Orchids Under Glass

[1] *Ceratocentron fesselli* is a biserially growing epiphyte that produced flowers only once, but had several aborted buds, which prompted a change in watering and lighting conditions.

[2] Tiny flowers that last about one week each arise from between the leaves of *Angraecum distichum*. It blooms periodically, with just a few to more than 50 flowers open at any one time.

[3] Overall picture of the author's new top-access terrarium with continuous glass front. Notice the space between the rocks filled with orchid bark to reduce the weight of the landscape. The lights are elevated on one side to reduce heat transfer from the lights.

A WHILE AGO, I WANTED TO INstall a small indoor terrarium with tropical orchids. Although I had a hard time finding information and some people even suggested the effort was doomed to fail, I moved ahead, eventually creating a terrarium in which my orchids grow and flower.

THE TERRARIUM Many aquarium and terrarium stores provide a good selection of prefabricated aquaria and terraria. Due to the tight temperature and humidity controls necessary for orchids, an aquarium with a fairly tight-fitting glass top is preferred over mesh-top terraria usually found in reptile stores. I have tried both front-access as well as top-access models, and prefer top-access as the front panel is not disrupted by disturbing lines from the opening window. Additionally, it is easier to put logs, heating elements and plants in the aquarium through the larger top opening. The downside is that lights placed on top of the aquarium have to be removed when accessing the inside. Suspending lights over the aquarium may solve that problem.

The size of the aquarium is integrally linked to lighting. Most fluorescent light fixtures come in either 24- or 48-inch (60- to 120-cm) units, with a smaller selection of 36-inch (90-cm) fixtures available. When purchasing an aquarium, consider the lighting fixtures that will be used. The shape of the aquarium (tall, wide) will also determine how you are going to light the space: usually, the light should be parallel to the long axis of the aquarium, i.e., on top of a wide aquarium, on the sides of a tall aquarium. It has to do with light intensity decreasing proportionally to the square of the distance from the light source.

POSITIONING PLANTS There are many options on how to display the plants, from organized wire racks to a naturalistic look. The advantage of wire racks is that they are neat and simple to rearrange, while cleaning is easily accomplished. Do not put plants directly onto the glass floor, as accumulating moisture may cause root rot.

Growing and Flowering Plants in a Terrarium

TEXT AND PHOTOGRAPHS BY DANIEL L. GEIGER, PHD

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[4] A view of the rear of the terrarium, showing how plants are surrounded by stones and elevated from the floor of the terrarium. This set-up was too heavy and caused the glass to break.

[5] Top view of space for pots with fewer stones, styrofoam as spacers at the bottom, and orchid bark as general fill.

I prefer a more naturalistic look with epiphytes on wood, and terrestrials in a type of landscape. Starting from the bottom up, I used some large pebbles from a garden center to form the space for the individual pots, while the spaces in between were filled with orchid bark. I keep the plants in their pots or on individual pieces of bark so that they can easily be handled, for instance to trim dead leaves or to remove spent flowers with a sterilized cutting tool. I try to use as few stones as possible with styrofoam pieces as spacers between the pots and the bottom of the aquarium. Too many stones may cause the bottom glass to crack and the terrarium has to be reinstalled.

Mold may grow on wood in a high-humidity environment. Blackjungle (www.blackjungle.com) offers mold-resistant wood (ghost wood) for terraria that works. Their live moss, though, did not grow onto the wood.

HEATING ELEMENTS A variety of heating elements is available for terrarium use, from heat pads attached to the underside of the terrarium to heat rocks in all kinds of shapes. I would recommend either to have more than one heating element, or to include one with a rheostat. For my 36 × 18 × 18-inch (90 × 45 × 45-cm) terrarium I use two large heat rocks and one large heat pad, approximately 25 watts each. With the change of the seasons, the heating requirements change dramatically. In southern California, winter nights can be quite cold, while the summer heat is dramatic with no extra heating required. Also consider the lights as a heat source. Place the lights directly on the top glass in winter to provide some extra heat, while placing them a few inches away in summer will avoid overheating.

