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Hawaiian Mistletoes (*Korthalsella* Species)

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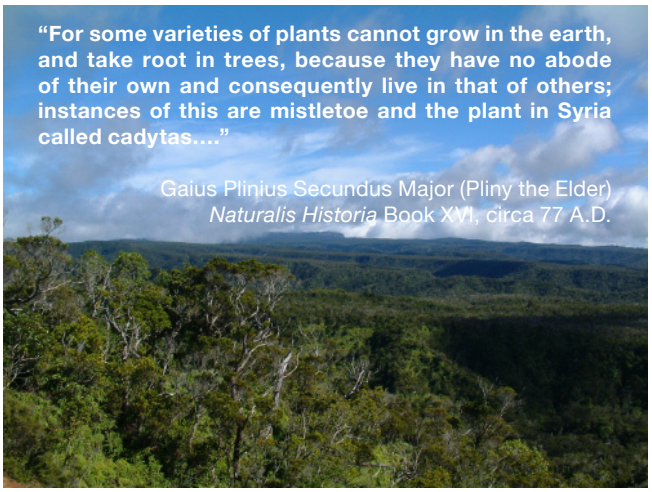
Although nearly 2,000 years ago Pliny the Elder recognized the epiphytic or parasitic habit of certain plant species, much of what we know about these fascinating organisms derives from our study of them during the past 130 years. Still, "our knowledge about how they induce disease [in plants] remains fragmentary and filled with conjecture" (Knutson 1979).



The *Metrosideros* forest habitat for *Korthalsella remyana*, overlooking the Alaka'i Swamp on Kaua'i (Photo: Dean Meason).

Most genera of parasitic seed plants are tropical or subtropical. There are a number of important genera in Hawai'i, including *Cuscuta* species (dodder), *Cassytha filiformis* (woe-vine or laurel dodder), and *Korthalsella* species ("korthal" or Hawaiian mistletoes, see Table 1).

Mistletoe is a type of seed plant that grows as a parasite on other plants. They are among the nearly 3,000 species of plant-parasitic angiosperms in 15 plant families (Table 2). Leafy mistletoes can be quite damaging to their hosts, slowly killing them. These chlorophyllous hemiparasites include the infamous *Viscum album*, which has been associated with 25-percent reductions of tree growth in coniferous forests. Australian eucalyptus forests infested with plant-parasitic *Amyema* have experienced growth losses of 50 percent or more.

The strange-looking mistletoes in Hawai'i, with their enlarged stems and reduced leaves, resemble aerial cacti. These odd, rootless plants can be inconspicuous to the casual observer, but there is no mistaking their presence where infections are severe. In heavy infections, the leaves and stems of these parasites can be the predominant foliage on the host plant.

This publication discusses the korthal mistletoes in Hawai'i as parasitic seed plants capable of inducing disease in their woody hosts. Although they are plant pathogens, they are also functional components of natural ecosystems in Hawai'i, providing food and shelter for many creatures.

The pathogen

The common name for these plants comes from the Old English *mistiltan*. The root of mistiltan, *mistel-* (mistletoe), is derived from the Proto-Germanic *mikhstilaz*. The suffix is from *-tan*, meaning "twig." The plant was venerated by the Druids, and the custom of hanging it at Christmastime and kissing under it was mentioned by Washington Irving. In Hawaiian the plant is called kaumahana (warm perch) or hulumoa (chicken feathers).

In Hawai'i there are six *Korthalsella* species (Table 1). The genus has been described (Wagner et al. 1999) as follows: "Shrubs or subshrubs parasitic on flowering plants, monoecious. Branches opposite or dichotomous; stem internodes usually flattened, successive internodes

