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Morphology of the Labial Gland System of the Mature Larva of the Black Carpenter Ant, *Camponotus pennsylvanicus* (DeGeer)

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The morphology of the labial gland system of mature larvae of *Camponotus pennsylvanicus* is described. Regions of the labial gland system (gland tubes, reservoirs, thin and thick portions of the paired ducts, and common duct) were examined with electron microscopy, and a comparison of organelle and cell morphology was made. The gland tubes secrete silk which is stored in the reservoirs. The final water and/or ion content of the secretion may be modified by the paired ducts and common duct.

INDEX DESCRIPTORS: Carpenter ant; Hymenoptera; larvae; labial gland; silk gland; salivary gland.

The black carpenter ant, *Camponotus pennsylvanicus*, is a widespread insect, and can be a serious household pest.

The systematics and external morphology of larvae of *Camponotus* were described by Wheeler and Wheeler (1953, 1968); that of the tribe Comptonotini were described by Wheeler and Wheeler (1953, 1982). The feeding specializations of the larvae of *Camponotus* were described by Petralia and Vinson (1979) and Wheeler and Wheeler (1953, 1970). Athias-Henriot (1947) and Valentini (1951) described the internal anatomy and histology of larvae of *Camponotus*. Specific aspects of the histology of larvae of *Camponotus* were explained by Bonavita-Cougourdan and Poveda (1972) and Casal (1948).

The morphology of the labial gland system of ant larvae reflects its possible functions in silk spinning and/or digestion. Labial glands of mature larvae of many taxa of ants including *Camponotus*, secrete silk for cocoon formation (Wheeler and Wheeler 1976). Enzyme activity (i.e. for pre-oral digestion of food) of labial gland secretion was described for larvae of *Acromyrmex octospinosus* (Febvay and Kermarrec 1981) and *S. invicta* (Petralia et al. 1980).

Histological studies (light microscopy) of the labial gland systems of any larvae other than *Camponotus* include those of Emmert (1968, 1969); Lappano (1958); Ofer (1970); Petralia and Vinson (1980); Wang and Happ (1974); and Wheeler (1910). Athias-Henriot (1947) and Valentini (1951) described the labial gland systems of the larvae of numerous ant species including some species of *Camponotus*. Petralia et al. (1980) described the ultrastructure of the gland tube and reservoir regions of the labial gland system of the larvae of the imported fire ant, *Solenopsis invicta* Buren. This is the only published study on the ultrastructure of the labial glands of ant larvae. We report on the ultrastructure of the labial gland system in mature larvae of *C. pennsylvanicus*.

MATERIALS AND METHODS

Mature larvae (6-8 mm) (undetermined instar- the exact number of instars has not been described [see Wheeler and Wheeler 1953]) of *C. pennsylvanicus* were collected from Scott County, Iowa, and identified from adult workers. Adults, pupae and larvae from this study are preserved in the insect collection of the Department of Biology, St. Ambrose College.

Colonies were collected according to the techniques described for *S. invicta* (Petralia and Vinson 1978). Colonies were maintained in talcum-lined, clear plastic shoe boxes, containing cotton-plugged, water-filled glass tubes, and fed an artificial diet.

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The labial gland system was dissected from larvae, and was immediately fixed in cool 6% glutaraldehyde in cacodylate buffer for 3-5 hours, then postfixed in 2% osmium tetroxide. Glands were dehydrated and imbedded in Spurr's medium (Spurr, 1969) before sectioning. Sections were stained with uranyl acetate and lead citrate, mounted on grids, and examined at 50 kV in an RCA EMU-3E transmission electron microscope. One micrometer thick sections were stained with 1% methylene blue - 1% sodium borate and examined with a compound light microscope.

RESULTS

General Anatomy of the Labial Gland System (Fig. 1)

A pair of gland tubes joins to a common gland tube, on each side. Extra branches are common, particularly from the dorsal gland tube, extending cephalad from the attachment to the common gland tube. The two common gland tubes open into narrow, thin-walled reservoirs. Thin portions of the paired ducts connect the reservoirs to the thick portions of the paired ducts. The thick portions of the paired ducts intersect with the thick-walled common duct, which opens onto the labium. The cells of both the common duct and the thick portion of the paired duct stain densely with osmium tetroxide, and contain a prominent cuticular intima.