Day–night cycles are mainly provided by the heat generated from the lights. In spring and autumn, it may be necessary to put some of the heating elements on a timer to ensure the proper 10 to 15 F daily temperature modulation. I place a digital mini–max thermometer into the aquarium and check it periodically for the range. Some thermometers come with a temperature probe connected with a wire to the main unit. They are advantageous because one can check minimum and maximum temperatures from outside the tank. Seasonal temperature adjustments are carried out as necessary.

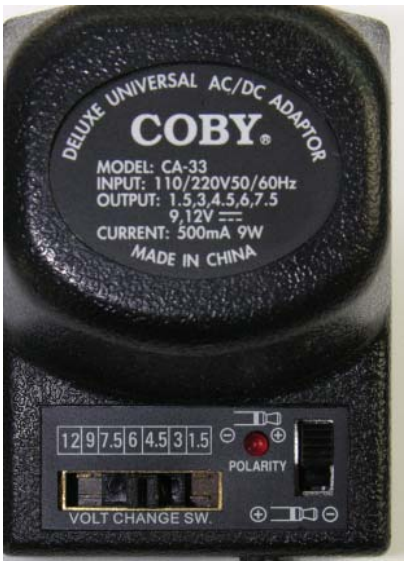
During the few days where the terrarium reaches over 95 F (35 C), I place a .43 gallon (1.5 L) plastic bottle with frozen water into the terrarium, ensuring that it does not touch the plants. It will keep the top temperature about 5 F lower, thus helping the plants to not become heat shocked.

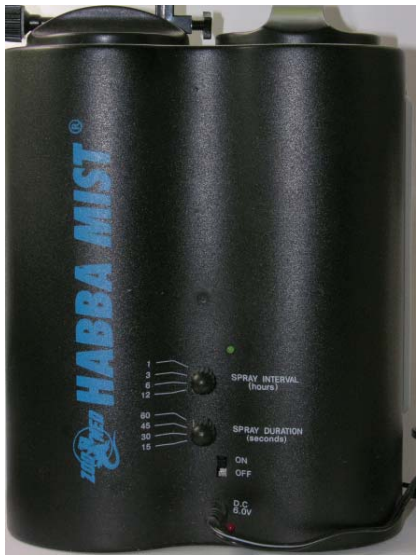
AIR CIRCULATION Air movement is important in orchid growing. I am using a small computer fan, which nominally runs at 12 V. I connected it to a variable voltage wall transformer, which allows me to adjust the voltage from 1.5 V to 12 V in six steps, with which I adjust the speed of the fan so that the larger leaves are just slightly swaying in the breeze. The fan is placed close to the low point in the aquarium so that any accumulating moisture is dissipated throughout the enclosure. It has two benefits: first, no water accumulates in the bottom in which algae and mold may grow; second, the humidity in the aquarium is increased.

WATERING AND HUMIDITY I wanted a fairly autonomous setup, with minimal maintenance requirements, hence spraying of epiphytes had to be automated. I first had two automatic sprayers (Habra Mist from Zoo Med), that can be adjusted for spray intervals of one, three, six and 12 hours and

spray duration of 15, 30, 45 and 60 seconds. Initially, I set them for every six hours for 45 seconds. This may be a bit much watering, and I have reduced it to every 12 hours for 60 seconds. As the sprayer starts its first spray cycle when it is turned on, the unit can also be set with an electric timer at intervals not available on the mister itself. I spray early in the morning, and then at around 2:30 pm, so that water can evaporate from the plants before nightfall. With the new setting, one fill of the holding container allows for one week of automated spraying. The Habra mister can be modified with a drip-irrigation line available from garden centers, into which the Habra mist-head is inserted. Only one spray nozzle can be used per unit; if two are connected they will no longer spray, but drip. The mist heads are positioned and aimed with metal wire bent to shape. This is possibly the most difficult part of the entire setup.

