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RECOGNIZING THE LARVAE OF KEY PESTS AND BENEFICIALS FOUND ON WOODY LANDSCAPE PLANTS[1]

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Abstract. Proper identification of pests and beneficial organisms found on landscape plants is vital if sound pest management is to be practiced. This paper presents techniques and information useful in the identification of some of the more commonly encountered insect larvae found on the leaves and bark of trees and shrubs. It is by no means an exhaustive summary but is intended to aid in the recognition of broad groups of insects including the larvae of moths and butterflies, sawflies, leaf beetles, lacewings, flies, and lady beetles. Through proper identification of larvae, practices that reduce the activities of or kill beneficial organisms can be avoided.

Résumé. L'identification de parasites et d'organismes bénéfiques que l'on retrouve sur les plantes d'aménagements est vitale si on veut pratiquer une gestion des parasites. Cet article présente des techniques et des informations utiles dans l'identification de quelques-unes des larves d'insects les plus souvent rencontrées sur les feuilles et l'écorce des arbres et des arbustes. Ce n'est d'aucune façon un résumé exaustif, mais une intention d'aider dans la reconnaissance d'un large groupe d'insects incluant les larves de chenilles et papillons, tenthrèdes, coléoptères, hémérodes, mouches et coccinelles. Par une identification des larves, les pratiques qui réduisent les activités ou tuent des organismes bénifiques peuvent être évitées.

The last decade has seen the development and implementation of integrated pest management (IPM) programs for the commercial tree care industry. These programs have had a profound effect on the way in which companies conduct their business. Many companies consider the IPM approach to be a more professional one and find a high level of customer satisfaction with these programs (1, 2). The IPM approach has the added benefit of reducing unnecessary pesticide use (2, 3, 4, 5, 6).

To implement successful IPM programs the arborist must embrace the philosophy that pesticide sprays will be used only when needed and that alternative control tactics should be considered whenever they are feasible. The arborist must also possess certain knowledge and adopt certain practices if the IPM program is to be successful. These include a knowledge of the key pests and plants found in the landscape system, a systematic monitoring approach, a set of tactics and strategies, and an evaluation plan. These components have been discussed in greater detail elsewhere (2-17). However, the foundation for any pest management program to build upon is the accurate identification of living organisms in the system. The first step is the proper identification of the plants and the next step is the proper identification of the organisms found on the plants. This includes not only the pests but also the beneficial and neutral organisms on the plant. One of the most widely held misconceptions of arborists, landscapers, and the general public is that the majority of insects encountered on plants is harmful. This clearly is not the case. The majority of insects found on any given tree or shrub cause no damage to that plant. Many are incidental and occur there for reasons other than consuming the plant. Others are beneficial and occur on the plant because their prey, the true plant pests, are present. A minor portion of the insect species found on plants are, or have the potential to be, damag-

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ing. Sometimes these pests can be extremely abundant as in outbreaks of gypsy moths. But the majority of the time pests are relatively uncommon or occur in low numbers.

Many arborists wonder why it is important to distinguish pests from other groups of insects, especially beneficial ones. The most important reason for accurate discrimination between pests and nonpests is to avoid the destruction of beneficial organisms. Although the exact role of natural enemies in regulating pest populations remains a topic of debate, natural enemies are generally considered to play a critical role in reducing and limiting the populations of insect pests in a variety of systems, including trees and shrubs. When pesticides are applied indiscriminately, or without accurate knowledge of the target organisms, adverse results occur. Too often I have received plant samples that received treatments to control an insect that was incorrectly identified as a pest when, in fact, the sample contained beneficial insects that were killed by the treatment. In these cases the treatments were unnecessary and unwarranted. The true pest was undetected by the pest manager. If left alone, the beneficials would have consumed the pests present on the plant, and may have reduced the pest population below a level that required treatment. This type of mistake occurs commonly and ultimately results in greater amounts of pesticide being used than are necessary if natural enemies are left undisturbed. Proper identification of beneficial organisms gives the pest manager one or more options in a potential spray situation. If beneficial organisms are present and have the potential to reduce pest populations, then the arborist may decide not spray, or he or she may wait and see the beneficials are reducing prey numbers. If beneficials are present, the arborist may select a material that is least disruptive to the activities of the natural enemy. These considerations are an important part of a sound IPM approach.

