The Native Orchid Conference

Journal

ISSN 1554-1169

Native Orchid Conference, Inc.
Founded 2002

Volume 13(1)
Jan-Feb-Mar 2016

Volume 13, Issue 1 Table of Contents ISSN 1554-1169

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The Native Orchid Conference, Inc.
P. O. Box 2047 Boone, NC 28607-2047
Web Sites
http://nativeorchidconference.info
http://groups.yahoo.com/group/nativeorchidconference/

The Native Orchid Conference Journal is published four times a year by the Native Orchid Conference, Inc., a non-profit [501(c)3] organization, as a service to its members. The organization is devoted to fostering the study, conservation, and enjoyment of orchids native to North America. Membership dues are: US Individual: $30; US Family: $35; Student: $15, and non-US Individual or Family: $40. Address inquiries about membership, back issues of this journal, and requests for copies of the bylaws to the editor at 343 John Wayne Trail Victoria, Texas 77905, or NOCeditor@gmail.com

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Notes from the Editor's desk

We begin with a clarification. Fig. 2 on page four of the last issue, does not refer to the unusual light chocolate spotted coralroots mentioned on that page. The explorers were to photograph those plants the following day. Instead, Fig. 2 *should* have clearly identified the flower in Fig. 2 as only a lightly colored group of *C. maculata* which was photographed that day. In an attempt to show a larger image, both text and image on the same page becomes, at times, an editorial impossibility with the end result misleading.

Readers will note an additional sheet included with this issue. The time for firming up plans and reservations for this summer's conference in Arizona is now! Don't be one of those nebulous "few months from now" individuals!

Long after last year's last issue had been mailed, the NOC president received the following hand written note from Helen Horwitz. Her letter and his reply is shared below.

"Dear Phil, Please accept this check for the NOC Fred Case Fund in Hal's memory. Our good fortune to be personal friends with Fred Case as well as being used for continuing education makes this a fitting area to honor Hal's love of NOC, orchids, and education. Helen Horwitz."

A portion of the president's reply follows.

"Dear Helen, I hope this letter finds you well. On behalf of the Board of the Native Orchid Conference, Inc., I am pleased to accept your very generous donation of $5,000 to the Fred Case Grant fund in honor of your husband Hal. With your donation, the fund has now surpassed the initial goal of $20,000. Both you and Hal are very special people and I am certain he would be pleased as well. Thank you.

Your friends in the Native Orchid Conference, "

...editor's comment: Awards, medals, and similar items can speak of past accomplishments to the present, but to speak from the past and encourage and abet education in peaceful pursuits is to give an even finer voice *beyond* one's life - to individuals in the present and generations in the future!

January, 2016 brought news to your editor's desk of another orchid species having spread into a new geographic location: "*Goodyera viridiflora* is reported in India so far only from Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Meghalaya, and Nagaland. Hence the present find of the species in Manipur becomes a new distributional record to the state."

As NOC members think ahead to field work during this summer's conference, it would be well to consider the length of the border between Mexico and the U.S. states bordering that country of a little over 1,300 orchid species. Don't just look to photograph what's pointed out on tours. If you *observe*, not just "look" as would a tourist, you may well come across an orchid species new to the U.S.!

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Corallorhiza odontorhiza (Wildenow) Nuttall

Autumn Coralroot: A Pictorial Monograph

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Introduction: *Corallorniza odontorhiza* is a small inconspicuous woodland orchid found in eastern North America and in Central America. Two varieties are currently recognized. The nominative and most common variety, *C. odontorhiza* var. *odontorhiza* is characterized by cleistogamous flowers that readily self-pollinate. The less common variety *C. odontorhiza* var. *pringlei* (Greenmann) Freudenstein is characterized by chasmogamous flowers that are self-compatible, but require an external vector to transfer pollinia to the stigma in order to effect pollination. This article briefly summarizes the taxonomic history of *C. odontorhiza* and then moves on to summarize the two varieties and their color forms. Most of the information in this article is drawn from the botanical literature, supplemented by the author's personal observations of this plant in Michigan and Wisconsin.

