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LIFE HISTORY, DAMAGE, AND GALL DEVELOPMENT OF THE GALL MIDGE, *NEOLASIOPTERA BREVIS* (DIPTERA: CECIDOMYIIDAE), INJURIOUS TO HONEYLOCUST IN MICHIGAN

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ABSTRACT

Neolasioptera brevis is univoltine in Michigan. Adults issue in late spring, and females deposit eggs in rows on the lower side of young shoots of honeylocust. Larval eclosion occurs shortly after; there are three larval instars. The gall is polythalamous and may have 20 or more larvae. The third-instar larvae overwinter, and pupation occurs in spring. The gall injury kills some shoots, but most damage is cosmetic. One can monitor for adult emergence in late April or May by observing cast pupal cases protruding from the gall. Control, if needed, should be directed at adults.

The gall midge, *Neolasioptera brevis* Gagné, was described as a new species in 1984 from adults issuing from ornamental and wild honeylocust, *Gleditsia triacanthos* L., twig galls at Harrisburg, Pennsylvania (Gagné and Valley 1984). Felt (1911, 1940) listed an undescribed species of *Neolasioptera* from honeylocust galls collected in Missouri, which from his description was assuredly *N. brevis*. The known range of *N. brevis* is sketchy, but it probably occurs endemically throughout much of the range of its host. Besides occurring in Pennsylvania and Missouri, this insect in known from Michigan, Ohio, and Illinois (H.L. Morton, Univ. of Michigan, pers. comm.). In Michigan it has been detected in Calhoun, Ingham, Livingston, Montcalm, Oakland, Washtenaw, and Wayne counties. Wertheim and Morton (1986) called *N. brevis* the honeylocust twig-gall midge.

N. brevis injury has been either ignored or misidentified and hence not recognized as a problem pest on honeylocust. In recent years, even when injury has been readily detectable, most nursery managers and city foresters have passed off *N. brevis* damage as unaccountable dieback or winter injury. The biology and injury are reported in this paper to aid in detecting, identifying, and controlling the midge.

METHODS

Alerted to this insect in 1984, we studied its life history and gall development intermittently in 1984 and in detail from April 1985 to June 1986 in a privately owned forest nursery in Oakland County, Michigan, on the unarmed cultivars of honeylocust 'Halaka' and 'Sunburst.' The trees were 4–8 m tall and moderately infested with midge galls. We collected insect specimens and galls every 5–7 days in the springs of 1985 and 1986 and every two weeks in the summer of 1985. Specimens were preserved in 70% ethanol or KAA, and representatives were measured later. Photos were made from fresh-collected specimens.

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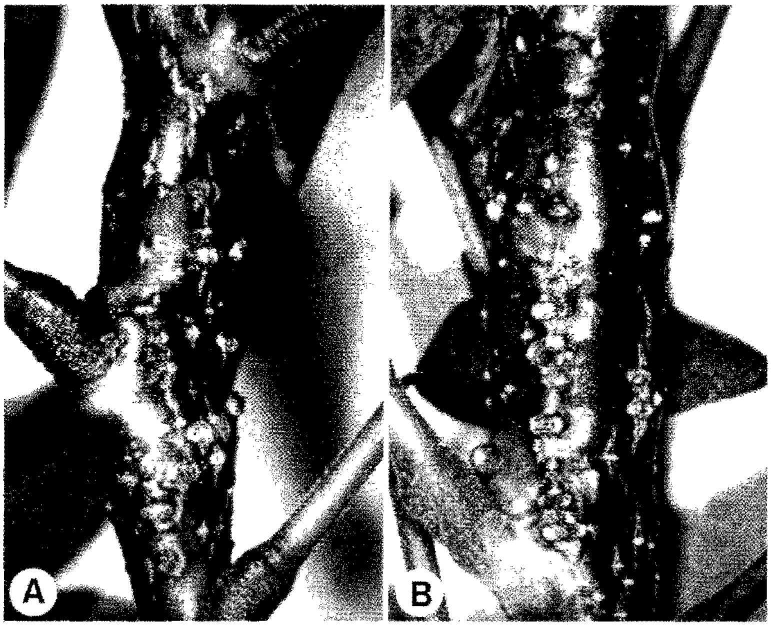

Fig. 1. Polythalamous gall of *Neolasioptera brevis:* (A) small gall (side view), (B) large gall (bottom view). Oval areas are "caps" of tissue at the entrance to the larval cells. The smaller diamond-shaped areas are lenticels.

