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DIAGNOSIS AND MANAGEMENT STRATEGIES FOR FOUR KEY INSECT PESTS, OF TREES AND SHRUBS,

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This wpaper iww w wbrief wsummary wofwa wpresentation wgiven wfor wmwmbers wof wthe wNew ww yw Turfgrass Association at their annual mweting in Atlantic City in Dwcember ofw1995. whe objectivew of wthe wpresentation was wto wdiscuss womw w cent w arch w indings wthat would whelp wlandscapew managers wdeal wmore w ctively with wa w w kwy wlandscape wpests. ww o waccomplish wthis, w presented information to awsist in the wecognition of three major categories of damage caused byw insect pests owwoody landscape plants. Nwxt, wor weach damage category, e w viewed wexamplesw of causal agents associated with the wpecific type of damage. Ww discussed information on lifew cycles, wmonitoring wapproaches, wand wmanagemwnt w trategies wor weach wtype wof wpest. wwParticularw emphasis was wgiven wto wnon-chemical wapproaches, wsuch wasw the wuse wof wplant wculture, wlandscapew design, and biological control.w

Defoliation,

he w irst wgroup wof winsects wdiscussed e w defoliators. wwDwoliators whave wchewingw mouthparts and injure plant lwaves by wemoving tissue as they weed. If the jaws are welatively largew and powerful or ifwthe leaves awe twnder, portions owwomwtimws the wntire leaf disappears. Ifwthew jaws are wmall or the leaves awe tough, womwtimwes only the tissue between the veins of the leafw disappears. We call this *skeletonization*.w

An wxample wofwa well wknown wdefoliator wis wthe wgypsy wmoth. wLarvae wor wcaterpillars wofwthisw insect pest are among the mowt common and damaging in the northeastern wegion of the Unitedw States. Young gypsy moth larvae take wmall bites of lwaves and create a type of damage knownw as "wshot wholes." wwAsw wcaterpillars wage wthey wemove wlarger wportions wofwleaves wand wentually willw consumw all of the leaf wxcept the toughest leaf wweins. High populations ofwthese insects mayw defoliate wentire wtrees wand worest wtands. wwDwefoliation wmay weaken wtrees wand wmake wthem wmorew susceptible to other werious pests, including wflat-headed borers or the whoe wtring wfungus, that mayw ultimately cause tree death.w

The gypsy moth wpends the winter as weggs in a buff colored wegg mawws on the bark of itsw host wtree wor won wurrounding w tructures w uch was w tones wand wbuildings. wwIn wthe wpring whenw temperatures waw w avorable, wthese wggs whatch wand whairy, wblack wcaterpillars w mw ge. ww hesew caterpillars awe lwss than 1/4 inch in length and they climb to the tops ofwtrees and other wtructures.w This wis wnot wthe wbest wtimw wor warborists worwlandscape wmanagers wto wtreat wgypsy wmoths wrom wthew ground. Many ofwthe wmall caterpillars will wpin a thread of wilk and migrate to other twees nearby. w After the migratory behavior is complete, most will wettle and begin to weed. whey will woon molt tow the wecond instar larvae. whis is an wexcellent timw to initiate control. where are many conventionalw materials labeled wfor control of the gypsy moth, and these will work well. In addition to wyntheticw

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insecticides, there is a bacterium known as w*Bacillus thuringiensis* which isw very wffective againstw young wcaterpillars. wwWe wwere wcurrently winvestigating wan winnovative way wto wcontrol wgypsy wmothw caterpillars uswing nematodes. Nwematode wroundwormw normally inhabit wsoil where they attack andw kill insect larvae. However, nematodes have been wformulated wfor use in landscapes, nurseries,w and greenhouses where they have been used to control a wide variety of insect pests. Wwwoundw that nematodes applied to lweaves and bark of twrees prwoduced high levels ofwmowrtality in both youngw and the pesticide wresistant older larvae. whe wresults of these preliminary wstudies aw wncouraging,w and with wurther w inemwent, this approach could wreplace mowre toxic insecticides currently uwd worw gypsy moth control.w

