

**Disease Index for the Rust
Puccinia psidii on ‘Ōhi‘a
(*Metrosideros polymorpha*)
in Hawai‘i**



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On the cover

A severely diseased 'ōhi'a branch with numerous pustules of yellow urediniospores

Photo credits

R. Anderson: 1, 5 G, 8 A,B, 10 A,B,C, 11 F, 12 J,K,L, 14 A,B,C,D. C. Kadooka: 5 A,B,C,F, 6 A,B, 7 C,D, 8 C,D, 10 D,E, 11 G,I, 13 A,B,C,D, 15 A,B,C,D. Anne Marie LaRosa/Cheresa Coles: 7 E, 11 H, 12 Category 4 photo. J. Uchida: 5 C,D.

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A rust disease first found on potted 'ōhi'a (*Metrosideros polymorpha*) on O'ahu in 2005 has become a threat to Hawai'i's forests. This plant composes as much as 80 percent of some of the remaining native forests, and its genetic diversity is highly valuable to these ecosystems. 'Ōhi'a is one of the first plants to colonize new lava flows and is adapted to both wet and dry environments from sea level to high elevations. As a keystone species in the forest, 'ōhi'a provides habitat for numerous populations of native flora and fauna, including some endangered species, and helps maintain the hydrological cycle; without it, the entire ecosystem is at risk.

The rust was identified as *Puccinia psidii*, which is known to have a wide host range within the Myrtaceae. Crucial to investigations of the rust is determining its distribution throughout the state. By 2006, it had spread to Hawai'i, Maui, and Kaua'i. By 2007, it was also found on Lāna'i and Moloka'i. However, the actual distribution on each island remains unknown.

Many of the people who frequent Hawai'i's forests could help map the distribution of this rust on 'ōhi'a and its other hosts. In addition to identifying the rust and noting its location, it is also valuable to determine the severity of the disease. Because some other diseases and growths resemble the rust, complicating its identification, this document was prepared to illustrate the rust symptoms and their varying degrees of severity on 'ōhi'a and to compare them with symptoms caused by other pathogens.

This disease index thus aids a statewide program to monitor and document the incidence and severity of the rust *Puccinia psidii* on 'ōhi'a. A companion index illustrates symptoms of *P. psidii* on another member of the Myrtaceae, rose apple (*Syzygium jambos*), a naturalized tree that is highly susceptible to the rust and serves as a reservoir of the pathogen. A third related index illustrates symptoms of diseases on other plants caused by algae and algae-like organisms that may be mistaken for *P. psidii* rust. All three publications will be issued in 2008 and posted at www.ctahr.hawaii.edu/freepubs under the category Plant Disease.

Directions for recording observations of *Puccinia psidii*

- For all sites, record the host plant, location, date, and disease category (as described below). Morphologically, 'ōhi'a is a very diverse species, so note the type of leaf, i.e., glabrous (smooth) or pubescent (hairy), leaf size, and any unusual flower color or plant form. A survey form is provided.
- For location, GPS coordinates are ideal. Lacking a GPS device, if you are on a trail, you can note which part you are on by estimating the distance traveled (first quarter of the trail, half way along, etc.), or you can note some land feature (near a certain stream, ridge, etc.); if near a highway, give its name and nearest milepost marker if available.
- Determine if the rust is present at a site by checking all sides of at least five trees; if no rust is found, the site's record is zero (absence of the rust at a site is valuable information). For tall trees, check the lower canopy and make a note of the tree size.
- Place specimens in separate bags; wipe hands with a moist tissue before handling a new plant. Label each bag with the location, host, and other notes. Avoid touching healthy plants if you have handled plants with heavy infection levels. Wiping hands is recommended after each sampling. Although movement of the pathogen is largely by the wind and rain splash, contact can also move spores.

- Water is needed for rust infections and disease development. Record the weather conditions and observations on the environment's moisture. In some areas the rust may not be present during the dry season but present during wet periods of the year. If you revisit locations and find plants with a different disease level, please report these changes.

In general, it has been easier to find the rust symptoms on young leaves. Rapidly growing rust colonies on young leaves often form concentric circles of pustules (A). Pustules are groups of rust spores (or urediniospores) that are single-celled and have tiny spines (C, D). Small blister-like lumps or pimples are also present; these are the spores covered by the host epidermis (skin) (B). The urediniospore infects the leaf on the undersurface, and the developing spot penetrates to the top surface. Thus spots on the top surface of the leaf that have no corresponding spot on the opposite side of the leaf are not likely to be rust spots.