THE GALL AND ITS DAMAGE

The gall of *N. brevis* is polythalamous and comprises the basal portion of the new shoot. Formed by hypertrophy of the new-growth stem tissues, the gall embodies a series of coalesced swellings that together may be more than 8 cm long and contain 20 or more insects. When fully developed in mid-August, the gall is somewhat knobby, green below, and reddened above from the sun. Most attacks are on the lower surface of the shoot (Fig. 1).

Large galls may kill the shoot, and the resulting dead twig and gall may persist for 2–3 years afterwards (Fig. 2A). Sublethal galls remain indefinitely and eventually become overgrown by new tissues. New shoots growing from buds distal to the sublethal galls appear normal (Fig. 2B). Moderately attacked trees, as we observed in this study, had less than 5% shoot mortality each year and yet 30–80% of the shoots were attacked on each tree. The external features of the injured stem vary as the gall forms in four stages: the "pimple stage," "crater stage," "split-center stage," and "black-cap stage."

In mid-June when the insect attack begins, the shoots are green and succulent and have just begun expanding (ca. 3–6 cm long). Within a day after the larvae penetrate the soft bark, the resulting injury around the entrance site appears as a small raised circular swelling with a papilla in the center. This pimple stage begins as a small central necrotic brown spot that expands into a scab-like encrustation in 4–5 days. At peak development the papilla is light brown and surrounded by a dark brown zone on a raised area that is slightly yellower than the adjacent normally green tissue (Fig. 3A, B).

Fig. 2. Honeylocust shoots injured by *Neolasioptera brevis:* (A) shoot dead beyond gall, (b) heavily attacked shoot but injury is below mortality threshold. Leaves develop normally beyond sublethal galls in the year following gall formation.

About 6–8 days after attack, the swollen area expands radially leaving a depressed zone around the expanding tan-brown papilla. Overall the damaged area resembles a lunar crater with a raised center and raised circumference (Fig. 3C).

In the third stage, beginning 5–6 weeks after attack, the injured tissues become less defined. Radial tension from the enlarging gall causes the injured area to expand faster laterally so that an oval or prolate-shaped scar forms. Usually the expanding growth causes the dead tissues in the center of the injury to split as well (Fig. 3D).

