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Damage to Ornamental Trees and Shrubs Resulting from Oviposition by Periodical Cicada[1,2]

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ABSTRACT

Oviposition by brood X periodical cicadas, *Magicicada septendecim* (L.), in woody ornamentals in 1953 and 1970 occurred in 69 of 84 species and cultivars. Current season wilting and death of branches resulted from oviposition wounds in 24 of the 69 species. Physiological effects the same year included sharply curved branches due to greater growth on the uninjured than the injured side of branches. Healing of oviposition wounds during the 2 years following 1953 or 1970 varied depending on the species or cultivar involved, from none to rough partial healing with stunted growth and reduced flowering, to rapid healing and complete recovery. Incompletely healed oviposition sites were usually associated with retarded growth distal to the site and, in some species, with progressive dieback. Heartwood decay or discoloration occurred at and beyond the oviposition sites and in some species progressed from the branches to the main stem. Rejuvenation of top growth was accomplished by pruning out injured or dead branches to force new lateral branches.

The sudden appearance of periodical cicadas, *Magicicada septendecim* (L.), and the plant damage resulting from their oviposition was recognized by early American colonists (Oldenburg 1666, Collinson 1764). Marlatt (1907), in his summary of the available information on the periodical cicadas, described cicada injury in pear trees and the scars that persisted on branches for years. Craig (1941) observed that cicada injury persisted for 17 years on apple twigs in West Virginia after oviposition by brood V females in 1927 and 1940. Peairs and Davidson (1956) stated that the oviposition wounds of cicada weaken the twigs of fruit trees which then break off or are permanently scarred. Hopkins (1897) described twig death beyond the punctured areas and the destruction of 1- or 2-year-old branches; the result was misshapen trees with scars that furnished points of attack for borers and woolly apple aphids, *Eriosoma lanigerum* (Hausmann).

Graham and Cochran (1954) recognized that fruits were lost on broken apple tree branches, and were smaller than normal on severely damaged limbs. They concluded that when injured areas healed over as a result of cambial activity, the wound scars persisted in the bark and the productivity of the trees was reduced no more than 5%.

The delayed decline and dieback of damaged apple tree branches was described by Feit (1916) but the alteration of the woody cylinder resulting from the insertion of the ovipositor and the decay associated with these wounds were not included. Since most of the information published on cicada damage relates to fruit trees, little or no attention has been paid to the reduction in market value due to reduced aesthetic quality. We have observed cicada damage on a broad representation of deciduous and evergreen ornamental trees and shrubs grown in a nursery, and these observations are presented here.

Materials and Methods

Preliminary observations in 1953 and more complete ones in 1970 were made in a nursery near Ashton, Montgomery County, Md., on brood X of the periodical cicada. The nursery contained a large variety of deciduous and evergreen trees and shrubs that were being grown as ornamentals. Part of the nursery was bordered by mixed hardwoods (oaks—*Quercus* spp., hickories—*Carya* spp., tulip poplar—*Liriodendron tulipifera* (L.) and part by scrub pine (*Pinus virginiana* Mill.). No insecticides were applied to kill the adult cicadas and reduce oviposition damage.

Observations and records were taken on 84 differ-

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Table 1.—Response of some woody ornamentals to damage by ovipositing periodical cicadas. Ratings are evaluations of severity of infestation and branch breakage during 1970, and the nature of the oviposition wounds 2 years after oviposition (1972).