Landscape wmanagers whould walso wbe waware wthat wtwo wother wpathogens wcontributew significantly wto wmowrtality wof wgypsy wmoth wcaterpillars wthroughout wthe wNortheast. wwIt whas wlong wbeenw known wthat wthe wnucleopolyhedrosis wvirus w(NPV) iwww ponsible w or wdwramatic wreductions win wgypsyw moth wpopulations when wpopulation woutbreaks woccur. wwMore w cently, w a wungal wpathogen,w *Entomophaga m im iga* , whas wbeen widentified was wa wmajor wcontributor wto wgypsy wmoth wpopulationw decline throughout the east, including New Jersey.w

Another defoliator that appears to be on the increase in the past year isw the bagworm. Likew the gypsy moth, this insect has a vwery broad host wrange. Although it wfeeds on many wpecies ofw deciduous wtwrees wand wshrubs, wits wmajor wimpact wis won wconifers, wparticularly wpines, wjunipers, wandw arborvitaes. It can defoliate these trees completely, which may wresult in twree death. whe wearlyw instars wremove grween tissues wrom needles ofwconifers and leave behind discolored brown wfoliage. w As larvae mature, they consumwwentire needles and wsmall branchlets, lweaving large wsections ow plants wstripped of wfoliage. whe bagworm is oftwen overlooked as a pest due to its crwyptic habit ofw constructing a bag of leaf matter bound together by strands of silk.w

The bagworm wspends the winter months asw an wgg wresting inside the bag constructed byw its mother the previous ywear. In the latter part of wpring, these weggs complete their developmwntw and the larvae wmw ge wfrom the bag. Like the gypsy moth, many larvae will wspin a thread of wilkw and balloon away wrom their host in wsearch ofwanother plant. Others will wsettle down, begin to w d,w and will soon construct their protective bag. During the course of the summwr, bagwormw will grow and wconsumew wlarge wamounts wof wfoliage. wwIn wlate wsummwr, wlarvae will wpupate wand wadults will wbew produced. whe wfemale bagworm never wmw ges wrom the bag. Instead, whe wreleases a chemicalw odor wthat wthe wmale wbagworm wmoth wcan wdetect. ww he wmale wbagworm wuses wthis wodor, wcalled waw pheromone, to wfind the wfemale and mate with her. whe wfemale will then lay weggs inside the bag. Inw the mid-Atlantic region these eggs will not hatch until the next spring.w

Managemwnt wowwthe wbagworm wis wmost w ctive w if winfestations waw wdetected wbeforew populations have attained high levels. If populations aw w mall and the trees to be protected arew latively w hort, wit wiwweasy wto wemove wthe wbagworm with wclippers wand wdispose wof wthem. wwHandw removal of bags to destroy weggs isw mowt w ffective after October and prior to May while weggs aw still in the bags. Once the weggs have hatched it isw difficult to wfind and wremove numwous w mallw larvae. Many insecticides awre labeled wfor control of the bagworm. Our colleague at the Universityw of Maryland, Stanton Gill (1), has wrecently demonstrated that wentomopathogenic nematodes whow omw promiswe as an alternative to conventional pesticides for bagworm control. w

Dieback

A wsecond wtype wof winjury wassociated with winsect wpests wofwlandscape wplants wis wdieback. w Dieback wcan woccur win w hoots wand wbranches wand wis windicative wofwproblemw with wthe wvascularw transport of nutrients and water. Other symptoms associated with dieback include the wilting of foliage, the cracking and splitting of bark resulting in resin or sap flow, and the production of water sprouts in some plants. Clearwing borers represent a major group of insect pests responsible for dieback in woody landscape plants. These borers belong to a family of moths whose adults closely resemble wasps. Some of the most common clearwing borers in landscapes are the dogwood borer, peach tree borer, lesser peach tree borer, rhododendron borer, lilac borer, and banded ash clearwing.

