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Pierce's Disease in the North Coast

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Causal agent: Pierce's disease (PD) is caused by the bacterium *Xylella fastidiosa.*

Mode of action

The bacterium lives in the water-conducting system of plants (the xylem) and is spread from plant to plant by xylem-feeding insects. The chief function of xylem tissue is to transport water and minerals from the soil to above-ground plant organs. Bacterial cells taken up by insect vectors from diseased plants attach to the mouthparts and multiply, forming a bacterial plaque. During subsequent feeding, bacteria dislodged from the insect's mouth enter the host's xylem tissues. In infected grapevines the bacteria multiply for several months and spread throughout the xylem system, eventually blocking the movement of water. Symptoms appear when a significant amount of xylem is blocked.

Insect Vectors

Insect vectors capable of transmitting PD belong to the sharpshooter (Cicadellidae) and spittlebug (Cercopidae) families. The blue-green sharpshooter *(Graphocephala atropunctata)* is the most important vector in the North Coast. The *green (Draeculacephala Minerva)* and red-headed sharpshooters *(Carneocephala fulgida)* are also present in the North Coast and are vectors under some circumstances.

Since the xylem fluid is under negative pressure, insect vectors able to tap into it must have strong muscles that operate the sucking pump in their mouthparts. These bulky muscles give the face a swollen appearance which differentiates them from other sucking insects.

Other sucking insects, such as grape leafhoppers are not vectors; they feed on mesophyll cells and phloem tissue. Recently a large leafhopper, *Thamnotettix zeleri,* which is not a PD vector but which is similar in appearance to some sharpshooter vectors, has been found in the North Coast. To be able to differentiate between sharpshooters and this look-alike non-vector, please contact your local UC Cooperative Extension Office for a key of distinguishing characteristics.

Vector capability and efficiency of bacteria transmission

Bacterial transmission to grape is extremely efficient for some vectors. Insects are able to transmit the bacteria immediately after acquiring it from an infected plant. Less than 100 bacteria per insect are required for efficient transmission. An infectious blue-green sharpshooter has more than a 90% chance of transmitting the bacteria.

Once the adult acquires the bacteria the insect remains capable of transmitting it throughout its life. Immature insects are able to transmit until they molt, shedding the lining of the mouth along with the outer skin. Every time immatures molt they must reacquire the bacteria by feeding on an infested plant to be capable of transmitting the disease.

Vector Habitat

Xylem-feeding insects require succulent plant tissue or rapidly growing plants as food sources. They are found primarily in habitats where soil moisture promotes vigorous plant growth. Grapes are a good feeding host for the vectors because they are pruned every year, thus producing succulent new growth annually.

In coastal areas, riparian (riverbank) vegetation is the principal breeding habitat for blue-green sharpshooters, which have been collected from over 150 species of plants. These insects shift their feeding preferences as the season progresses always preferring succulent growth. Blue-green sharpshooters can also be found in ornamental landscapes in residential areas or parks. Woody ornamentals when pruned, especially in the winter, will produce spring growth that is very vigorous and succulent. This growth is often very attractive to the insect, even when the same plants would otherwise be minor feeding hosts. For example, live oaks that are heavily pruned produce suckers that the blue-green sharpshooter finds highly attractive for laying eggs. Otherwise oaks are a transient feeding host for this insect in the spring.

In the Central Valley, irrigated pastures, hay fields, or grasses on ditch banks are the principal breeding habitats for the green and red-headed sharpshooters, which prefer grasses and certain annual weeds for breeding and feeding. Grapes are only accidental hosts of grass feeding sharpshooters.

Even though the blue-green sharpshooter is the most important vector in the North Coast, all three vectors are present in this region and the green and red-headed sharpshooter can be a source of the disease in vineyards near irrigated pastures or ditches.

Vector Life Cycle

- **Blue-green sharpshooter**

There is only one generation per year in most areas. Adults overwinter mainly in riparian habitats, but also may be distributed at low density in areas with trees and shrubs. Eggs are laid singly in green tissues of leaves and stems beginning in April, depending on temperature. Most adults (80-90%) breed in riparian areas, hence the majority of the eggs are laid within riparian plants. Adults that have started to migrate will lay their eggs in vines at the edge of the vineyard. Their dispersal into the vineyard increases as natural vegetation dries up. Most overwintered adults die out by the end of June.

The flightless immatures (nymphs) emerge from late April or early May through July and remain on the same plant where they had emerged from the eggs, thus the majority of the nymphs are found on riparian plants. Nymphs become adults between late June and the end of August. As adults begin to emerge in late June they move deeper into the vineyard. At the beginning of September, when grape foliage is less succulent, sharpshooters begin to move back into nearby natural habitats.

