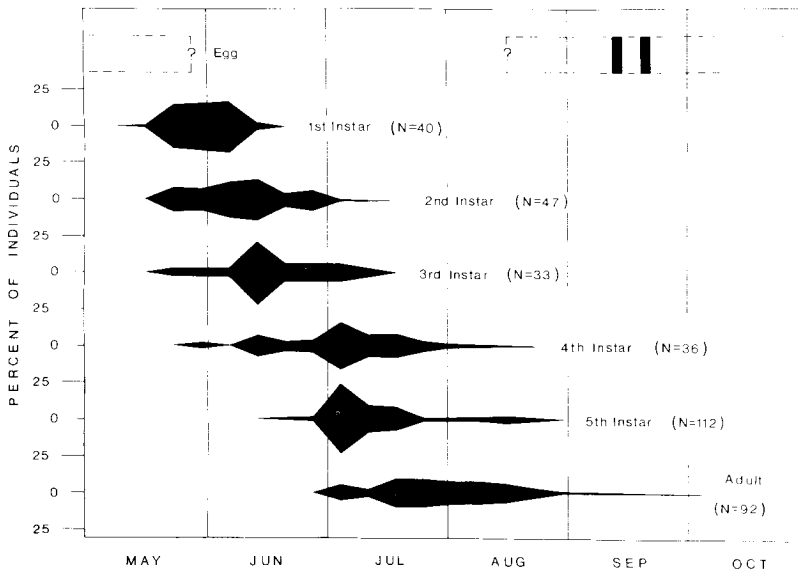


FIG. 3.—Seasonal occurrence of *A. conica* instars in southern Illinois. Number of individuals of each stage is expressed as percentage of total observations of that stage.

a second carina (inner carina) approximately midway between it and the midline of the frons; 11 to 12 pits between each inner and outer carina. Clypeus brown with light markings; narrowing distally, consisting of a subconical, basal postclypeus and a beak like, cylindrical, distal anteclypeus. Beak three-segmented, white to gray, black laterally and apically, extending beyond metacoxae; segment 1 covered by anteclypeus; segments 2 and 3 subequal. Eyes red. Antennae three-segmented, brown; segment 1 short, cylindrical; segment 2 subcylindrical, pale apically; segment 3 bulbous basally, with an elongate bristle-like extension apically.

Thoracic nota white to light brown, with brown markings and pits; divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, extending laterally to ventral level of antennae; each plate subtriangular, narrowing laterally, anterior margin slightly arcuate and posterior margin curved laterally, with a row of 11 pits which parallels the anterior margin

(lateralmost pits not visible in dorsal view). Mesonotum longest medially, median length 1.5 to 2 times that of pronotum; each plate subrectangular, posterior margin arcuate, with an oblique carina extending from near anterior midline of mesonotum to approximately the middle of posterior margin of plate, two pits between carina and lateral margin of mesonotum and two pits (often only one visible in dorsal view) in posterolateral corner of mesonotum. Metanotum longest laterally, median length approximately half that of mesonotum; each plate subrectangular, posterior margin slightly arcuate, with one pit approximately midway between midline and lateral margin of metanotum and one pit in posterolateral corner of metanotum. Pro- and mesocoxae elongate, subcylindrical, posteroventrally directed; metacoxae subrectangular, transverse; remaining segments of legs with very fine setae (not illustrated). Pro- and mesotibiae with a pair of brown incomplete transverse bands; metatibiae bearing an apical row of four black-tipped spines

