Appendix: Orchid potting mixtures – An abridged historical review[1]

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Introduction

There is little doubt that potting media development over time has been the salvation of orchid growers (Bomba, 1975). When epiphytic orchids were first introduced into England and other European countries in the 18th century growers could not envision plants growing in anything but soil. "'Peat and loam' were good for everything and frequently became the mass murderers of the first generation of epiphytic orchids," Hooker is believed to have said around the end of the 19th century; England had become the graveyard of tropical orchids. Undoubtedly this was in reference to the concern individuals were having over the potting media problems. This problem also drew the attention of such noted individuals as John Lindley and Sir Joseph Paxton, as well as the *Gardener's Chronicle*, who noted that "The Rule of Thumb" had nothing to say about orchid growing; it was only effective in orchid killing (Bomba 1975). Fortunately, the ingenuity of growers solved the problem as innovative potting mixes evolved over the years.

After visiting a number of orchid growing establishments it immediately becomes obvious to any orchid grower, professional or hobbyist, that orchids, both epiphytic and terrestrial, will grow in a wide variety of media. It has often been stated that epiphytic orchids can be grown in any medium except soil as long as watering and fertilization are adjusted to fit the mix being used. Terrestrial orchids seem to thrive in any medium that contains 40% or more organic matter. Reading cultural recommendations from the early days of orchid growing is most interesting and highly recommended. On the following pages, the history and evolution of orchid potting media during more than 100 years will be surveyed as a comprehensive review of a fascinating subject. Potting mixes are the backbone of orchid culture, so the more that is known about them the better the plants will grow. When reading the literature it becomes obvious that some authors are not aware of the Latin word 'medium' and its use. People will often say the one best media or I have a media when they should have used the word 'medium.' In other works the plural 'media' is used in place of the singular 'medium.' Another erroneous use of these

[1] The survey of literature pertaining to this appendix was completed in May 1995; it was submitted in July 1995, and the revised version was accepted in November 1995.

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words is to add 's' to make 'mediums' or 'medias.' Properly the terms are 'medium' for the singular and 'media' for the plural. It should also be noted that the spelling of some words may differ, e.g., mould (UK) versus mold (USA), hapu versus hapuu, or fibre (UK) versus fiber (USA). Throughout the text these words will be spelled as they appeared in the original sources and no attempt will be made to edit them.

Chronological review

Early potting mixes: prior to 1900

The popularity of orchids began to increase very rapidly as more plants were imported into England in the 1800s. Unfortunately many did not survive long under the cultural conditions of the times. The plants were subjected to hot and moist conditions in small dark glass structures often referred to as stoves or stove houses. At that time growers did not readily distinguish between terrestrial and epiphytic genera, subjecting them all to similar cultural conditions. A typical grower would use a mixture of leaves and some form of rotted wood as a potting medium. The pots would then be placed on a bench with sawdust or bark from the tanning industry as a mulch around them, almost burying the pots. This was undoubtedly to keep the pots from drying out.

Miller (Reinikka, 1972) in 1768 bemoaned the fact that plants "grow naturally on trees in America and both Indies, but as these plants cannot by any art yet known be cultivated in the ground, it would be of little purpose to numerate them here, though, could the plants be brought to thrive by culture, many of them produce very fine flowers of very uncommon form." Even as early as the mid-1700s growers were well aware that potting mixes needed improvement if orchids in culture were to survive. However, the literature indicates that there was little communication among growers at that time.

In the early 1800s Sir Joseph Banks started experimenting with growing orchids in coarsely woven wicker baskets, almost cylindrical in shape and of varying diameters depending on the size of the plants (Reinikka, 1972). The openings in the weave were to allow the growth of the plants in any direction. He placed a layer of 'mould' (probably leaf mold) in the bottom of the basket and positioned the plant on top on the mold. Moss was added to cover the roots. Depending on its age, the consistency of leaf mold changes, and at some stage it may have less aeration and become soggy. To replicate the medium, it would be necessary to know the right stage of decomposition of the leaf mold which was used. Around the same era the Rev. William Herbert, Dean of Manchester, successfully grew some epiphytes on tree limbs. His method was likened to grafting as he would notch the limb, place the plant in the notch, and then pack moss around its base. He also developed an automatic watering device to assure that the moss would stay wet. This was an early attempt to

try to duplicate as closely as possible the conditions under which epiphytes grow in nature.