Taxonomy: Originally named *Cymbidium odontorhizon* by Wildenow in volume four of Species Plantarum in 1805 (Wildenow 1805), it was transferred to the genus *Corallorhiza* by Thomas Nuttall in 1818, thus creating the accepted name (Nuttall 1818). However, the early descriptions of *C. odontorhiza* (Fig. 1) leave something to be desired as a consequence of the presence of cleistogamous and chasmogamous forms; flowers can range from closed or just barely open (cleistogamous) to fully open (chasmogamous). Although populations in the eastern United States are mostly cleistogamous, early authors such as Nuttall, whose original description is reproduced in Fig. 2, did not distinguish between these forms, tending to ignore cleistogamous specimens, and base their descriptions on the few

Fig. 1. *Corallorhiza odontorhiza* root showing the branching structure characteristic of the genus. The specific epithet *odontorhiza* is derived from Greek meaning tooth-root, referring to the tooth-like appearance of the swollen base of the stem just above the main body of the coralloid root.

chasmogamous flowers they observed. It was not until 1972 that Luer in his erudite work "The Native Orchids of Florida", provided the first clear description of cleistogamous plants (Luer 1972), stating that "Nearly all plants, regardless how fresh they are, are found with pendant fruit in varying degrees of development, while the minute flower parts at the end of the capsules seem to assume an unimportant role". Greenmann formally described chasmogamous plants in 1898 (Fig. 3) as *C. pringlei*, based on plants collected in 1894 by C.G. Pringle in the southern Mexican state of Oaxaca (Greenmann 1898).

2. *Odontorhiza.* Lip entire, oval and obtuse, margin crenulate; spur obsolete, every where adnate to the germ; leaves none; capsule subglobose. HAB. In New Jersey and Pennsylvania, abundant. *Cymbidium Odontorhizon*, Willd. —Root much branched, dentate; scape 8 to 10 inches high, attenuated and rather slender, roundish and bulbous at the base; sheathes ochreate, about 3 in number; flowers numerous, pendulous; petals brownish, connivent, and all inclined to the upper side of the corolla; lip dilated, white, and elegantly spotted with violet-purple, palate bidentate; base of the column marginated; capsule short and subglobose.

Fig. 2. Original description of *C. odontorhiza* by Thomas Nuttall.

Corallorhiza Pringlei. Glabrous throughout, aphyllous: stems slender, 1 to 3.5 dm. high, more or less scaly-bulbous at the base; caudex provided with 1 to 3 sheathing bracts: racemes rather few-flowered; floral bracts minute, shorter than the pedicels, the latter 2 to 3 mm. in length: flowers small, 5 to 8 mm. in breadth when fully expanded; sepals oblong-lanceolate, obtuse, inconspicuously 3-nerved, 3 to 4 mm. long, about 1 mm. broad, exceeding in length the obtuse slightly broader lateral petals, both sepals and lateral petals marked with a semi-translucent oblong punctation; lip white variegated with purple, ovate-rotund or sometimes slightly obovate-rotund, narrowed at the base into a short claw, strongly emarginate at the apex, with an irregular crenate margin, 3–5-nerved, bearing two somewhat diverging lamellæ about one third distant from the base; clinandrum short, thick, about 2 mm. long: capsule oblong-elliptic, 7 mm. long, reflexed on slender pedicels. — Collected by C. G. Pringle on shaded banks, Las Sedas, Oaxaca, altitude 2000 m., 1 November, 1894, no. 5804; and on the Sierra de San Felipe, altitude 2600 m., 13 December, 1895, no. 6295.

Distributed in 1895 as *C. Mexicana*, Lindl., from which it is distinguished by the more slender habit, smaller flowers, and by the well marked characters of the lip.

Fig. 3. Original description of *C. pringlei* Greenmann, 1898).

In 1953 Ames and Dressler recognized that *C. odontorhiza* and *C. pringlei* were conspecific and reduced *C. pringlei* to synonymy under *C. odontorhiza* (Ames, 1953). In 1997 Freudenstein proposed that two varieties be recognized; choosing as the nominative variety the cleistogamous plants of the eastern United States and assigning chasmogamous plants to var. *pringlei* (Freudenstein 1997) (Fig. 4).

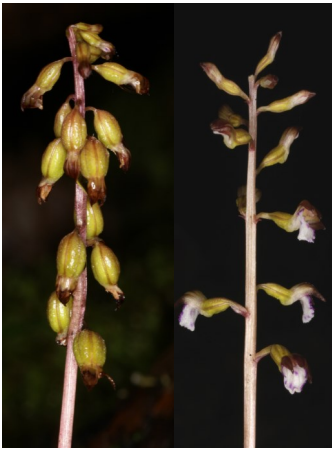


Fig. 4. Comparison of var. *odontorhiza* and var. *pringlii*. A) The flowers of var *odontorhiza* never open fully and readily self pollinate; the ovaries swelling before the flowers open. B) The flowers of var. *pringlei* do not readily self-pollinate and the flowers fully open.