	Severity of infestation[a]	Current season breakage[b]	Epinasty[c]	Healing of oviposition wounds[d]	Growth and flowering on injured shoots[e]	Continued dying of injured shoots[f]
Acer ginnala Maxim. Amur maple	3	+	+	1,2	–	–
A. palmatum Thunb. Japanese maple	3	+	–	2	+	+
A. platanoides L. cv. Crimson King Norway maple	2	+	–	3	+	+
A. rubrum L. Red maple	3	+	+	1,2,3	±	–
A. saccharinum L. Silver maple	2	+	+	2,3	+	+
A. saccharum Marsh. Sugar maple	3	+	+	1,2,3	±	–
Betula pendula Roth European white birch	1	–	+	1,2	+	+
Carpinus caroliniana Walt. American hornbeam	1	–	–	3	+	+
Chamaecyparis pisifera (Sieb. & Zucc.) Endl.	1	–	–	3	+	+
Cornus florida L. White flowering dogwood	3	+	+	0,2,3	–	–
C. florida f. *rubra* (West.) Schelle Pink flowering dogwood	3	+	+	0,2,3	–	–
C. kousa Hance Kousa dogwood	2	–	+	2,3	–	–
C. mas L. Cornelian cherry	3	–	–	3	+	+
Cotoneaster divaricata Rehd. & Wils. Spreading cotoneaster	3	–	–	2	–	+
Crataegus crus-galli L. Cockspur thorn	3	–	–	0,1	–	–
Deutzia scabra candidissima Thunb. Snowflake deutzia	3	–	–	0,2,3	±	–
Euonymus alatus (Thunb.) Sieb. Winged spindletree	0					
E. sieboldiana Blume Siebold's euonymus	1	–	–	1	+	+
Exochorda racemosa (Lindl.) Rehder Common pearl bush	3	–	+	2	–	+
Fagus sylvatica cv. Riversi Rivers purple beech	0					
Cotinus coggygria Scop. European smokebush	3	+	–	1	–	–
Forsythia × intermedia cv. Spectabilis Showy border forsythia	1	–	–	1,2	–	–
Hamamelis mollis Oliver Chinese hazel	3	+	+	0–1	–	–
Ilex aquifolium L. English holly	1	+	+	2,3	±	+
I. cornuta cv. Burfordii Burford holly	2	–	–	2	+	+
I. crenata cv. Compacta Compact Japanese holly	0					
I. crenata cv. Convexa Convex leaf Japanese holly	1	–	+	3	+	+
I. crenata cv. Helleri Dwarf Japanese holly	0					
I. crenata cv. Hetzii Hetz Japanese holly	1	–	+	3	+	+
I. crenata cv. Rotundifolia Roundleaf Japanese holly	2	+	+	0–1	–	+
I. crenata cv. Stokes Stokes Japanese holly	0					
I. decidua Walt. Possum haw	3	+	+	2	–	+

Table 1.–(Continued)

	Severity of infestation[a]	Current season breakage[b]	Epinasty[c]	Healing of oviposition wounds[d]	Growth and flowering on injured shoots[e]	Continued dying of injured shoots[f]
I. opaca Ait. American holly	3	—	+	1,2	—	—
I. verticillata (L.) A. Gray Winterberry	2	—	+	1	±	+
Juniperus × media cv. Pfitzeriana Pfitzer juniper	1	—	+	2,3	+	+
Kalmia latifolia L. Mountain laurel	0					
Laburnum watereri (Kirchn.) Dipp. Golden chain	2	—	—	2,3	—	—
Ligustrum lucidum Ait. Glossy privet	1	—	+	2	+	+
Magnolia grandiflora L. Southern magnolia	1	—	—	3	+	+
M. × *soulangiana* Soul. Saucer magnolia	0					
M. stellata (Sieb. & Zucc.) Maxim Star magnolia	0					
Malus cv. × Almey Almey flowering crab	1	—	—	2,3	+	+
M. × *purpurea* cv. Eleyi Eley flowering crab	1	—	—	2,3	+	+
M. floribunda Sieb. ex Van Houte Japanese flowering crab	3	+	+	1,2	—	—
M. cv. × Hopa Hopa red flowering crab	1	—	—	2,3	+	+
M. sargentii Rehd. Sargent crab	3	—	+	1,2	±	—
Metasequoia glyptostroboides Hu & Chang Dawn redwood	0					
Nyssa sylvatica Marsh. Sour gum or tupelo	3	+	+	2,3	—	—
Oxydendrum arboreum (L.) DC. Sourwood-sorrel-tree	3	—	+	1,2	—	—
Phellodendron amurense Rupr. Amur cork-tree	2	+	+	3	+	+
Philadelphus virginalis Rehd. Virginal mockorange	1	—	—	3	+	+
Photinia villosa (Thunb.) DC. Oriental photinia	1	—	—	1	—	—
Physocarpus opulifolius (L.) Maxim Ninebark	1	—	—	2	+	+
Pieris japonica (Thunb.) G. Don Japanese andromeda	2	—	+	2,3	—	+
P. cerasifera cv. Atropurpurea Purple leaf flowering plum	3	—	+	1,2	—	—
Prunus × cistena (Hanson) Koehne Purple leaf sand cherry	3	+	—	1,2	—	—
P. serrulata cv. Sekiyama Kwanzan cherry	2	—	+	2	—	+
P. padus cv. Plena Double European bird cherry	2	—	—	3	+	+
P. persica cv. Rubro-Plena Red flowering peach	3	+	—	1,2	—	—
Pyracantha coccinea cv. Lalandii Laland firethorn	1	—	—	1,2	—	—
Quercus laurifolia cv. Darlington Darlington oak	3	+	—	1,2	—	—
Q. phellos L. Willow oak	3	+	+	1,2	—	—
Q. palustris Muench. Pin oak	3	+	+	1,2	—	—
Rhododendron mucronatum (Blume) G. Don	2	—	—	2,3	+	+
R. (*kurume* hybrid group) cv. Snow	2	—	—	2	+	+
R. indicum cv. Gaiety	2	—	—	2,3	+	+

