



***Cephaleuros* Species, the Plant-Parasitic Green Algae**

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C*ephaleuros* species are filamentous green algae and parasites of higher plants. In Hawai'i, at least two of horticultural importance are known: *Cephaleuros virescens* and *Cephaleuros parasiticus*. Typically harmless, generally causing minor diseases characterized by negligible leaf spots, on certain crops in moist environments these algal diseases can cause economic injury to plant leaves, fruits, and stems. *C. virescens* is the most frequently reported algal pathogen of higher plants worldwide and has the broadest host range among *Cephaleuros* species. Frequent rains and warm weather are favorable conditions for these pathogens. For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae.

Symptoms and crop damage can vary greatly depending on the combination of *Cephaleuros* species, hosts and environments. The most severe disease combination in Hawai'i is *C. parasiticus* on guava (*Psidium guajava*). Spots caused by *C. parasiticus* on guava leaves are a top-down, intercellular, full-thickness necrosis, destroying both upper and lower epidermal cell layers and all intervening tissues. Then, a bright but relatively sparse orange algal bloom bursts forth from the undersides of leaf lesions, rather than from the upper side of leaves as is usually the case with *C. virescens*, the more commonly occurring species in the genus.

The distinctive and much more common spots caused by *C. virescens* on many hosts in Hawai'i appear on the upper leaf surface as raised yet flattened, textured, burnt-orange to brown or rust-colored, circular areas up to about 2 cm in diameter, having indistinct, filamentous margins and fuzzy surface topographies. Yet, this species is generally a relatively harmless, subcuticular leaf parasite.

For information on other *Cephaleuros* species and their diseases in our region, please refer to the technical report by Fred Brooks (in References). To see images of *Cephaleuros minimus* on noni in American Samoa, visit the Hawai'i Pest and Disease Image Gallery (www.ctahr.hawaii.edu/nelsons/Misc), and click on "noni."

The pathogen

The disease is called algal leaf spot, algal fruit spot, and green scurf; *Cephaleuros* infections on tea and coffee plants have been called "red rust." These are aerophilic, filamentous green algae. Although aerophilic and terrestrial, they require a film of water to complete their life cycles. The genus *Cephaleuros* is a member of the Trentepohliales and a unique order, Chlorophyta, which contains the photosynthetic organisms known as green algae.



Algal leaf spot of avocado (*Persea americana*) in Hilo, Hawai'i, caused by *Cephaleuros virescens*

(Photos by S. Nelson unless otherwise noted.)

Cephaleuros species consist of branched filaments that comprise a thallus in the form of irregular discs. The thallus grows below the cuticle or sometimes below the epidermis of the host plant. This pigmented thallus (orange to red-brown) consists of a prostrate portion that is branched irregularly with irregular cells and an erect portion of unbranched hairs, with cylindrical cells, sterile or fertile, protruding through the cuticle. Haustorial cells are sometimes present inside the plant host's tissue. Sporangioophores bear one or more head cells subtending sporangiate-laterals. Gametangia are terminal or intercalary on the prostrate cell filaments.

Cephaleuros species are found in tropical and subtropical climates, on all continents and probably all islands between about 33°N and 33°S of the equator, provided the temperature and humidity are suitable for their growth and reproduction. On the U.S. Gulf Coast, *C. virescens* has been recorded on at least 287 plant species and cultivars, including 80 that are subject to stem infections. *Cephaleuros* species are capable of both asexual and sexual reproduction. Through sexual reproduction, the resulting zygote produces a dwarf sporophyte. The life history consists of alternation of heteromorphic generations, with the sporophyte reduced to a dwarf plant. The asexual stage is probably much more important to the typical infection and disease processes.