The objective of this paper is to provide some easy techniques that will aid in the identification of common groups of beneficial and pest insects found on woody landscape plants. This information has been presented in a series of annual workshops conducted by extension specialists at the University of Maryland. Arborists, nurseryman, and landscapers that have attended these workshops have found this information useful.

By necessity the scope of this work is limited. There are more than a million described species of insects with many more million yet undescribed. This work will be limited to a few of the most commonly encountered groups of insects found on plants. The adult stages of insects are not considered in this paper. The adults of the large group of plant feeding insects, the Lepidoptera, are moths and butterflies and are not injurious to plants. In a practical sense it is the immature feeding stages or larvae of insects with complete metamorphosis (those having egg, larval, pupal, and adult stages) that are the most difficult to identify correctly. Insects such as moths, butterflies, beetles, sawflies, and flies have immature stages called larvae. The immature plant feeding stage of insects with incomplete metamorphosis such as scales, aphids, and bugs, is called a nymph. They will not be treated in this paper. Therefore, insect larvae found on the leaves and bark of woody landscape plants will serve as the primary focus of this paper. The pest groups that we will attempt to identify with the information presented in this paper are the larvae of moths and butterflies, commonly known as caterpillars, the larvae of leaf-eating sawflies, and the larvae of leaf-eating beetles. The beneficial larvae considered here include the predaceous beetles (primarily lady beetles), lacewings and their close relatives, and some predaceous flies. Many flies and wasps have larvae that develop inside pests and kill them. These larvae are called parasites or parasitoids and, because they are rarely seen by pest managers, they will not be discussed.

Characteristics Useful in Identifying Larvae

The tool we will use in the identification process is a dichotomous (two choice) key similar to those used for identifying trees by their leaves. In this key the user will be asked a question that can be answered with a yes or no such as "does the larva have thoracic legs?" If the answer to the question is yes the user will proceed one way in the key and, if the answer is no, he or she will proceed another way until an identification is made.

Before the key can be used in a meaningful way the user must know a little about the morphology, or important body parts and structures, that are used in the key. First, the user must know the three principal body regions of a larva. These are the head, thorax, and abdomen (Fig. 1). The head is the most anterior portion of the larva and houses important structures used for sensing a wide variety of stimuli such as light and odor. The head also bears the mouthparts some of which are paired structures that either face downward (hypognathous) or forward (prognathous). Look at Fig. 2 to observe what is meant by forward or downward facing mouthparts. The orientation of the mouthparts is a very useful characteristic in identifying larvae and will help to distinguish beneficials from pests.

The next body region is the thorax. It comes immediately behind the head and is composed of three segments. Segments can usually be identified as indentations or folds that run across the long axis of the larvae. The thorax bears several features extremely useful in identification. The feature or character of greatest utility for our purposes is the thoracic leg. Thoracic legs are found on many types of insect larvae both beneficials and pests. When present, they are jointed hard structures that occur as pairs on the thoracic segments. For example, the larvae of most sawflies will have three pairs of well developed thoracic legs (total of six legs). Observe the thoracic legs of a caterpillar in Fig. 1.

The last body region of the insect is the abdomen. It is composed of many segments, up to ten in the larvae of moths and butterflies, however in some groups such as the flies the number of segments is less than ten. For our purposes the most useful characters found on the abdomen are the prolegs (Fig. 1). These are not like the true jointed appendages found on the thorax. Instead, the prolegs are fleshy outpockets of the abdominal wall. These paired structures usually occur on the underside of the abdominal segments. The number of pairs of prolegs helps differentiate between pests and beneficial larvae. Larvae of Lepidoptera always have five or fewer pairs of prolegs while larvae of sawflies (Hymenoptera) often have six or more pairs. Some beneficial larvae lack prolegs entirely. Prolegs are used in locomotion and to aid in adhering to plant surfaces. In the moths and butterflies the function of the prolegs is enhanced by other structures known as the crochets (Fig. 3). Crochets are dark hooklike structures that occur in circles, ellipses, or rows on the underside of the prolegs. These hooks help to grip the plant as the larva moves. The presence of crotchets can be used to differentiate the larvae of moths and butterflies from other larvae commonly found on leaves and bark.

