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RAGGED AND SHOT-HOLED LEAVES DIAGNOSING INSECT INJURY

by A.G. Wheeler, Jr. and K. Valley

Abstract. Various abiotic and biotic factors that caused ragged edges and holes in leaves of trees and shrubs are sometimes difficult to diagnose. When insects are responsible for such injury, a chewing species is not always involved. Perforated foliage may result from feeding by sucking insects and leafminers and from egg laying or oviposition. Common examples of such activity on shade trees and ornamentals are discussed.

Of the many symptoms of tree and shrub disorders, the cause of perforated foliage would seem to be one of the easiest to diagnose; however, various biotic and abiotic agents produce ragged or shot-holed leaves. Usually the cause of this injury is not readily apparent, and diagnosis must be based solely on symptoms.

An entomologist might logically blame holes in foliage on some chewing insect, perhaps a caterpillar or beetle. A plant pathologist, depending on the host plant involved, might suspect a bacterial spot or a leaf spot caused by a fungus. Others might attribute the holes to hail or mechanical damage, and years ago, the use of arsenical sprays could have been invoked to explain this type of injury (Dunegan 1932). It is also known that leaf buds of oak and maple, injured by low temperatures during early spring, may give rise to foliage with holes in the interveinal areas (Wilson and Ellett 1980).

Diagnosis of shot-holed or tattered leaves requires a sophisticated knowledge of plant diseases and insects. When insects are suspected as the cause of injury, a chewing species usually comes to mind. In this paper we discuss specific examples of foliage damage on common trees and shrubs, problems that may have puzzled arborists and nurserymen, as well as entomologists. In each case the holes or tattered appearance result not from the most obvious type of insect feeding, chewing injury, but from other insect activity: feeding by sucking insects, leaf mining by fly larvae, and damage by egg laying or oviposition.

Sucking Insects

Most arthropods with sucking mouthparts produce similar symptoms when they extract sap from leaves of their host plants. Foliage fed on by lace bugs (Tingidae), plant bugs (Miridae), leafhoppers (Cicadellidae), and spider mites (Tetranychidae) often will appear stippled or chlorotic. Feeding by certain species of plant bugs or mirids produces symptoms atypical for sap-feeding insects. At the sites where the bugs' mouthparts or stylets penetrate the leaf, tissue may die and drop out, giving rise to small holes.

The best-known example of such injury is associated with the sycamore plant bug, *Plagiognathus albatus* (Van Duzee) (Hamilton 1941). Eggs that overwinter near the base of new leaf buds hatch in mid-April to early May in central Pennsylvania (Wheeler 1980). The immature bugs, or nymphs, of this plant bug feed mainly on the lower leaf surfaces, with discoloration and chlorosis of host foliage beginning to appear in late May. Discolored tissue eventually dies and sometimes drops from the leaves so that they take on a tattered appearance (Fig. 1). In Pennsylvania this characteristic injury has been most severe on London plane (*Platanus* × *acerifolia*) in street plantings and nurseries (Wheeler 1980).

Another, mirid, *Lygocoris vitticollis* Reuter, ex-

tracts sap from leaves of red maple (*Acer rubrum*), silver maple (*A. saccharinum*), and sugar maple (*A. saccharum*). Overwintered eggs begin to hatch shortly after leaf flush in early spring. Nymphs feed on the undersides of unfolding leaves and, within 24 hours, transparent spots appear at sites of feeding. Tissue at these sites soon becomes membranous. As the damaged leaves expand, dead tissue tears from the membranous areas, resulting in ragged edges (Fig. 2). These symptoms have appeared on silver maple in Missouri (Murtfeldt 1887) and red maple in Pennsylvania (Wheeler in press).