– Blue-green sharpshooter breeding host plants (plants on which the insect will lay eggs):

Woody Perennials	Perennial Herbaceous Plant	Ornamentals in Residential Settings
Wild grapes	California Mugwort	Ivy
Himalayan blackberries	Stinging nettles	Virginia creeper
California blackberries		Roses
Elderberry		Fuchsia
Sandbar willows		Periwinkle
Snowberry		Geranium
Wild rose		Liquid amber
		Woody shrubs

- **Green and Red-headed Sharpshooters**

The green and red-headed sharpshooters have three generations per year. They feed primarily on grasses. The green sharpshooter breeds and feeds on water grass *(Echinochloa crusgalli)* Bermuda grass *(Cynodon dactylon)*, perennial rye *(Lolium perennae)*, and fescue grass *(Festuca* spp.). The red-headed sharpshooter breeds and feeds primarily on Bermuda grass. They are found on grasses in wet spots, sump ponds, irrigation ditches, irrigated pastures or where the growth of grasses is lush and continuous all year. They overwinter as adults and lay eggs from late February to early March. The overwintering adults do not live long (no later than March or April). Thus it is probably the second generation that migrates to the vineyard.

Vector characteristics and relationships to grapevines are presented in a Table at the end of this document.

Geographic distribution of PD

One consistent requirement of PD appears to be mild winters. PD is present across the southern US from Florida west through southern Texas to California. In the eastern US it extends up to Virginia. In the West it has not been found north of California or equivalent latitudes. In general, the disease is rarer and less severe in areas that are further north, more inland from the ocean or at higher altitudes. The geographical distribution of PD on grapevines appears to be related to the ability of the bacteria to survive winter temperatures. The effects of low winter temperatures on bacterial survival are not well understood.

Spread of the disease in vineyards

In the North Coast, the distinctive spatial patterns of the disease (a border effect with high mortality of vines adjacent to native vegetation) match the early season spatial distribution of the blue-green sharpshooter vector entering vineyards from their nearby overwintering habitat. Chronic vine infections are found in the first 200 to 300 feet from the blue-green sharpshooter breeding habitat receiving the initial adult migration. When vines are infected early in the growing season there is a long period of time for the bacteria to reproduce and spread throughout the vine. A high bacterial population present in the vine by autumn increases the chance the infection will survive through the following winter. This implies that eliminating vectors for disease control should be done very early in the season to most effectively prevent new chronic infections.

After June, the blue-green sharpshooter can be found throughout the vineyard even in sections where symptomatic vines are rare. Infective sharpshooters can establish infections of *X. fastidiosa* in grapevines throughout the growing season. Most vines (depending upon variety and vine age) infected late in the growing season "recover" during the winter, and are non-infected the following spring. For this reason vine-to-vine spread during the same growing season is not considered significant. Note that late-season infections usually have mild or no symptoms. It takes approximately five months for vines to show symptoms in the field. Thus, you will not be aware that overwinter recovery occurs unless vines are tested for the bacteria before and after the winter.

While vine-to-vine spread is not significant, vine-to-insect-to-alternate host may be a significant factor in reinfection from one year to the next. As feeding continues on an increasing number of infected vines during the season, the number of insects carrying the disease also increases. In the late summer and fall sharpshooters migrate to the riparian habitat carrying the bacteria to the alternate hosts where they overwinter. Since infected adults remain capable of spreading the disease throughout their lives, these overwintering insects are a source of infection the following spring.

Irrigated pastures, sump ponds, irrigation ditches or areas where Bermuda grass and other perennial grasses or sedges flourish and remain lush year-round are major sources of the green and red-headed sharpshooters. Although spread from these sources is not the most common, it has been documented in the North Coast. Cleaning up grasses and sedges growing along ditches and roads prior to bud break in grapes should prevent the green or red-headed sharpshooters from being a source of infection for PD.

Annual cover crops are not important vector sources unless the cover is allowed to grow throughout the year. Summer cover crops that result from repeated mowing and irrigation generally do not provide the kind of weeds or the permanent habitats needed to build up sharpshooter populations.

Ornamentals such as ivy, small periwinkle, rose, fuchsia and other woody plants support populations of the blue-green sharpshooter in residential or commercial landscape and can create 'hot spots' of PD in adjacent vineyards.

PD does not spread by way of contaminated pruning shears. Graft transmission does not appear to be a major factor in commercial vineyards. Hot water treatment of dormant cuttings (immersion at 45° C for three hours or at 50° C for 20 minutes) will destroy *X. fastidiosa.* If fall budding is done with fresh budwood make sure the buds come from a non-infected vine. Late-season infections in vines are symptomless. To ensure that a vine is free of bacteria, collect wood samples and test for the presence of bacteria.