The life cycle of a clearwing borer begins when the female moth deposits an egg on the bark surface of a plant. The egg will hatch and a small larvae will emerge and enter the bark, often through an existing wound. Once inside, the larvae will feed beneath the bark on vascular tissues. In some species of clearwings, larvae bore into the heartwood of the plant. When populations are high or if infestations have been ongoing for prolonged periods, branches or entire trees may be girdled with resultant dieback or plant death. In the case of the banded ash clearwing, the integrity of branches may be compromised due to the boring and tree tops may be blown out by winds. After feeding beneath the bark, larvae turn in to pupa, and shortly thereafter, adult moths emerge. As with the bagworm and gypsy moth, the female clearwing borer releases a pheromone to attract males. After mating, the female borer deposits an egg on the bark of the tree and the life cycle is complete. Some species such as the banded ash clearwing have only a single generation each year, while others such as the lesser peach tree borer have two. Most clearwing borers spend the winter as larvae beneath the bark of the tree.

Clearwing borer management is multifaceted. First, it is important to keep trees from being wounded by maintenance equipment such as lawn mowers or weed whackers. A properly mulched tree should be less prone to this type of mechanical injury. Cultivar selection is another good way to reduce borer attack. For example, in Maryland, the Kousa dogwood is attacked far less frequently by dogwood borer than is our native *Cornus florida*. When a tree is under attack by clearwing borers, insecticides with prolonged residual activity are often applied to the bark to kill newly hatched larvae as they attempt to enter the tree. If this approach is used, then the timing of these residual insecticides becomes critical. If applied too early, materials will weather off the bark before the eggs hatch. If applied too late, larvae will have entered the plant before they ingest or are contacted by the insecticide. Fortunately, a number of clearwing borer moth pheromones are commercially available and may be used in conjunction with sticky traps to assist in the timing of insecticide treatments. Sticky traps containing pheromone lures should be hung well in advance of the emergence of adult clearwings. When adult male moths begin to appear in traps, the deposition of eggs is imminent and residual insecticides should be applied. Landscape managers should recognize that pheromone traps usually capture more than one species of clearwing borer moth (2). To assist in the identification of species caught in pheromone traps, we recommend the use of the pictorial reference by Taft et al. (3).

In addition to the use of residual bark pesticides, researchers have recently shown that entomopathogenic nematodes can also give very acceptable levels of control of clearwing borer moth larvae. Nematodes are applied directly to the bark of the tree at a time when larvae are present beneath the bark. Stanton Gill, John Davidson, Wanda MacLachlin, and Will Potts demonstrated in a series of studies that nematodes could significantly reduce clearwing borer populations in dogwood (4), cherry laurel (5), and green ash (6). The use of nematodes has potential for managing several other species of clearwing borers, including the rhododendron borer, lilac borer, and viburnum borer.

Leaf discoloration,

Leaf discoloration can occur for a number of reasons on landscape plants. One of thew most common ways insect pests discolor leaves is through their feeding activities. Many of ourw most important insect pests have sucking mouthparts. Examples include aphids, scale insects,w and bugs such as the azalea lace bug. Insects with sucking mouth parts insert fine stylets intow plant tissues and remove the contents of cells or vascular tissues. Somw insects like leaf hoppersw or lace bugs rupture mesophyll cells and remove the cell contents. whe loss of green chlorophyllw from ruptured cells creates w mall white spots on the leaf. whese small white spots are calledw stipples. Pests w uch as spider mites have very small mouth parts and create very minute, finew stipples. Insects such as lace bugs and leaf hoppers have larger mouthparts and their w dingw results in large, course stipples. Often, when pests such as mites or lace bugs are abundant,w almost all green cells on a leaf may be emptied and the entire leaf surface appears white, yellow,w or silver. whese leaves may ultimately turn brown and appear scorched. whey often abscise fromw the plant prematurely.w