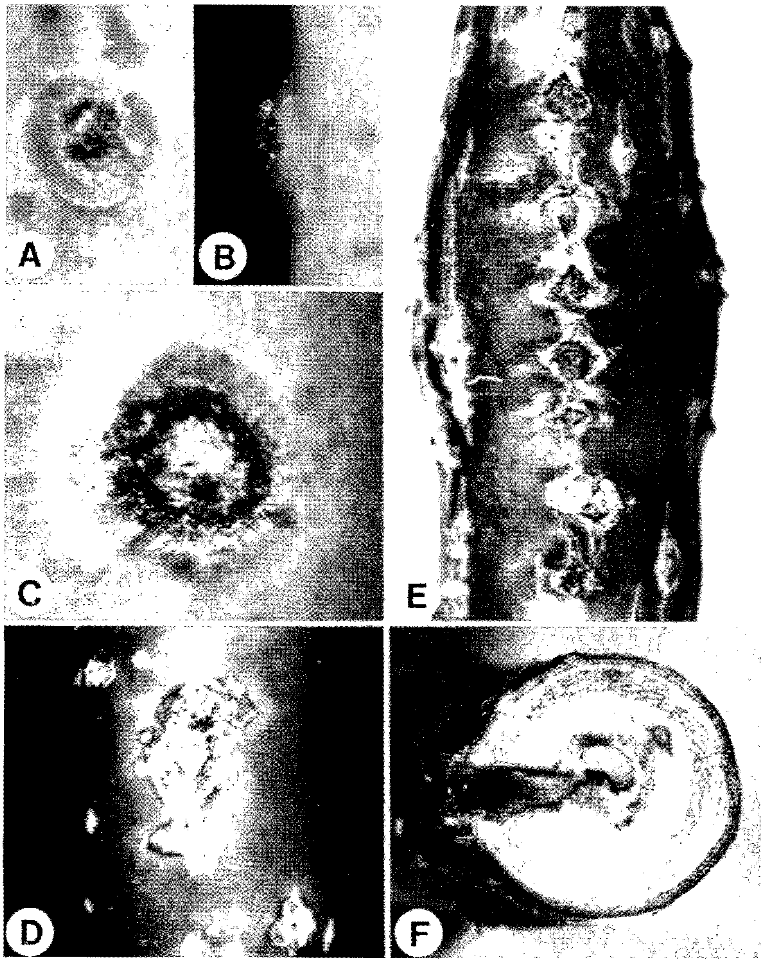

Fig 3. Stages of gall formation of *Neolasioptera brevis:* (A, B) pimple stage (top and side views), (C) crater stage, (D) split-center stage, (E) black-cap stage, and (F) third-instar larvae in center of mature gall (end view).

About the 10th week after attack, the center of the injured area darkens to form a black cap (Fig. 3E). This cap separates further from the surrounding tissues in the 2 or 3 weeks following, and thereafter it is a major characteristic of the mature gall. Internally the cap appears as a plug of darkened tissue (Fig. 3F).

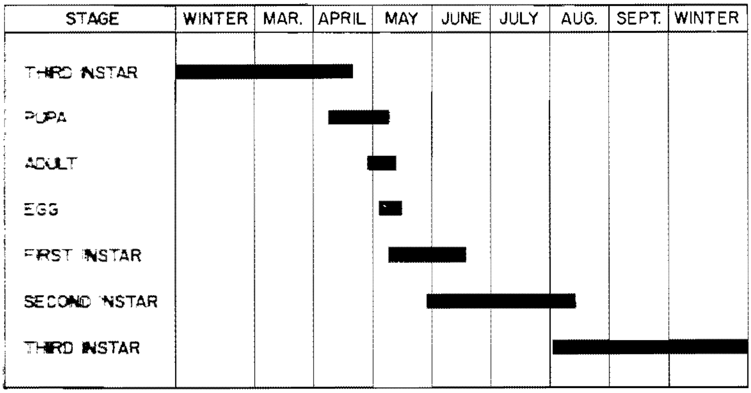

Fig. 4. Seasonal development of *Neolasioptera brevis* on honeylocust in southern Michigan, 1985.

LIFE HISTORY AND HABITS

Neolasioptera brevis is univoltine in Michigan. The last-instar larva overwinters in the gall. The complete life history, based mostly on 1985 data, is depicted in Figure 4. Because 1985 was unseasonably warm for nearly a week in April, the pupal, adult, egg, and first-instar stages shown in Figure 4 are earlier than in years with average spring temperatures. Wertheim and Morton (1986) recorded time of adult emergence and apparent oviposition for *N. brevis* in Ann Arbor, Michigan, during 1984 and 1985.

Oviposition and Egg Stage. Oviposition occurs the first week in May (in 1985) shortly after adult eclosion and mating and when the new succulent shoots are 2–3 cm long. The egg-laying period is only about 3 weeks long, and all eggs are gone by mid-May. The freshly laid egg is yellow-orange and glossy with a small diffuse red spot within, as seen through the smooth transparent chorion. Somewhat elongate, the egg tapers slightly at one end (Fig. 5A). Thirty eggs averaged 0.336 (0.300–0.380) mm long by 0.118 (0.100–0.133) mm wide.

Wertheim and Morton (1986) mentioned finding midge eggs on 20 May 1985 and suggested they may have been laid a week earlier. These white eggs, which they dissected from inside the shoots of the partly developed gall nearly a month after oviposition, were parasite eggs and incorrectly identified as those of *N. brevis*.

Each female deposits several eggs on the new shoots in a straight or slightly irregular row and nearly equal intervals, a habit that assures a safe distance between larval cells in the gall later on. Most eggs are on the lower surface of the shoot (Fig. 5B). Although the shoot and leaf tissues emerge concurrently, the female easily discriminates between them and lays eggs only on the developing shoots. Both shoots and petioles appear the same at this stage except the shoot is naked and the petiole is lightly pileus, a character that may be used by the female in choosing one over the other.

Larval Behavior and Gall Development. Head-capsule measurements indicated three larval instars. Mean head-capsule widths for 5, 26, and 20 larvae of the three instars respectively were 0.015 mm, 0.025 mm, and 0.045 mm. The first instar is yellow-white, glossy, nearly transparent, and contains a small red spot; the second instar is also glossy but more translucent from numerous yellow fat bodies; and the third instar is yellow-orange, lacks the glossy sheen, and has a sternal spatula. (See Gagné and Valley [1984] for spatula and identifying features of the third-instar larva.)