These pathogens are dispersed by wind and splashing water. On leaves, symptoms vary according to the *Cephaleuros*-host species combination. For *C. virescens*, leaf spots are usually on the upper leaf surface, raised, velvety in appearance, in shades of orange or brown. Leaf spots caused by *C. parasiticus* on guava are top-down, full-thickness necrosis, destroying both epidermal layers (abaxial and adaxial) and all intervening tissues. The bright but relatively sparse but brilliantly pigmented orange algal bloom occurs on the undersides of leaves, rather than the upper. On some guava types a chlorotic, yellow halo surrounds the lesions. On guava fruits, spots are slightly sunken and cracked and when severe lend a scabby appearance to the fruit skin. On twigs and branches, lesions may lead to dieback and loss of distal organs.

Cephaleuros disease cycle

Hosts are inoculated when sporangia or thallus fragments with sporangia are deposited on susceptible host tissues. Infection occurs and symptoms develop under moist conditions when motile zoospores are released from



Algal leaf and fruit spot of guava caused by *Cephaleuros parasiticus*

the sporangia, penetrate the host cuticle, and generate disc-like algal thalli with threadlike algal filaments. The effects of the spots on plants are reduced photosynthetic area of leaves, defoliation, loss of fruit marketability, twig dieback, and tissue necrosis. The pathogens reproduce and survive in spots on leaves or stems and in fallen plant host debris.

Hosts

Species of *Cephaleuros* are very common on the leaves of such economically important tropical trees and shrubs as tea (*Camellia sinensis*), kava (*Piper methysticum*), pepper (*Piper nigrum*), magnolia (*Magnolia grandiflora*), coffee (*Coffea arabica*), oil palm (*Elaeis guineensis*), avocado (*Persea americana*), vanilla (*Vanilla planifolia*), mango (*Mangifera indica*), breadfruit (*Artocarpus altilis*), guava, coconut (*Cocos nucifera*), cacao (*Theobroma cacao*),



Algal leaf spot of magnolia (*Magnolia grandiflora*) in Kurtistown, Hawai'i caused by *Cephaleuros virescens*

as well some citrus (*Citrus* spp.) cultivars. *Cephaleuros* species do not affect certain key subsistence crops in the Pacific, such as banana (*Musa* spp.) and taro (*Colocasia esculenta*), although coconut and breadfruit are hosts for leaf spots.

Crop damage

Generally, on most hosts, leaf infection is of little direct economic importance and is confined to low-hanging branches near ground level. On more susceptible hosts such as guava there can be significant tissue necrosis, extensive defoliation, economic injury to fruit quality, crop loss, and reduced photosynthesis and plant vigor.

We may separate *Cephaleuros* species and the damage they cause into two groups on the basis of their mode of parasitism: subcuticular vs. intercellular. *C. virescens* is a subcuticular parasite, while *C. parasiticus* is an intercellular parasite. This latter mode of parasitism permits more tissue damage than subcuticular parasitism.

In Hawai'i, *Cephaleuros* damage to limbs, twigs, and shoots does not seem to be important as in some other locations. On carambola (starfruit, *Averrhoa carambola*) in Florida, twigs and limbs may be attacked by *C. virescens*. Symptoms include rough circular greenish-grey or rusty-red areas and shoot dieback.

Most fruit damage from *Cephaleuros* in Hawai'i probably occurs on guava and is associated with *C. parasiticus*. The damage to guava fruits is limited to the



Typical raised, velvety, coppery brown algal spots on leaves of avocado (*Persea americana*) caused by *Cephaleuros virescens*. The spots consist of the brightly pigmented thallus of the plant parasitic algae.

skin of the fruit and there is no soft rot. The fruit spots are slightly sunken and cracked with a dark, somewhat corky aspect. When severe, the fruits appear scabbed.

A recent survey of *Cephaleuros* spp. host range in American Samoa found it to be extremely broad, affecting plants in dozens of families.

Cephaleuros leaf spot of avocado

Algal leaf spots caused by *C. virescens* are commonly seen on avocado. The symptoms are responsible for many of the questions raised by backyard growers. The disease usually attacks leaves on low-hanging branches. Often, there will be no spots at all on the upper leaves. Damage to avocado plant vigor and yield is generally insignificant.

