Breeding Improved Species – Selfings and Sib Crosses

by Sue Bottom, sbottom15@hotmail.com

Pollinators are nature's hybridizers, they select which orchid to pollinate based on the flower color, shape or fragrance and then the environment selects for those individuals that germinate, grow and flower best. Within a given population of orchids, the pollinators are combining and recombining genetic materials for generations and concentrating whatever trait it was that attracted them to that orchid in the first place. Unusually colored flowers or plants that bloom at a different time may be ignored by pollinators so that atypical forms may not be propagated by Mother Nature. Mutations may disappear or lie hidden, masked in the genome (DNA) of that plant.

Selfings. When using an orchid for the first time in a breeding program, it is impossible to know what is concealed in the chromosomes of that plant without following a tried and true approach used by hybridizers; making a selfing of the plant. A selfing occurs when pollen from a plant is placed on the stigmatic surface of that same plant, so that plant is both the mother and father to its seedlings. The plant label will say 'Orchid Name x self'. Sometimes selfings are made just for the sake of convenience, because the hybridizer only has a single plant from which to produce additional plants, but there are other reasons for making selfings.

A quick and simplified review of some basic genetics is in order before going much further, courtesy of Rebecca Northen's *Home Orchid Growing.* To paraphrase: Every cell in all plants and animals contains chromosomes, and on each chromosome there are smaller structures called genes which control all the characteristics of the individual. For an orchid, there are genes that control its color, size, leaf thickness, flower texture, stem strength and the myriad of other factors that control how that orchid grows and flowers. Chromosomes exist in pairs and both members of the pair are identical in size and shape and contain genes that do the same thing in exactly the same position on each chromosome. However, genes often contain variations that occur over time, mistakes or mutations that arise by accident. Variations of an individual gene are called alleles. Most mutations cause a gene to malfunction and not do what it normally would without the mutation. Fortunately, orchids have two copies of each gene. As long as one copy is normal there may be no indication that a defective gene is present. Within any wild collected orchid there are many hidden mutations. In most cases, alleles are either dominant or recessive. If dominant they alone control the characteristics of the plant, e.g. flower color. If recessive they can only manifest themselves in the absence of the dominant allele. Plants that have the exact same version of a gene on both chromosomes (a double dose) are said to be pure or homozygous for that trait, and if dissimilar, they are heterozygous having dominant and recessive alleles. Hidden or recessive alleles can produce flowers with very different characteristics when expressed, i.e., found on both pairs of chromosomes.

Selfing to Confirm Desired Traits are Present in Double Dose. There are often various forms within a species and these types can each pass their characteristics on to their progeny. Northern uses the example of *Cattleya trianae*, in which there may be one

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population that has good form and another with poor form. If they are well separated geographically, the two populations may be respectively homozygous, but if there has been interbreeding between populations, they may be heterozygous. The only way to tell whether an individual plant will breed true for good form (in this example) is to self the plant and if the progeny are all similar, the plant is homozygous for form. Selfing is a way of proving that the plant is a suitable parent for whatever desirable trait the hybridizer is pursuing.

Selfing to Allow Recessive Traits to Be Expressed. Species lovers would like nothing better than to improve on Mother Nature by giving rare genes and color forms a chance to be seen and enjoyed, and selfing is a means to that end. The hybridizer starts with a plant from a given population. The hybridizer selfs a plant in an effort to express whatever recessive traits hidden within the genome, even if only a small percentage of the offspring show the hidden characteristics.

Developing coerulea color forms in the cattleya alliance has been the Holy Grail for many cattleya hybridizers. Often referred to as blue, the coerulea cattleya and laelia species are unusual although some have been jungle collected so the recessive trait is expressed in the wild. Other rare color forms have not been found in nature, like the coerulea form of *C. aclandiae*. *C. aclandiae* is a small bifoliate from Brazil with sepals and petals that are normally greenish or yellowish with varying amounts of dark spotting and a magenta colored isthmus lip with white edged side lobes. The 'Gulfglade' cultivar having the common color form was selfed by Ken Griffith of Lenette's, presumably to amplify its unusually large flower size. Most of the progeny had the typical color form but there were a very few coerulea forms produced, including the awarded cultivar 'Blue Sky', HCC/AOS.