The fourlined plant bug, *Poecilocapsus lineatus* (F.), is a common mirid known to injure more than 250 plant species (Wheeler and Miller 1981). This pest feeds on various shrubs, particularly azalea, deutzia, dogwood, forsythia, viburnum, and weigela, and occasionally on trees, where feeding usually is restricted to foliage of water sprouts. When these bugs pierce plant tissue, they apparently inject a potent lipid enzyme which causes a violent clearing of tissues. Histolysis begins at the point of penetration and radiates to form a roughly circular spot or lesion of almost 2 mm. External evidence of feeding, sometimes obscured on strongly pubescent leaves, is especially noticeable on thin, smooth foliage. After several weeks the membranous tissue at the feeding sties may drop out, leaving tiny, discrete holes (Fig. 3). The symptoms produced could easily be confused with those resulting from flea beetle injury.

Leafmining Diptera

Members of the Agromyzidae, commonly called leafmining flies, seem unlikely candidates for producing symptoms that could be confused with chewing damage. Larval feeding typically results in discrete, easily noticed mines such as those made by holly leafminer. However, leaf damage to red, white, and pin oaks (*Quercus rubra, Q. alba, Q. palustris*) and Chinese chestnut (*Castanea mollissima*) by adults and larvae of the genus *Japanagromyza* could be mistaken for chewing activity.

In spring, the females use their ovipositors to produce pinholes in juvenile leaves. The pinholes provide a source of food when females imbibe the sap around the wound, and some also serve as an oviposition site. When a pinhole is made, the cells in the area rupture, desiccate, and die. Further growth by the young leaf enlarges the original pinhole. The dead cells gradually become separated from the hole in the leaf and eventually drop out, so that the enlarged pinhole now ap-