In addition to the two varieties, a closely related sister species exists. *C. wisteriana* is morphologically similar; the primary difference being the slightly larger size of *C. wisteriana* (Gibson 1909, Morris and Eames 1929). Phylogenetic studies by Freudenstein show that the two species are closely related to each other (Catling, P.M. 1983, Freudenstein, J.V. 1997). In North America there is a dramatic temporal separation in blooming times; *C. wisteriana* is one of the first orchids to bloom in spring, while *C. odontorhiza* is one of the last, typically blooming in late summer or autumn (August to October).

Description: The leafless stems typically range from 4 to 20 cm tall and bear 3 to 15 tiny flowers. The stem and floral parts, other than the lip, typically range from purplish-brown, to pale brown, sometimes tinged with green. Two distinct varieties occur: in var *odontorhiza* the flowers are cleistogamous; readily undergoing self-pollination before they fully open (Fig. 5 A B); while in var. *pringlei* the flowers are chasmogamous (Fig. 6 A B C) and fully open for visitation by small insects (Brown, 2002).

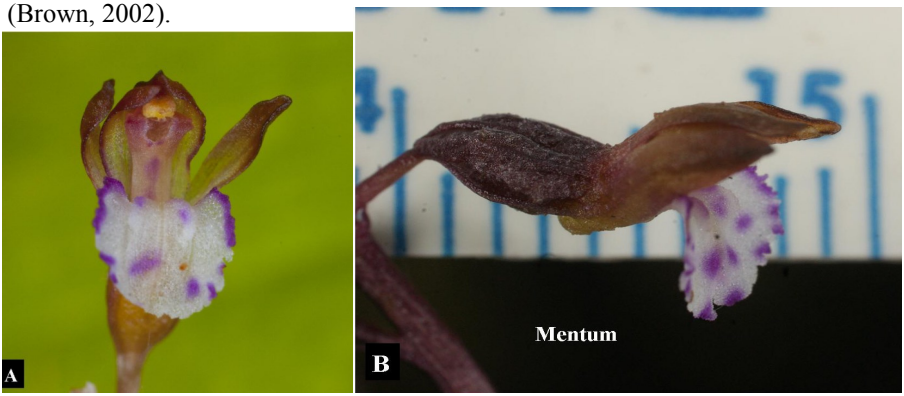


Fig. 5. (A) Front view of var. *pringlei*, showing the column arcing above the lip with the petals and sepals forming an enclosed hood. (B) side view of var. *pringlei* with scale showing distinct mentum

Fig. 6. Views of var. *odontorhiza* with cleistogamous flowers. (A) young flower: ovary just beginning to swell, showing absence of any discernable mentum. (B) mature flower with swollen ovary. (C) mature fruit capsule with senescing flower parts.

The flowers are at most 1 cm long including a two mm pedicle. The ovary is 3-4 mm long and 2 mm in diameter. The pedicle in young flowers is often straight resulting in flowers perpendicular to the stem. As the flowers age and the ovary begins to swell, the pedicle often, but not always, arches downward, resulting in flowers pointing downward parallel to the stem. The mature capsules are 6-7 mm long and 4 mm in diameter, often decreasing somewhat in size upwards on the stem. The lip of var. *pringlei* is typically 5 mm long, white, spotted with purple, with a wavy margin, sometimes edged with purple. Two longitudinal ridges are present on either side of the centerline.

The petals and sepals form a hood over the column and rarely spread fully. The lateral sepals are lanceolate, and often project forward, like the horns of a charging bull. In var. *odontorhiza* the mentum is vestigial and barely visible, while in var. *pringlei,* the mentum is quite prominent and easily observed on the underside of the ovary. Observations by Catling indicated that while the two varieties occur together; individual plants were uniformly either chasmogamous or cleistogamous (Catling 1983). However, I have personally observed mixed populations in Wisconsin where chasmogamous and cleistogamous flowers seem to occur on the same plant. Whether the putative cleistogamous flowers were truly cleistogamous, or were merely chasmogamous flowers that had either not yet opened, or had undergone early pollination relative to adjacent clearly chasmogamous flowers, is a study I intend to pursue in future years.