A second type of spore is the teliospore (E, stained teliospores). For all categories, older spots may have teliospores that are easily confirmed microscopically. As the leaf tip in Figure A ages, spots will remain but spore levels may be low. Given the disease severity on this 'ōhi'a tip, spores should be present on older leaves. Confirmation of the rust on other older leaves with fewer spots will be more difficult, and microscopic examination is needed to confirm rust spores. Researchers on the Big Island, Maui, O'ahu, and Kaua'i will help with rust confirmation and are listed on p. 16. Try to submit your samples to the researchers soon after the specimens are collected. If you cannot submit your samples in a day or two, place them in Ziploc bags, label with date and location, and freeze them.

If any 'ōhi'a has symptoms associated with more than one category, use the higher category. Thus if a plant has some leaves with 10–15 small spots each and other leaves with only one or two spots, make a note of the variation and rate the plant as category 2. Until a large number of 'ōhi'a plants can be inoculated in laboratory studies, the effect of low inoculum levels, host resistance, and insufficient humidity cannot be known.

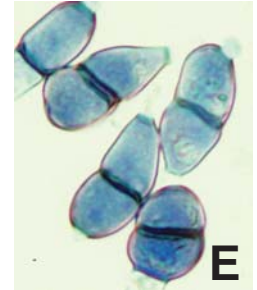
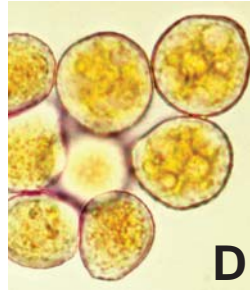
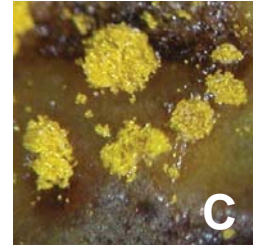
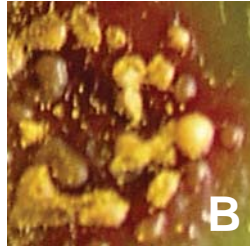
Buds and flowers (F, G) may also be diseased. Seeds may be contaminated by the diseased plant, so avoid collecting seeds from diseased plants or plants near them. If seeds are needed from a diseased plant, surface-disinfect them before planting and monitor them after germination.

Individuals to whom reports should be sent are listed on page 16. Statewide data summaries will be prepared by Janice Uchida and Robert Anderson.

The following categories describe the types of symptoms that have been observed in the field and will guide data collection.

Disease index categories for the rust *Puccinia psidii* on 'ōhi'a

Category	Disease symptoms
0	No symptoms found, or symptoms found but no rust spores confirmed
1	1–5 spots, yellow or white urediniospores confirmed
2	3–7 large or about 10–15 small spots, with a moderate level of disease; yellow / white urediniospores confirmed
3	Severe disease levels; stems with pustules and / or no leaves
4	Dead apical tips and numerous defoliated tips



- A. Young 'ōhi'a shoot tip with reddish spots and yellow rust pustules in concentric circles
- B. Detail of a spot showing yellow spore groups with opened and covered pustules
- C. Open pustules of urediniospores
- D. Photomicrograph of yellow single-celled urediniospores with tiny spines
- E. Photomicrograph of stained two-celled teliospores



Plants may have flowers that are infected. Infections of sepals on buds can be common, and older lesions will occur on flowers.

Category 1

Young leaves / new shoots

- Very low disease levels with only a few spots per tree or bush; spots can vary in size.
- The adaxial (upper) leaf surface has spots that may be slightly yellow to pink, dark with a yellow border, dark without a border, or reddish; they may have a few spores (A, C, E).
- The abaxial (undersurface) of the leaf has spots with few to many pustules producing many yellow spores (B, D).



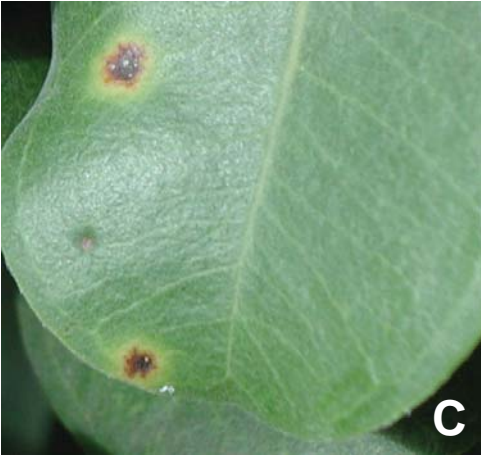
Adaxial (upper) leaf surface with a few dark spots per leaf

Older leaves

- Spots on older leaves have few yellow urediniospores and may have teliospores. These need microscopic confirmation and should be sent to one of the researchers willing to confirm rust identifications (see back cover). If confirmation is not possible and only old spots are present, make note of this.