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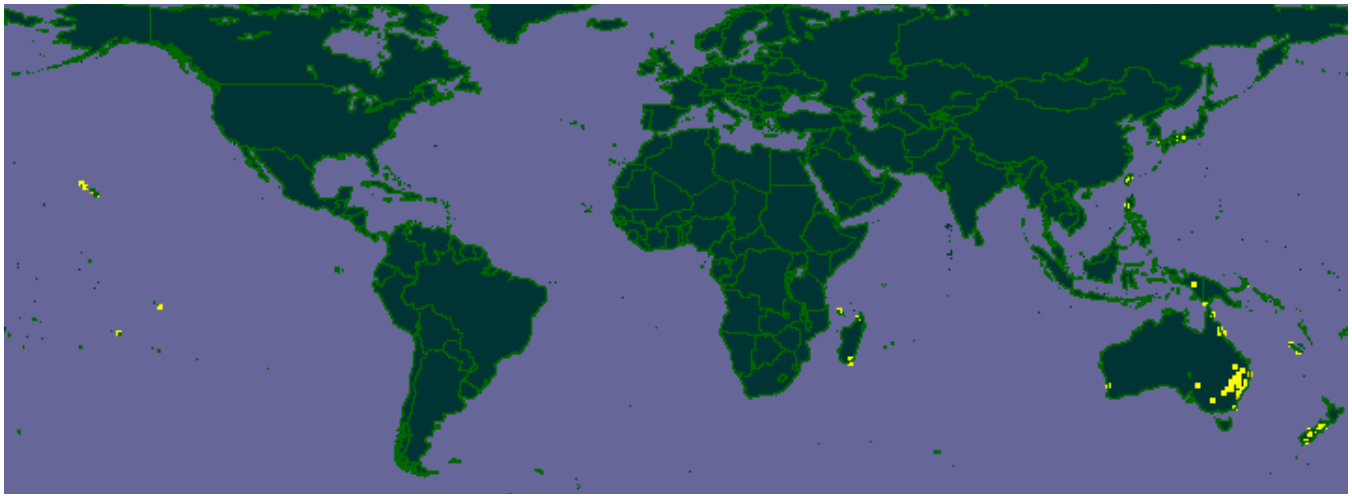

Worldwide distribution of *Korthalsella* (Global Biodiversity Information Facility Network)

in the same plane. Leaves reduced to scales, in 2 ranks, usually fused into a ring. Inflorescence axillary, a cyme, the flowers in each group developing successively to form a dense cluster; peduncle and pedicel +/- absent; bracts absent, but flowers subtended by hairs. Male flowers globose in mature bud; perianth lobes 3. Anthers sessile, circular, 2-loculed, introrse, connate into a synandrium, dehiscence longitudinal. Pollen grains prolate, semicircular in polar view. Female flower ovoid in mature bud; perianth lobes 3, minute. Placentation free, central. Style absent; stigma nipple shaped. Berry elipsoid or pyriform, mostly less than 4 mm, crowned by persistent perianth, exocarp smooth, weakly explosive at maturity." There are about 25 species in tropical and subtropical temperate regions of the Old World (except Europe), and one species in China (Hua-Shing 1988).

The taxonomy of the genus *Korthalsella* appears to be confused, with the number of species listed varying among authors. According to Wagner et al. (1990), *Korthalsella* is "a genus of about 20 species from Ethiopia eastward through the islands of the Indian Ocean and continental southeastern Australia and New Zealand, and eastward to Hawai'i and Henderson Island." The greatest concentration of *Korthalsella* is in Hawai'i, where it is abundant in some places, such as the Keanakolu area on the island of Hawai'i, but uncommon in other, similar forests.

In 1997 Molvray, in *A Synopsis of* Korthalsella *(Viscaceae)*, proposed a sweeping revision of the genus, reducing the number of species significantly. Wagner et al. (1999), however, rejected Molvray's revision, and this publication follows the 1999 recommendation.

The genus *Korthalsella* was named in honor of P.W. Korthals (1807–1892), a Dutch botanist. Wagner et al. speculated that the six *Korthalsella* species in Hawai'i probably resulted "from three independent introductions, one for each of the following groups: (1) *K. complanata* and *K. latissima*; (2) *K. cylindrica* and *K. remyana*; and (3) *K. platycaula* and *K. degeneri*."