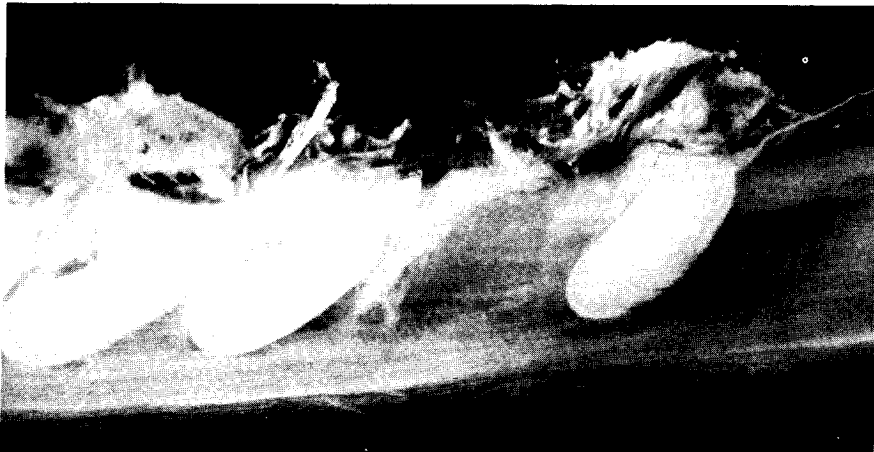


FIG. 4.—Longitudinal section of bean peduncle containing eggs of *A. conica*.

Table 4.—Duration (in days) of each immature stage of *A. conica*^a

Stage	No. beginning stadium	No. completing stadium	Days	
			Range	Mean \pm SE
Egg	155	23	143–269	218.5 \pm 8.49
Nymph				
1st instar	23	1	—	24
2nd instar	44	22	7–26	14.2 \pm 1.32
3rd instar	59	31	7–44	16.9 \pm 1.99
4th instar	93	37	7–46	17.4 \pm 1.71
5th instar	65	21	14–59	20.1 \pm 2.09

^a Laboratory and field specimens combined.

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 2; segments 7 through 9 partially 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 8 with tergites curving around lateral margin to ventral side,

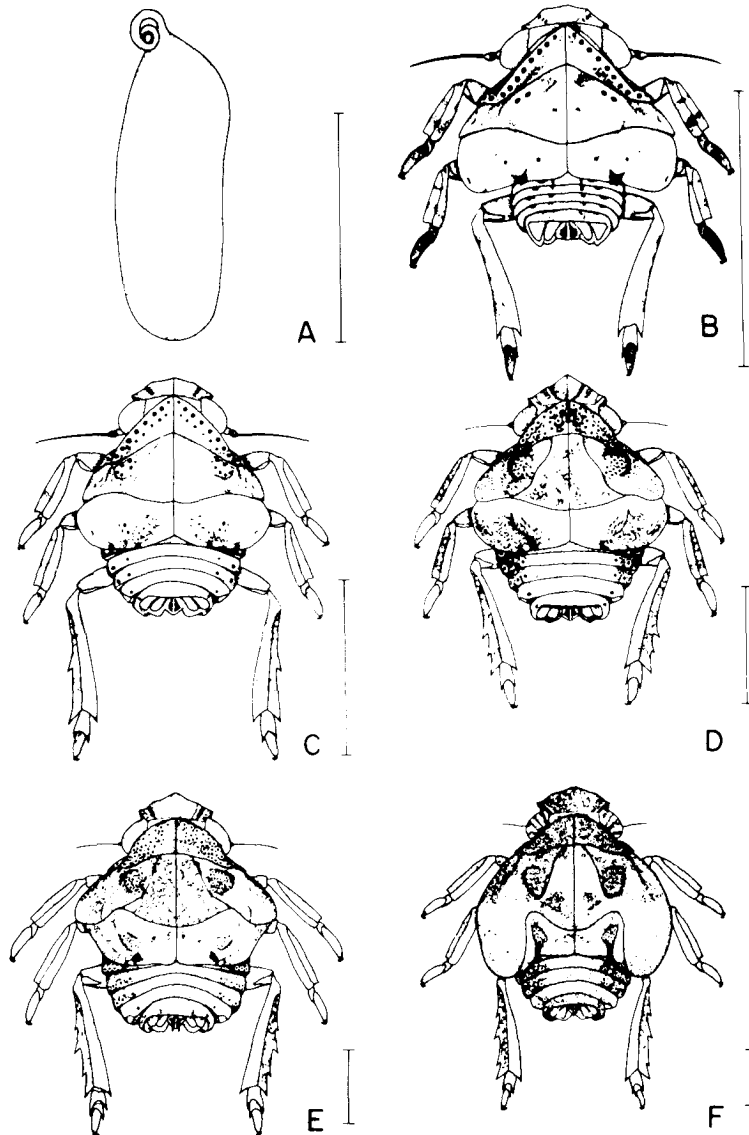


FIG. 5.—Immature stages of *A. conica*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