Cephaleuros leaf and fruit spots of guava

Both *C. virescens* and *C. parasiticus* can cause substantial damage to some varieties of guava in Hawai'i. Leaf spots can be severe, leading to reduced plant vigor and defoliation. Fruit spots can affect marketability of fresh fruits and cause fruits to be rejected by harvesters or at juicing facilities. The disease occurs commonly wherever *Psidium* species are growing in relatively wet conditions, such as the eastern half of the island of Hawai'i or in many of Hawai'i's coastal forests. There are two main types of symptoms on guava leaves: velvety spots and non-velvety spots.



Left: *Cephaleuros parasiticus* spots on guava leaves appear initially as tiny, dark brown specks that enlarge into roughly circular lesions with ash-colored centers and dark brown to blackened margins (Hakalau, Hawai'i). **Right:** On the underside of the same leaf, spots appear as dark gray, circular and watersoaked. The brightly pigmented algal thallus and sporangiophores emerge in yellowish-orange clusters within rings in the dark, watersoaked lesions. Lesions tend to form along the leaf midrib and as damage progresses the vein can collapse and die (Hakalau, Hawai'i).



***Cephaleuros parasiticus* leaf spots on some guava cultivars are surrounded by yellow halos, and the associated fruit damage can be significant (near Hilo, Hawai'i).**

C. virescens leaf spots on guava consist of velvety patches of algal bloom on the upper leaf surface. Fruits can be severely spotted. *C. parasiticus* causes a non-velvety spot type that mimics a rust disease.

Integrated management of *Cephaleuros* diseases

Accurate diagnosis of the disease is by microscopic examination of the alga.

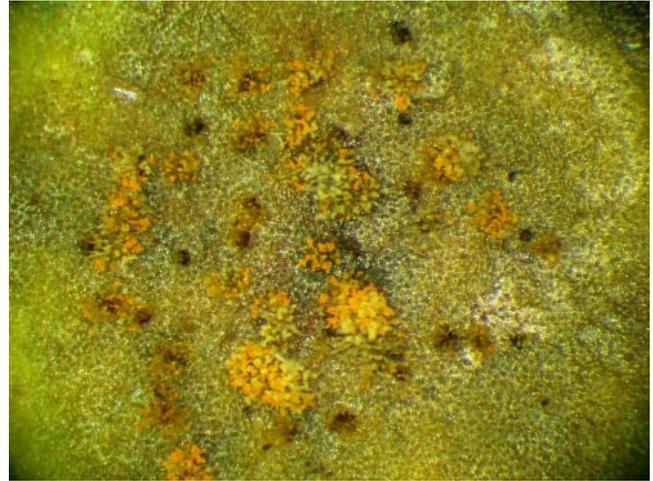
Diseases caused by *Cephaleuros* spp. in Hawai'i rarely warrant management, except in the case of guava in wet environments. However, the disease may be a nuisance

in landscapes. To control these parasites, integrate a combination of the following practices:

- Sanitation: remove spotted leaves by hand from lightly diseased plants; prune low hanging branches that are affected by the disease; collect and discard all fallen leaves.
- Pruning: prune overhanging trees around diseased plants (this will reduce relative humidity and speed up leaf drying after rains).
- Reduce plant stress: keep plants well fertilized; improve soil drainage.
- Weed control: keep weeds around affected plants under control (this will reduce relative humidity in the plant canopy and reduce plant stress); prevent climbing and vine-like weeds from establishing on the host plant.
- Fungicides: some fungicides will provide control; use chemicals only according to directions on the label; the Bordeaux mixture is commonly recommended.
- Intercropping: interplant very susceptible hosts with less susceptible hosts.
- Variety selection: try to select a more tolerant variety (for example, of guava) where the crop is grown in a wet environment.
- Choice of planting location: for highly susceptible crops, select a planting location with moderate rainfall, well drained soil and good air circulation.
- Manage: plant spacing and thinning to improve aeration and light exposure.