Taxonomy of *Korthlasella complanata*

Domain: Eurkaryota Whittaker & Margulis, 1978 (Eukaryotes)
Kingdom: Plantae Haeckel, 1866 (plants)
Subkingdom: Viridaeplantae Cavalier-Smith, 1981 (green plants)
Phylum: Tracheophyta Sinnott, 1935 ex Cavalier-Smith, 1998 (vascular plants)
Subphylum: Spermatophytina (auct.) Cavalier-Smith, 1998 (seed plants)
Infraphylum: Angiospermae (auct.)
Class: Magnoliopsida Brongniart, 1843 (dicotyledons)
Subclass: Rosidae Takhtajan, 1967
Superorder: Santalanae Thorne ex Reveal, 1992
Order: Santalales Dumortier, 1829
Family: Viscaceae Batsch, 1802 (Christmas mistle-

Table 1. The six *Korthalsella* mistletoe species in Hawai'i, with their distribution,* habitat, hosts, and distinguishing morphological features. (Source: Wagner et al. 1999)

Korthalsella complanata
Indigenous
H, L, K, Mo, Ma, O
Most vegetation types except coastal and open bogs; most common in wet and mesic forests (100–)600–1350(–2140) m
The most widespread *Korthalsella* species in Hawai'i; occurs on the greatest number of hosts; the most morphologically variable *Korthalsella* species in Hawai'i

K. cylindrica
Endemic
H, L, Mo, Ma, O
Dry to mesic forests and open bogs, 400–1250(–1830 m)
Metrosideros, *Diopsyros*, *Chamaesyce*, *Sapindus*
Distichous branching; branches in same plane

K. degeneri
Endemic, rare
O
Diverse mesic forests, ca. 300 m
Sapindus, *Nestegis*
Cylindrical stems for 2(3) internodes and short internode length 7–15(–22) mm

K. latissima
Endemic
H, O, principally on K
Wet and mesic forests, 1100–1220 m
Myrsine, *Metrosideros*
Internodes (7–)10–22(–28) mm wide at widest point; fruits larger than those of any other *Korthalsella* species in Hawai'i

K. platycaula
Indigenous
L, O, primarily on K
Diverse mesic forest, 300–1200 m
Woody species including *Syzygium sandwicense*
Stems 15–50 cm long, many branches; central stem usually not obvious past the first internode; all stems of similar width

K. remyana
Endemic
H, Ma, L, Mo, O, K
Dry to wet forest and open bogs, 300–1200 m
Diospyros, *Metrosideros*, *Acacia*, *Eugenia*
Closely related to *K. cylindrica*, but has decussate rather than distichous leaf axils and branches; stems cylindrical

*Key to distribution of *Korthalsella* species: H (Hawai'i); Ma (Maui); L (Lāna'i); Mo (Moloka'i); O (O'ahu); K (Kaua'i).

Table glossary: *decussate*: arranged along the stem in pairs, with each pair at right angles to the pair above or below; *distichous*: in two vertical ranks or rows on opposite sides of an axis, two-ranked (branches alternate in two planes at right angles); *endemic*: peculiar to a specific geographic area or edaphic type; *indigenous*: native to a particular area, not introduced; *mesic*: moist.

Table 2. Important disease-inducing genera of parasitic seed plants and their hosts.*

Genus of parasitic seed plant	***Example of host plant attacked***
I. Root parasites	
A. Broomrapes (Orobanchacea)	
1. *Aeginetia*	maize, rice, sugarcane
2. *Christisonia*	sugarcane
3. *Orobanche*	legumes, tobacco, tomato, cabbage, flax, hemp, grapes, watermelon, cucurbits, mint, sunflower, clover,eggplant
B. Figworts (Scrophulariaceae)	
1. *Alectra* (*Melamsa*)	cowpea, soybean, peanut, legumes, sugarcane
2. *Rhamphicarpa*	maize, cowpea, rice, sorghum
3. *Striga* (witchweed)	maize, sorghum, sugarcane, tobacco, grasses
II. Stem or leaf parasites	
A. Cuscutaceae	
1. *Cuscuta*	alfalfa, clover, sunflower, potato, sugar beet, tobacco, bamboo, asters
B. Lauraceae	
1. *Cassytha*	orange trees, evergreen shrubs and ornamentals
C. Viscaceae	
1. *Arceuthobium*	conifers
2. *Dendrophthora*	rubber, mango, avocado, cacao
3. *Korthalsella*	acacia, eucalyptus
4. *Notothixos*	eucalyptus
5. *Phoradendron*	coffee, avocado, teak, various forest trees
6. *Viscum*	rubber, conifers, fruit trees, deciduous trees
D. Loranthaceae	
1. *Amyema*	eucalyptus
2. *Elytranthe*	rubber, cashew
3. *Phthirusa*	rubber
4. *Psittacanthus*	citrus