segment 9 with tergite short and bearing a median carina. Each segment with the following number of pits and wax pads on either side of midline (lateralmost, ventral, and caudal pits and wax pads often not visible in dorsal view): segments 4 through 7 each with two lateral pits on tergite, segment 8 with one ventral pit, segment 9 with three caudal pits; segments 6 through 8 each with one caudal oval yellow wax pad, segment 9 without pads.

2nd instar (Fig. 5C). Length 1.40 ± 0.036 ; thoracic length 0.90 ± 0.009 ; width 1.11 ± 0.016 .

Frons with a median carina; with 13 to 15 pits between each inner and outer carina.

Each plate of pronotum with two rows of pits which parallel the anterior margin, anterior row with 14 to 15 pits (lateralmost pits not visible in dorsal view), posterior row with 5 to 7 pits. Mesonotum light brown with white markings; median length approximately two times that of pronotum; each plate with a raised area bearing 7 to 8 pits between carina and lateral margin of mesonotum, and three to four well-defined pits (lateralmost pits often not visible in dorsal view) near lateral margin of mesonotum. Metanotum white, marked with brown posteriorly; each plate with a raised area bearing four to five pits approximately midway between midline and lateral margin of metanotum, and one to two pits near lateral margin of metanotum. Metatibiae 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.

Abdominal segment 9 with the same number of pits as previous instar; other segments with the following number of pits on either side of midline (lateralmost, ventral, and caudal pits often not visible in dorsal view): segment 3 with one lateral pit on tergite, segments 4 to 7 each with three lateral pits on tergite, segment 8 with one to two ventral pits.

Otherwise, similar to 1st instar.

3rd instar (Fig. 5D). Length 2.03 ± 0.086 ; thoracic length 1.32 ± 0.028 ; width 1.66 ± 0.038 .

Body more heavily marked with brown.

Frons anteriorly produced, dorsal margin almost straight; with 18 to 20 pits between each inner and outer carina.

Thoracic nota more strongly humpbacked. Each plate of pronotum with three rows of pits, anterior row with 15 to 16 pits (lateralmost pits not visible in dorsal view), middle row with 7 to 8 pits, posterior row with 4 to 5 pits. Each plate of mesonotum with raised area bearing 12 to 16 pits, and with 6 to 7 obscure pits near lateral margin of mesonotum. Each plate of metanotum with raised area bearing seven to nine pits, and three well-defined pits (lateralmost pits often not visible in dorsal view) near lateral margin of metanotum. Pro- and mesotibiae without well-defined brown transverse bands; metatibiae bearing one to two 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 to seven black-tipped spines ventrally.

Abdominal segment 9 with the same number of pits as previous instar, other segments with pits generally more numerous.

Otherwise, similar to 2nd instar.

4th instar (Fig. 5E). Length 2.36 ± 0.034 ; thoracic length 1.78 ± 0.028 ; width 2.17 ± 0.053 .

Body darker, mottled with white, often with black markings along posterior border of metanotum.

Frons more anteriorly produced, appearing conical; median and inner carinae weakly developed; with 22 to 26 pits between each inner and outer carina.