Color forms: *C. odontorhiza* plants most commonly range in color from deep purplish-red to greenish-brown. Fig. 7A-B). In 2015 the author observed bright lime-green plants with pure white unspotted lips in Door county, Wisconsin. (Fig. 7C). In 1927 Wherry described forma *flavida*, a yellow color form, near Washington D.C. (Wherry 1927). It appears to be extremely rare: the only photograph is that of Bentley, who observed this color form in West Virginia (Bentley 2000). In 2015 Richards reported a bright pinkish purple form in western Pennsylvania (Richards 2015).

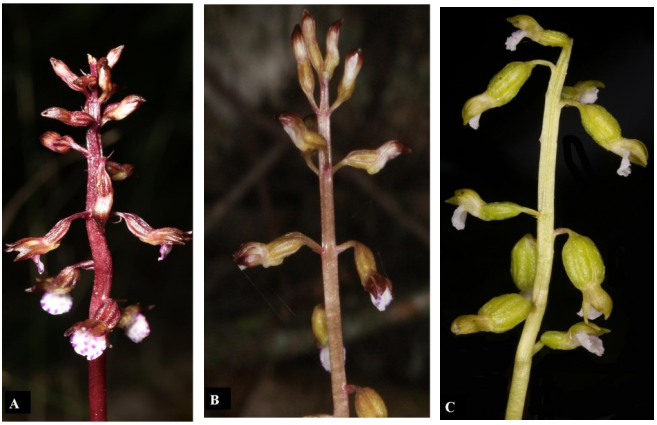


Fig. 7. Color variation in *C. odontorhiza* due to variations in the quantity and distribution of anthocyanin pigments. (A) Plants with dark reddish brown stems and ovaries. (B) Plants with brown stems and greenish-brown ovaries. (C) Plants with pure green ovaries and stems.

Pollination: Studies by Catling demonstrated that both varieties of C. *odontorhiza* are self-compatible (Catling 1983). The flowers of var. *pringlei* do not self-pollinate but require an external agent to remove and deposit the pollinia. As a result, fruit set is variable. In his study of plants in Ontario, Catling reports that fruit set is often low, with many plants having a many as 75% of flowers failing to set fruit. My personal observations in the Upper Peninsula of Michigan gave a value of 33% for capsule development. Of a total of 66 flowers observed on six plants, only 22 flowers showed evidence of capsule formation. The values ranged from a low of 0% on one plant to a high of 43% on a nearby plant. The flowers of var. *pringlei* possess a distinct well developed rostellum which blocks self-pollination. The pollinia rest on top of the rostellum, to which they are attached by a short stipe. (Fig. 8 A, B). An external vector is required to remove the pollinia, and deposit them on the stigma (Fig. 8C). Both small bees and ants visit the flowers. I once observed a small bee repeatedly probe multiple flowers at a location in Door County Wisconsin, apparently seeking a nectar reward contained in the mentum (Fig. 9C). Photographs by Steve Baker, taken in Michigan show both a small bee and an ant removing pollinia (Fig. 9 A, B, D).

Autogamy in var. *odontorhiza* is very efficient with most flowers readily setting fruit. This is a result of the rostellum being poorly developed. Consequently, the pollinia reach maturity in contact with the stigmatic surface, resulting in nearly 100% of the flowers setting fruit (Fig. 9D).

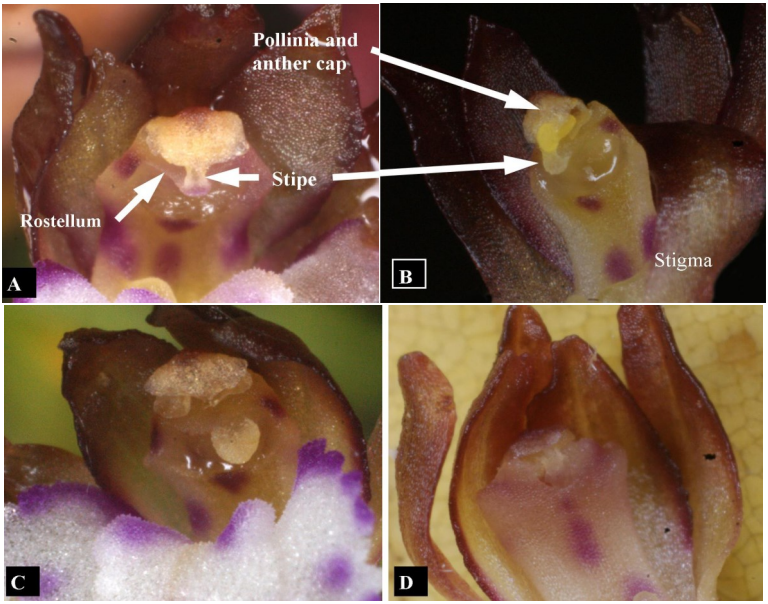


Fig. 8. Column structure of *C. odontorhiza var. pringlei* & var. *odontorhiza* A, B. Front views of var. *pringlei* showing well developed rostellum that serves as an effect barrier to prevent the pollinia from coming into contact with the stigmatic surface. (C) var. *pringlei* with pollen removed and attached to stigma. (D) *var. odontorhiza* column showing poorly developed rostellum, resulting in pollinia collapsing onto the stigma.