Susceptibility of the disease in grapevines

Some vines infected during the season appear to recover from PD the first winter following infection. Recovery from PD depends on variety. In Cabernet recovery is high while in Barbera, Chardonnay and Pinot Noir it is low. In more tolerant cultivars, the bacterium spreads more slowly within the plant than in more susceptible cultivars. Once the vine has been infected for over a year (i.e. bacteria survive the first winter) recovery is much less likely. Young vines are more susceptible than mature vines, possibly because the bacteria can move more quickly through younger vines that through older vines.

Rootstock species and hybrids vary greatly in susceptibility. Testing of rootstock plants show that *V. riparia* is rather susceptible; *V. rupestris* (St. George) and 420A are very tolerant. Rootstock does not confer resistance to susceptible *vinifera* varieties grafted on to it.

Climate, variety and age determine how long a vine with PD can survive. One-year old Pinot Noir or Chardonnay can die the year they become infected, whereas chronically infected 10-year-old Chenin Blanc or Ruby Cabernet can live for more than five years. Long before that, however, these chronically infested vines will cease to bear a crop.

All *vinifera* cultivars are susceptible to PD but cultivars can vary markedly in levels of field resistance and tolerance:

Most susceptible	Less susceptible	Most tolerant
Barbera	Cabernet Sauvignon	Chenin Blanc
Chardonnay	Gray Riesling	Sylvaner
Mission	Merlot	Ruby Cabernet
Pinot Noir	Napa Gamay	White Riesling
	Petite Sirah	
	Sauvignon Blanc	

Alternate hosts of *Xylella fastidiosa:*

Many plants harbor the bacterium without having symptoms of disease. Of 100 plants tested by placing infective sharpshooters on them, 75 harbored the bacteria but only a few species developed disease symptoms. Natural vegetation near vineyards and wild plants distant from agricultural areas can harbor the bacteria.

Plant species vary in their role as reservoirs of *Xylella fastidiosa* for disease spread. Plant species are highly variable in how easily the PD bacterium infects the plant, how rapidly it will spread and the maximum population size it will reach within the plant. *X. fastidiosa* does not move systemically in all its plant hosts and must multiply in the plant for the vector to acquire bacteria.

In *Vitis vinifera* and in wild grape, the bacteria multiply, spread systemically and build up to concentrations of ten million to one billion bacteria per gram of plant tissue. The more the bacteria multiply and move within the plant, the greater the probability that a vector can pick it up by feeding on the plant. Blackberry is a systemic host like grape but has many fewer bacteria (1/100 to 1/1000 fewer), and these move more slowly than in grapevines. Mugwort is a propagative host (bacteria multiply) but not a systemic host. Thus sharpshooters can only acquire the bacterium from mugwort by feeding on the limited portions of the plant where the bacterium has multiplied after being introduced by the previous feeding of infectious vectors.

The PD strain of *Xylella fastidiosa* causes alfalfa dwarf disease and almond leaf scorch in California. In eastern U.S. various strains of *X. fastidiosa* cause phony peach disease and leaf scorch diseases in oak, elm, maple, mulberry, plum and sycamore. In South America strains of *X. fastidiosa* cause citrus variegated chlorosis and plum leaf scald. The relationship among the different strains is presently under investigation.

The role plants play as hosts of *Xylella fastidiosa* is presented in a Table at the end of this document.

Symptoms

Symptoms are caused by blockage of the water-conducting system by the bacteria. Water stress begins in midsummer and increases through fall. Summer and fall symptoms are more reliable for positive identification of the disease than spring symptoms.

First symptoms mid- to late summer

The combination of these three symptoms is a definitive indication that PD is present:

1) Leaves become slightly yellow or red along margins in white and red varieties respectively. As the disease advances, leaf margins progressively dry or die (turn brown) in concentric zones.
2) Scorched leaves dry down and the blade falls, leaving the petiole attached to the cane.
3) Wood on new canes matures irregularly, producing patches of green, surrounded by mature brown bark.

Leaf symptoms vary among grape varieties. Pinot Noir and Cabernet Sauvignon have highly regular zones of progressive marginal discoloration and drying on blades. In Thompson seedless, Sylvaner and Chenin Blanc the discoloration and scorching may occur in sectors of the leaf rather than along the margins.

Usually only one or two canes will show PD symptoms late in the first season of infection. Symptoms gradually spread along the cane from the point of infection out towards the end and more slowly towards the base. By mid-season some or all fruit clusters may wilt and dry up. Tips of canes may die back, roots may also die back. Climatic differences between regions can affect the timing and the severity, but not the type of PD symptoms. Hot climates accelerate symptoms due to moisture stress even when there is more than adequate soil moisture. Vines deteriorate rapidly after appearance of symptoms. Shoot growth of infected plants becomes progressively weaker as symptoms become more pronounced.