Table 1.–(Continued)

	Severity of infestation[a]	Current season breakage[b]	Epinasty[c]	Healing of oviposition wounds[d]	Growth and flowering on injured shoots[e]	Continued dying of injured shoots[f]
Rhus chinensis Osbeck						
Chinese sumac	0					
Salix gracilistyla Miquel						
Big catkin willow	0					
Sorbus aucuparia L.						
European mountain ash	3	+	–	1,3	–	–
Spiraea japonica cv. Atrosanguinea						
Anthony waterer spirea	0					
S. prunifolia cv. Plena						
Bridalwreath spirea	0					
S. × *vanhouttei* (Briot) Zabel						
Vanhoutte spirea	0					
S. tomentosa L.						
Hardhack spirea	0					
Styrax japonica Sieb. & Zucc.						
Japanese snowbell	3	–	–	1,2	–	–
Syringa vulgaris L. (hybrids)						
French hybrid lilacs	3	+	–	0–1	–	–
Thuja occidentalis cv. Nigra						
Dark American arborvitae	1	–	+	2–3	+	+
Tsuga canadensis (L.) Carr.						
Canada hemlock	2	+	+	2–3	+	+
Viburnum opulus L.						
European cranberry bush	3	–	+	1	–	–
V. opulus cv. Roseum						
European snowball	3	–	+	1,2	–	–
V. plicatum Thunb.						
Double file viburnum	3	–	–	1,2	–	–
V. plicatum f. plicatum						
Japanese snowball	3	–	+	1–3	±	–
V. rhytidophyllum Hemsl.						
Leatherleaf viburnum	3	–	+	0–1,2	–	–
V. setigerum Hance						
Tea viburnum	2	–	–	2	–	+
V. wrightii Miquel						
Wright's viburnum	1	–	+	1–2	–	–
Zenobia pulverulenta (Bartr.) Pollard						
Zenobia	0					

[a] Oviposition rating: none (0); 1–4 sites (1), 5–10 sites (2), more than 10 sites (3).
[b] Current season breakage (+); no branches broken (–).
[c] Branches curved (+) or not curved or bent (–) due to growth differential.
[d] No cambial activity (0); healing from sides of wound, wood exposed (1); rough irregular healing, splinters present (2); rapid smooth healing, puncture scars still evident (3).
[e] Normal growth and flowering (+); short weak shoots with little or no flowers and fruits produced (–).
[f] Shoots with restored normal vigor (+); weak damaged shoots dying (–).