General Cell Structure

The nuclei of cells of all regions are slightly irregular, euchromatic and with scattered heterochromatin (Fig. 2, 3). Mitochondria have a dense matrix and are more common near the apex (Fig. 2, 3, 4). Elongate mitochondria are most evident in the cells of the common duct and thick portion of the paired duct. The rough endoplasmic reticulum is most abundant in the cells of the gland tubes. Numerous enlarged rough endoplasmic reticulum cisternae are most common in the cells of the gland tubes, particularly in the basal half of each cell.

Intercellular Junctions

Cells of all regions are joined by septate desmosomes (Fig. 6). Wide basal spaces are evident. An apical belt desmosome is found in the cells of the gland tubes, reservoir and thin portion of the paired duct, and is notably longer in the latter two regions (Fig. 4). Cellular interdigitations are found in all regions but are most extensive in the unexpanded reservoir and thin portion of the paired duct (Fig. 4).

Secretory Granules

Apical secretory granules are found only in the cells of the gland tubes (Fig. 2). These granules have varying density, and assume a bowling-pin shape with a dense apex. Large, dense granules, often containing lamellae, are found in the cells of the common duct and

DISCUSSION

General Anatomy

The labial gland system of larvae of *C. pennsylvanicus* resembles that described in the larvae of other species of *Camponotus* (Athias-Henriot 1947, Valentini 1951). However, neither the accessory gland-tube branches nor the thick portion of the paired duct were described by those authors. Accessory gland-tube branches are found also in specimens of *Lasius alienus* and *Formica pallidefulva nitidiventris* (unpublished data). The thick portion of the paired duct is present in *C. noveboracensis* (unpublished data), and is homologous to the shorter "bulbus" region in the labial gland system of *Formica pratensis* (Emmert 1968, 1969). A cuticular spiral is well-developed in the common duct of the larvae of some species of ants (Petralia and Vinson 1980). However, it is only poorly developed in *C. pennsylvanicus*. This may explain the inconsistencies in the literature concerning the presence (Athias-Henriot 1947) or absence (Valentini 1951) of a cuticular spiral in *C. sylvaticus* ssp. *barbarica*. The common duct and thick portion of the paired duct stain densely with osmium tetroxide due to the abundance of basal lipid droplets.

Cell Structures

The arrangement of the rough endoplasmic reticulum and numerous mitochondria is indicative of active secretion of proteinaceous substances (Akai 1984). The relatively small amount of rough endoplasmic reticulum in the duct regions is typical of labial glands in insects (Dailey and Crang 1978b, Engster 1976).

Intercellular junctions are similar to those described in the labial glands of larvae of *S. invicta* (Petralia *et al.* 1980).

The lamellar bodies found in the thick portion of the paired duct resemble those found in the duct transport system of the salivary glands of the cockroach, *Gromphadorbina portentosa* (Dailey and Crang 1978b). The lamellar bodies of the common duct and thick portion of the paired duct are probably autophagosomes (Dailey and Crang 1978a, Akai 1984). The "bowling pin" secretory granules of the gland tubes resemble the coalescing vesicles of the salivary glands of *G. portentosa* (Dailey and Crang 1978a) and the secretory granules of the salivary glands of *Locusta migratoria*. The granules of the latter contain a densely staining protein-rich region and a lighter region which is rich in acidic mucopolysaccharides (Lauverjat 1972, 1973).

The arrangement of microvilli under the cuticular intima of the common duct and thick portion of the paired ducts resembles that described in the salivary glands (Dailey and Crang 1978b, Engster 1976) and other glands (Landolt and Akre 1979) of some insects. The presence of mitochondria in some apical microvilli is indicative of very active fluid transport (Green 1979, 1980). Also, the well-developed basal infoldings of the gland tube cells are typical of actively secreting labial glands (Engster 1976, Petralia *et al.* 1980).

Specializations of the duct regions are comparable to those found in some other insects (Dailey and Crang 1978b, Engster 1976). Engster (1976) suggests that the duct region may absorb excess ions and/or water from the luminal secretion of the silk glands of the larvae of Trichoptera. Dailey and Crang (1978b) indicate that the duct region controls the water and/or ion content of the salivary gland secretion of the cockroach, *G. portentosa*. The possible role of the common duct and thick portion of the paired duct in modifying the labial secretion is supported by the presence of lipid droplets in the basal region of the cells. Numerous lipid droplets are found in the basal region of some cells in the Malpighian tubules of the New Zealand glow-worm, *Arachnocampa luminosa*, and may be an energy source for reabsorption of ions from the tubule lumen (Green 1979).