In 1860, Linden published *Pescatorea*, a book that was envisioned as a comprehensive work on all the orchids grown at that time: in short, it was to be an illustrated catalog. Unfortunately, his sponsor died suddenly, and only one volume with 48 color plates was published[2]. This book not only described the orchids but also gave cultural directions for each one. In most cases specific instructions for potting mixes were given. Rather than repeat all 48 recommendations four examples have been taken at random:

(1) *Dendrobium farmeri* requires a medium with good drainage. This was accomplished by putting a layer of charcoal and sphagnum moss in the bottom of the pot. Then "the pot was filled to above the brim with a mixture of $\frac{1}{3}$ very fibrous peat, sieved to remove the smallest soil particles; $\frac{1}{3}$ charcoal and $\frac{1}{3}$ sphagnum." (2) *Odontoglossum hastilabium* also requires good drainage in the bottom of the pot. Here potsherds were suggested. They were covered with "layers of fibrous peat, intermixed with sphagnum, alternated with layers of upright pieces of potsherds. The upper part of the pot was filled with a mixture which consisted of $\frac{1}{3}$ fibrous peat, in small pieces; $\frac{1}{3}$ cut sphagnum and $\frac{1}{3}$ charcoal. The entire mixture should be sieved before hand." (3) The description for *Schomburgkia undulata* depicts the general thinking on culture for that era very clearly. In suggesting that the plants be mounted on sphagnum moss-covered blocks of wood, it was noted that the "roots attach only partly to the wood and their extremities *search for food* (emphasis added) in the humid atmosphere of the greenhouse." (4) *Phragmipedium* (*Uropedium*) *lindenii* is "best cultivated in a medium-sized pot with the bottom $\frac{1}{3}$ filled with potsherds. This layer is covered with a layer of sphagnum moss and then the pot is filled with a mixture of $\frac{1}{3}$ washed and dried charcoal in pieces just about the size of a walnut, $\frac{1}{3}$ fibrous peat, broken between the fingers, again into pieces of the size of a walnut, and $\frac{1}{3}$ sphagnum that is cut with scissors."

Since growing plants on blocks of wood requires considerable care, the author (Linden, 1860) suggested that this plant should really be grown in pots or baskets. The medium for pots or baskets was prepared as follows: "first the receptacle is filled nearly to the rim with long pieces of acacia bark or charcoal, placed upright. The empty spaces are filled with sphagnum. The plant is fixed on top of this construction in such a way to ensure its base is somewhat below the rim of the receptacle, in order to stop new roots from passing across."

It appears that growers felt orchid roots would not grow out of the pot if the medium were below the rim. There are many growers at present who wish this were a reality today[3]. During this era it was a common practice to suggest

[2] This book has now been translated into English with the original illustrations reprinted in color.
[3] It is hard to envision an orchid greenhouse with all epiphytic orchids having most of their roots in the pots.

TABULATED INSTRUCTIONS FOR

Many of the more popular and well-known Orchids are included in the This cannot possibly be avoided without materially increasing the size and price of Should, however, any reader desire further information respecting any of the is a working gardener) will be pleased to supply full particulars on receipt of a

ON WATERING.—All Orchids during the summer months, when making growth, porous, and whenever the compost becomes dry give the plant a good soaking.

NAMES OF PLANTS	Page	Whether to grow in Cool, Intermediate, or Warm House	Whether preferring a shady, sunny, or partial sunny position	Whether best grown in baskets or pans and suspended, or in pots on the stage	The most suitable compost
ACINETA BARKERI		Intermediate	partial	baskets	peat and sphagnum moss
—— DENSA					
—— HUMBOLDTII					
ACROPERA LODDIGESII		ditto	ditto	baskets or pans	ditto
*—— ARMENIACA					
ADA AURANTIACA	91	Warm end of Cool house	shady	pots	ditto
AËRIDES CRASSIFOLIUM		Warm	ditto	pots or baskets	sphagnum moss
—— ORISPUM		Intermediate		pots	
—— —— LINDLEYANUM					
—— —— WARNERI					
—— FALCATUM		Warm		pots or baskets	
—— HOULLETTIANUM					
—— LEONIÆ					
—— LAWRENCEÆ					
—— ODORATUM	113				
—— QUINQUEVULNERA					
—— SAVAGEANUM					
—— SUAVISSIMUM					
—— VIRENS					
—— MACULOSUM					
—— AFFINE					
—— LOBBII					
AGANISIA CYANEA		ditto	sunny	baskets pots or baskets	peat and sphagnum
—— IONOPTERA					
ANGRÆCUM EBURNEUM		ditto	shady	pots	sphagnum
—— SESQUIPEDALE	114				
—— ARTICULATUM				basket or pans	
—— CITRATUM					
—— FASTUOSUM					
—— LEONIS					
—— SCOTTIANUM					
—— SANDERIANUM	115				
ANGULOA CLOWESII	90	Cool	ditto	pots	peat and sphagnum
—— RUCKERI	132				
—— UNIFLORA					
ANSELLIA AFRICANA		Warm	partial	baskets or pots	ditto
ARPOPHYLLUM GIGANTEUM		Intermediate	sunny	pots	ditto
BARKERIA ELEGANS		ditto	very sunny	baskets or blocks	sphagnum
—— LINDLEYANUM					
—— SKINNERI					