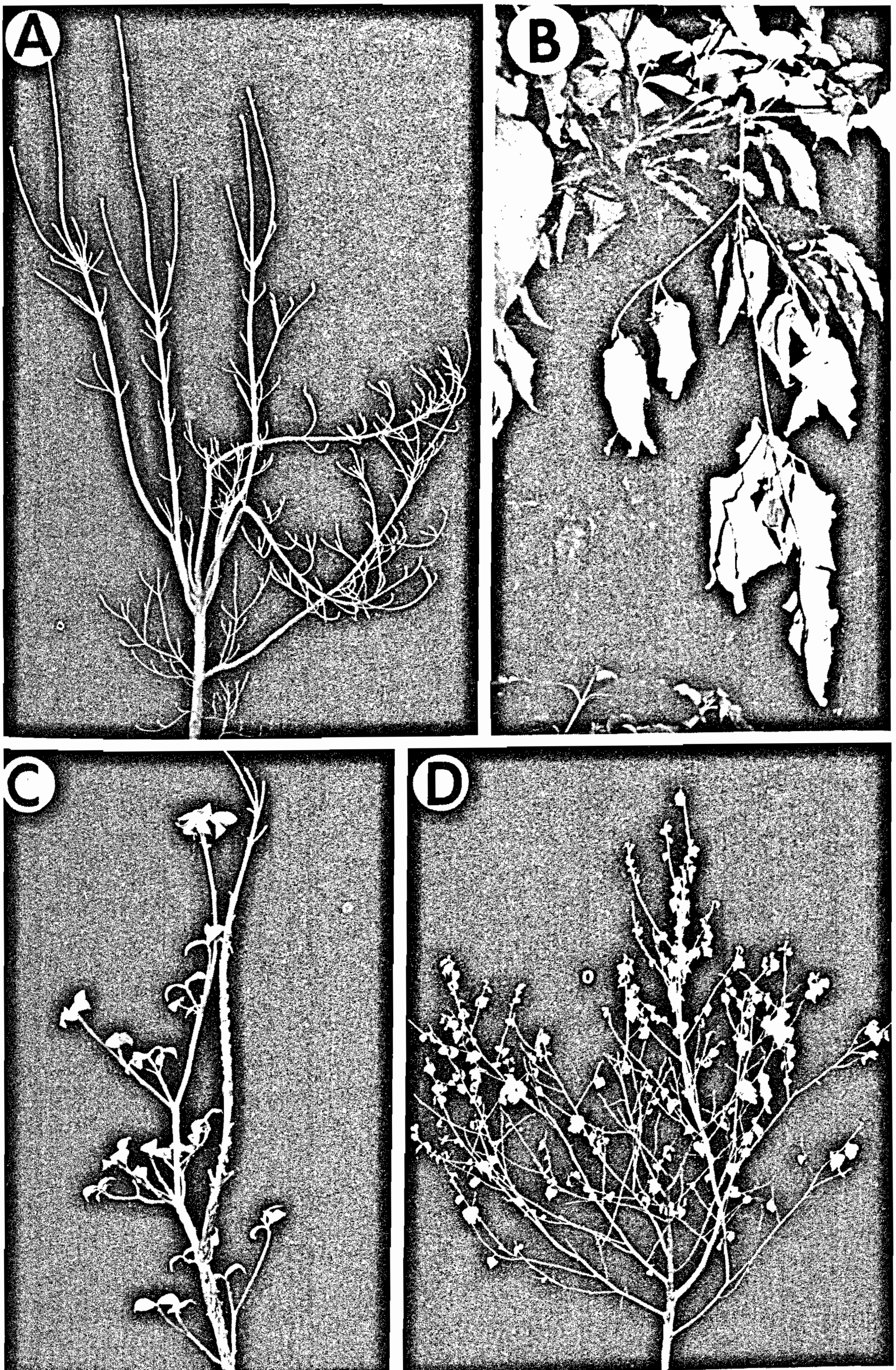
ent species and cultivars. Notes were made on several types of cicada damage: 1) degree of infestation as indicated by numbers of oviposition sites; 2) whether or not current season breakage of branches had occurred; 3) whether or not branch epinasty due to differential growth at the oviposition sites occurred; 4) degree of wound healing as indicated by cambial activity sealing off the wound; 5) abnormality of shoot growth; and 6) presence or absence of shoot die-back. These criteria were given ratings and tabulated (Table 1).

