Camelhair Confidential

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Techniques for sexual propagation of Operculicarya species

Remote, exotic and difficult environments have long been a source of rare and intriguing plant material, and Madagascar reigns supreme among succulent and xerophytic treasure troves. Among its treasures is *Operculicarya*, a genus of deciduous shrubs and trees found only on the Great Island, currently placed in the Anacardiaceae, a diverse and wide-ranging family of 72 genera, including *Anacardium* (Cashew), *Rhus* (Sumac), *Mangifera* (Mango), *Toxicodendron* (Poison Ivy), *Cotinus* (Smoke Tree), *Schinus* (Pepper Tree) and *Pistacia* (Pistachio).

O. decaryi **female flowers, dwarfed by a pollinating brush, have a receptive stigmatic surface at the ends of the five styles.**

The search and identification of operculicaryas is complicated, because they leaf out for only a portion of the year, their range is limited and often inaccessible, and their habitats are rapidly disappearing. Thus, obtaining specimens is a challenge, and identifying them is even more problematic. Nevertheless, interest in the eight known species continues to grow as xerophyte collectors discover the structural beauty of their caudiciform trunks. Artificial propagation, besides benefiting wild populations already under pressure, is increasingly the only practical way to legally obtain plants.

A few good incantations

Succulent growers are blessed with many easy opportunities for propagation success, but *Operculicarya* presents special challenges. So little is known regarding the reproductive processes of these rare plants

▲ Left *O. decaryi* male flowers with pollen-laden anthers. Right Male flowers of *O. pachypus* appear in abundance, begging for a nearby female to be in flower too.

▼ Left Despite their diminutive size, male *O. pachypus* flowers can be spectacular when viewed from the proper perspective. Right The results of successful pollination appear quite rapidly. Here ovaries of *O. pachypus* are beginning to swell.

that the propagator must also be an experimenter. Many factors can be considered when devising appropriate cultural practices that lead to good flowering and seed production, but just getting these rare plants to bloom in the first place is hard enough. Some species require many years of development before they are capable of producing flowers, and, complicating matters, all species of *Operculicarya* are dioecious*, a relatively rare condition among plants in which male and female flowers are found on separate individuals. Not only are two flowering plants required to produce seed, but they must also be of different sexes.

We take the time to document and share our methods in hopes that successes may

* Though only 6% of the world's flowering plants are dioecious, it seems to be more common in island floras, probably serving as a mechanism to promote genetic diversity through outcrossing.

◀ ***O. decaryi* female flower and developing bud.** ▼ **With a bit of imagination you can stage a selected 18 month old seedling, such as this *O. decaryi* × *O. pachypus* hybrid, as a handsome bonsai.**

***O. pachypus* female (left) and male (right). In dioecious plants, plants of opposite sexes are required to make seed.**

be repeated and failures understood. Of course, as soon as you assert an elaborate protocol (our recommendations for getting operculicaryas to flower are found in Table 1) someone will step forward and allege that they simply broke off a branch, stuck it in the ground, muttered an incantation, and achieved success. Nevertheless, we believe there are pertinent things to consider, including soil mix, soil pH and soil temperature; water quality (with special attention to salt buildup), watering technique and frequency; ambient humidity, which is monitored and adjusted with humidification and automatic misting; and light levels, with special attention to seasonal variations.

Consideration of conditions in the wild is also useful—and sometimes essential—to success with plants new to cultivation. When considering watering regimes and soil chemistry, for example, we discovered that *O. decaryi*, *O. hyphaenoides*, *O. hirsutissima*, *O. pachypus*, *O. capuronii* and all of their varieties are found on limestone soils in the extreme south and southwestern parts of Madagascar—pre-

► One waits excitedly for anthesis. These *O. pachypus* buds are getting close. ▼ The action of a camel hair brush is somewhat indiscriminate, leaving pollen spread across the ovary of *O. pachypus*.

dominantly arid regions (350–500 mm rainfall annually) of xerophytic scrub. O. *borealis* and *O. multijuga* hail from the extreme north, an area that also has a relatively low annual rainfall. *O. gummifera* (by some accounts a member of genus *Poupartia*) is distributed along the western half of the island—somewhat dry, though not as extremely so.

Operculicaryas flower in habitat at the onset of the growing season, corresponding with the rainiest summer months, October–April*, and xerophytic, low rainfall environments like these frequently produce alkaline soils, whereas soil in areas of high rainfall is often acidic. These combinations of factors certainly play a role in the distributions of the species in addition to suggesting successful cultivation strategies, such as our rule of thumb regarding propagation soil, which we keep slightly alkaline.

Finally, in both the wild and in the greenhouse there is the microclimate factor: plants respond to subtle variations in the environment, and part of the horticultural art is to recognize and manipulate these affects much as a painter uses subtle variations of color to craft a desired image. In the end, propagation is not just following directions; it is also a matter of maintaining a flexible perspective. But who knows, having a few good incantations at the ready might help.