* These Orchids, with a few others, are apt to get a little irregular in making growth.

Figure A-1. Two of the 16 pages of the 'Instruction Table' from *The Amateur Orchid Cultivator's Guide Book* by Burberry published in 1900. In the column 'the most suitable compost' only materials are listed, leaving growers to decide on their own how much of each ingredient to use when more than one ingredient is listed.

THE TREATMENT OF ORCHIDS.

following Calendar, but, unfortunately, there are also many that are omitted. the book, which, in the interest of the numerous small growers, is not desirable. species mentioned, or those not included, the author (who, it must be remembered, remittance of 1s. for each name.
delight in a good supply of water, that is, supposing the compost is, as it should be,

The best time to repot or top-dress	The usual time of blooming	From whence flower spikes appear, and whether on old or new growth	Whether showing spike directly growth is finished or otherwise	The proper resting period, if any	Amount of water at the roots when resting	Whether to winter or rest in Cool, Intermediate or Warm House
after flowering	spring	base of new pseudobulb through bottom or side of basket	spikes push soon after bulb is completed and grow slowly	the winter months	water sparingly	Warm
when new growth commences	summer or autumn	base of new pseudobulb	after rest	when growth is finished	ditto	Intermediate
spring	early spring	ditto	when growth is nearly matured	never inactive	water sparingly during winter	ditto
February	summer	stem; axil of the 3rd or 4th leaf from the top	ditto	winter	water moderately only	warmest end of Intermediate
spring						
February						Warm
when new growth commences	summer or autumn	base of new pseudobulb	as soon as growth is finished	ditto	ditto	ditto
February	winter	stem: axil of the 3rd or 4th leaf from the top	ditto	ditto	keep moist to support flower spikes	ditto
spring	spring	stem; axil of the 2nd or 3rd leaf from the top				
ditto when growth commences	early summer	from base of new growth	flower spikes come simultaneously with new growth	ditto	very little	Intermediate
ditto	early winter	apex of new pseudobulb	when pseudobulb is completed	late winter	ditto	Warm
ditto	spring	ditto	after rest	winter	ditto	Intermediate
early spring	autumn	ditto	just before growth is finished	ditto	very little indeed	ditto

Figure A-1. Continued

specific media for specific genera. Unfortunately, most descriptions were vague as to size of particles, or what was meant by 'sphagnum moss,' 'cut sphagnum moss' or 'long sphagnum moss.' This makes it difficult at present to reproduce these media exactly. In that era authors recommended mounding the medium above the pot and placing the plant on top of the medium, a practice which was definitely a detriment to watering. If the moss were allowed to dry between waterings any additional applications of water would just run off, and the plants would not thrive.

Williams (1885) suggested a medium for epiphytic orchids consisting of half rough fibrous peat (the size of hen's eggs) and half live sphagnum moss. Terrestrials, on the other hand, were described as requiring a stronger compost consisting of turfy loam chopped into pieces (the size of a walnut), leaf mold or peat and a little rotten cow or horse dung. Although Williams made an effort to be explicit regarding size, he failed to state how much of each material should be used. A grower taking three different amounts of each of the three materials listed for terrestrial orchids could come up with 27 different media, some of which would undoubtedly produce poor growth. A few years later Watson and Bean (1890) recommended media similar to those suggested by Williams but added that the compost should not be packed 'tolerably' firm. There is no notation how to determine when the medium is 'tolerably' firm. Shortly thereafter, Burberry (1890) devoted 16 pages in his book on orchid culture to tables entitled Tabulated Instructions for the Treatment of Orchids, wherein he had a column entitled 'the most suitable composts' (Fig. A-1). Basically in this column he listed four composts: peat and sphagnum moss, sphagnum moss, peat and loam and peat, sphagnum moss and loam or fibrous loam. Unfortunately no amounts were given for the ingredients to assist in making up any of 'the most suitable composts.'