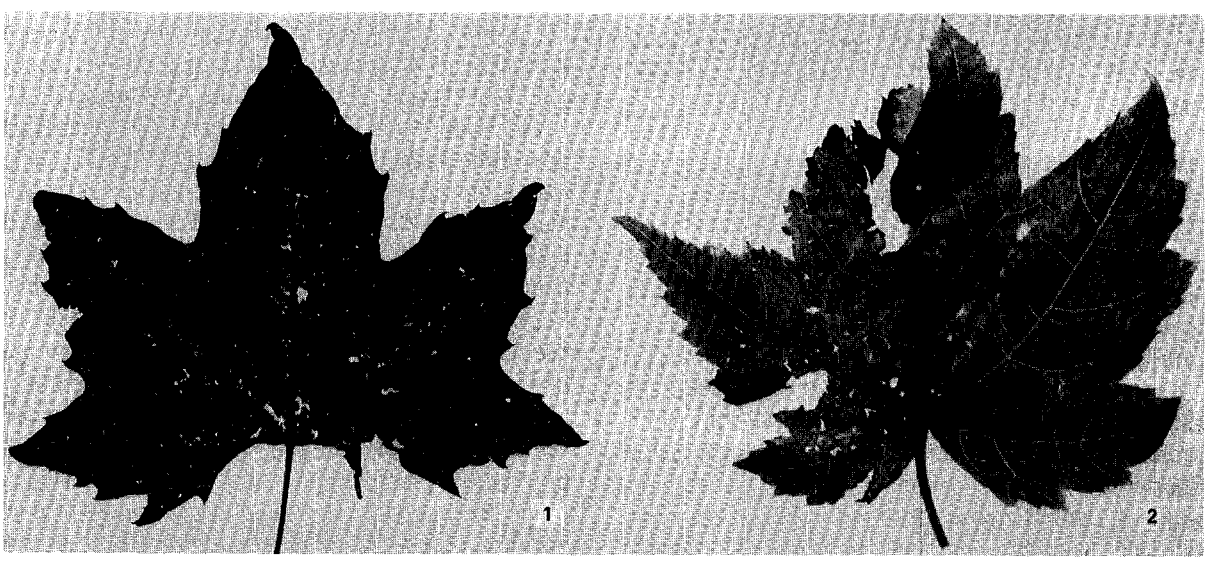


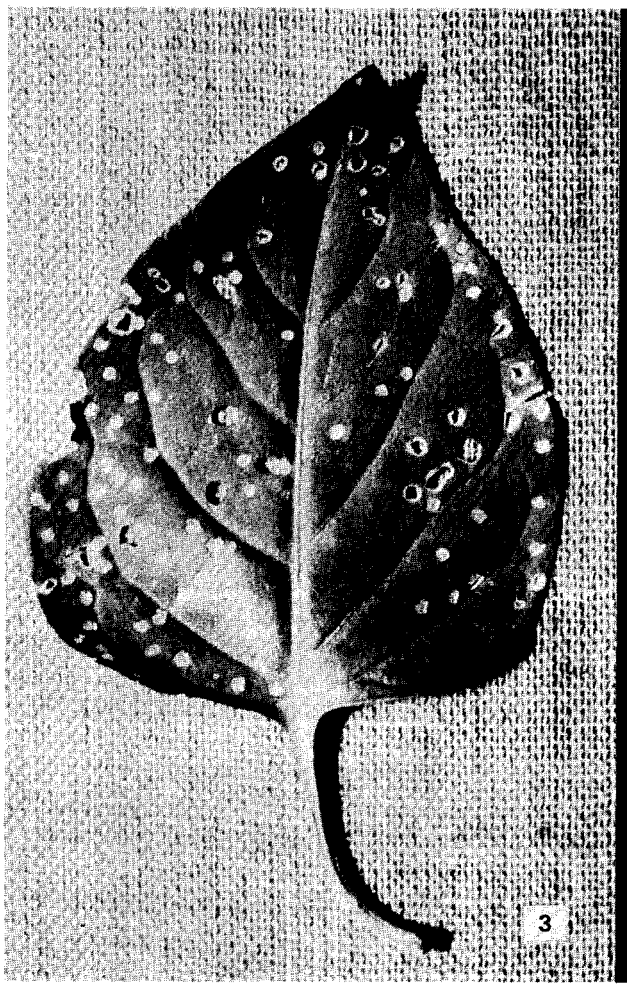
Figure 1-2. Plant bug damage on London plane (1) and red maple (2).

pears as if it were formed by a chewing insect (Fig. 4). LaBonte and Lipovsky (1967) studied this phenomenon on ornamental red and white oaks in Maine and provided excellent photographs of what they termed oak-leaf shot-hole. The shot-hole condition often seen in summer results from pinholes made by agromyzid females in tender, juvenile leaves in the spring.

On Chinese chestnut, larval infestations range from leaves with only one mine to those having the apical one-third or more completely mined, an indication that several feeding trails have coalesced. Feeding completed, the small, white maggots abandon the mines, which are now composed largely of thin, fragile epidermal layers. Eventually the mined areas drop out, and a rough, tattered margin remains (Fig. 5).

The flies apparently attack only young, developing leaves rather than the dark green, mature foliage of oak and chestnut. Although most mining activity is found in the spring, we have observed fresh mines and shot-hole damage on new growth of pin and white oaks in late June and early July.

Careful inspection of ragged margins may help distinguished mined leaves from those damaged by chewing insects. Thin, browned, epidermal tissue with drops of fecal matter and necrotic areas where pinholes were originally made are evidence of leafmining activity. Unfortunately, these symptoms are so ephemeral that they are