Fig. 9. Insect visitation to *C. odontorhiza* var. *pringlei*. (A, B) this small bee probing *C. odontorhiza* with pollinia on its face was photographed by Steve Baker near Grand Marais, Michigan in 2013. (C) At Peninsula State Park in northeastern Wisconsin, the author observed a similar small bee probing several flowers vigorously for several minutes, but without pollinia removal. (D) Photo by Steve Baker of an ant bearing pollinia on its head, crawling over the surface of *C. odontorhiza*.

Habitat: C. *odontorhiza* is a species of heavily forested areas. It is most commonly associated with broad–leaved deciduous forest, often in sandy to loamy soil. Most often associated with Maple (*Acer*), Basswood (*Tilia*), Oaks (*Quercus*), Tulip Tree (*Liriodendron*), and Beech (*Fagus*); it sometimes grows under pines; ei-

ther natural stands or human created pine plantations. It can be found in old growth forests, but is somewhat to highly tolerant of human disturbance, often growing in younger forests only a few decades old. The author has observed plants growing within a mowed picnic ground, and along a roadside shoulder within two feet of the paved surface. At one location in Door County, Wisconsin it grows in a deciduous forest with an overstory consisting primarily of Sugar Maple (*Acer saccharum*), large-tooth Aspen (*Populus grandidentata*), Yellow Birch (*Betula alleghaniensis*), and Red Oak (*Quercus rubra*). Also present here in small numbers are Ash (*Fraxinus*), White Pine (*Pinus strobus*), and White Cedar (*Thuja occidentalis*). Two miles away it can be found growing in a forest dominated by conifers; primarily Eastern Hemlock (*Tsuga canadensis*) and White cedar (*Thuja occidentalis*). The deciduous elements that dominate only a few miles away are now only a minor component. Two hundred miles to the north at Grand Marais, Michigan, *C. odontorhiza* occurs under nearly pure stands of Jack Pine (*Pinus banksiana*) with minimal numbers of maple (*Acer saccharum* and *Acer pennsylvanicum*).

Separate studies by Freudenstein and by McCormick show that *C. odontorhiza* associates primarily or solely with fungi of the genus *Tomentella*, which also form an ectomycorrizal relationship with surrounding trees. As they invade the orchid roots and are consumed, the fungal hyphae serve as a means of transferring sugars produced by photosynthesis in the leaves of the surrounding trees to the orchid (McCormick 2009, Freudenstein 2014). McCormick and Whigham also demonstrated that the abundance and spatial distribution of *C. odontorhiza* within a study plot was strongly correlated with the abundance of particular clades of T*omentella* fungi in the soil (McCormick 2009). Although *Tomentella* was present throughout the study plot only those areas where it was most abundant tended to support *C. odontorhiza*.