Results

General Observations

Damage to a large variety of deciduous and evergreen trees and shrubs grown as ornamentals was observed (Table 1). Injury by the invading cicadas was more severe on plants grown near the border of

FIG. 1.—A, Epinasty of branches of Kousa dogwood due to differential growth of tissues opposite cicada oviposition sites. Note stunted growth of laterals on affected branches compared with growth of unaffected branches. B, Typical flagging of branches due to severe mechanical damage caused by oviposition of female periodical cicadas. C and D, Dieback of terminal shoots of (C) white flowering dogwood and (D) European white birch due to excessive cicada damage. Note stunted growth on laterals on dogwood (C) and the strongly developing laterals on the birch (D) originating below the damaged terminal.


A
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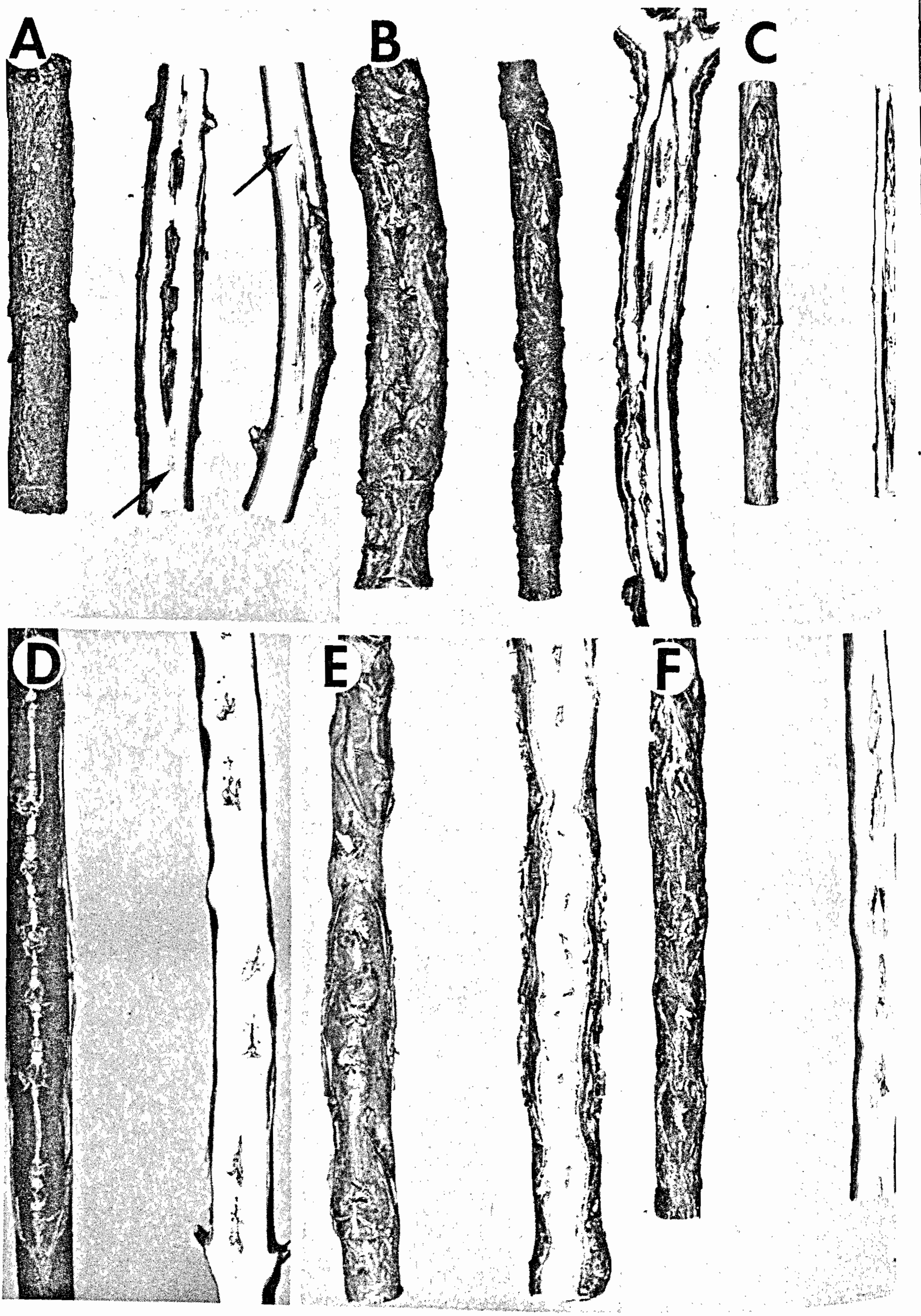
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hardwood trees than near the border of scrub pine. The cicadas oviposited in 1- to 4-year-old twigs, branches and terminals with diameters varying from 8–22 mm. The rows of punctures tended to be on the underside of horizontal branches and on all sides of vertical branches and terminals.