Camel hairs and conscience

A good deal of the value in propagated plants resides in being able to say with some certainty what they are and where they are from. Taxonomy attempts to define a dynamic Tree of Life, that is, the evolutionary relationships among organisms, by examining a wide spectrum of factors—everything from environment to gross morphology to DNA sequence. Of course, this is complicated work, not least of all

▲ **The duration of the *O. pachypus* flowering cycle makes it possible to observe freshly opened flowers and maturing fruit at the same node.** ▼ **At the beginning of the growing season *O. decaryi* flowers emerge first (top) followed in about three weeks by leaves (bottom).**

*As expected, the reversal of seasons in the northern hemisphere results in summer growth and flowering of the plants in our collection, and even field collected plants normally take the "reversal" in stride.

▲ Occasionally a plant, such as this male *O. decaryi*, will surprise with extraordinary fertility.

▼ *O. decaryi* can produce new flowers adjacent to well-developed fruit.

because things like natural hybridization and isolation are at work altering the genetic makeup of plants and the characteristics of populations. "Good species" is a nebulous concept! It is especially true for specimens of *Operculicarya* in that origin is a key piece of information in the identification process. For example, there are morphologically distinct populations allied with *O. pachypus* that live on pure limestone soil. Is this evidence of speciation? Recent lines of thought suggest that localities and divisions among taxa are inseparable, but opinions differ. Propagation thus resides in a context where knowing which species one has depends on often-missing locality data. Without intention, hybrids are created in the greenhouse much like (or very unlike!) what happens in the wild. This is not to say that it is wrong to cross species that are distinct in habitat, but to avoid confusion, crosses should be well documented. If you have a female *O. pachypus* and a male *O. decaryi* in flower it is logical to presume that you will take advantage of the situation. A camel hair brush in the hands of the propagator has no conscience.

The rhythm method?

It is a satisfying horticultural achievement to have your own seed-grown plants produce flowers and seed of their own. We have brought our successes with *Operculicarya* full circle, producing flowers and fruits on *O. decaryi*, for instance, in their fifth year. But one of the main challenges associated with successfully propagating these plants is getting a male and female plant to flower at the same time, especially since each flower lasts only about five days, with female flowers receptive for 2–3 days at most.

A number of observations have shown us that careful microclimate control can lead to spectacular success in this regard. For example, we have a female *O. decaryi* plant that, kept for a number of years in a con-

▲ **Left Pay close attention to your plants for signs of growth at the nodes toward the end of dormancy. On a mature plant the new growth will likely be flowers. Right Sometimes, as with this *O. pachypus*, flowering will continue even as the plant leafs out.**

▼ **The progress of drupe maturation in *O. decaryi* (left) and *O. pachypus* (the red drupe is ready to drop) reveals the relative time of pollination.**

Left Squeezing out the endocarp of *O. pachypus* and preparing to sow. **Right** After three days the *O. decaryi* radicle emerges. Shortly thereafter the entire embryo will have left the protection of the endocarp.

trolled environment, regularly flowers beginning in April. Several male plants grown outside in the ground began their flowering cycle in late May or early June, while males kept in another greenhouse consistently blossomed mid-May. Relocating all males into the same controlled environment as the female led to near-simultaneous mid-April bloom the following year. A female *O. pachypus* held in the same controlled environment also flowered at about the same time. We were able to borrow an *O. pachypus* male from a sympathetic colleague and were surprised to find it stunningly covered in flowers in July. After a year residing in the same microclimate as our female, the plants synchronized their flowering cycles, allowing us to successfully pollinate our female in mid-April.

Operculicaryas are deciduous and can appear stark for extended periods of time. Typically, though not strictly, operculicaryas flower before leafing out. Look for new spring buds forming at the nodes of the branches, but be aware that flowers can spring forth from unexpected locations. Since the female flowers have a relatively short period of fertility, it is important to act quickly when they become available.

The flowers of *Operculicarya* are small (~3–4 mm diameter), fragile, and they do not last long: anthesis (opening) to abscission (dropping) takes about five days. It requires a delicate touch in order to extract the pollen and then to transfer it to a female flower, and while it is not a disaster if male flowers are dislodged (collecting

Table 1 Guidelines for getting *Operculicarya* plants to flower*.