Cephaleuros parasiticus thallus and sporangiophores. Upon making a slide mount in a drop of water, zoospores may be released immediately (Photo: Fred Brooks, from material collected in American Samoa.)



Cephaleuros parasiticus algal thallus emerging through the epidermis of the underside of a guava leaf (*Psidium guajava*, highly magnified). This brightly pigmented alga is often mistaken for a rust fungus. The hematochrome pigments, astaxanthin and B-carotene, lend a yellow-green to dark reddish-orange color to the thallus of **Cephaleuros**. (Photo: S. Nelson and B. Bushe, from infected material near Hilo, Hawai'i)



Guava cultivars may express symptoms differently. Here, leaves of three *Psidium* cultivars growing in a UH-CTAHR collection in the Hilo area display their unique reactions to association with **Cephaleuros parasiticus**.

Finding a number of different algal species on a leaf is common in shaded, moist environments. Most of the algae are not parasitic on plants. If you can easily rub off algae with your fingers, they are probably not plant parasitic.

References

- Brooks, F. 2004. Plant parasitic algae (Trentepohliales, Chlorophyta) in American Samoa. Technical Report no. 39. (Also published in Pacific Science 58: 419–428, University of Hawai'i Press).
- Chapman, R.L. and M.C. Henk. 1985. Observations on the habit, morphology, and ultrastructure of *Cephaleuros parasiticus* (Chlorophyta) and a comparison with *C. virescens*. J. Phycol. 21:513–522.
- Harrison, N., and P. Jones. 2003. Diseases of coconut. p. 197–225 in: R.C. Ploetz, ed., Diseases of tropical fruit crops, CABI, Wallingford, UK. 544 p.
- Holcomb, G.E. 1986. Hosts of the parasitic alga *Cephaleuros virescens* in Louisiana and new host records for the continental United States. Plant Disease 70: 1080–1083.
- Holcomb, G.E. 1998. First report of *Cephaleuros virescens* in Arkansas and its occurrence on cultivated blackberry in Arkansas and Louisiana. Plant Disease

- 82: 263.
- Joubert, J.J., and F. H. Rijkenberg. 1971. Parasitic green algae. p. 45–64 in: K.F. Baker and G.A. Zentmeyer, eds. *Annual Review of Phytopathology*, vol. 9. Annual Reviews, Palo Alto, California.
- Keith, L., Ko, W.-H., Sato, D. 2006. Identification guide for diseases of tea. University of Hawai‘i at Mānoa, College of Tropical Agriculture and Human Resources, Plant Disease no. 33. www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-33.pdf.
- Knorr, L.C. 1964. A suggestion that Lee tangerine may be hypersensitive to *Cephaleuros virescens*. *Plant Disease Reporter* 48: 478–479.
- López-Bautista, J.M., D.A. Waters, and R.L. Chapman. 2002. The Trentepohliales revisited. *Constancea* 83.
- López-Bautista, J., F. Rindi, and D. Casamatta. 2007. The systematics of subaerial algae. p. 599–617 in: *Algae and cyanobacteria in extreme environments*. Springer, Netherlands.
- Misra, A.K. 2004. Guava diseases—their symptoms, causes and management. p. 81–119 in: *Diseases of fruits and vegetables: vol. II*. Springer, Netherlands.
- Ruehle, G.D. 1941. Algal leaf and fruit spot of guava. *Phytopathology* 31: 95–96.
- Winston, J.R. 1938. Algal fruit spot of orange. *Phytopathology* 28: 283–286.

Acknowledgments

Fred Brooks (UH-CTAHR), for providing *Cephaleuros* photographs, information, and a critical review of this publication; Brian Bushe (UH-CTAHR) for making tissue mounts and taking photographs.