First-instar larvae appear about the second week in May and are present until mid-June. Shortly after eclosion each larva stands on its head perpendicular to the stem and penetrates the soft tissue by slowly gyrating its body. Of special interest is that the larvae

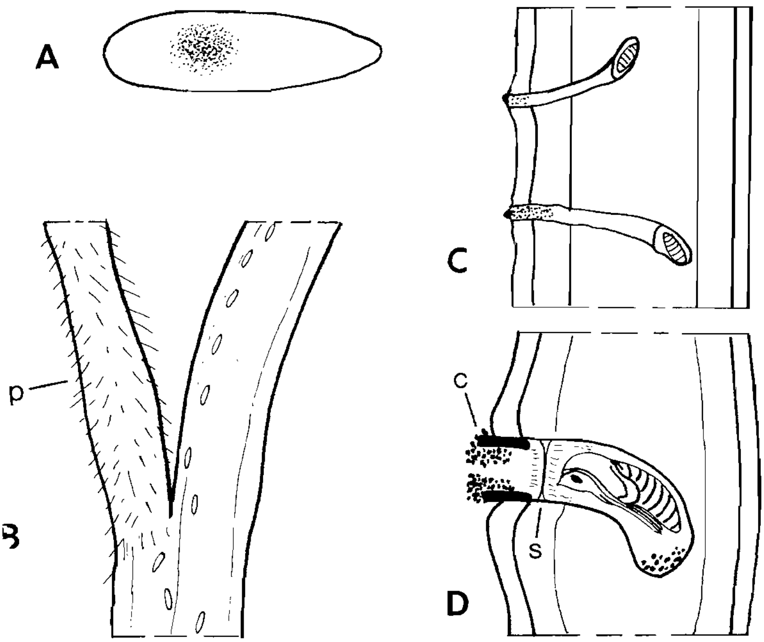

Fig. 5. Some stages and development of *Neolasioptera brevis:* (A) egg, (B) eggs on expanding shoots of honeylocust, (C) first-instar larvae penetrating the shoot, (D) pupae in cell (note hole in cap and septum). c = cap, p = petiole, s = septum.

in this position mimic similar-size glands on the leaves and leaf axils of the petioles. These upright glands are transparent with red tips. Penetration of the tissue by the larvae is usually complete in 8–10 h.

Within a week the larvae have passed through two-thirds of the soft green pith, leaving no distinct gallery. Each pathway or trail, however, is evident due to a narrow "circum-trail" cylinder of white tissue that may be largely fungal mycelia (R.J. Gagné, U.S. Nat. Museum, pers. comm.). Noticeable swelling of the stem begins about the same time. In late May the second-instar larva appears and completes the trek across the pith, and thereafter the larva dwells in a distinct cell. The circum-trail area whitens further and expands into a larger cylinder. Externally the larval entrance injury is in the late crater stage or early split-center stage and the tissues below the injury are turning dark brown. During this approximate period, Wertheim and Morton (1986) observed parasite eggs inside the galls, and, noting the accompanying external necrosis, they incorrectly dubbed the injury "oviposition wounds."

During June and July the second instar concentrates on feeding and expanding the cell in the pith adjacent to the now woody xylem. Meanwhile the circum-trail fungal mat expands to its maximum diameter, forming a white cylinder that extends from the far side of the green pith outward through the xylem to the black surface plug or cap (Fig. 6). The black material comprising the gall cap may be fungal sclerotium or excrescence (R.J. Gagné, pers. comm.).

The gall is fully expanded by the onset of the third instar in early August and changes little externally thereafter. The larva continues to enlarge the cell until late fall when it reaches maximum size and then overwinters.

