

Plant Diseases in Hawaiian Parks: Prevention or Preservation?

By Donald E. Gardner

Although the science of plant pathology is alive and well in Hawaii, as in other localities, most research emphasis is directed toward economically important diseases of major crops such as sugarcane and pineapple. Diseases occurring in native ecosystems, including those of Hawaii's national parks, have received relatively little attention. Such research is important for several reasons.

Hawaii, as an isolated, self-contained island ecosystem, is well known for its vulnerability to the destructive influences of alien introductions. The effects of alien plants and animals in these systems is increasingly well documented; however, potential influences of pathogenic microorganisms (e.g. fungi, viruses) and invertebrates inadvertently introduced have not been as well investigated. The susceptibility of native flora to attacks by introduced pathogens leading to destruction of epidemic proportion is an ongoing possibility. Such an introduction led to the almost complete decimation of the highly susceptible native American chestnut in eastern forests when the virulent chestnut blight fungus was introduced probably from the Orient in the early 1900s.

On the other hand, certain pathogenic fungi are considered, like their host plants, to be endemic to Hawaii, having evolved from ancestral introductions into unique forms as their hosts themselves have evolved. Such microorganisms, as components of native ecosystems, should be recognized, understood, and afforded the same protection provided the more visible higher plant and animal park resources. Without knowledge of the biology, life cycles, host ranges, nutrient requirements, or even the existence of such organisms, along with a recognition of their symptoms and signs on host vegetation, it is possible neither to manage nor to interpret park resources comprehensively. It is sometimes difficult to determine whether a fungus, with microscopic wind-borne spores, is endemic, indigenous, or was introduced on plant material as a direct result of human activity. Ambiguity in this categorization is therefore more common than are such determinations for higher plants and animals. My, and my coworkers' work on the following three prominent disease conditions illustrates the challenges encountered and the knowledge gained from plant disease research in native systems:

Red Leaf Disease of 'Ohelo

'Ohelo (*Vaccinium reticulatum*) and tree 'ohelo (*V. calycinum*)

are endemic Hawaiian shrubs. 'Ohelo is a major component of upper elevation dryland forests of both Hawaii Volcanoes (HAVO) and Haleakala (HALE) NPs, whereas tree 'ohelo is an important rainforest species. 'Ohelo, like its mainland relatives, cranberry and blueberry, produces succulent, edible fruit and receives considerable attention from park visitors. A disease I have termed the red leaf disease attacks both Hawaiian species (Gardner 1985). It is widespread in 'ohelo stands and is especially prominent along the well-frequented Hosmer Grove nature trail near HALE headquarters. In early stages, disease symptoms include strikingly bright red foliage produced usually on individual branches or twigs, in contrast to the surrounding normal green leaves.

Prior to my investigations the symptoms were generally not recognized as representing a disease condition. Park staff sometimes mistakenly referred the disease to the normal condition of newly-developing 'ohelo leaves, which also tend to be red. However, on close examination, including monitoring the development of tagged symptomatic branches, I noted that leaf drop, followed by twig death occurred rather than normal maturation of new growth. Affected branches also become abnormally thickened, with a proliferation of small twigs resulting in a "witches' broom" (Fig. 1). Such broom formation is a common symptom associated with plant diseases caused by several types of pathogens. Microscopic examination of leaf undersurfaces revealed minute fruiting structures of the fungus *Exobasidium*, a pathogen known to attack crop species of *Vaccinium* in North America and Europe.

I have referred the fungus for the present to *E. vaccinii*, the common species on *Vaccinium* hosts elsewhere, presumably having been introduced to Hawaii on imported azaleas or other ornamentals of the Ericaceae. This scenario, if correct, would suggest the need for management action toward the eradication or control of the alien pathogen from the endemic *Vaccinium* population. However, there is also evidence that the fungus may represent an undescribed endemic species and thus would belong in the 'ohelo population to be preserved and interpreted accordingly. Appropriate management action must await conclusive determination, by specialists in this group of fungi, of the status of red leaf disease in Hawaii.

Koa Rust

The endemic koa tree (*Acacia koa*) occurs throughout the islands in mid to upper elevation forests and is the second most common overstory species of HAVO. Aside from its obvious importance in native ecosystems, koa is also a valuable timber source in non-



Fig. 1. A partially defoliated "witches' broom" on an 'ohelo shrub affected with red leaf disease in Haleakala National Park. Earlier disease stages are characterized by conspicuous clusters of bright red leaves on infected twigs or branches.

NPS administered forests. Park visitors sometimes mistake koa for eucalyptus because its sickle-shaped phyllodes, which assume the function of true leaves in mature growth, resemble eucalyptus leaves.

Two closely related rust fungi, *Atelocaula* (*Uromyces*) *koa* and *A. digitatus*, cause conspicuous abnormal growth on phyllodes, twigs, and branches (Hodges and Gardner 1984). *Atelocaula koa* is con-



Fig. 2. A witches' broom of abnormally thickened, fleshy phyllodes (substitute leaves) infected with one of the koa rust fungi in Hawaii Volcanoes National Park. The diseased growth is covered with powdery masses of cinnamon-brown spores.