The final set of characteristics that we will use in identifying larvae are not morphological ones. They are attributes associated with the feeding behaviors of the larvae. This necessitates that the pest manager be observant when he or she collects larvae from the plant. To discriminate between plant eating and predaceous beetle larvae the pest manager must observe whether or not the larvae are associated with leaf skeletonization (Fig. 4). If the beetle larvae are found on skeletonized leaves, they are likely to be leaf beetle larvae. If the beetle larvae are found on leaves

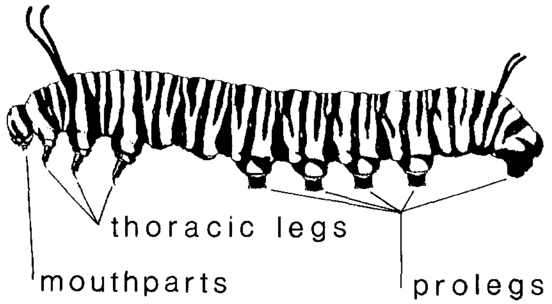

Figure 1. A butterfly larva showing the location of the mouthparts, thoracic legs, and abdominal prolegs.

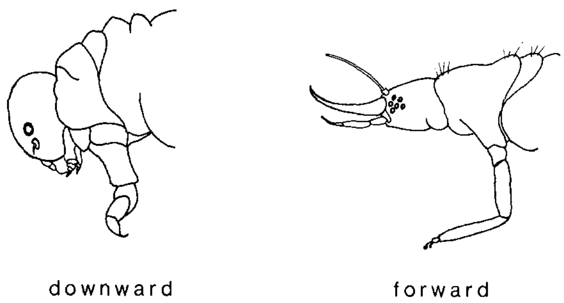

Figure 2. Underside of a caterpillar showing the location of the prolegs and crochets.

or bark and not associated with skeletonized leaves, they are likely to be predaceous beetles such as lady beetles. Sometimes lady beetles are found on skeletonized leaves but this does not occur nearly as frequently as with pests. With the information provided above we are prepared to identify some larvae commonly found on the leaves and bark of trees and shrubs.

A key to insect larvae commonly found on leaves and bark

	Character	*Go to*
1a.	Thoracic legs present (Fig. 1)	2
1b.	Thoracic legs absent	Predaceous Flies
2a.	Prolegs present (Fig. 1)	3
2b.	Prolegs absent	4
3a.	Crochets present (Fig. 2), usually 5 or fewer pairs of prolegs	Moths and Butterflies
3b.	Crochets absent, usually 6 or more pairs of prolegs	Sawflies
4a.	Mouthparts forward facing (Fig. 3)	Lacewings
4b.	Mouthparts downward facing	5
5a.	Skeletonizing leaves (Fig. 4)	Leaf Beetles
5b.	Not skeletonizing leaves	Lady Beetles

Predaceous flies. The predaceous flies most commonly encountered on the leaves and bark of trees and shrubs are the larvae of flower flies (Family:Syrphidae). Flower flies are small to medium sized flies that are brightly colored. Many resemble bees and hornets. Adults are frequently seen hovering near flowers. They lay eggs near colonies of aphids, scales, and other soft bodied insects. The eggs hatch into larvae (maggots) that may be dull or brightly colored and are somewhat translucent. These larvae consume large numbers of prey before moving to the soil to pupate. Another group of predaceous flies commonly encountered with soft bodied insects especially aphids is the predaceous midges (Family:Cecidomyiidae). These are close relatives of midges that damage plants such as the boxwood leafminer and rhododendron gall midge. Many predaceous cecidomyiids have the interesting habit of seizing their prey by a leg joint and sucking their blood.