A few months ago I found a better watering system from Big Apple Pet Supply (www.bigappleherp.com), the Big Apple Misting System. It allows a single pump to operate multiple spray nozzles, has a larger storage tank (2 gallons [7.6 L]) and the spray nozzles





[6] *Bulbophyllum roxburghii* (syn. *Cirrhopetalum sikkimense*) produces a web of 1-inch (2.5-cm) pseudobulbs and rhizomes. The inflorescences are on thin 2- to 2½-inch (5- to 6.5-cm) stalks with approximately a dozen flowers, each about ¼ inch (5 mm) long. This plant took two years to produce its first flowers, which were rather short-lived, but spectacular.

[7] An adjustable voltage wall transformer used to adjust the speed/intensity of the fan.

[8] The Habramist unit with the water tank, and the two knobs to adjust spray duration and spray interval. The nozzle on the unit is closed, and black drip irrigation line from the hardware store connects to the spray nozzle inside the terrarium.

produce a much finer mist than the Zoo Med sprayer. Due to the finer mist, the timer is set to two minutes each at 8 am and 2:30 pm.

All other water considerations (rain, distilled, tap) apply as with all other orchid growing parameters. I place the plants and the misters so that only the epiphytes are misted, while the potted plants are manually watered (and fertilized) as needed.

I have experimented with humidity levels. At 90 percent and higher, water condenses on the aquarium glass and on the flowers, which may lead to more rapid wilting. Levels of 70–80 percent seem to work fine, although I observed some brown leaf spots and overall browning of leaves (perhaps due to humidity, heat or both). Now I try to reduce it to 60–70 percent to avoid some leaf rot. Moisture can be reduced by producing an opening in the top cover glass, either by tilting it open or by sliding it to the side, whatever your set-up permits. Note that small changes have a strong effect on humidity levels; for 60–80 percent humidity the top lid is open about ¼ inch (7 mm) in one long axis. Moisture levels can be increased by placing a water container in the aquarium. Or, simply pour a liter of water into the aquarium, which will be

Table 1. Monthly flowering records and temperature/humidity ranges in the terrarium. Key: - = no flowers or buds. B = Buds. F = flowers.

	2006			2007								
Species Name	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Amesiella minor						B	B	B	B	B	B	-
Angraecum distichum	F	F	F	F	F	-	-	F	F	-	-	F
Bulbophyllum acutebracteatum	F	F	-	-	B	-	-	-	-	-	-[1]	-
Ceratocentron fessellii	B	B	B	F	-	-	-	B	B	B	B	-
Bulbophyllum roxburghii	-	-	-	-	-	-	-	-	-	-	-	-
Dendrobium lichenastrum	F	F	-	-	-	-	F[6]	F	F	F	F	F
Dendrobium rigidum										F	-	
Dryadella zebrina	-	B	F	F	F	F	F	F	F	F[5]	B/F	F
Epidendrum peperomia	F	-	-	-	-	-	-	-	-	-	-	-
Eria amica											-	-
Haraella retrocalla	B/F	F	F	F	F	B	F	F	F	F	F	-B
Lepanthes calodictyon		F	F	F	F	F	-	†				
Madevallia livingstoneana						F	F	-	-	-	-	-
Ornithocephalus × *Zygostates*	-	B	F	F	F	F	F	-	-	-	-	-
Platystele ortiziana	F	-	F	F	F	B	F	-	F	F	B	B
Specklinia grobyi	F	f	-	F	F	-	-	F	F	F	-	-
Specklinia tribuloides	F	-	-	F	F	-	-	B	F	F	F	F
Scaphosepalum microdactylum	F	F	B	F	F	-	-	-	-	†		
Sophronitis cernua	F	-	-	-	-	-	-	-	-	-	F	F
Change in Setup[3]				[4]								
Temp min[7]	60	60	60	60	60	60	65	65	75	80	72	60
Temp max[7]	80	80	80	80	80	80	80	80	85	95	95	85
Humidity[8]	80–90	80–90	80–90	70–80	70–80	70–80	70–80	70–80	70–80	70–80	60–70	60–70

Notes: 1) Placed in regular spray path. Pseudobulbs still shriveled up, but some new root formation. 2) Most likely due to high summer heat. Leaves turned spotty, then brown, then fell off. 3) Changed fluorescent tubes to higher output type. 4) Doubled up high output fluorescent tubes, doubled light output. 5) High summer heat caused leaf browning and many leaves fell off, but plant seems to be a

mostly absorbed by the orchid bark used in landscaping the terrarium. The watering regimen has to be adjusted with changing seasons. I have to increase misting in the summer. Also, be aware that water evaporation has a cooling effect that has to be compensated in winter by heating, while in summer it may help prevent overheating.