Castle (1887) stated that "Good results in plant culture are largely dependent upon the soil employed for them, and too little attention is often paid to the subject." He further stated that this was particularly important for orchids. After that he proceeded to list the ingredients used in orchid composts. Peat, which is highly variable should be ordered stating it is for orchids so the dealer will supply the right kind[4]. Sphagnum, loam, charcoal and pot shards were also mentioned. He stated that for exotic orchids "loam is not much used except for *Calanthe* and some *Cypripedium* species. The loam should be of a light fibrous character, heavy and clayey loam being especially avoided. He also stated that soils of a very sandy nature should be avoided." Manures, too, played a prominent role in his cultural outline. Cow, horse, sheep and fish manures were mentioned as well as soot. Nowhere in the paragraph on these materials is there any information on the amount of each component to be used in any one mixture. This only leads to problems. For example, too much

[4] Since orchid culture was still in its infancy at that time, how many dealers would be aware of the proper form of peat to supply?

manure could be incorporated, to the detriment of the plants. The age of manure is also very important as some manures are high in ammonia and can be toxic to plants[5].

Cultural notes provided by Watson and Bean (1890) cited drainage as an important fact in developing potting mixes. They stated that since the majority of orchids require more frequent watering, "there must be provided ample drainage or the material around the roots of the plants rots or becomes sour, and the plants sicken." Their recommendation for a potting medium was "For soil take equal parts of living sphagnum moss and fibrous peat – that is, peat from which nearly or quite all of the fine particles have been removed. The mixture should be pressed *tolerably firm*, but not hard, and it should be built up into a small cone, the apex of which may be about an inch, or, in larger specimens, two inches above the rim of the pot; and upon this the plant should sit, for, if buried below, the chances are that the eyes which spring from the base of the pseudo-bulbs will decay and great injury to the plants will occur." As noted earlier, this mode of potting can only lead to problems in watering, because as the surface of the medium dries, chances are high that the water would run off the surface without penetrating the medium. Modern growers know that it is far better to keep the medium about 1.25 cm ($\frac{1}{2}$ inch) below the rim of the pot so that adequate amounts of water can be applied.

Potting mixes: 1900–1950

During the first half of this century a number of changes were made, and some new substrates were introduced. This was the era when osmunda was the preferred medium, and there was limited interest in searching for substitute media. However, some changes occurred in the latter part of the period.

Osmunda[6] came into vogue in the early 1900s and soon became the medium of choice for epiphytic orchids. It was the most widely used medium in the USA during the subsequent 50 years (Davidson, 1957). No other medium before or since enjoyed such great popularity, although throughout the first 75 years of this century a variety of media have come and gone. A compendium of many of these is presented in the following paragraphs.

An early book of note on orchid culture in the United States was written by White (1927). It includes a brief table summarizing media used at that time. White's recommendations for terrestrials was $\frac{1}{2}$ chopped fibrous loam, $\frac{1}{4}$ leaf mold and $\frac{1}{4}$ sharp sand. *Calanthe* was cited as an example of a genus to grow in this medium. *Cypripedium* and *Cymbidium* plants were considered semi-terrestrials and were to be grown in $\frac{1}{3}$ chopped sod, $\frac{1}{3}$ leaf mold and $\frac{1}{3}$ osmundine. Osmundine was deemed suitable for epiphytes, such as *Vanda* and *Phalaenopsis*. White also listed a class he called semi-epiphytic, which included

[5] Fresh manure applied as a mulch to rose beds in a greenhouse will completely defoliate plants.
[6] Osmunda, osmunda fiber and osmundine have been used interchangeably as common names for the root of one of the three species of *Osmunda* fern growing in the United States.

Cattleya, Laelia, Dendrobium as well as a number of additional genera and their hybrids. A mixture of $\frac{3}{4}$ osmundine and $\frac{1}{4}$ live sphagnum moss was recorded for them. For seedlings coming out of flasks White recommended spongy Oregon peat moss. At the same time Costantin (1927), writing in France, noted that sphagnum and *Polypodium* root mixtures were being used successfully with *Cattleya* plants.

There were few changes of note as far as potting mixes were concerned in the 1920s and 1930s. Orchid growing was still in its early stages, and communication among growers was minimal. The 1940s saw a number of changes in orchid potting mixes. There was also an upsweep in orchid growing due to the favorable economy after World War II and the fact that many American GIs visited areas of the Pacific basin and became interested in tropical plants, especially orchids.