The labial glands of the mature larvae of *C. pennsylvanicus* secrete silk for cocoon formation. The initial secretion is produced in the glandular portions and stored in the reservoirs. We suggest that the duct regions function as follows: The thin portion of the paired ducts

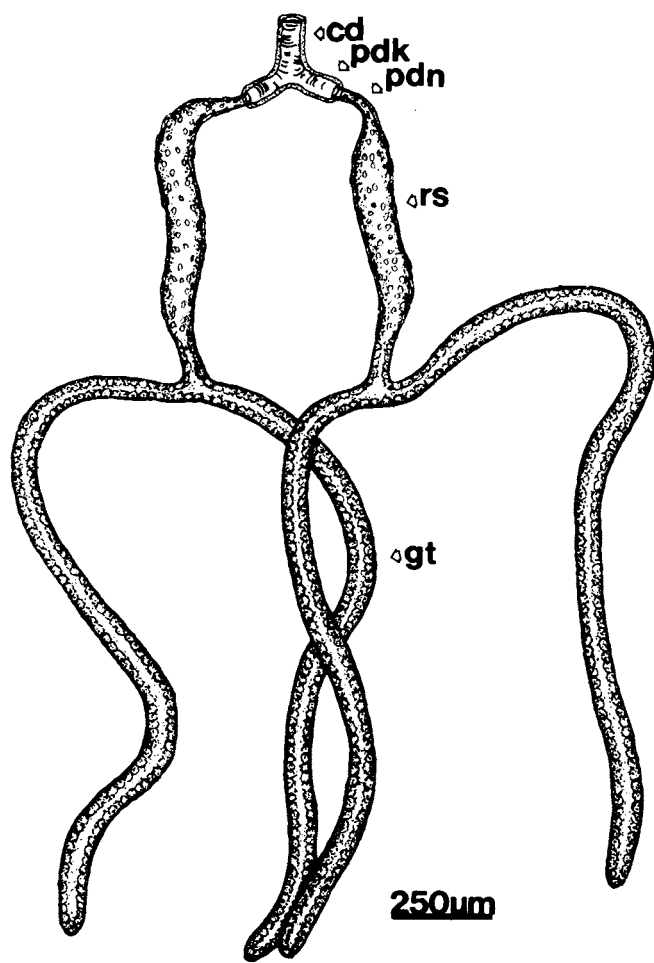


Fig. 1 Labial gland system. cd=common duct; gt=gland tube; pdk=thick portion of paired duct; pdn=thin portion of paired duct; rs=reservoir.

thick portion of the paired duct (Fig. 7).

Apical Region

Microvilli are present in the cells of the gland tubes, reservoirs and thin portions of the paired duct (Fig. 2, 3, 4). Some microvilli contain mitochondria (Fig. 2, 3). Microvilli are notably longer and more numerous in the cells of the gland tubes. The common duct and the thick portion of the paired duct are lined with a cuticular intima, apical to scattered microvilli (Fig. 6, 8). An indistinct spiral cuticular ridge is present in both regions (Fig. 8).

Basal Region

The cells of the gland tubes contain extensive basal infoldings, with scattered mitochondria and rough endoplasmic reticulum (Fig. 2). Relatively fewer infoldings are found in cells of other regions of the labial gland system (Fig. 3). The basement membrane of the reservoir and thin portion of the paired duct is thick, wrinkled and contains densely-staining structures where these regions are not expanded (Fig. 5). The basement membrane of an expanded reservoir is similar in thickness to that of other regions of the labial gland system. The cells of the basal region of the common duct and thick portion of the paired duct contain numerous lightly-staining lipid droplets.