1a. *C. aclandiae* 'Gulfglade'

1b. *C. aclandiae* 'Blue Sky', HCC/AOS

1c. *C. aclandiae* 'Blue'

1a – c. *C. aclandiae* 'Gulfglade', AM/AOS was selfed, probably because its flowers were unusually large, and the selfing produced a very few coerulea forms, including the awarded cultivar called 'Blue Sky' HCC/AOS, although most of the progeny of the 'Gulfglade' selfing looked for like the typical color form of *C. aclandiae*. The 'Blue Sky' cultivar was then selfed and the progeny all exhibited the coerulea form, including the 'Blue' cultivar, although the intensity of color in the lip varied.
Photos courtesy of Fred Clarke, Sunset Valley Orchids

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Selfing to Produce More Plants with Rare Traits. If a hybridizer has one of the rarer color forms in which recessive genes are expressed, he or she might self the species plant in order to produce a higher percentage of progeny exhibiting the atypical trait, somewhat akin to blue eyed parents producing blue eyed kids. Continuing the *C. aclandiae* example, Fred Clarke of Sunset Valley Orchids selfed the 'Blue Sky' cultivar and all the progeny from the selfing exhibited the coerulea color form although the intensity of color in the lip varied. Unusual color forms are often selfed in the hybridizers efforts to produce and intensify the atypical flower colors, in that selfings are almost always the fastest way to stabilize and concentrate a rare gene. Potentially deleterious genes may likewise be concentrated, so it is not uncommon for fewer viable seeds to be produced in a selfing.

Selfing to Determine Species Status. Species may be selfed as a means of demonstrating that the plant is, in fact, really a species if the offspring produced are relatively uniform. Depending on the degree of variation exhibited, a hybridizer can conclude that the plant is not a pure species but rather a natural hybrid or a species where introgression has occurred if the progeny of the selfing shows a high degree of variation. Dr. Rubén P. Sauleda, who is both an orchid taxonomist and hybridizer, has used selfings to show that certain *Encyclias* that were once thought to be species are really natural hybrids between species. In a paper recently published (Sauleda, 2016), he discusses two *Encyclia* populations once thought to be two color forms of a single species that are really separate species. As Dr. Sauleda so whimsically puts it:

> *Both E. cordigera and E. macrochila range from Mexico through Central America and much of northern South America. There appear to be within the populations of both species ecotypes or forms that exhibit gradual phenotypic and/or genetic differences over their geographical area possibly as a result of environmental heterogeneity. The populations of both species exhibit a behavior typical of a clinal distribution (King, Stansfield and Mulligan, 2012), which results from the change of allele frequencies within the gene pool of each species. However, the differences are not sufficient to classify individuals from the extreme ends of each population as distinct species since intermediates exist within each species throughout the range. In addition, there is no evidence of gene flow between the two species.*

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2a. *E. cordigera*

2b. *E. macrochila*

Encyclia cordigera and *Encyclia macrochila* are found from Mexico, through Central America and much of Northern South America.

All photos courtesy of Ruben Sauleda

Translation for the non-taxonomist: There are two separate populations of Encyclias that coexist within a fairly large geographical area, *Encyclia cordigera* that always has a purple lip and *Encyclia macrochila* that always has a white lip with a purple spot on the labellum (not to be confused with the Brazilian species *Encyclia randii* which also has similar coloration). Within the broad geographical range over which the two populations occur, there is some variation in the shape and color of each population, but these slight differences are normal given the expression of different genes within the population gene pool and there is no evidence of interbreeding between the two populations.

Plants from each population were selfed. If separate species, the expectation was that the majority of the progeny would be fairly homogenous in shape and color while if the offspring were intermediate between the two populations, it would suggest that the parents were simply different color forms of the same species. Rubén summarizes his results:

> *Selfings of both E. cordigera and E. macrochila always result in progeny consistently similar to the parent. The progeny of E. macrochila always has a white labellum with a purple spot or purple veins on the disc. The labellum of selfings of E. cordigera always range from light purple to reddish-purple depending on the color form that was selfed. In addition, results of hybrids made with E. macrochila are distinctly different to hybrids made with E. cordigera demonstrating the genetic difference between E. cordigera and E. macrochila.*

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3a-c. Selfings of *E. macrochila*

Some minor variations in the color and form of progeny from selfings of plants within the population of *Encyclia macrochila*, all showed a white lip with purple spot or veining.

All photos courtesy of Ruben Sauleda

Sibling Crosses and Line Breeding. With a sibling cross, two plants that originated from the same seed pod are interbred. The plant label for this hybrid between brother and sister will say 'Orchid Name x sib'. Typically a group of seedlings are bloomed out and then the hybridizer selects plants that have superior form, color, vigor or some other valued trait and uses them in his or her breeding program to concentrate the desired characteristics. The expectation is that there will be a higher proportion of desirable traits expressed in the offspring from sib crossing. Multiple generations of successive sib crossings results in what is referred to as line breeding. Often line bred species are superior to their relatives found in the wild.

4. The standard color form of *Phal. violacea* is beautiful as well as fragrant, with fuchsia coloration and yellowish greenish tips.