Humidity is instantaneously increased when the plants are sprayed, and thereafter decreases. The orchid bark filler between the pots helps to avoid excessive decrease in humidity, as it

[9] *Haraella retrocalla* (syn. *odorata*) is a seasoned performer, with up to about five flowers at a single time. Although it does not do well in high temperatures (up to 90 F [32 C]), it recovers during cooler periods.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† = Plant died. B/F = (Bud/Flowering) During any day of that month; does not mean flowered during entire month.

	2007			2008								
Species Name	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Amesiella minor	-	-	-	-	-	-	-	-	-	-	-	†[10]
Angraecum distichum	F	-	F	F	F	F	F	F	F	-	-	F
Bulbophyllum acutebracteatum	-	-	-	-	-	-	-	-	-	-	-	-
Ceratocentron fessellii	-	-	-	-	-	-	-	-	-	-	-	B
Bulbophyllum roxburghii	-	-	-	-	-	-	-	-	-	F	F	F
Dendrobium lichenastrum	F	F	-	F	F	F	-	-	-	-	F	F
Dendrobium rigidum	-	-	-	F	-	-	F	F	F	-	-	-
Dryadella zebrina	F	-	-	-	F	-	-	-	F	-	-	-
Epidendrum peperomia	-	F	F	F	F	-	-	-	-	-	-	-
Eria amica	-	-	-	-	-	-	F	F	F	F	-	-
Haraella retrocalla	-	-	F	F	F	-	F	F	-	-	-	-
Liparis condylobulbon	-	-	-	-	-	-	-	-	-	-	-	-
Lockhartia lunifera	-	-	-	-	-	-	-	-	-	-	B	F
Masdevallia livingstonaeana	-	-	-	F	F	-	-	-	-	-	-	-
Ornithocephalus × *Zygostates*	-	-	-	-	-	-	-	-	-	-	F	F
Platystele ortiziana	F	F	F	F	F	-	-	-	-	-	-	-
Specklinia grobyi	-	F	-	-	F	F	-	F	F	-	-	-
Specklinia tribuloides	F	F	F	F	F	F	F	F	F	F	F	F
Rodriguezia decora	-	-	-	-	-	-	B	B	F	F	F	F
Sophronitis cernua	F	-	-	F	F	F	-	-	-	-	-	F
Change in Setup									[9]			
Temp min[7]	60	60	60	60	60	60	60	65	65	65	65	65
Temp max[7]	85	80	80	80	80	80	80	85	90	95	95	95
Humidity[8]	60–70	60–70	60–70	60–70	60–70	60–70	60–70	60–70	60–70	60–70	60–70	60–70

survivor. One month later already flowers again. 6) Moved *Dendrobium lichenastrum* (syn. *prenticei*) much closer to light, immediately starts flowering. 7) Temperature listings up to July 2007 are estimates +/- 5F. 8) Temperature listings up to July 2007 are estimates +/- 10 percent. 9) Switched to Big Apple Mister. 10) Grew poorly for a long time, and did not thrive when switched to new misting system.

[10] Brown spots developing on the leaves of *Masdevallia livingstoneana*, most likely due to high temperature (greater than 95 F [35 C]), or a combination of high temperature and moisture. The plant is now recovering in temperatures of approximately 80–85 F (26–29 C).

[11] A temperature-humidity dial meter placed inside the terrarium.

soaks up excess water that is released by evaporation as needed. Surprisingly, there is no excess water accumulating at the bottom of the terrarium, hence a drain or a siphoning mechanism is not necessary. This may be dependent on the humidity in the general area; in southern California humidity is quite low, so a lot of water vapor escapes from the terrarium. In Florida's panhandle, however, it may be advisable to have some means to remove excess water from the terrarium.