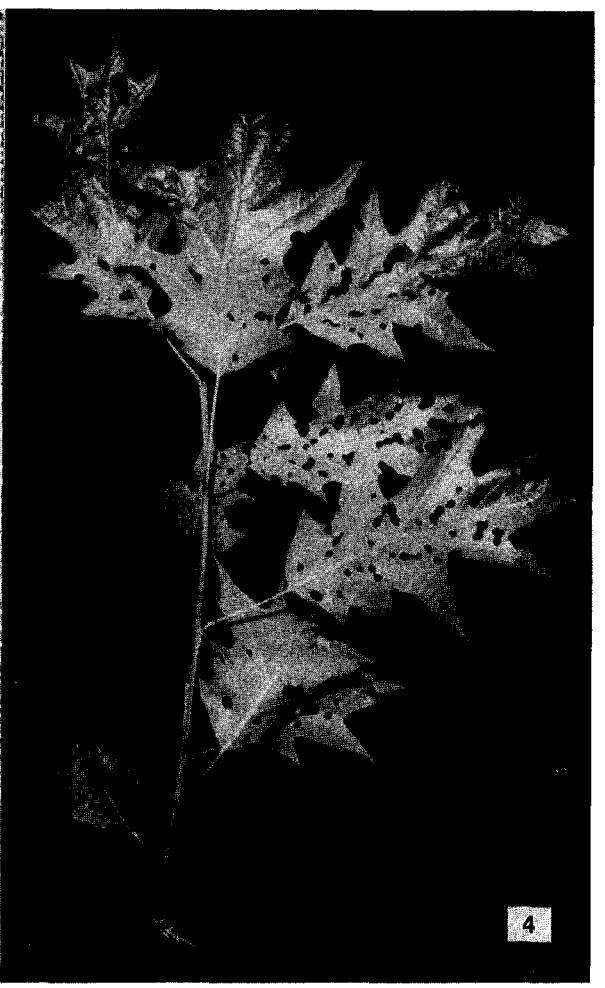


Figure 3-4. Fourlined plant bug damage on bitter nightshade (3) and agromyzid injury on red oak (4).

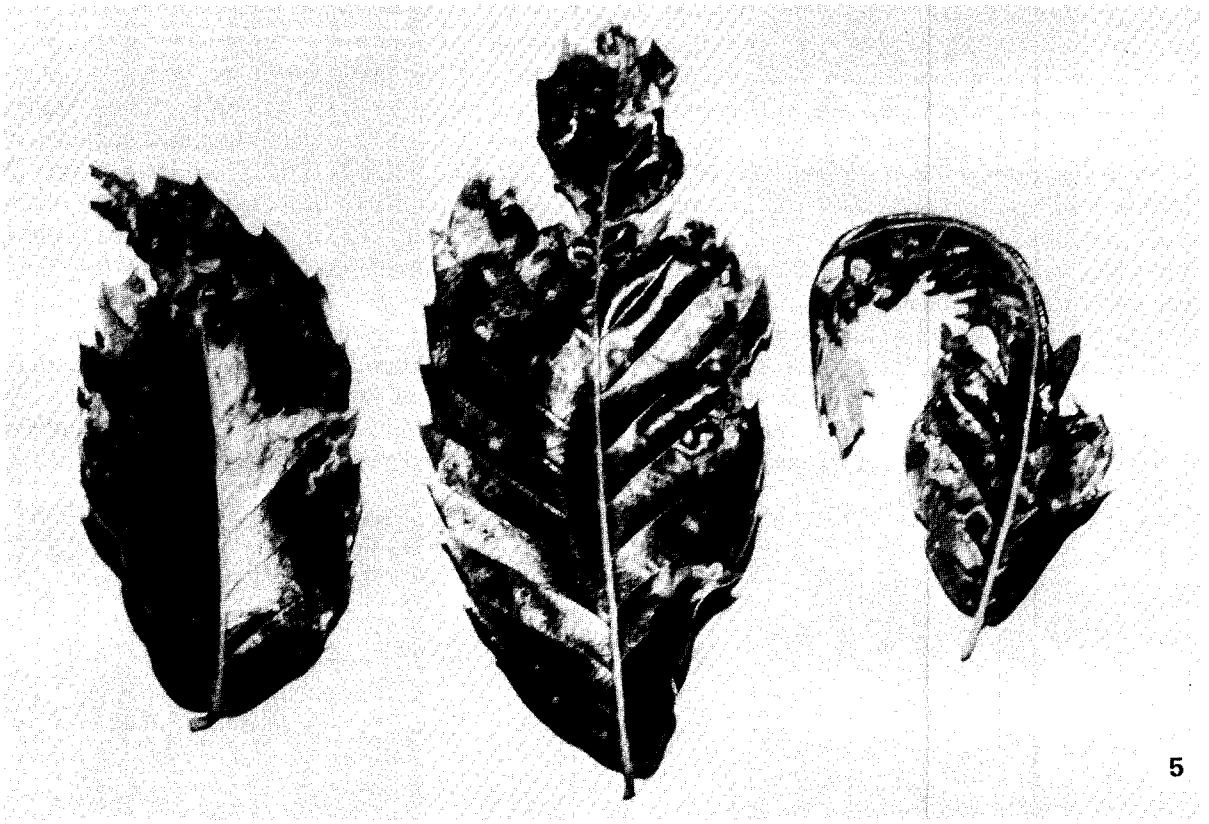


Figure 5. Agromyzid damage on Chinese chestnut.

seldom seen. They are less likely to be noticed when leaves are young and developing, and are usually detected after leaf growth has increased the size of the pinholes.