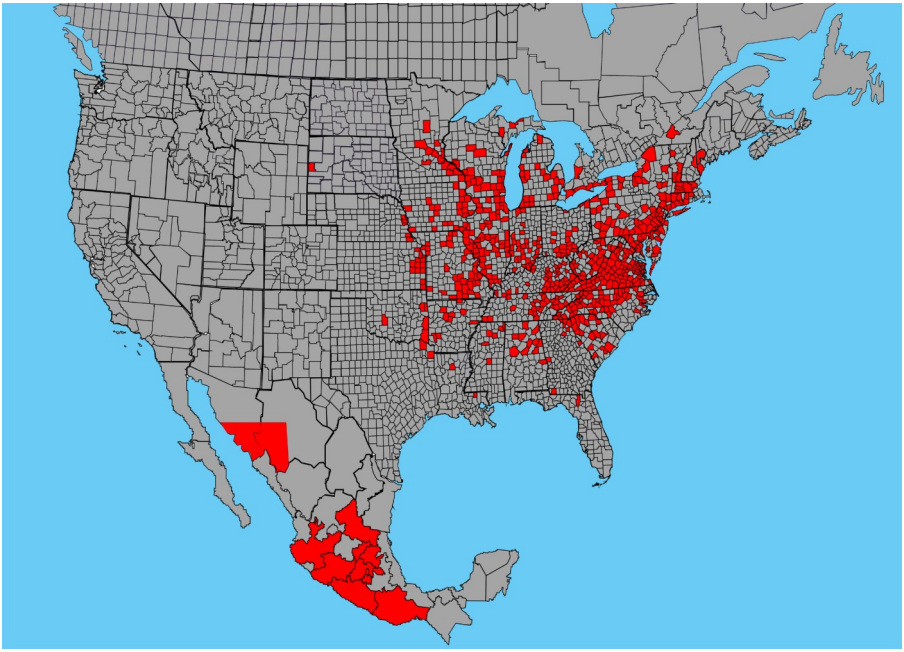
Plants commonly occur singly, but can also be found growing in tightly grouped clusters. This clustering is often the result of a process of vegetative asexual reproduction recently described by Whigham and co-workers, who observed that the rhizomes, which commonly senesce after flowering, often produce bud-like structures capable of growing into new rhizomes (Shefferson 2011).

Distribution: *Corallorhiza odontorhiza* has two centers of distribution; the first in the forested regions of the eastern and Midwestern United States and extreme southern Canada; the second in the forested regions of Mexico, Guatemala, and Belize (Map. 1). It reaches its northeastern limit at a still extant site near Montreal Quebec, and has been reported from a few counties in Maine, New Hampshire, and Vermont (Beausejour 2008, Williams 1995, Brown 2005). It becomes far more common in the Appalachian Mountains from Pennsylvania to South Carolina (Bentley 2000). It is uncommon on the Atlantic and Gulf Coastal Plains, being known only from a few coastal counties from North Carolina to Louisiana (Pridgeon 1977, Brown 2002, Porcher 1972). It reaches its southeastern limit at a single site in extreme northern Florida. (Brown 2002) In the north the range extends westward through the southern Great Lakes region to Minnesota, where it reaches its northwestern limit in the Mississippi River Valley near the Twin Cities (Minneapolis/St. Paul) (Smith 2012). In the western Great Lakes region it reaches

its northern limit in the Upper Peninsula of Michigan. (Baker, personal communication) In the central United States from Minnesota to Texas, where forest gives way to the prairies of the Great Plains, *C. odontorhiza* populations become less common and scattered, tending to be found in river valleys or forest remnants surrounded by prairie (Johnson 1999, Magrath 2001). It reaches its southwestern limit in extreme northeast Texas in Cass and Red River Counties (Liggio, 1999). A disjunct population is found in the Caddo Canyons area of central Oklahoma, where local geographical features favor the growth of forest (Magrath 2001). The Flora of North America distribution map shows *C. odontorhiza* in the Black Hills area of South Dakota (Magrath 2002), but its continued presence there must be considered tenuous at best. A search of online herbarium databases turned up a single specimen collected by L.K. Magrath near Deadwood South Dakota in 1971 (McGregor Herbarium, University of Kansas). No other mention of this occurrence could be found in botanical or popular literature.

Var. *pringlei* is the predominant form in southern Mexico, where it was originally recognized. It also becomes more common at the northern edge of the range (Freudenstein 1997), being found, for example in pure stands near Grand Marais along the Lake Superior shoreline in the Upper Peninsula of Michigan (Baker, personal communication).

Map 1. Distribution map, *Corallorhiza odontorhiza.* Based, in part, on material from Homoya (1993).



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Variation in the Western *Corallorhiza wisteriana* S.W. Conrad (Orchidaceae)

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I had not seen *Corallorhiza wisteriana* other than in photographs until moving to Arizona in 1994. I still remember the thrill of finding it for the first time on Mt. Graham in southern Graham County. Over the years I was amazed by the differences in color and shape within this species. This article documents the variation in *C. wisteriana* I've seen over the last 20 plus years.

Corallorhiza wisteriana is a smaller, daintier plant than either *C. maculata* or *C. striata*, but typically slightly larger than *C. trifida*. The lip is usually scattered with fine to course reddish to purplish dots. The shape of the lip varies from narrowly elliptic to ovate. The sides of the lip turn slightly up so it is somewhat canoe shaped, and the margins of the lip vary from nearly smooth to coarsely jagged. It is easy to distinguish *C. wisteriana* from *C. maculata* even though both usually have spotted lips. *Corallorhiza maculata* has small lateral lobes on the margins of the lip, and *C. wisteriana* is without lobes.