Moths and Butterflies. The larvae of Lepidoptera are diverse in color, form, and feeding habit. They represent more than 70 families. Many of the freely feeding Lepidoptera such as the gypsy moth, cankerworms, oakworms, webworms, tent caterpillars, and bagworms are among the most important key pests of woody landscape plants. Other larvae of Lepidoptera such as the tip moths (Nantucket pine tip moth), clearwing borers (dogwood borer), and carpenterworms bore in shoots, branches, and trunks of trees and shrubs. Although they have not been treated in this key, larvae found boring in stems, branches, and trunks that have thoracic legs, and prolegs bearing crotchets are wood boring Lepidoptera. Other larvae of Lepidoptera roll and tie leaves together. These too can be identified by the characteristics listed previously. Larvae of many leaf and needle miners such as the

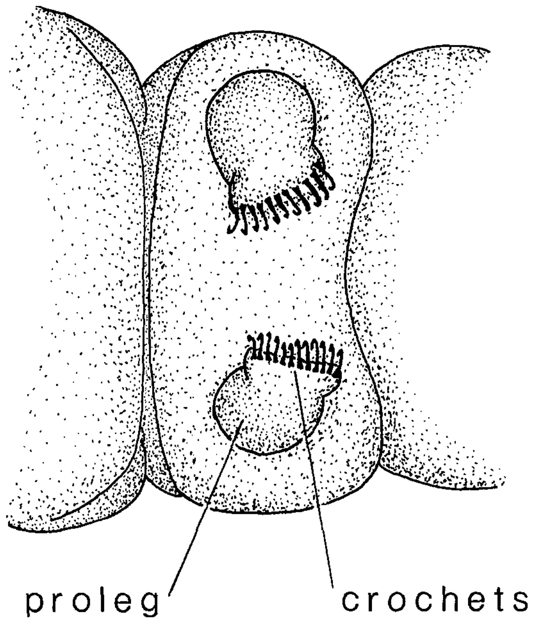

Figure 3. Heads and first thoracic segments of sawfly and lacewing larvae showing downward and forward facing mouthparts.

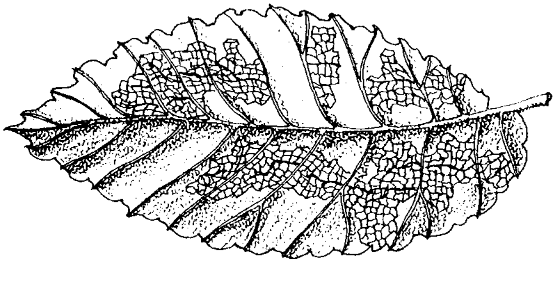

Figure 4. An elm leaf showing skeletonization damage caused by leaf beetles.

oak blotch leafminer and pine needleminer can be distinguished from other leaf mining groups such as leaf beetles, flies, and beetles by the presence of prolegs bearing crotchets.

Sawflies. Sawflies (Hymenoptera) are somewhat similar in appearance to the larvae of the Lepidoptera. It is important to differentiate between the two groups because they often are controlled in different ways. For example, small larvae of many foliar feeding Lepidoptera are easily controlled with timely applications of *Bacillus thuringiensis* (B.t.). However, commercially available strains of this pathogen are specific to Lepidoptera and a few Coleoptera (beetles). If sawfly larvae are incorrectly identified as Lepidoptera, and B.t. is applied, a control failure will surely result. Sawfly larvae are most commonly observed on the foliage of narrow leaved evergreens and deciduous trees and shrubs. They may be brightly colored such as the redheaded pine sawfly and are often found feeding gregariously. Others, such as the rose slug, are rather inconspicuous. Although most pest species feed freely on leaves, some such as the pine false webworm, construct silken webs. Others bore in leaves, petioles, shoots, and wood. The most important leaf mining sawfly in the eastern United States is the birch leafminer. This larvae can be distinguished from those of leaf mining Lepidoptera or Coleoptera by the presence of prolegs lacking crochets. It is noteworthy that while the larvae of one group of sawflies, the tenthridinids, are plant feeders, the adults are beneficial predators.