CULTURAL CATEGORY	SUGGESTED PRACTICE	COMMENT
Daytime Temperature	86–87° F	Narrow control is difficult to achieve without adequate facilities. Try to avoid extreme fluctuations.
Night Temperature	72–73° F	
Watering Regimen	Hand water. Don't allow the soil to go dry in this temperature range.	Watering regimen depends a lot on the soil mixture and on the presence of bottom heat.
Water Quality	Water should be free of chlorine and fluorine additives. Let available city water stand for 24 hours before use.	May be impractical on a continuous basis.
Humidity Control	In extremely dry conditions (5–15% relative humidity), or conditions that have suddenly gotten much dryer, the use of a swamp cooler can help reduce desiccation. Aim for 40–50% humidity in this extreme situation, and adjust for preexisting levels.	Pay attention to humidity just as much as temperature. In some climates humidity is less of an issue.
Light Control	6000–7000 footcandles. Intervene with shade cloth as necessary to restrain temperature. The required shade factor will vary depending on latitude and exposure.	Be aware of light variations in the growing space and of the seasonal changes in light intensity and the sun's position.

* Results may vary. There is no single correct way.

▲ **Left In the 1500 footcandle environment of the prop house this seedling is a bit etiolated. Right This *O. decaryi* seedling has leaves reddened by anthocyanins formed under bright light conditions.**

▼ **After one month *O. decaryi* (left) and *O. pachypus* (right) have developed both above below ground and are ready for transplantation.**

▲ An *O. decaryi* seedling can produce spectacular roots in just 18 months.

► After two years *O. pachypus* displays an interesting, though somewhat less spectacular root system. All photos by Daniel M Houston.

them in a petri dish can, in fact, be a convenient way to move them around), the female flower is another matter. If it is damaged during pollination there will be no fruit. We have had success with a #5 camel hair brush as a tool for transferring pollen (though note *O. pachypus* flowers, unlike those of *O. decaryi*, are quite moist. A pollinating brush will quickly get infused in its sticky juices and become useless). By using tweezers to grasp a dislodged male flower, a deft touch is all that is required to bring its anthers into contact with a receptive stigma. Another useful tool is a headband magnifier. With flowers this small one needs some optical leverage.

After pollen transfer, continue to closely observe the flowers, checking for evidence that a fruit is beginning to form, which, if you were successful, will begin within a day or so. At this point, constancy in the environment is critical. If temperatures fluctuate through extremes, or if watering techniques change, the flowering cycle may abort, and all of the flowers—filled with so much promise—may dry up and fall away.

Haste, not waste

As with almost all the genera in the Anacardiaceae, the fruit of *Operculicarya* is a drupe—a type of fruit, like a peach, with an outer skin (epicarp), fleshy tissue (mesocarp), and an inner stone called the endocarp*, which contains the embryo as well as endosperm from which the seedling will derive sustenance upon germination. Between the fertilized flower and a ripened drupe lies 30 days over which the light cycle evolves, fruits swell and then begin to change color (signaling ripeness) and the plant leafs out. With a vigorous flowering cycle there are typically ripening fruits at the same nodes where flowers are still developing. Consistent care over this interval will help ensure larger, more viable seed.

The cycle for individual fruits will vary slightly, but close observation will reveal when they are ready. The laterally compressed fruit of *O. decaryi*, for instance, will turn a purplish brown

*It is the endocarp of *O. decaryi*, having a characteristic, small, cover-like feature, from which the genus got its name: *operculum* = Latin for small cover, *karya* = Greek for nut.

Table 2 Appropriate cultural practices for seed germination and seedling care.

	SUGGESTED PRACTICE	COMMENT
Labeling	Note date, cultivar, special circumstances.	
Soil mix	20% peat, 20% Cocoa fiber, 60% perlite, dolomitic lime to neutralize peat's acidity, Micromax micronutrient supplement, 14–14–14, 6 month Osmocote for controlled release of NPK.	This is a light but well structured mix which has good drainage but requires more attention to watering. These constituents promote an advantageous cation exchange capacity and thus provide an environment that aids nutrient availability.
Other soil amendments	Mefonoxam	Fungicide which greatly enhances the viability of seedlings.
Container preparation	Pre-moisten soil and lightly load into germination containers.	Access to oxygen is an important aspect of seed germination.
Sowing	Drop extracted seed into a hole that is one inch deep. Lightly cover.	A pencil works well for making the sowing depression.
Post-sowing treatment	Top Dress with #12 silica sand, water in with dehalogenated water.	Sand provides evaporation control.
Soil temperature for seedlings	77° F night and day	
Air temperature for seedlings	80° F daytime, 70–75° night	
Humidity for seedlings	90–93%, mist with discretion.	Seedlings are subject to damping off. Soils need to breathe. Avoid saturating the soil.
Light levels for seedlings	1500–2500 footcandles during initial phase	Prolonged exposure to low light environment leads to etiolation (stretch).
Supplemental Fertilization	$CaNO_3$ (125), KNO_3 (100), $(NH_4)_2HPO_4$ (125). Number in parenthesis is NPK ratio for calculating purposes.	Fertilize at ¼–½-strength to avoid burning.
Soil mixture at first transplant	Reduce percentage of perlite to 35%.	A richer mix.

and begin to develop a mottled appearance, and you can see in the pedicel (stem of the flower/fruit) the approach of abscission (fruit drop). *O. pachypus* fruits are more spherical than the kidney shaped drupe of *O. decaryi* (though we note that the endocarp itself is not nearly as spherical as one might expect, differing only slightly from that of *O. decaryi*), and they transition from green, through light orange, to nearly red, at which point they are ready to drop. The slightest vibration will dislodge a ripe fruit, so collect them with haste, but avoid premature harvest, which may compromise viability.