*Source: Knutson 1979

Close-up of a branch of *Korthalsella complanata* (Photo: J.B. Friday)

Korthalsella complanata plants dominating the canopy of an old, declining *Acacia koa* tree near Keanakolu on the island of Hawai'i (Photo: J.B. Friday)

toe family)
Genus: Korthalsella Tieghem, Bull. Soc. Bot. France. 43: 83. 1896. (Korthal mistletoe)
Specific epithet: complanata (v. Tiegh.) Engl.
Botanical name: *Korthalsella complanata* (v. Tiegh.) Engl.

The hosts

Mistletoes infect the stems and branches of native hardwoods such as *Metrosideros polymorpha* ('ōhi'a lehua), *Acacia koa* (koa), *Myrsine sandwicensis* (kōlea lau li'i), *Diospyros sandwicensis* (lama), *Sapindus* (lonomea, or Hawai'i soapberry), *Nestegis* (olopua), *Eugenia* (nīoi), and *Chamaesyce* ('akoko). The habitats of mistletoes are species dependent (see Table 1).

Mistletoe seeds are dispersed by animals (birds associated with host trees, including native birds and introduced birds such as the khalij pheasant), strong winds, and water. Also, seeds of *Korthalsella* species are often explosively ejected from the fruits.

Relationship of *Korthalsella* species to other parasitic seed plants

There are about 3,000 species of parasitic seed plants. A parasitic seed plant is a plant that derives food and water from another plant through root-like sinkers and haustoria. They vary in their dependence on the host plant. Some parasitic seed plants are without chlorophyll (or are greatly deficient in chlorophyll) and therefore, like parasitic fungi, must rely on the carbohydrates produced by the host plant in order to complete their life cycle. Some mistletoes have chlorophyll, but no roots.

How *Korthalsella* infects and induces disease in hosts

1. *Korthalsella* seed lands on a suitable "infection court" (young stem or branch of woody host species). Seeds are explosively ejected from fruits and are also carried by some bird species.
2. Seeds germinate and the parasite produces a contact organ called a holdfast. The purpose of the holdfast is threefold: (a) attachment to the host; (b) penetration into living host tissue; and (c) establishment of nutrient-flow pathways.
3. An intrusive organ develops from the holdfast. This wedge-shaped structure penetrates suberized dermal tissues by enzymatic and mechanical force.
4. The host xylem and parasite xylem unify. The parasite ramifies throughout the tissues of the host, forming the endophytic system.
5. The mistletoes invade the phloem tissue, producing growth structures called sinkers. As the tree grows

A population of *Korthalsella complanata* infecting a young stand of *Acacia koa* near Umikoa, on the island of Hawai'i (Photo: J.B. Friday)

A stem of *K. complanata*; members of this species are somewhat variable in morphology, in this case the flattened stem tends to narrow appreciably at the nodes. (Photo: C.H. Lamoureaux, permission granted by G.D. Carr)

Typical specimens of *K. cylindrica* on Hawaiian hardwoods. This species is characterized by distichous branching, with branches in same plane. (Photos by J.K. Obata, G.D. Carr, and G.K. Linney, used with permission)

and lays down annual rings, the sinkers become incorporated into the central ray tissue.

6. Mistletoe initials, present in the plane of the host cambium, produce derivative cells in both the host phloem and xylem, greatly increasing the amount of contact area between parasite and host tissues.

This process creates a sink for nutrients and photosynthates, which is the mistletoe plant. Disease is induced by the diversion of nutrients and photosynthates needed for host growth into the parasite. Damaging modifications to the host anatomy and physiology are also induced by mistletoe infections.

Integrated management of mistletoes

The Hawaiian mistletoes are unique, highly specialized, beautiful, and sometimes rare plants with a useful place in Hawaiian ecosystems. Therefore, controlling these parasitic plants may not be warranted except in high-value forestry or landscape settings. The best way to control them is to prune affected branches as soon as infections are evident and destroy the pruned material (do not use it as mulch).

Korthalsella platycaula, French Polynesia, Marquesas Islands (Photos: Kenneth R. Wood, National Tropical Botanical Garden, 3530 Papalina Road, Kalaheo HI 96741; © Smithsonian Institution and Kenneth R. Wood).