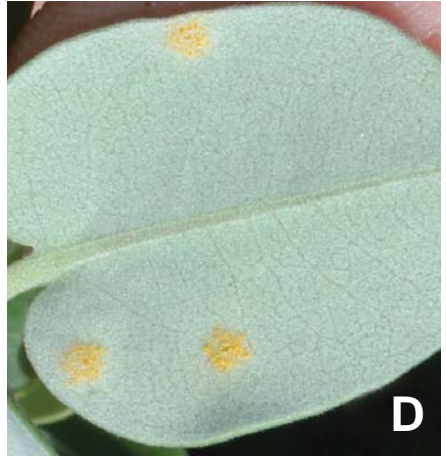


Abaxial (lower) surfaces of several leaves, each with a few spots and many spores; these spots are either black on the top surface (A) or light in color (E).



C

Adaxial surface of a leaf with two older spots



D

Abaxial side of the leaf in C showing numerous pustules and spores



E

Young plant with a single yellow-pink spot

Category 2

Young leaves / new shoots

- Moderate infection level with six or more spots per leaf (A and B).
- The number and size of spots are larger, although leaves with many small spots can occur (C and D).
- Spots may merge to form larger spots. Spots and pustules are easy to find on young tissue.

Older leaves

- On older leaves, there may be three to seven spots per leaf, and spores will be more difficult to find when the spots are old. Again, these symptoms need microscopic confirmation to determine if they are rust spores (either yellow/white urediniospores or two-celled teliospores); if confirmation is not obtained, make a note that only old lesions were present.



The adaxial leaf surface has rust spots with numerous spores (A) and fewer spores (B).



C, D. The adaxial and abaxial surfaces of leaves with numerous spots caused by the rust. Only a few spores were found on the abaxial surface because all spots were old.

Category 3

Young leaves / new shoots

- This category contains severely infected leaves with numerous spots and pustules on young leaves and on stems.
- Plants that have rust spots on the young stems belong in this category (A, D, and F).
- Many spots, 20 or more with many sporulating pustules on the leaf, are present (A, B, C, F, and G).
- The disease can be so severe that the entire surface of the leaf or stem is covered with spores (D and E). In general, more spores form on the leaf undersurface.
- Spots with pustules in concentric rings can be observed on young tissue (G).
- After several weeks, teliospores may be found, often on the undersurface of the leaf.



Abaxial surfaces with many spots



Adaxial surface with spots producing spores



Adaxial surface, close-up of pustules



Numerous spots on a twig (D) and the abaxial surfaces (E) of young leaves



Category 3 (continued)



Numerous spots on the twig (F) and abaxial surface of a young leaf (G)

Pink-orange/yellowish spots on apical tip

Older leaves

As with category 2, older leaves with spots can be more difficult to confirm as caused by the rust. With age, spores become white and are fairly common. These are fairly easy to recognize microscopically as they retain their tiny spines. Note the white spores in the centers of the spots in Figure I.



Category 3 (continued)



After 2 months, spores may be very few on the top surface (J) but will continue to be formed on the undersurface (K). With time, the older pustules lose their spores, and only fragments of the epidermis remain with a few white spores (L). New pustules continue to produce yellow urediniospores (L). After 6 months, however, it becomes more difficult to confirm and a microscope is needed.

Category 4

- Numerous dead apical tips
- Twigs without leaves are common.
- Dead twigs are common.
- Seedlings are killed.

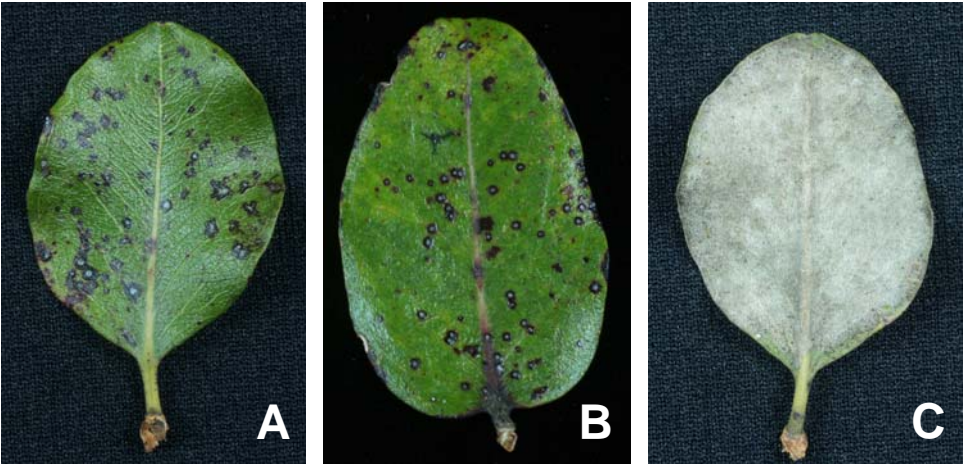


Symptoms *NOT* associated with the rust

Although there are others, the following are a few of the symptoms we have recorded, in the few months we have worked on this project, that are *not* caused by the rust *Puccinia psidii*. Over 110 species of fungi have been recorded from the leaves of 'ōhi'a, and some are likely to be pathogens that cause leaf symptoms.

