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Naturalizing Orchids and the Hawaii Pacific Weed Risk Assessment System

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Invasive species are not only changing the composition of ecosystems; they are also impacting ecosystem functionality and services. The orchid family, thought to be non-invasive, now has species that are adapting to novel (newly formed) ecosystems globally. While scientists note that orchids are a conservation concern, because they are threatened by habitat alteration, invasive species, and climate change, there is limited discussion of how the orchid family's adaptation to novel ecosystems might promote the invasion of other species.

Arundinia graminifolia **(photo: Forest and Kim Starr).**

Orchids are integral to ecological connections in their native habitats, providing ecosystem services not yet fully understood. This family interacts with mychorrizal and pollinator services that connect many species and is an important component of the ecosystem's synergistic web. If this is the case, how can orchids be problematic, and why do gardeners and landscapers need to make informed decisions when choosing one for the house, garden, or landscape? While earlier data suggested that the orchid family is not invasive, recent research indicates that the lag time, or sleeper effect; that is, the time between introduction and invasiveness, might prove otherwise.

The orchid family (Orchidaceae) is considered by some scientists to contain the most species of all angiosperm (flowering) plant families, currently about 25,000 recognized species. Orchids occur on all continents except Antarctica, although there are species on some Antarctic islands. The distribution and abundance of the orchid family, however, tends to be centered in the tropics. Most orchids are epiphytes, which grow on trees and shrubs, or terrestrial, while some are lithophytes, growing on rocks, and a few are aquatic. Orchids range in size from plants that could fit into a thimble to vines over 100 feet tall.

While orchids have a wide global distribution, they have evolved to become ecologically specialized in terms of their local habitat requirements. There are several ecological traits that have limited orchids to certain habitats. This rapidly evolving family has formed unique interactions with both pollinators and mycorrhizal fungi, the latter of which have a symbiotic relationship with orchid roots. The pollination trend in the orchid family is towards specialist pollinators. Orchids also require mycorrhizal fungi for seedling development, and in some species this interaction is necessary into adulthood. Because of these relationships, orchids are one of the most specialized flowering plant families. This has tended to limit their invasive tendencies.

However, there is an emerging trend, or perhaps evolutionary adaptation, within the orchid family. Some species, after introduction to an area outside of their na-

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Dendrobium antennatum **(photo: Danielle Frohlich and Alex Lau).**

Dendrobium crumenatum **(photo: Danielle Frohlich and Alex Lau).**

tive distribution, are naturalizing and possibly becoming invasive. Naturalized species are able to reproduce and sustain populations without human assistance. Invasive species also produce self-sustaining populations and spread, at which point they may negatively impact human health, the economy, or the environment. Some orchid species are naturalized in certain regions and invasive in others. How can this adaptation happen? Daehler (1998) noted that the Orchidaceae family is underrepresented in invasive families, and that there were at that time no serious or widespread weeds among the estimated 17,500 species in the family. Is this underrepresentation actual, and due to ecological limitations, or is it merely based on the lack of orchid research?

If there is indeed an increase in naturalization in this family, it may also be related to increased global trade and the introduction of more generalist species that can adapt to a variety of pollinators and mycorrhizal fungi or other environmental conditions. Scientists and orchid enthusiasts are seeing a number of orchid species and hybrids naturalizing in temperate and tropical climates. Puerto Rico and Hawai'i are at similar latitudes and share some of these naturalizing species. Perhaps these species are some of the generalists within this family, newly introduced to the region, or they can adapt to the novel ecosystems developing due in part to invasive species impacts and/or global climate change.

The naturalization of orchids in disturbed and native habitats is a concern for conservation efforts. The relationship of each species in the orchid family to the environment to which it is native is not well understood. Orchids may perform a synergistic role within the ecosystem and support many community relationships, though orchid researchers have yet to identify large-ecosystem services (e.g., the production of food and water, the control of climate and diseases, or the pollination of crops) within this family. Conservation efforts are using the term "bioindicators" for orchids in their native ecosystems to express these species' importance as an early warning system to indicate the state of the ecosystem (Swarts and Dixon 2009). Because orchids are interconnected with pollinators and soil fungi, if either of these components of the ecosystem is disrupted, the orchid population can decline or disappear, and with it the health of the ecosystem. Perhaps what we are seeing with the naturalization of orchids in the tropics is an indication of multi-level changes in the composition, structure, and function of ecosystems. Are naturalizing orchids "bioindicators" of severe stress in disturbed and natural ecosystems?

As orchid enthusiasts, we can use these questions and their answers to assist us in selecting orchids that not only evoke the vision of an exotic land but will stay in cultivation and leave the natural world to the native species. The invasive characteristics of orchid species are still somewhat elusive; however, some characteristics have been identified from naturalizing species.