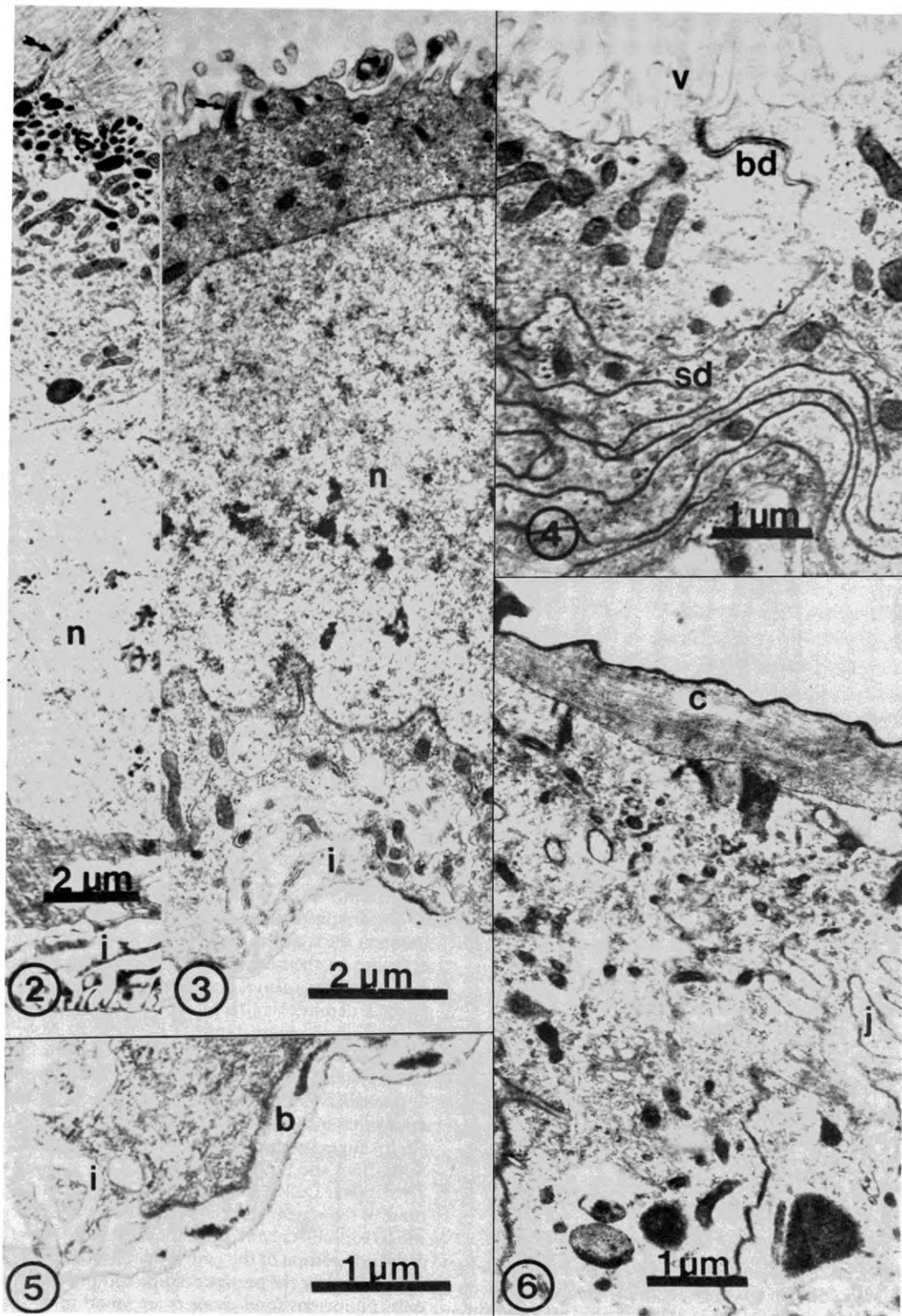


Fig. 2-6. Fig. 2 Epithelial cell of the gland tube region. Fig. 3 Epithelium of the reservoir. Fig. 4 Apical region of the epithelium of the reservoir. Fig. 5 Basal region of the epithelium of the reservoir. Fig. 6 Apical region of the epithelium of the thick portion of the paired duct. b = basement membrane; bd = belt desmosome; c = cuticle; i = basal infoldings; j = cell junctions; n = nucleus; s = secretory granules, sd = septate desmosomes; v = microvilli. Arrow indicates a mitochondrion in a microvillus.