Leafhopper oviposition damage

The strikingly colored leafhopper *Graphocephala coccinea* (Forster) is known to feed on a wide variety of host plants. In the Harrisburg area we recently studied its life history on ericaceous shrubs (Wheeler and Valley 1980) and found that pouch-like eggs are deposited in the upper or lower surface of rhododendron and mountain laurel leaves (Fig. 6). Following egg hatch, the oviposition scars remain and become progressively darker. The leaf tissue in the scarred areas may in time drop out, leaving small round holes that could be confused with chewing damage (Fig. 7).

Discussion

The insects we have discussed may detract from the appearance of their hosts but seldom affect plant vigor. Even so, their damage should be diagnosed correctly so that a more serious pest is not blamed for the injury. As Nielsen and Balderston (1972) have emphasized, "appearance can be deceiving." Arborists, horticulturists, and homeowners should avoid a casual diagnosis of plant disorders.

Shade trees and ornamental shrubs serve as hosts for hundreds of insect species as well as provide temporary shelter and resting sites for adults of additional species. An insect may be abundant on a particular plant without detriment; in fact, it may not even feed (or be capable of feeding) on the plant, its presence merely being fortuitous.

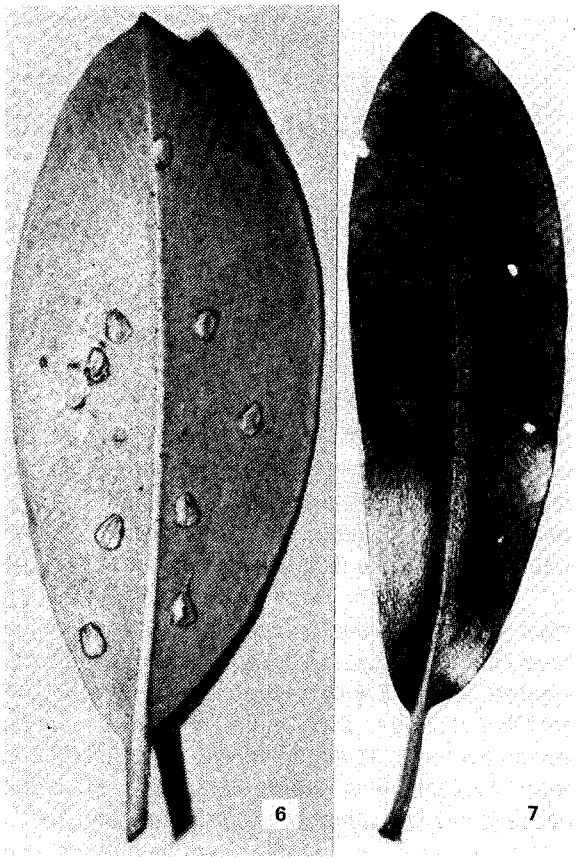


Figure 6-7. *G. coccinea* eggs in mountain laurel leaf (6) and holes in rhododendron leaf resulting from oviposition during previous seasons.

Any insect suspected of damaging trees and shrubs should be accurately identified when possible; however, because of the complexity of pest problems, a positive diagnosis is not always possible. In such cases familiarity with a particular plant species and its associated insect fauna may allow a tentative identification of the pest. Be aware that controlling tree and shrub pests requires specialized knowledge of entomology, plant pathology, and horticultural practices. Needless spraying based on mistaken identity costs time and money and may harm the environment.

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Bureau of Plant Industry
Department of Agriculture
Harrisburg, PA 17110