Dendrobium rhombeum **(photo: Joel Lau).**

Spathoglottis plicata **(photo: Forest and Kim Starr).**

Common characteristics of many naturalizing or invasive orchids (Adamowski 1999; Cohen and Ackerman 2009):

- Rapid development from seed to flower (1–3 years is short, but not uncommon)
- Autogamy (self-fertilization)
- Apomixes (seed production without fertilization)
- Obligately outcrossing systems with deceptive pollination system
- Tuber production (vegetative reproduction)
- Abundant seed production
- High levels of phenotypic plasticity (observable physical or biochemical traits that can change with the environment)
- Wide ecological amplitudes (range of environmental tolerance)
- Broad natural distribution
- Disturbance tolerant (colonizes disturbed areas)

Characteristics that might be associated with naturalizing or invasive orchids:

- Associated with widespread mycorrhizal fungi
- Associated with a variety of mycorrhizal fungi

Research indicates that cultivation, accidental introductions, and habitat alteration are important factors for the establishment and spread of most naturalizing or invasive orchids (Adamowski 1999). However, *Oeceoclades maculate*, an invasive orchid found throughout much of the neotropics, is expanding its distribution into not only disturbed sites but also old-growth forests with limited anthropogenic disturbance. This species may be negatively impacting two native orchid species in Puerto Rico (Cohen and Ackerman 2009).

Scientists and orchid enthusiasts are also seeing naturalizing orchids forming ecological connections with a variety of organisms. Liu and Pemberton (2010) have noted that the invasive orchid *Cyrtopodium polyphyllum* is pollinated by an invasive bee, *Centris nitida*, in Florida. In its native range, *Cyrtopodium* is pollinated by two native species of the same genus, *Centris tarsata* and *Centris labrosa*. In Puerto Rico, *Spathoglottis plicata* has naturalized and occupies the same habitat as a native orchid, *Bletia patula*. A native weevil, *Stethobaris polita*, an orchid specialist, is now negatively impacting the reproductive success of *Bletia*, due to its association with the increasingly abundant and widespread *Spathoglottis*. Emerging evidence also links orchids to non-orchid species in a plant community through the mycohrrizal fungi associations (Zettler et al. 2003). These complex interactions are developing worldwide, due in part to the introduction of non-native species.

In Hawai‘i, orchid species are also naturalizing. They are spreading along trails, into disturbed habitats, and into natural areas.

***Epidendrum* x *o'brienianum* (hybrid) (photo: Forest and Kim Starr).**

Table 1. Orchid species naturalized in Hawai'i

Species	Weed Risk Assessment Rating
Arundina graminifolia	High risk
Cymbidium dayanum	Not assessed
Dendrobium antennatum	Not assessed
Dendrobium hybrid (antelope type)	Not assessed
Durabaculum mirbelianum	Not assessed
Dendrobium rhombeum	Not assessed
Epidendrum x *o'brienianum* (hybrid)	Not assessed
Epidendrum nocturnum	Not assessed
Habenaria rodeiensis	Not assessed
Phaius tankarvilleae	Not assessed
Polystacha concreta	Not assessed
Spathoglottis plicata	High risk
Vanda tricolor	High risk
Zeuxine strateumatica	Not assessed

Lau, A., & D. Frohlich (2011)

Will these naturalizing or invasive orchids cause harm to Hawai'i's native species? Can they displace the three orchid species endemic to Hawai'i? The answers to these questions are still unknown. However, we do know that gardeners introduce orchids into their gardens, lanais, and homes. Some of these orchids may be able to escape from cultivation and spread into the semi-natural or natural areas that border the urban edge. What steps can we take to prevent the introduction of an orchid species into an area where it may become a weed?

Luckily for Hawai'i, scientists and other plant enthusiasts noticed that some species were naturalizing and becoming invasive. To address this issue, a Weed Risk Assessment system was developed to predict the potential of a plant species to become invasive.

Hawaii Pacific Weed Risk Assessment

The Hawai Pacific Weed Risk Assessment (HPWRA) system is a biosecurity tool that predicts the potential of a plant species to become invasive. The system uses a series of 49 questions in sections covering biogeographical origin, historical introductions, biology, ecology, pest status elsewhere, and undesirable traits, each of which contributes to the HPWRA score. The section scores are added together, and based on the total score the species is rated low risk, "evaluate" (not enough available information to complete assessment), or high risk. Species in the "evaluate" category go through a second screening, after which it is usually possible to place them within the low-risk or the high-risk category. Species that fall in the high-risk category have the potential to be invasive in Hawai'i or other Pacific Islands. The WRA system has approximately a 95% success rate in identifying high-risk species.

While this system is not legally binding, it does allow gardeners, members of the horticultural industry, landscape architects, and land management agencies to make informed decisions before they introduce a plant into the landscape. Preventing the introduction of an invasive species is the most economically efficient and ecologically sound way to protect Hawai'i from invasive species. More information about the HPWRA system is

***Vanda trimerrill (V. merrillii* x *tricolor)* (photo: Joel Lau).**

available at the Hawaii Pacific Weed Risk Assessment Web site (www.hpwra.org) or the Plant Pono Web site (www.plantpono.org), including a list of species that have already been screened. If a species you are interested in is not on this list, you can contact the Weed Risk Assessment Specialists at hpwra@yahoo.com to have the species screened.

The orchid family has ecological secrets that are not yet understood. However, we do know that species are expanding their distribution due in part to their ornamental popularity and introduction to the landscape. As the orchid story unravels and orchid enthusiasts are born, both orchid admirers and invasive species researchers can look to the HPWRA system to assist them in their choice of orchids that will not jump the garden fence.

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