Photo courtesy of Courtney Hackney

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Sib Crosses to Improve on Mother Nature. A case history from the annals of *Phalaenopsis violacea* breeding by H.P. Norton of Orchidview in South Carolina shows the value of making sib crosses. The standard color form of *Phal. violacea* is a fragrant and beautiful fuschia with yellowish green tips on the petals and sepals. In the early 1980's, the Nortons were given 25 *violaceas* by Michael Ooi of Malaysia. They bloomed the seedlings and selected the two best cultivars from the original gift and started line breeding to produce better and better *violacea* flowers. Within a few generations cultivars with intense magenta color as well as alba and coerulea forms were produced. The best progeny of each color form were selected from each cross and used as the parents for the next group of seedlings, concentrating the desirable traits to produce a high percentage of more intensely colored progeny with better and better form.

After eight generations of sib crossing, a small proportion of the seedlings from the series of sib crosses that aimed to further intensify the magenta color bloomed a royal purple color, and a new variety of *Phal. violacea* termed 'Indigo' was born. Somehow in the process of recombining genes from the two magenta cultivars to intensify color, a new combination arose from genes long hidden that might never have never arisen in nature. Perhaps, a double dose of the recessive blue color genes or some new mutation that changed the pH of the cells in flowers was inherited and eventually concentrated in some of the seedlings which together with the intense color saturation from the line breeding expressed itself in the fabulous indigo coloration.

5a. *Phal. violacea*
'Hilltop's Gabby' AM/AOS
H.P. line bred *Phal. violacea* by selecting the best of this color form from each generation and making sib crosses. This is the result after eight generations, a beautiful deep magenta color form.

5b. *Phal. violacea* var. *indigo*
'Hilltop's Sapphire' AM/AOS
A very small percentage of the line bred magenta seedlings bloomed a royal purple color. This indigo form was then selfed and the offspring sibbed to improve form and color.

Photos courtesy of Craig Plahn

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Inbreeding Depression. You may wonder about inbreeding, is there is a down side to generation after generation of selfings and sib crosses? The term inbreeding depression refers to the reduction in plant vigor of progeny derived from inbreeding relative to those derived from out crossing. The fear with inbreeding is that some detrimental recessive trait that can compromise the health and fitness of the plant will become expressed. In nature, many orchids have evolved strategies to avoid self pollination although it may occur. If this results in offspring that are less vigorous, the likelihood is that these plants will not survive. In a breeding program, the hybridizer selectively chooses important characteristics to impart to the next generation. Usually the hybridizer selects only vigorous plants with the desired traits, bypassing the weak sisters on the bench.

In nature, it is the pollinators that decide who gets to carry on the family name, but beauty is in the eye of the beholder. The thoughtful hybridizer can improve on Mother Nature by employing various inbreeding techniques. Selfings are an effective way to get rare recessive genes to express themselves in the offspring and sib crosses of select cultivars can result in progeny that are an improvement over their parents. Selective inbreeding with a careful eye to maintaining plant vigor is an efficient means of producing a higher percentage of unusual color forms and quality offspring. If you understand the hybridizer's goal, you may even seek out those selfings and sib crosses in the hopes of finding that truly remarkable species plant.

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Citations and Additional Reading:

Hackney, Courtney. T., 2004. American cattleyas species and outstanding clones that define American hybridizing. Self Published. USA.

King, Robert C., Pamela Mulligan, and William Stansfield. 2013. *A dictionary of genetics*. Oxford University Press, New York.

Northen, Rebecca Tyson, *Home Orchid Growing*, Simon & Schuster, New York, New York, 1990, 61-83.

Norton, Katherine. , 2010. Good old red, white and blue. *Orchid Digest,* 74-2, 96-101.

Sauleda, Ruben P. and Pablo Esperon, The proper name for a Central and South American species of Encyclia Hooker. *New World Orchidaceae – Nomenclatural Notes,* Issue No. 20, May 30, 2016. Accessed online 5/31/16

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http://rsauleda.tripod.com/newworldorchidaceae.html

Sauleda, Ruben P. Artificial Self-pollination (Autofecundation) as a Taxonomic Tool – *Encyclia tampensis* (Lindl.) Small. *New World Orchidaceae – Nomenclatural Notes,* Issue No. 26, July 25, 2016. Accessed online 9/3/16
http://rsauleda.tripod.com/newworldorchidaceae.html

Whitlow, Carson. 1966. The Blue Cattleya and Laelia Species. *American Orchid Society Bulletin*, 35:10, 834-835.

Whitlow, Carson. 1970. The Blue Cattleya and Laelia Species – Revisited. *American Orchid Society Bulletin*, 39:5, 422-424.