In the eastern United States, *C. wisteriana* grows from Pennsylvania south to Florida, and over to Texas and Oklahoma. Further west it ranges from Montana and Wyoming south to Utah, Arizona and New Mexico, and into Mexico.

My initial concept of *C. wisteriana* was formed by images I had seen in books such as Luer (1975), Case (1987), and Homoya (1993). These showed flowers slightly nodding, with the sepals and petals connivent over the lip and column. More recent books also showing the sepals and petals tightly cupped over the lip and column are Fowler (2005) and Brown (2007). However, the plants I was finding did not fit that pattern.

Fig. 1. *Corallorhiza wisteriana,* perianth open, spreading.

Most of the flowers I was seeing in Arizona had the same lip structure as the images referenced above, so they were clearly *C. wisteriana,* but were held more upright on the stem and with an open, spreading perianth as shown in Figure 1. Some plants had flowers that looked more like those back east, such as Figure 2, but most in the west exhibit at least a partially spread perianth as evident in the rest of the figures with this article.

Another character that varied from plant to plant was the number, size, and intensity of the spots on the lip. Figure 3 shows relatively few, boldly colored spots, and Figure 4 shows a lip with more spots, but faintly colored.

The extreme in spot variation is the total absence of spots. Like *C. maculata*, many plants of *C. wisteriana* may have pure white lips, such as shown in Figures 5, 6, and 7. Throughout their range plants with pure white lips grow inter-

Fig. 2. *C. wisteriana,* perianth partially spread.

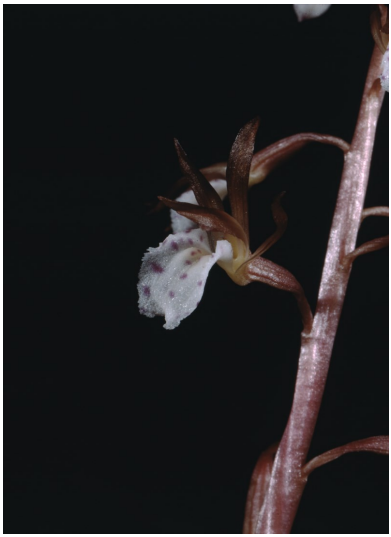

Fig3. Spots relatively few, boldly colored.

Fig. 4. Spots copious, but faintly colored.

mixed with those with normally spotted lips. However all flowers on an individual plant have lips that are either spotted or pure white.

Figs. 5, 6, 7. *Corallorhiza wisteriana* flowers, each with a plain white labellum.

Corallorhiza is a myco-heterotrophic terrestrial orchid genus, which manufactures no food on its own, but is dependent upon its mycorrhizal fungal associate for carbon and mineral nutrients. As with another local myco-heterotrophic orchid genus, *Hexalectris*, there is little chlorophyll in the plants, and the leafless stems in shades of browns, tans, pinks, and yellows appear above ground only to bloom and set seed. Exceptions to the lack of chlorophyll are in *C. trifida*, *C. wisteriana*, and *C. odontorhiza*. (see Horner 2016 in previous article for comments on green in *C. odontorhiza*.) At the western limits of its range, in New Mexico and California, *C. trifida* has pure green stems, sepals, and petals (Fig. 8).

Fig. 8. Plant with green stems, sepals, and petals.

Similarly colored *C. trifida* are scattered across its range in the United States and Canada. Although not as common as the green form of *C. trifida,* green plants of *C. wisteriana* are sometimes encountered as shown in Figures 9 and 10. The intensity of the green varies slightly on the plants in Fig-

Figs. 9, 10. *Corallorhiza wisteriana* plants green, but lips pure white.

ures 9 and 10, but both plants have pure white lips.

Because the color of the stem is the same color as the sepals and petals, it is easy to predict flower color on emerging stems of *C. wisteriana*. Figures 11 shows emerging green stems found in April of 2015 in the Santa Catalina Mountains just north of Tucson, AZ. Even at this early stage of growth the green coloration is obvious in the plants would develop green color bearing flowers, and indeed, the flowers of Figure 10 are evidence of this. Correspondingly, a similar set of shoots, but ones not bearing the green color (Fig. 12) are certain to produce only the brownish usually darker colored flowers.

Fig. 11. Green shoots make green flowers.