Fertilizing is done with a common liquid fertilizer. As the quantities needed are small, I use a 200 µl adjustable volume pipette and add 300 µl of fertilizer to a half liter spray bottle. I have not much experimented with fertilizer concentration or frequency of application.

LIGHTING Lighting is critical for successful flowering of orchids. In general, the problem is too little rather than too much light. There are high-output mercury arc lamps, but they also produce a lot of heat. I prefer fluorescent tubes. Orchid-specific fluorescent lights are marketed, but they have too low a light output. Rather, look at hydroponics supply houses, and possibly aquarium stores. The two viable options are compact fluorescent bulbs and high-output T5 bulbs (not T8 or T12 household/industrial lighting bulbs).

The light quality should be full-spectrum or daylight, around 5,000–6,500 K color temperature. Reptiles and tropical aquaria require a lot of UV light (>10,000 K), which is not suitable for plants. Before making a purchase, talk with the sales rep to be sure the product is suited to your plants' needs. Once, I was told the bulb was of daylight quality, but my Minolta color meter III indicated a temperature in excess of 35,000 K. If you don't have a color meter, use a simple visual comparison as a first approximation. If the light looks blue it is not suitable for orchids; it should be color-neutral to slightly orange compared with sunlight.

I use T5 bulbs in a Nova Extreme fixture from Marine Depot (www.marinedepot.com). I chose it due to its simple look, built-in cooling fan and the short legs that let me elevate it from the glass top for temperature control, as described above. The fan was a bit noisy, so I replaced the factory-provided wall transformer with an adjustable voltage unit and run it at a little more than half speed. The Tek light seems to be an excellent alternative choice both for suspended and top-of-glass versions.

To ensure sufficiently high light intensities, cover almost the entire surface of the top glass with T5 bulbs. On an 18-inch- (45-cm-) wide top, use a six- or eight-bulb fixture. I measured light output with a high quality photographic light meter (Sekonic L-558). T5 bulbs have a light output of 13.2–14.5 EV (~ 2,000–3,800 foot-candles) at the surface of the fixture, while compact fluorescent bulbs have an output of around 12.4 EV (~ 1,300 foot-candles; i.e., half to quarter the output of a T5 bulb). Different brands may vary in light output by a factor of two (= 1 EV) at the same power consumption (watts), hence, trying different brands may be necessary. Note also that the wattage indication on the bulb is not the same as the light output. At the level of the plants, light intensity drops to 11.5–12.5 EV (673–1,350 foot-candles) at distances ranging from about 4 to 10 inches (10 to 25 cm).

ELECTRICAL First, water and electricity do not mix. Please take all precautions to safely operate the various components in the terrarium. I put all electrical components on a ground fault interrupt switch (GFI) available at hardware stores. The heating elements are plugged in continuously in winter or are placed on the same timer cycle as the lights and the misters (12–14 hours on and 10–12

Table 2. Values of EV measured by light meter and corresponding light intensity measured in foot-candles. EV (photographic exposure value) = 3.32 log (N exp2 /t) where N square = photographic f-stop number squared; t = exposure (time). For details, see Ray, S. 1999. Scientific photography and applied imaging. Focal Press, Oxford.

EV	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Foot-candles	240	336	476	673	951	1,345	1,903	2,691	3,805	5,382	7,611

hours off) in spring. The fan runs continuously day and night. The cheapest powerstrip with built-in timers I found on amazon.com under home improvement for $4.14 (Philips strip timer). However, they are not reliable for long-term use, as the timer switch fails to operate consistently. Intermatic heavy duty digital timers seem to be more robust; they are supplied with the Big Apple Misting System (see above) or can be purchased at the local hardware store.