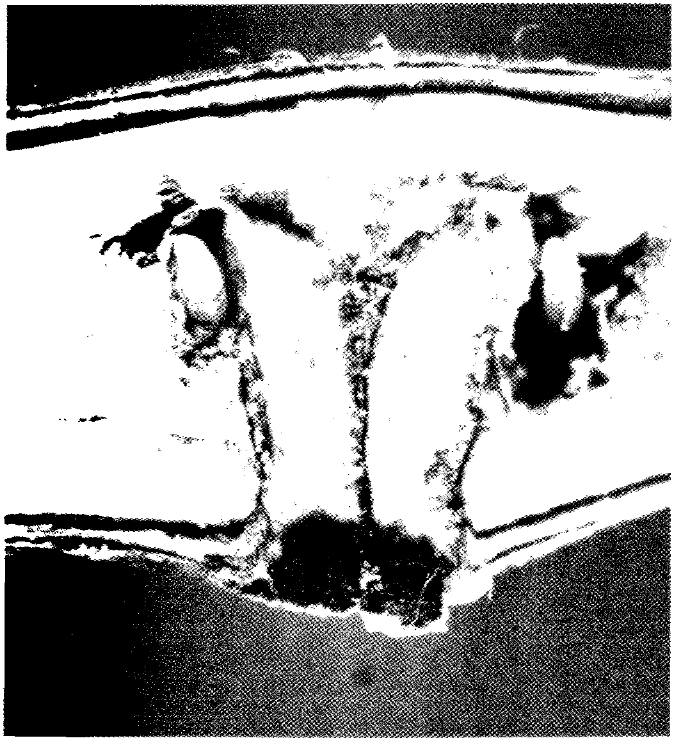

Fig. 6. *Neolasioptera brevis* gall (longitudinal view) showing interal features and two cells with second-instar larvae.

In March after the weather warms, the larva prepares its escape route by cutting through all of the white of circum-trail fungal tissue with its spatula. When it confronts the black plug, the larva makes a hole through its center leaving much of the debris on the surface of the gall or in the chamber of the plug. Then, retreating to the newly formed cell behind the plug, the larva covers one-quarter to one-third of the cell walls with white silk and seals the passageway with a silken septum (Fig. 5D). Resting behind the septum in its cocoon-like structure it awaits pupation. The full-grown larva at this time measures 2.8 (2.4–3.2) mm long.

Pupation and adult emergence. Pupae appear in early April in the cell within the gall, and all larvae have pupated by the last week in April. The pupa is light orange. When ready to eclose, the pupa wriggles up the cell to the outside, piercing the septum in the ascent. Adults first appeared 28 April 1985 in our study area, and the same date was recorded in Ann Arbor, Michigan (Wertheim and Morton 1986). When the anterior of the pupa is exposed, the skin splits along the dorsal midline through which the adult ecloses. After eclosion the protruding pupal skin usually remains attached to the gall for a week or more.

DISCUSSION

The gall midge on honeylocust is one of several species that construct a silken septum and line the wall of the cell with silk that most likely substitutes for a cocoon, and is unlike certain leaf-gall species such as *Oligotrophus papyriferae* Gagné or *Contarinia negundifolia* Felt that pupate in a cocoon in the soil (Wilson 1966, 1968b). The stem-gall insect *Mayetiola rigidae* Osten Sacken constructs 1–7 septa across its passageway before pupation (Wilson 1968a). Although the septum of *N. brevis* probably discourages natural enemies from entering the passageway, parasites readily invade the gall long before the passageway is constructed. We noted small parasitic larvae in the midge cells or on the midge larvae by mid-July 1985, and up to 80% of the cells had parasitic larvae in April 1986. We did not rear parasites for identification, but Gagné and Valley (1984) reported three species of the genera *Platygaster* (Platygasteridae), *Eurytoma* (Eurytomidae), and *Pediobius* (Eulophidae) from Pennsylvania collections.

Although this insect did not cause more than minor cosmetic injury to the nursery-grown honeylocust in this study, there still may be a need to control the midge in order to allow state regulatory agencies to certify nursery stock for transport across municipal boundaries. Control should be directed against the adults and the freshly eclosed larvae. The timing for control can be determined by monitoring galls on the branch terminals in late April or early May for empty pupal cases. Treatments against adults should be applied within a day after the first pupal cases are detected. Wertheim attempted chemical control of *N. brevis* in an Ann Arbor, Michigan, infestation, but his results were inconclusive because of low midge population levels.[2]

ACKNOWLEDGMENTS

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[2]C. G. Wertheim and H. L. Morton. A twig midge of honeylocust in southeast Michigan. Talk presented at the Forestry Section of the Michigan Academy of Sciences, Arts, and Letters annual meeting at Michigan State University, East Lansing, MI, 1984.