The green color in some plants indicates there is significant amount of chlorophyll in both *C. trifida* and *C. wisteriana*. Some plants of *C. wisteriana* that appeared to have only brown stems and flowers while blooming develop vestiges of green coloration when the capsules

Fig 12. The plants of Figs. 10, 11, and 12 are all *C. wisteriana*, but the green flowers of Fig. 10 are from the same green shoots shown in Fig. 11.

Fig. 13. The plants in which the green color is absent in the shoot stage are crertain to show only a vestige of chlorophyll in their flowers.

mature as shown in Figure 13. This suggests there is chlorophyll in many plants of *C. wisteriana* and the role of photosynthesis in food production for those plants merits additional study. Look carefully at the edges of the lips in the photographs. The denticulation on the margins of the lip varies from essentially none, to very uniform, to very jagged. This is seen in the plants of Figures 2, 3, 4, and 5.

Perhaps the most unusual plant I've found of *C. wisteriana* was one plant with peloric flowers (Fig. 14). I photographed the plant early in my studies of *C. wisteriana* and have not seen it or any like it since. The year after I first saw it, the trail it was growing by was re-routed and perhaps its habitat was inadvertently destroyed.

Three areas of additional study could help us understand the science of *C. wisteriana.* First, what role does photosynthesis play in food production of the green plants? Is it more or less important than in the more commonly colored plants of tan and brown that eventually show green in their capsules?

Second, are the more open flowers of the western plants a result of habitat and environment, or are there perhaps slight differences in DNA?

Third, what are the pollinators? Both Freudenstein (1997) and Argue (2012) observe that there are no published reports on the pollination of *C. wisteriana*. My

Fig. 14. *C. wisteriana* with pelorc flowers.

experience is that fruit set is nearly complete, with every flower forming a capsule, suggesting they were pollinated. When every flower on a plant is pollinated, my first thoughts are to consider self-pollination. Freudenstein examined 253 open flowers and reported only 2.8% had self-pollinated, and 15% had pollinaria removed. He said it is difficult to draw conclusions on the pollination mechanism based on those data. So studies are needed to determine the method of pollination. Additionally, if outcrossing is at play, do the western plants with an open perianth have different pollinators than the plants more typical in the east with sepals and petals connivent over the lip?

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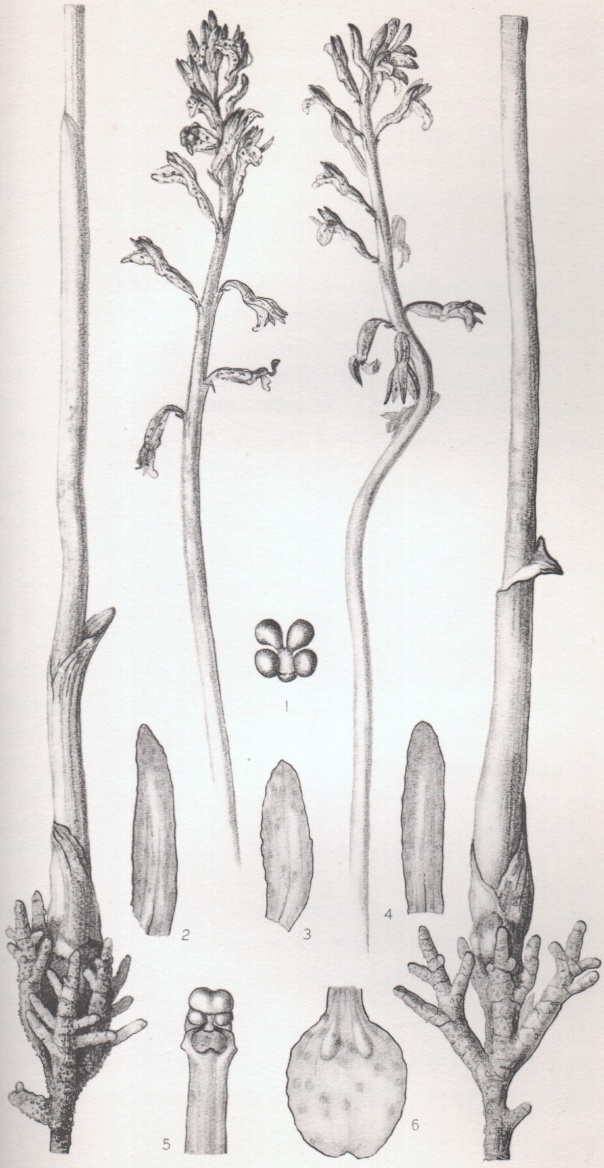

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