Tiny black spots

Leaves may be covered with numerous black spots that are tiny (less than 1 mm [$\frac{1}{32}$ inch]) or up to 3–5 mm ($\frac{1}{8}$ – $\frac{3}{16}$ inch) in size (A and B). Many of the small black spots have a central dead area, which is gray. Frequently there is a hole in the center, which may be caused by tissue age or insect damage. Many of these spots have been dissected, and no rust spores have been found. The etiology of these spots is unknown. The undersurface may not have corresponding damage (C).



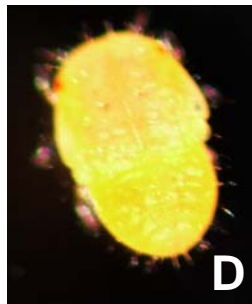
Dark spots with brown growths

At other times, a few of the black spots are larger (D) and have a brownish growth on the surface. These are likely to be algal growths as thin sections reveal what appears to be a brownish algal colony. However, no spores or mature algal colonies have been found as yet.



Psyllid galls

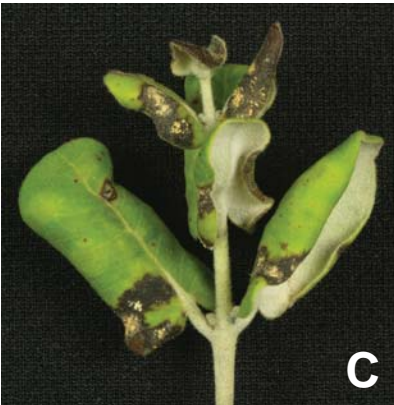
Galls of the psyllid insect can also confuse the diagnosis. Large galls are obvious (A), and when dissected, a psyllid can be found inside (C and D). Open galls can be found after the psyllid emerges from the leaf undersurface (B). At least 15 species of psyllid are known to attack 'ōhi'a. Some of the galls can be confused with the rust, and unless rust spores can be found, small "lumps" or indentations on the leaf are not the rust. The rust can occur on the same leaf as the psyllid, and rust pustules have been found on the surface of insect galls. On a typical leaf with numerous galls that was examined, one gall contained a large fifth-instar psyllid nymph (C) (less than 2 mm), while 15 other galls each contained a small first-instar nymph (D) (less than 1 mm).



Symptoms *NOT* associated with the rust (continued)

Potential new fungal disease

Dark brown to black leaf spots with tan to salmon colored spore masses have been collected on the Big Island (A to D). These spots resemble the rust spots. However, when the spores are examined under a microscope, they can be seen to be oval and long and hyaline (clear) and thus definitely are not the rust *P. psidii*.



Field survey for *Puccinia psidii* rust disease

Host observed: rose apple 'ōhi'a other _____
Use a separate form for each host/observation.

Collector _____ date __/__/__ phone/e-mail _____

sample taken; sample no. _____
(Sample number might include your initials, the date, and a sequence number; e.g., RA 4/15/08-2.
Please give this form to the researcher along with the sample.)

Environment nursery natural location
island _____ location _____ trail/road _____
trail section/milepost _____ elev. (est.) _____
GPS _____

If no GPS, include further description of the site in the comments field.

Description of plant

young mature with flowers and seeds in decline, repeated loss of young leaves
plant size _____
For 'ōhi'a: leaves pubescent (hairy) leaves glabrous (smooth)
flower color: _____

Rust occurrence leaf spots/rust spores not observed present
disease index category: 1 2 3 4 5 (check all that apply)

Extent of field examination 4 sides of host checked, at least 2-3 branches on each side examined; _____ sides checked and branches examined; only 1 side observed

Disease present mostly on young leaves mature leaves old leaves all leaves
Extent of rust infection in area: 1 tree only a few trees many trees all trees in the area have some infection

Nearby infected host plants rose apple 'ōhi'a paperbark java plum
 mountain apple bush cherry downy rose myrtle *Eugenia reinwardtiana*
others _____

Other *Metrosideros* species present:

rugosa *macropus* *waialealae* *tremuloides*

M. polymorpha varieties present (specify) _____

Comments:

Researcher findings: initials _____ date _____ urediniospores teliospores

Please submit rust survey results to these researchers:

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Find a file for the survey form at www.ctahr.hawaii.edu/oc/forms/rustsurvey.pdf.

We greatly appreciate any **findings of new hosts**. If you find a plant not mentioned in this publication that may have the rust, please submit it to Janice Uchida, Robert Anderson, Robert Hauff, Scot Nelson, Norman Nagata, or Jeri Ooka. We will confirm the pathogen and report back to you.



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