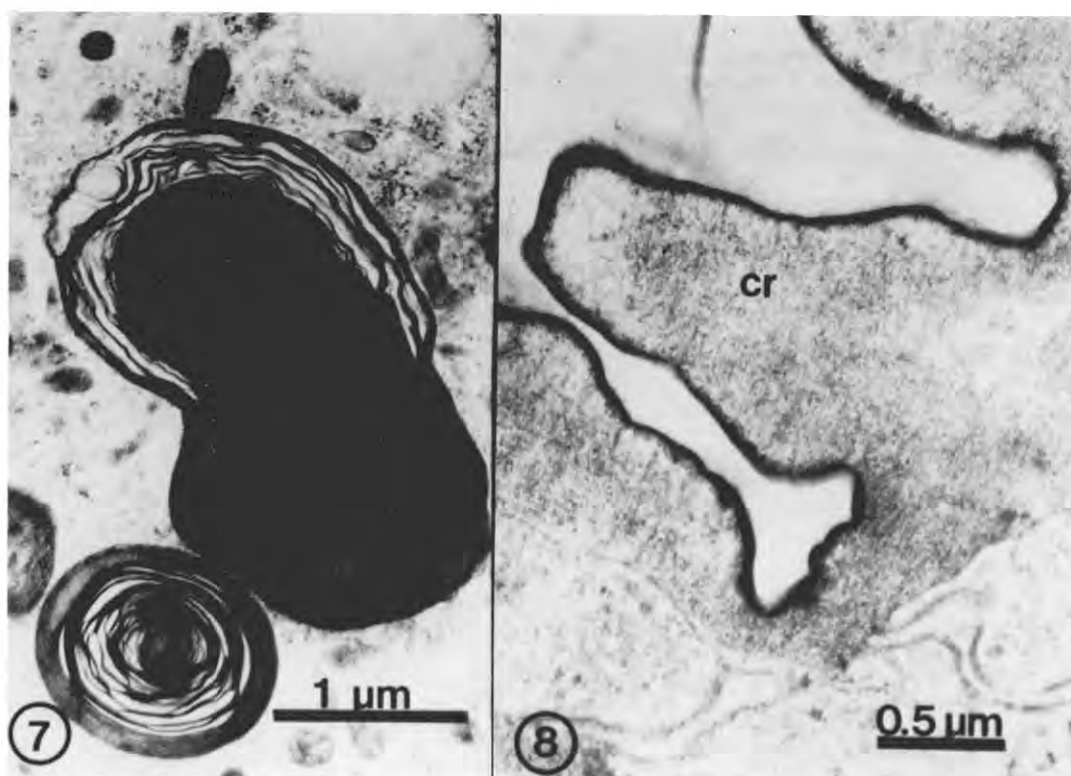


Fig. 7-8. Fig. 7 Lamellar granules of an epithelial cell of the common duct. Fig. 8 Apical region of the epithelium of the common duct. cr=cuticular ridge.

functions mainly or entirely for transport, and the thick portion of the paired ducts and the common duct remove ions and/or water in preparation for secretion of the final silk product.