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Zip Code Zoo. *Korthalsella* (genus information for *Korthalsella* and photographs)

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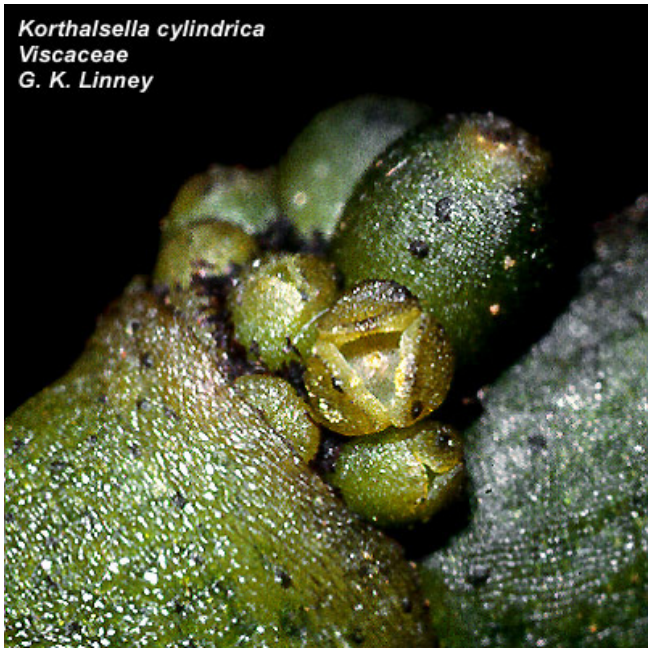
Gerald Carr (Oregon State University) and his colleagues in the U.H. Botany Department shared photographs and information; Dean Meason is acknowledged for photography; Fred Brooks (UH-CTAHR) for his review.



Seeds of Korthal mistletoes are ejected explosively into the environment. (Photo by J.K. Obata, G.D. Carr, and G.K. Linney, used with permission)

Korthalsella complanata infecting *Metrosideros polymorpha* (Photo: J.K. Obata, permission granted by G.D. Carr)

A vigorous *Korthalsella complanata* plant infecting *Acacia koa* near Keanakolu on the island of Hawai'i (Photo: J.B. Friday)

Korthalsella remyana infecting a branch of lama (*Diospyros sandwicensis*) at Kaupulehu on Hawai'i (Photo: J.B. Friday)

Flattened stems and reduced leaves make *K. latissima* resemble an aerial cactus.
(Photo: G. Deida, permission granted by G.D. Carr)

Close-up of flowering stem of *Korthalsella platycaula* from O'ahu (Photo: Warren L. Wagner, © Smithsonian Institution and Warren L. Wagner).

A *Korthalsella complanata* plant infecting *Acacia koa* near Keanakolu on the island of Hawai'i (Photo: J.B. Friday)

Korthalsella latissima, as the name implies, has wider internodes than the other species, and the stem does not narrow as appreciably at the internodes as stems of *K. complanata*. (Photo: C.H. Lamoureux, permission granted by G.D. Carr)

Korthalsella remyana infecting a branch of *Metrosideros polymorpha* at Alakai Swamp, Kōkeʻe, Kauaʻi
(Photo: J.B. Friday)

A large *Korthalsella complanata* plant infecting a young *Acacia koa* tree near Keanakolu on the island of Hawaiʻi
(Photo: J.B. Friday)

The flattened stems of this specimen of *K. latissima* are wider than and do not narrow as appreciably at the nodes as the stems of *K. complanata* on p. 5.
(Photo: J.K. Obata, permission granted by G.D. Carr)

K. cylindrica and *K. remyana* are closely related species. According to Wagner et al. (1999), "...the only character that consistently separates them [*K. cylindrica* and *K. remyana*] is the axil arrangement, which is distichous in *K. cylindrica* and decussate in *K. remyana*. The basis of branching in this genus would make an interesting study and should prove very useful in an overall revision of this highly specialized group of plants." The photo shows a typical specimen of *Korthalsella remyana* on a Hawaiian hardwood, *Metrosideros polymorpha* (ʻōhiʻa lehua). (Photo: C.H. Lamoreaux, permission granted by G.D. Carr)