Fig. 3. Abnormally proliferated, elongated twigs draping in a dense broom on an a'ali'i (*Dodonaea viscosa*) shrub with an advanced stage of *Dodonaea yellows* disease.

sidered endemic, whereas *A. digitatus* is indigenous, also occurring in Australia on *Acacia* hosts native to that country. However, the life cycle of *A. digitatus* in Hawaii differs from that in Australia, having an extra spore state. As a further complication, we have identified a distinct, microcyclic form of *A. digitatus*, believed to be unique to Hawaii. Microscopic examination of the spores of this group of fungi has shown a highly ornamented type of reticulate surface structure, rare elsewhere among the rusts, which serves as a strong link establishing the affinity of the *Acacia* rusts to one another.

The diseases caused by these fungi produce contortion of new growth, and abnormally much-thickened, fleshy growths on phyllode surfaces or cause finger-

like modifications on the phyllodes themselves to form witches' brooms (Fig. 2). The fleshy growth is covered with powdery cinnamon-brown spore masses, contrasting with the normal green foliage. Systemic infection eventually kills branches, which retain their leaves and become conspicuous. Extensive damage in koa stands is rare, however, since the host-pathogen relationship among these coevolved species is well balanced.

The obvious close affinity of the Hawaiian rusts to those of Australia, as well as that of the *Acacia* hosts themselves between these regions separated by wide expanses of the Pacific Ocean, leads to interesting speculation concerning the ancestral origins both of the endemic fungi and their host in Hawaii. The frequent assumption by visitors that my interest in these fungi is to develop an effective treatment to "cure" the trees sets the stage for a "fungus appreciation" discussion emphasizing the uniqueness of these organisms and their place in native Hawaiian systems.

Dodonaea yellows

Dodonaea viscosa (formerly *D. eriocarpa*), known locally as a'ali'i, is an indigenous shrub or small tree of the soapberry family. It represents the dominant or a codominant woody vegetation type in drier regions of Hawaiian parks. I first observed a disease condition in 1977 on a small number of a'ali'i shrubs in HAVO (see Gardner 1988). Symptom progression relative to that of other diseases is slow. However, affected branches, or entire plants themselves, eventually lose their leaves and die. I have designated this apparently newly discovered disease "*Dodonaea yellows*" because the symptoms strongly suggest a "yellows"-type disease often associated in other plants with a mycoplasma agent (a submicroscopic bacteria-like organism). However, investigations led by University of Hawaii graduate student Wayne Borth have thus far revealed only unidentified virus particles rather than mycoplasmas associated with diseased tissue (Borth, et al. in review). Notwithstanding this association, we cannot yet conclude that the virus is actually causing the disease. Borth is continuing work to clarify the probable cause, means of spread or transmission, and other characteristics of the disease.

Since my initial observations, the disease has become more prevalent such that in some stands of a'ali'i in HAVO it is difficult to find many unaffected plants. We have now observed the disease, which appears specific to this host, in HALE as well as HAVO, and in other widespread a'ali'i populations throughout the Hawaiian Islands. Symptoms are particularly conspicuous, with entire plants uniformly affected, or individual, isolated branches or twigs may be symptomatic in contrast to surrounding normal growth. Leaves are stunted, often strikingly yellow, and have wavy margins. Abnormal twig proliferation and elongation causes a dense, draping broom-like growth (Fig. 3). Severely affected plants can be recognized at a distance in the field by their overall abnormal growth form, even giving the appearance of a separate, unrelated plant species (Fig. 4).

At present, nothing is known of the origin of the disease, whether arising as a new condition in Hawaii or introduced from elsewhere. Likewise, nothing is known of the means of spread or transmission and whether possible arthropod vectors are native or introduced, or what the potential long-range effect on a'ali'i populations may be. I have corresponded with plant scientists and foresters in other regions of the Pacific where *Dodonaea* spp. occur but have thus far found no other record of a disease resembling *Dodonaea yellows*. A mycoplasma disease of *Dodonaea* has been reported from India, however. Any connection between the Indian disease and the condition in Hawaii remains to be determined.

Management action, whether directed at disease control through removal of affected plants or control of possible vectors, or, on the other hand, toward preservation of the disease as a natural phenomenon, must await research answers to the many questions posed by *Dodonaea yellows*. We hope that the pieces of the *Dodonaea yellows* puzzle eventually can be assembled to allow resource management to approach this problem in a way consistent with NPS objectives.

Agriculturists, gardeners, homeowners, and the public in general are often conditioned to regard all plant diseases and their causative agents as undesirable entities to be gotten rid of by "spraying them with something." Such action may be warranted where park resources are clearly under serious attack by alien invaders. However, as protectors of our native environments, park managers should be cautious vis-à-vis the "spray everything" mind-set. Much can be learned and appreciated by our taking time to become acquainted with the smaller, lesser known components of the resources for which we also have responsibility.

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References

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Fig. 4. A healthy a'ali'i (left) closely associated with a diseased shrub of the same species (right) in the field in Hawaii Volcanoes National Park. The diseased shrub has yellow foliage and an abnormal growth form.