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REFERENCES

- ATHIAS-HENRIOT, C. 1947. Recherches sur les larves de quelques fourmis d'Algérie. *Bull. Biol. Fr. Belg.* 81:247-72.
- BONAVITA-COUGOURDAN, A. and P. POVEDA. 1972. Étude préliminaire d'un organe mettant en rapport intestin moyen et intestine postérieur chez les larves de Fourmis (Hyménoptères, Formicidae). *C. R. Acad. Sci. Paris D274*:775-8.
- CAZAL, P. 1948. Les glandes endocrines rétro-cérébrales des insectes. *Bull. Biol. Fr. Belg. (Suppl.)* 32:1-227.
- DAILEY, P. J. and R. E. CRANG. 1978a. The fine structure of the salivary glands in the cockroach *Gromphadorbina portentosa*: secretion. *J. Morphol.* 156(2):157-72.
- _____. 1978b. The fine structure of *Gromphadorbina portentosa* salivary glands: duct transport system. *J. Morphol.* 157:329-46.
- EMMERT, W. 1968. Die Postembryonalentwicklung sekretorischer kopfdrüsen von *Formica pratensis* Retz. und *Apis mellifica* L. (Ins., Hym.). *Z. Morphol. Tiere* 63:1-62.
- _____. 1969. Entwicklungsleistungen fragmentierter Labialdrüsen-Imaginalanlagen von *Formica pratensis* Retz. (Hymenoptera). *Wilhelm Roux' Arch.* 162:97-113.
- ENGSTER, M. S. 1976. Studies on silk secretion in the Trichoptera (F. Limnephilidae). *J. Morphol.* 150(1):183-212.
- FEBVAY, G. and A. KERMARREC. 1981. Activités enzymatiques des glandes salivaires et de l'intestin moyen d'une fourmi attine (adultes et larves): *Acromyrmex octospinosus* (Reich) (Formicidae, Attini). *Arch. Biol. (Bruxelles)* 92:299-316.
- GREENE, L. F. B. 1979. Regional specialization in the Malpighian tubules of the New Zealand glow-worm *Arachnocampa luminosa* (Diptera: Mycetophilidae). The structure and function of type I and II cells. *Tissue & Cell* 11(4):673-702.
- _____. 1980. Cryptonephric Malpighian tubule system in a dipteran larva, the New Zealand glow-worm, *Arachnocampa luminosa* (Diptera: Mycetophilidae): a structural study. *Tissue & Cell* 12(1):141-51.
- LANDOLT, D. J. and R. D. AKRE. 1979. Ultrastructure of the thoracic gland of queens of the western yellowjacket *Vespa pennsylvanica* (Hymenoptera: Vespidae). *Ann. Entomol. Soc. Am.* 72:586-90.
- LAPPANO, E. R. 1958. A morphological study of larval development in polymorphic all-worker broods of the army ant *Eciton burchelli*. *Insectes Soc.* 5:31-66.
- LAUVERJAT, S. 1972. Rôle des cellules zymogènes dans les sécrétions salivaires de *Locusta migratoria* (Orthoptères, Acridoidea). *Tissue & Cell* 4:301-10.
- _____. 1973. Ultrastructure des glandes salivaires de *Locusta migratoria*. *Arch. Zool. Exp. Gen.* 114:129-47.
- OFER, J. 1970. *Polyrbachis simplex* the weaver ant of Israel. *Insectes Soc.* 17:49-82.
- PETRALIA, R. S., A. A. SORESENSEN, and S. B. VINSON. 1980. The labial gland system of larvae of the imported fire ant, *Solenopsis invicta* Buren. *Cell Tissue Res.* 206:145-56.
- PETRALIA, R. S. and S. B. VINSON. 1978. Feeding in the larvae of the imported fire ant, *Solenopsis invicta*: behavior and morphological adaptations. *Ann. Entomol. Soc. Am.* 71:643-8.

- _____. 1979. Comparative anatomy of the ventral region of ant larvae, and its relation to feeding behavior. *Psyche* 86(4):375-94.
- _____. 1980. Internal anatomy of the fourth instar larva of the imported fire ant, *Solenopsis invicta* Buren (Hymenoptera, Formicidae). *Int. J. Insect Morphol. Embryol.* 9:89-106.
- SPURR, A. R. 1969. A low-viscosity epoxy resin embedding medium for electron microscopy. *J. Ultrastruct. Res.* 26:31-43.
- VALENTINI, S. 1951. Sur l'adaptation des larves de Formicoidea. *Ann. Sci. Nat. Biol. Anim.* 13:249-76.
- WANG, Y. J. and G. HAPP. 1974. Larval development during the nomadic phase of a nearctic army ant, *Neivamyrmex nigrescens* (Cresson) (Hymenoptera: Formicidae). *Int. J. Insect Morphol. Embryol.* 3(1):73-86.
- WHEELER, G. C. and J. WHEELER. 1953. The ant larvae of the subfamily Formicinae, part II. *Ann. Entomol. Soc. Am.* 46:175-217.
- _____. 1968. The ant larvae of the subfamily Formicinae (Hymenoptera; Formicidae): Supplement. *Ann. Entomol. Soc. Am.* 61(1):205-22.
- _____. 1970. Ant larvae of the subfamily Formicinae: Second Supplement. *Ann. Entomol. Soc. Am.* 63:648-56.
- _____. 1976. *Ant Larvae: Review and synthesis*. Proc. Entomol. Soc. Wash. 108 pp.
- _____. 1982. Supplementary studies on ant larvae: Formicinae (Hymenoptera: Formicidae). *Psyche* 89(1-2):175-81.
- WHEELER, W. M. 1910. *Ants*. Columbia Univ. Press, New York. 663 pp.