Lace bugs, such as the azalea lace bug, are among the most common of all insect pests inw the landscape. whis occurs because azaleas aw w o widely planted throughout the region. Azaleaw lace bugs spend the winter as eggs inserted into the tissue of a plant leaf. In spring, usually inw April or May, the eggs complete their development and hatch. whe immature stage of the lace bugw is called a nymph and it feeds on the leaf surface and creates the stippling injury described above.w The lace bug nymphs molt five times before reaching the adult stage. wLace bug adults havew delicate multi-veined wings that gives them the appearance of being covered with lace, hencew their name. Adult lace bugs also have piercing mouthparts that cwate stippling injury to leaves. w After w ding for a period of several days, lace bugs mate and deposit eggs into the surface of thew leaf. There is more than one generation of lace bug each year in Maryland.w

Short term management of lace bugs iw w latively w traightforward and consists of treatingw newly w mw rged lace bugs with insecticides. wMany are labeled for use against lace bugs. w Insecticidal soaps and horticultural spray oils work well but must contact the bugs if they are to bew effective. whis means that sprays must be directed to the undersurface of leaves where lace bugsw feed and rest. Materials such as soaps and oil have the distinct advantage over somw w idualw materials in that they do not remain on plant surfaces as toxicants for long periods of timw. whisw reduces negative impacts on beneficial insects that frequent plants soon after the application ofw insecticides. Systemic insecticides applied to the leaves or through the soil may also work ellw and have the advantage of not directly affecting beneficial insects such as predators that may bw on the surface of the plant.w

A mow w ustainable approach to managing lace bugs and many pests of landscape plantsw is through sustainable landscape design. Studies by Trumbule et al. (7) revealed that azaleas inw sunny locations were much more commonly infested and severely damaged than those in shade. w It was initially believed that azaleas in sunny habitats were mow w requently infested and w erelyw damaged because they were planted in sites for which they were not well adapted. Azaleas aw typically denizens of shaded woodlands with rich acidic soils. However, research by Trumbule etw al. (7) found that shaded azaleas were actually a better resource for lace bugs than those grown inw sunny conditions. Our w cent w esearch demonstrates that natural enemies, such as spiders, aw far more abundant in shady, diverse landscapes. whese natural enemies feed on plant pests andw greatly reduce pest numbers in diverse shaded habitats. By diversifying landscapes, homeownersw can enhance biological control, thereby reducing pest populations and the use of pesticides.w

A wsecond type of lweaf discoloration occurs due to a highly wspecialized life cycle of a gwoupw of insect pests known as lweaf miners. Leaf miners are present in wveral wfamilies of insects and w share the trait of weeding between the wepidermal wsurfaces ofwleaves. whey consumew mwophyllw tissues and, in womw cases, parenchymal cells. Dwepending on how they move through the leafw tissue, they create galleries that are linear, serpentine, or blotchy.w

In Maryland, boxwoods in wresidential landscapes aw wrequently attacked by the boxwoodw leafminer. Each year, 25% ofwboxwoods wequire twatmwnt wor control of lweafminer. Cultivars ow Amwerican wboxwood, w*Buxus sempervirens*, ware wseverely wdamaged wby wthis winsect, which wcausesw damage in its larval wstage by mining and galling the parenchyma tissue of boxwood leaves. Minedw leaves have an ugly, discolored, blistered appearance that destroys the aesthetic quality of thew plant. In heavy infestations, leaves wenesce and drop prematurely, wrendering the canopy thin andw unsightly. Heavily infested plants are mow susceptible to cold injury and winter kill. w