PLANTS Generally, small plants are useful for terraria. Whether a particular species thrives in a terrarium depends on many factors, hence, there are no "terrarium" orchids, and the observations below apply to my case. I set my terrarium to intermediate to warm condition, with winter lows around 60–65 F (15–18 C), and summer maximums at around 90–95 F (32–35 C) with 60–80 percent humidity. Table 1 (pages 850–851) provides an overview regarding the temperature humidity regimen as well as monthly flowering records. Tables 2 and 3 provide measurements of light intensities for each plant, both in EV as well as in foot-candles.

Plants that both thrive in vegetative growth and are flowering regularly include *Angraecum distichum, Dryadella zebrina* (does not tolerate temperatures above 90 F [32 C]), *Specklinia* (syn. *Pleurothallis*) *grobyi, Haraella retrocalls* (syn. *odorata*), *Dendrobium lichenastrum* (syn. *prenticei*) (requires a lot of light to flower, i.e., place close to light source), *Platystele ortiziana* and (*Ornithocephalus iridifolius* × *Zygostates alleniana*). Occasional flowers are produced by *Sophronitis cernua, Epidendrum peperomia* (syn. *porpax*), *Bulbophyllum roxburghii* (syn. *Cirrhopetalum sikkimense*) and *Specklinia* (syn. *Pleurothallis*) *tribuloides*. *Masdevallia livingstoneana* has brown spots on its leaves (most likely due to heat, now recovering), while *Bulbophyllum acutibracteatum* is shriveling up as a potted plant but treating it like an epiphyte with daily spraying shows much promise. *Lepanthes calodictyon* and *Scaphosepalum microdactylum* died.

TERRARIUM FAUNA I had been toying with the idea of adding some live animals to the terrarium, particularly some frogs. However, working out animal care when away was difficult. As it happened, I received terrarium animals free of charge. The first ones were some caterpillars of moths that started to eat the orchids' leaves. Manual eradication solved that problem. In the meantime, some spiders, mites, centipedes, and snails have been discovered in the terrarium. Most likely they were introduced with new plants from orchid suppliers. As an invertebrate zoologist, I am rather enchanted by this microcosm.

Orchids can flourish in terraria. Fifty flowers on an *Angraecum distichum* do not lie. Such setups are particularly suitable for small spaces, or for people like me who want to get started without going straight to a greenhouse. It does take a bit of fiddling, and one has to accept some possible losses, yet the rewards are plentiful.

Daniel L. Geiger, PhD, is a marine invertebrate systematist working on biodiversity and evolution of basal marine snails at the Santa Barbara Museum of Natural History. His interests in plants come from natural history photography and gardening; he is a member of the California Native Plant Society. He has been growing native California orchids outdoors, and more recently added an indoor terrarium with tropical orchids. Santa Barbara Museum of Natural History — Invertebrate Zoology, 2553 Puesta del Sol Road, Santa Barbara, California 93105 (e-mail geiger@vetigastropoda.com).

[12] *Dendrobium lichenastrum* (syn. *prenticei*) is an epiphyte producing almost continuously one to three orange flowers that are ¼ inch (5 mm). The plant is placed close to the tubes.

Table 3. The EV and corresponding foot-candle (fc) values measured for each plant in the terrarium. These measurements were made August 2007.

Species Name	EV	Foot-candles
Platystele ortiziana	11.6	700
Bulbophyllum acutebracteatum	12.0	951
Bulbophyllum roxburghii (syn. *Cirrhopetalum sikkimense*)	11.4	650
Angraecum distichum	11.5	650
Specklinia (syn. *Pleurothallis*) *grobyi*	12.0	951
Epidendrum peperomia (syn. *propax*)	12.5	1,345
Specklinia (syn. *Pleurothallis*) *tribuloides*	12.6	1,400
Haraella retrocalla (syn. *odorata*)	12.7	1,600
Dryadella zebrina	12.0	951
Ornithocephalus × *Zygostates*	12.3	1,100
Ceratocentron fessellii	12.4	1,150
Dendrobium lichenastrum (syn. *prenticei*)	12.4	1,150
Sophronitis cernua	12.6	1,400
Masdevallia livingstoneana	11.6	700
Amesiella minor	11.6	700
Dendrobium rigidum	11.6	700
Eria amica	11.6	700