Immediate and Delayed Effects

After the 1970 oviposition period (late May and June), broken branches on many infested trees wilted and died (Fig. 1B). The most severe damage occurred in pink and white flowering dogwoods, *Cornus florida* L. The isolated dogwood trees were the most severely damaged, and practically all of the 1- and 2-year-old branches were involved. In block plantings of dogwoods, trees in the outer 2 rows were the most severely damaged. When affected branches of dogwood were pruned out, the tree size was reduced from 1–3 ft., i.e., from 6/8 ft size to 4/5 ft size. In addition, 15 min was required for a qualified person to prune out the damaged portions and restore the appearance of each tree, and additional pruning had to be done in 1971 and 1972 to repair the delayed damage resulting from weakened terminals or laterals that were broken or in stages of progressive dieback.

The small bundles of splinters protruding from oviposition punctures were most prominent on dogwood, lilac, maples, oaks, viburnums, and Chinese hazel. These same plants plus floribunda crabapple also exhibited the typical current season dying and breaking of branches with adhering dead leaves (flagging) (Fig. 1B). Delayed death of branches beyond oviposition injuries occurred in some species the following winter and spring. Such a response appeared to be associated with oviposition wounds that did not heal rapidly. For example, *Ilex crenata* cv. Rotundifolia had open wounds and associated delayed death of branches but *I.c.* cv. Hetzi and *I.c.* cv. Convexa, which have similar growth habits to *I.c.* cv. Rotundifolia, both exhibited rapidly healing wounds and no associated dieback the following spring.

The epinasty of damaged branches that resulted from growth suppression on the side with oviposition punctures became evident a few weeks after infestation (Fig. 1A), and was more pronounced when growth resumed the following year. The injured horizontal branches were bent down so they resembled those on weeping varieties of the same species. However, these curved branches with cicada punctures became stiff and brittle and broke when straightened or when being tied up in preparation for digging. Branch epinasty on pfitzer juniper, arborvitae, and hemlock was relatively inconspicuous, but when epinasty of the terminal leader occurred in hemlock, arborvitae, or in deciduous trees, symmetry was lost, and the terminal leader had to be pruned to force a new one to develop.

Injured branches or terminals, with or without epinasty, died on some plants during the winter after oviposition, possibly from desiccation or microbial activity (Fig. 1C, D). Dieback in the next 2 years was associated with incompletely healed oviposition wounds and with progressive decay, a discoloration of internal woody tissue above and below the oviposition puncture (Fig. 2A, B, C), especially in black gum, purple plum, leatherleaf viburnum, Korean maple, photinia, lilac, smokebush, and dogwood. In contrast, little tissue breakdown and decay or associated discoloration occurred around the oviposition sites in such plants as Japanese andromeda, azaleas, holly, maple, and euonymus (Fig. 2D, E, F).

Varietal Susceptibility

Various workers have reported differential susceptibility of plant species to cicada damage. For example, Hunter and Lund (1960) found more egg clutches per linear foot and more eggs per clutch in box elder (*Acer negundo*) than in 9 other species. However, the differences were not significant and none of the plants were immune. Cory and Knight (1937) found that saucer magnolia, *Magnolia soulangeana*, and *Rhododendron* (=*Azalea*) *calendulaceum* (Michx.) Torr. were severely attacked by ovipositing cicadas. In contrast, female cicadas rested on adjacent plants of star magnolia, *Magnolia stellata, M. virginiana* L., and *R.* (=*Azalea*) *mollis* but they did not oviposit in the branches. We observed no infestation during 1970 in either saucer or star magnolia. This report of Cory and Knight (1937) concerning differential susceptibility of adjacent species was further confirmed when we observed hundreds of female cicadas resting for the night on branches of Eley flowering crabapple (*Malus eleyi*) and relatively fewer resting on the more vertical branches of pink dogwood (*Cornus florida* f. *rubra*) where these plants were growing in contiguous rows. Nevertheless, no oviposition wounds were subsequently found on the crabapples, but ½ of the 1- to 3-year-old branches on the pink dogwoods were killed or damaged and had to be pruned off during the 1970 season. In another block of crabapples not adjacent to the dogwoods, low levels of oviposition were observed in Almey and Eley flowering crab and in Hopa red flowering crab (*M. almey, M. eleyi,* and *M. hopa,* respectively) all of which have similar vertical growth habits. Severe damage occurred in adjacent Japanese flowering crab (*M. floribunda*), which has a horizontal, spreading growth habit.