The boxwood leaf miner wpends the winter months asw a partially gwrown larva in the tissuew of the leaf. In the late winter and warly w pring, the larvae complete developmwent and cut a wsmall window in the wsurface of the leaf. It is wrom this window that the pupa and ultimately the adult wfly will wmwerge. Emwrgence of the adult boxwood leafminer coincides with the production of twnderw new lweaves on the wshoots of boxwood. whese tiny owange wflies wswarm about the plant, mate, andw the wfemale midge lands on the undersurface of the boxwood leaf where wshe deposits wveral wggsw into the leaf tissue. Awter wseveral days, these weggs hatch into wsmall legless larvae that begin tow mine the leaf and in wo doing induce the production of a lweaf gall. Leaf miner larvae wspend thew spring, summw, and fall feeding and developing within the leaf. w

Managemwent wofwthe wboxwood wleaf wminer whas wtraditionally welied won wthe wapplication wofw pesticides to the leaf wurface to coincide with the wflight activities of the adult wflies. Wwe are currentlyw developing wa wreliable wmwthod wfor wtiming wthe wapplication wof winsecticide wtreatmwnts wbased won wthew degree wday wor wheat waccumulation wmwthod wof wprediction. wHweat wunit waccumulations whave wbeenw mweasured at Longwood Gardens, PA, whe University ofwMaryland, College Park, MD, and the U.S.w National wArboretum wduring wthe wspring wand wsummwr wof w1995 wand w1996. wUsing wa w50ºF wbasew temperature, a March 1 wtart date, and the averaging mwthod, daily heat unit accumulations w made wfor wthe wkey wlife whistory wevents wof wadult wmwergence wand wflight, woviposition, wegg whatch, wandw larval developmwent. whese wvents will be correlated with heat unit accumulations to construct aw predictive model. This project will be completed during the spring and summw of 1996.w

In waddition wto wgenerating wa w liable wsystem wor wpredicting wkey wlife wcycle wvents, we warew valuating wthe w icacies wowthree wsystemic winsecticides w(Orthene, wAvid, wand wMwrit) wand wonew biological control agent (the nematode *Steinernem rpocapsae*) wfor the control of the boxwoodw leaf miner. All materials will be tested against three life wstages ofwthe leafminer (pupae, adults, andw larvae) wto wdetermine which wmaterial wprovides wthe wgreatest wefficacy wand wto wdetermine which wlifew stage wis wthe wmowt wvulnerable wto wpesticides. wPwreliminary wtudies were wcompleted win w1995 wandw showed good control wfrom both Avid and Mwrit on the adult/early larval wstage. whis data will bew coupled with the degree day model to provide a wreliable, highly wefficacious pwocedure wfor leafminerw control. whis allows landscape managers to plan their control wstrategies and to be prepared whenw the proper timwfor application of a control mwthod is appropriate. A more durable approach to thew managemwent ofwthe boxwood leaf miner involves the use of wesistant plant materials. Pwviousw researchers whave wobserved wariation win wthe wsusceptibility wof warious wpecies wand wcultivars wofw boxwood to lweafminer attack. However, mowst ofwthese wstudies lack quantitative data wregarding thew levels owsusceptibility. Wwe have developed mwthods wor quantifying wegg laying behaviors ofwthew boxwood wleafminer wand wtracking wthe wdevelopmwent wofwleafminer wlarvae. wOur wpreliminary wtudiesw indicate that much of the resistance observed in boxwoods is due to plant related mortality of developing larvae rather than avoidance of the plants by adult flies. This has important implications for breeding resistant lines of boxwoods. We found the cultivars Handsworthiensis and Vardar Valley are both highly resistant to boxwood leaf miner while others are susceptible. Arborescens (the American Box) is the most common boxwood in Maryland and shows the highest susceptibility.

There are many important and interesting insect pests of woody landscape plants for which we have just begun to scratch the surface with respect to understanding their biology and management options. We hope that this short discussion gives you some new insights into the management of defoliators such as gypsy moth and bagworm, leaf stipplers such as lace bugs, and leaf miners such as the boxwood leaf miner. When our research results are more complete, we hope to return and share our findings with you.

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