Thoracic nota more strongly humpbacked. Each plate of pronotum with three irregular rows of 32 to 38 pits (lateralmost pits not visible in dorsal view). Each plate of mesonotum with raised area bearing 17 to 22 pits, and with 9 to 11 obscure pits near lateral margin of mesonotum; each wingpad broadly rounded posterolaterally, covering one-third to one-half of each metanotal plate laterally. Each plate of metanotum with raised area bearing 11 to 13 pits, and with four obscure pits near lateral margin of metanotum; wingpad extending to third or fourth abdominal tergite. Metatibiae bearing two to three black-tipped spines on lateral margin and an apical row of seven black-tipped spines ventrally. Pro- and mesotarsi two-segmented; metatarsi three-segmented, segment 1 bearing an apical row of eight black-tipped spines ventrally, segment 2 bearing two apical black-tipped spines ventrally, segment 3 similar to segment 2 of previous instars.

Abdominal segment 9 with the same number of pits as previous instar, other segments with pits generally more numerous.

Otherwise, similar to 3rd instar.

5th instar (Fig. 5F). Length 3.44 ± 0.099 ; thoracic length 2.37 ± 0.042 ; width 3.04 ± 0.050 .

Body usually darker.

Frons with inner and outer carinae weak or absent; with 23 to 31 pits on either side of midline near lateral margin.

Pronotum with pits more numerous. Each plate of mesonotum with raised area bearing 23 to 30 pits and with 12 to 16 pits near lateral margin of mesonotum; wingpad broadly expanded, extending to apex of metanotal wingpad. Each plate of metanotum with raised area bearing 13 to 17 pits; wingpad extending to fourth abdominal tergite. 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 nine black-tipped spines ventrally.

Abdominal segment 9 with the same number of pits as previous instar, other segments with pits generally more numerous.

Otherwise, similar to 4th instar.

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REFERENCES CITED

- Bilising, S. W. 1920.** Quantitative studies on the food of spiders. *Ohio J. Sci.* 20: 215-260.
- Forbes, S. A., and C. A. Hart. 1900.** The economic entomology of the sugar beet. *Bull. Illinois Agric. Exp. Stn.* 60: 397-517.
- Hoffmann, C. H. 1942.** Annotated list of elm insects in the United States. *Misc. Publ. U.S. Dep. Agric.* 466: 1-20.
- Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks. 1979.** Catalog of Hymenoptera in America north of Mexico, vol. 2. Apocrita (Aculeata), pp. 1199-2209. Smithsonian Institution Press, Washington, D.C.
- Metcalf, Z. P. 1954.** General catalogue of the Homoptera. Fasc. IV. Fulgoroidea. Part 14. Acanaloniidae, 64 pp.
- Perkins, R. C. L. 1907.** Parasites of leaf-hoppers. General remarks on parasites of leaf-hoppers. *Bull. Hawaiian Sugar Planters Assoc. Div. Entomol.* 4: 5-59.
- Phipps, C. R. 1930.** Blueberry and huckleberry insects. *Bull. Maine Agric. Exp. Stn.* 356: 107-232.
- Scammell, H. B. 1917a.** *Amphiscepa bivittata* Say, in its relation to cranberry. *J. Econ. Entomol.* 10: 552-556.
- 1917b.** Cranberry insect problems and suggestions for solving them. *Farmers' Bull U.S.D.A.* 860: 1-45.
- Swezey, O. H. 1903.** Life history notes on two Fulgoroidea. *Ohio Nat.* 3: 354-356.
- Wilson, S. W. 1980.** The planthoppers, or Fulgoroidea, of Illinois with information on the biology of selected species. Ph.D. thesis, Southern Illinois University at Carbondale. 446 pp.
- Wilson, S. W., and J. E. McPherson. 1979.** Notes on the occurrence of *Epipyrops barberiana* in southern Illinois (Lepidoptera: Epipyropidae). *Great Lakes Entomol.* 12: 189-190.
- 1980.** A list of the host plants of the Illinois Acanaloniidae and Flatidae (Homoptera: Fulgoroidea). *Trans. Ill. State Acad. Sci.* (in press).
- Wray, D. L., and C. S. Brimley. 1943.** The insect inquilines and victims of pitcher plants in North Carolina. *Ann. Entomol. Soc. Am.* 36: 128-137.

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