It is easy to extract the seed from a ripe drupe. Taking advantage of the still-fluid relationship between the pulp and the seed, we gently squeeze the fruit. For *O. decaryi* we are left with an endocarp covered in green pulp. For *O. pachypus* we get a slightly larger and rounder seed wrapped in yellow pulp.

Recommendations for successful seed raising are outlined in Table 2. Operculicarya seeds require no stratification (heat, cold or drying) in order to sprout, so the next step is simply to discard the skin and drop the pulp-covered seed into a one-inch-deep hole (seed orientation is not a critical factor). Experience has shown that sowing seed within a day or two of harvest gives germination yields approaching 90%. This is not to say that seed that has been stored will not be viable, but we have heard of disappointing results with older seed.

Radicle to respectable

The radicle (first root), having burst through the operculum, emerges after two or three days of sowing, and within a week the green shoot will break through the top dressing. Within two weeks the first true leaves will develop, and the new sprout will be, depending on light levels, 2–3.5 cm tall. We prefer to sow in six-pack cells so that the root system can develop without becoming intertwined with other seedlings. As the true leaves develop the cotyledons fall by the wayside and the stem already begins to thicken. Stout *O. decaryi* seedlings develop much more quickly than the delicate starts of *O. pachypus*, showing robust first and second pairs of leaflets and the characteristic winged rachis (the main stem) far sooner, making them easy to differentiate even at this young stage.

Once the seedling is established and the root system is well-developed (about a month), it is ready for its first transplant into a 4" pot. Often seedlings will stretch under lower lights conditions of the prop house, and you can compensate at this stage by burying a portion of the elongated stem, with the added benefit of providing more support for the young seedling.

Operculicarya seedlings have great aesthetic potential in their roots, so give them plenty of room to expand. Bottom heat has proven to be a great stimulant for enhanced root development, and in only two or three years the trunk and upper portions of the roots can be exposed to reveal their surprising development. But consider that the purpose of those fat roots is not just for our appreciation but also to cope in an unforgiving habitat. The quicker an individual plant is able to store food in its roots and stems, the better its chances of survival when those dry months roll around. Finally, a healthy root system will enhance the development of the stem, which will quickly begin to display the caudiciform traits that make this genus so interesting.

Expectations and interventions

Commercial horticulture has trained us to expect uniformity in the plant world, but seed raising reveals the great diversity of forms that can appear within a single species—even those from a single seed parent. Nature is a harsh steward. Species evolve within a wide spectrum of available niches express a range of traits that allow them to succeed in a range of conditions, so in every group of seedlings there are runts and super-plants designed to contend with all manner of environmental hardship. From a population standpoint the more diversity the better. The runt may not use much in the way of resources, but it may survive unusual circumstances—and even thrive.

By attempting to create optimal conditions, we are selecting for certain desirable traits: quick growth, a robust trunk, a pleasing form. All of that nurturing interacts with nature in a variety of interesting ways, and you begin to cogitate all sorts of interventions to get the results you want (although some operculicaryas have a windswept bonsai look almost from the start). There is no doubt that propagation tinkers with the natural order of things, but by optimizing growing conditions, seedlings of two or three years may rival much older plants from habitat.

There are other interventions that can influence development. The use of pruning and restraint can guide a seedling in the direction of a desired form. Subterranean rocks cleverly placed beneath transplants stimulate interesting root formations to be revealed years later. Control and structure is only a starting point. Imagination and creativity are also tools of the propagator. ❖

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Northernmost sightings of *Bursera microphylla*

For years I believed that the northernmost locale for *Bursera microphylla,* or for any plants in the genus, was South Mountain in Phoenix Arizona, 33.2˚N, 112.3˚W. However, Turner, et al. in their book *Sonoran desert plants: an ecological atlas*, report two sightings further north: a pair of vouchered specimens from the White Tank Mountains at 33.6˚N, 112.6˚W and unvouchered sightings in 1998 by Paul R Krausman and John J Hervert from the Harquahala Mountains at 33.7˚N, 113.4˚W on (presumably south-facing?) steep canyon slopes and the canyon bottom. —Root Gorelick

Large *Bursera microphylla* at South Mountain.