Lacewings. Lacewings belong to an order of insects known as the Neuroptera. Unlike the other insect orders discussed thus far, this order contains only predators. Many of the Neuroptera are aquatic as larvae, such as the well known hellgrammites that are used as bait by fresh water anglers. The most commonly encountered Neuroptera on woody landscape plants are the lacewings (Family:Chysopidae). These small but voracious predators are often found moving quickly over the surface of leaves and bark in search of soft bodied prey including aphids, mites, caterpillars, and scale insects. Their powerful sabrelike jaws project forward and have a special blood groove that enables them to rapidly exsanguinate their hapless prey. Lacewing larvae are one type of beneficial insect that is available commercially. Less frequently encountered relatives of the common lacewing that feed on soft bodied insects and mites on leaves and bark include the brown lacewings (Hemerobiidae), dusty wings (Coniopterygidae), and owl flies (Family:Ascalaphidae). Lacewings should not be confused with lace bugs which are sucking insect pests of many plants. The names are similar but they appear entirely different.

Leaf beetles. Leaf beetles are members of the order Coleoptera in the family Chrysomelidae. This large family of plant feeding insects contains some of the most important pests of trees such as the elm leaf beetle, cottonwood leaf beetle, and imported willow leaf beetle. Leaf beetle larvae have thoracic legs but lack prolegs. Their small downward facing mouthparts cause a characteristic type of feeding damage known as skeletonization. Skeletonization is the removal of interveinal leaf tissue such that only veins and sometimes epidermis remains. Skeletonized leaves have a lacy appearance. Leaf beetle larvae are often found feeding in groups, especially when they are young. In some cases, such as in the cottonwood leaf beetle, larvae may feed on tender young leaves and cause defoliation rather than skeletonization. Adult leaf beetles are also plant feeders and many can be found simultaneously with their larvae.

Lady beetles. The lady beetles, ladybugs or ladybird beetles belong to a family of mostly predaceous beetles known as the Coccinellidae. The adults of this family are generally recognized as beneficial natural enemies. However, the larvae are often misidentified as pests. This is especially true in many of the smaller species that are covered with wax or spines. Ladybugs feed on many different kinds of pests including mites, scales, aphids, caterpillars, and other beetles. They are often found grazing on clusters of small soft bodied insects on leaves or bark. Many are brightly colored with spots or patches of red, orange, or yellow and all move rather quickly on the substrate compared to their prey.

Additional Clues for Identifying Larvae

There are a few additional characteristics that may be helpful in differentiating pests from beneficials. As mentioned above, many pests such as leaf beetles, sawflies, and caterpillars, are often found feeding in groups. Predaceous larvae tend to be solitary. The reason for this becomes obvious when one realizes that many predators are cannibalistic. Many pests are rather slow moving. In contrast, most predators move quickly when disturbed or searching for food. Recall that pests are usually associated with some type of plant injury such as defoliation or skeletonization whereas predators are not always associated with such damage. Also remember, predators are often found in the company of soft bodied insects such as aphids and scales that serve as their prey.

Final Caveats in Identifying Larvae

The identification of insect larvae will be greatly facilitated by the use of some type of magnification device such as a microscope or hand lens. Many larvae and their characteristic features are small. The key and other information presented here are not intended to be a complete and foolproof guide for identifying all insect larvae. More thorough works on this subject include the excellent texts by Stehr (12) and Peterson (13). This key will not identify larvae found in habitats other than on leaves and bark. For example, a larva lacking thoracic legs found boring in a branch is not a predaceous fly larva. It is much more likely to be the larva of a flatheaded or roundheaded wood boring beetle. This same caution applies to larvae found in other habitats such as inside leaves or in the soil. Keys for larvae in these habitats are presently under construction. Finally, there are exceptions to most of the rules presented in this key. For example, one family of relatively common caterpillars found on leaves, the saddlebacks and their relatives, lack crochets. Despite limitations, the information presented here will help arborists and other pest managers make better decisions regarding their pest management practices.

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