In the present studies, we found wide differences in the severity of damage done by the cicada between plant species or cultivars randomly inter-

FIG. 2.—External and internal views of cicada oviposition sites on: (A) Amur maple, (B) Leatherleaf viburnum, and (C) European smokebush, all showing progressive internal tissue decay (see arrows on A). In contrast note the well-healed oviposition sites and relatively little internal tissue decay on (D) Japanese maple, (E) American holly, and (F) *Rhododendron mucronatum*.

planted for their ornamental effect as well as in contiguous nursery rows. Of 84 species and cultivars examined, we found no evidence of egg deposition on 16, from 1–4 groups of egg punctures on 20, and from 5–10 scattered groups on 14. On the 34 others, numerous (more than 10) groups of egg punctures were located close together on the same branch or stem.

Discussion

The mechanical damage provided by cicada oviposition resulted in wilting, cessation of growth, and breaking of branches. The familiar "flagging" seen on trees and shrubs in 1953 and again in 1970 was the obvious evidence of cicada infestation. However, in this report we have drawn attention to the less obvious, yet no less significant, symptoms that appeared on many trees and shrubs during the succeeding 2 years after infestation and oviposition by cicadas. The physiological explanation of these delayed responses is apparent for some species, but only speculative for others. For example, the bending and epinasty on some young, unbroken branches or leaders probably resulted because stem tissue grew and elongated only on the uninjured side of the branch. However, the cessation of growth and elongation of tissue around oviposition puncture sites sometimes was caused by severe mechanical damage and in others by an interruption in physiological growth. Also, injured branches with or without curvatures (commonly dogwoods, lilacs, viburnums, and Chinese hazels) often died during the following winter, possibly because of desiccation or microbial activity. The dead or declining damaged terminals on Korean dogwood, red maple, and white birch (Fig. 1C, D) were replaced by new laterals. In some plants, the progressive internal decay and discoloration, with which a variety of fungi were associated (Smith and Linderman, unpublished data), appeared to have more long range effects.

We found no obvious reasons for the varietal susceptibility or immunity of the 16 species or cultivars that escaped damage due to oviposition. We suggest, however, that the dense, twiggy growth of certain Japanese hollies (*Ilex crenata* cvs. Compacta, Helleri and Stokes) may have prevented adult cicadas from reaching the larger branches for oviposition. Also, the rough, corky ridges on twigs of *Euonymus alatus* and the smooth, hard stems of the spireas and mountain laurel may have been undesirable oviposition sites.

The impact of periodical cicadas on the nursery industry is difficult to assess. However, the records of C. C. McComb (Maryland Department of Agriculture), obtained from nursery inspection reports, show that damage from oviposition by brood X adults in Maryland in 1970 continued to have an impact during the 2 succeeding years. For example, in 1970, a nurseryman near Fairland, Md., experienced cicada damage and resultant epinasty in leaders on ca. 60% of the hemlocks in 1 field. New leaders developed after pruning, but the damaged leaders resulted in the loss of at least 2 years' growth. In the nursery at Ashton, Md., where the present study was made, the damage to pink dogwoods due to necessary pruning and delayed recovery also resulted in extensive monetary loss. The time required for pruning and restorative training of new top growth represented an additional loss. We know of no way to estimate losses from the continuing decline and dieback seen on so many ornamental shrubs and trees, but the cost is considerable.

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