# Kahili-make
# A Biological Control Project Against Kahili Ginger (*Hedychium gardnerianum*) in Hawai‘i

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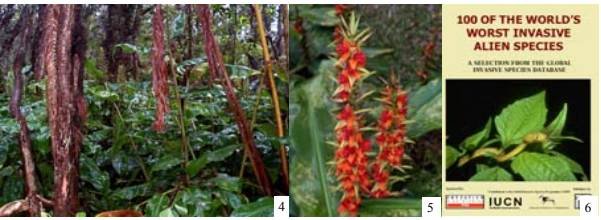
## INTRODUCTION

Plant species that are only regionally common or are confined to a specific ecological niche where they are native may become invasive when they are introduced to new environments. An example of this phenomenon occurs with wild ginger species in the genus *Hedychium*. Whereas these species are primarily confined to the forest edge in their native regions, they are invaders of montane rain forests in many areas where they have been introduced as ornamentals. The most invasive species of this genus is *H. gardnerianum*, also known as “kahili” or “wild” ginger (Fig. 1).

Kahili ginger has been introduced around the world through the horticultural trade, and with few exceptions, is an aggressive invader of montane rain forests wherever it has been introduced. Kahili ginger is a large rhizomatous herb (Figs. 2, 3) that can invade the understory of undisturbed, intact montane tropical rain forests, and is extremely difficult to remove once established. The numerous tall shoots (≈ 2m) of this species (Fig. 4) increase competition for light and nutrients, and negatively affect the growth of native understory plants. Prolific seed production (Fig. 5) and the resprouting of cut rhizomes and inflorescences following shoot removal compromise mechanical control of this weed. These biological characteristics, its threat to endangered taxa, and its impact on the overall biodiversity of invaded forests have earned kahili ginger distinction as a member of the “World’s 100 worst invasive alien species” (Fig. 6).




Because of its impact and threat to biodiversity, kahili ginger constitutes a significant noxious weed control problem in invaded forests. Although this weed can be controlled effectively with herbicides in some areas, environmental concerns (*e. g.,* soil leaching, ground water contamination, and non-target effects) limit their usefulness in others. In addition, the widespread distribution of kahili ginger across various nutrient, moisture, and altitudinal gradients would require amounts of herbicides in excess of label restrictions for large infestations. Therefore, biological control is now considered the only practical approach for the long-term management of large kahili ginger infestations. The “ginger strain” of the wilt-causing bacterium *Ralstonia solanacearum* has been identified as potential biological control agent for kahili ginger. This poster contains information on this project, and chronicles its progression from the time it began in May 1995.

## PROJECT OVERVIEW

•Project started in May 1995 with the isolation of the biocontrol agent from diseased Hawaiian edible ginger (*Zingiber officinale*) rhizomes.

•Agent: “Ginger Strain” (Race 4) of the bacterium *Ralstonia* (=*Pseudomonas*) *solanacearum* (Fig. 7).

•Bacterium infects through wounds and root absorption and causes wilt (Fig. 8) and rhizome decay (Figs. 9, 10) of infected tissues.

•Infections result in significant reductions in rhizome biomass occurring over a 2 to 5 year period (Figs. 11, 12 and 13, 14; respectively).

## APPLICATION DEVELOPMENTS

•May 1996 – First field trial: ginger stems inoculated with syringe in Hawai‘i Volcanoes National Park (HAVO).

•January 1998 – Tested first bioherbicide spray using inoculum made from rotting rhizomes (Fig. 15).

•January 2000 – Built prototype to microencapsulate bacteria into alginate beads (Figs. 16, 17).

•May 2000 – Tested alginate beads in field.

•January 2002 – Built mass-production system prototype to produce bacterial inoculum and alginate beads.

•January 2003 – Upgraded mass-production system (Fig. 18).

•August 2003 – Applied mass-produced inoculum and bacterial encapsulated alginate beads to large-scale field experiment (approx. 7000 m$^2$) in HAVO.


Table 1

**Results of Greenhouse Host-Range Testing for *R. solanacearum* Infection**

| | | | | | *H. gardnerianum control* | |
|---|---|---|---|---|---|---|
| **Family** | **Species** | **Common Name** | **No. inoc** | **No. wilted** | **No. inoc** | **No. wilted** |
| Costacaceae | *Costus speciosus* | Spiral ginger | 8 | 0 | 5 | 5 |
| Fabaceae | *Acacia koa* | Koa | 24 | 0 | 5 | 5 |
| | *Phaesolus lunatus* | Lima bean | 24 | 0 | 5 | 5 |
| Heliconiaceae | *Heliconia latispatha* | Heliconia | 12 | 0 | 5 | 5 |
| Marantaceae | *Ctenante burlemarxii* | Prayer plant | 24 | 0 | 5 | 5 |
| Musaceae | *Musa sapientum* | Banana | 6 | 0 | 5 | 5 |
| Myrtaceae | *Metrosideros polymorpha* | Ohia-lehua | 12 | 0 | 5 | 5 |
| Solanaceae | *Capsicum annuum* | Sweet pepper | 24 | 0 | 5 | 5 |
| | *Lycopersicon esculentum* | Tomato | 24 | 0 | 5 | 5 |
| | *L. pimpinellifolium* | Currant tomato | 24 | 0 | 5 | 5 |
| | *Nicotiana tabacum* | Tobacco | 24 | 0 | 5 | 5 |
| | *Nothocestrum longifolium* | Aiea | 6 | 0 | 5 | 5 |
| | *Physalis peruviana* | Poha | 24 | 0 | 5 | 5 |
| | *Solanum melongena* | Eggplant | 24 | 0 | 5 | 5 |
| | *S. pseudocapsicum* | Jerusalem cherry | 24 | 0 | 5 | 5 |
| | *S. tuberosum* | Potato | 12 | 0 | 5 | 5 |
| Zingiberaceae | *Alpinia purpurata* | Red ginger | 60 | 0 | 5 | 5 |
| | *A. zerumbet* [=*A. nutens*] | Shell ginger | 34 | 0 | 5 | 5 |
| | *Hedychium coronarium* | White ginger | 20 | 0 | 5 | 5 |
| | *H. flavescens* | Yellow ginger | 20 | 0 | 5 | 5 |
| | *Zingiber zerumbet* | Shampoo ginger | 12 | 0 | 5 | 5 |



## CURRENT DEVELOPMENTS

•Post-release monitoring – Spatial and temporal characteristics of *R. solanacearum* spread and ginger fitness are being monitored in test plots annually.

•Vector relationships – Studies involving Dipterae as possible vectors of the bacterium are underway (Figs. 19, 20).

## CONCLUSIONS

•*Ralstonia solanacearum* is a potential alternative to chemical control for remote or dangerous areas.

•*Ralstonia solanacearum* is established in HAVO soils and is spreading from treatment plots via soil water and potential insect vectors.

•Biocontrol agent has caused disease in ca. 12% (n = 2100) of nearby ginger populations within 5 years of release.

•Bacterium found to be host-specific among 21 species tested (Table 1).

•Biocontrol agent is easily produced and can be applied in a spray or alginate beads.

## FUTURE RESEARCH

•Determine pathogenicity of *R. solanacearum* in other kahili ginger populations.

•Determine genetic diversity of kahili ginger from native and alien populations.

•Test hypotheses regarding alien plant invasions such as “Escape from natural enemies” and “Biotic resistance” using the kahili ginger-*Ralstonia* pathosystem.

•Transfer technology to local and international cooperators.