"Osmundine or orchid peat is the horticultural name for the fibrous aerial roots of the large woods fern *Osmunda regalis*" (Watkins, 1942) that serves as an orchid potting medium. However, whether the black wiry portion or the soft brown portion of the root mass was best seemed to be a very controversial issue among growers. Even though osmundine was the medium of choice in that era, Watkins also felt that charcoal was an indispensable ingredient as it kept "the medium sweet and contributed to aeration." Live Florida sphagnum [moss around the base of newly potted plants made for a thrifty, healthy condition according to Watkins. He also recommended using hard wood forest leaf mold, in an advanced stage of decomposition, plus some well-rotted cow manure for terrestrials and semi-terrestrial orchids. No proportions were given[7].

A very interesting account about orchid potting media was written by Soysa (1943). He dealt with media prevalent in India, Sri Lanka (then Ceylon) and the surrounding areas. Soysa listed the various materials used by category. Vegetable: mosses, fibers, leaf mold, wood bark, charcoal, peat, cork and pine needles; mineral: burnt brick, cabook stone (laterite), potsherds, sand, loam, limestone and gravel; animal: bone, egg shell, and oyster shell. He stated that orchids are very versatile and can be seen growing in a variety of media. This contradicted some of the aforementioned media, and the views of Williams (1883) and Watson and Bean (1890) and many other early authors who believed that there was only one medium for each genus. Later publications supported Soysa's statement that most orchids will thrive in a variety of media.

Growers in Burma, according to Soysa (1943), used coconut fibers or *Asplenium* fern in their wood-block or tree-fern pots. Those using clay pots employed a mixture of brick and charcoal and watered it with a manure tea. These materials were preferred as they did not decay under high humidity and

[7] Here again ingredients are given but not ratios to use making it difficult to duplicate what the author used. Also Watkins does not define what he means by "in an advanced stage of decomposition."

temperatures. Growers in Java (then Dutch East Indies, now Indonesia) did not rely on the brick and charcoal mixes but instead used *Polypodium* fern roots and bird's-nest fern (*Asplenium nidus*) roots. Only the coarse roots were used as they were slow to decay. The root clumps were beaten before use to remove all other material, leaving only the coarsest roots. These roots are similar to osmunda but not as long lasting. When used to cultivate orchids they were handled in the same manner as osmunda.

Soysa (1943) also noted that in the Celebes, Indonesia, hollow coconut husks and wooden crates or baskets were the common containers into which a mixture of tamarind wood pieces, crushed limestone and chopped fern roots were added. Growers in the Celebes added limestone because *Dendrobium*, *Vandopsis* and *Paphiopedilum* species were found growing on limestone cliffs. Coconut husks were commonly used as containers or as part of media throughout the tropics where coconuts are either native or introduced. Unfortunately, during the 1960s and 1970s the lethal yellow disease devastated many coconut plantings in tropical areas. As a result husks are not as readily available at present as they were a few decades ago. This caused growers to seek new materials.

Watkins (1949) was still a great advocate of osmunda as a potting medium. He reported that American orchid growers believed that there was no better potting material than osmunda. At that time this material was still readily available. However, soon thereafter, during the 1950s and 1960s, commercial and residential development in many areas along the east coast of the United State wiped out many of the native stands where *Osmunda* fiber was harvested. Watkins further noted that while *Osmunda* was a popular medium in the United States, a fact also noted by Northen (1950), mixtures of *Polypodium* fern roots and sphagnum moss were being used in England with great success. The success with these mixtures was also evident in descriptions of media by Costantin (1927) for France and Soysa (1943) for Java, Indonesia. Watkins also mentioned that coconut husks were still popular in some Pacific islands. Other materials listed by Watkins as being used in the 1940s were silica gravel and Haydite, both of which are inert. He noted further that there was a "shredded bark of a hardwood tree from the west coast of the United States which had been suggested as a possible substitute for osmunda fiber." This was just prior to the influx of fir bark in the late 1950s. Cypress boards, baskets, logs and hollow cypress knees were also used as orchid containers, "either as a matter of economy or to gain artistic effect" (Watkins, 1949).

According to Watkins (1949) sphagnum moss and leaf mold were still being used by some growers. Watkins also listed composts for terrestrials, namely *Cymbidium*, *Paphiopedilum*, *Phaius* and *Calanthe*. They consisted of the following:

Cymbidium potting mixture no. 1
2 parts loam

2 parts osmunda screenings
1 part sharp sand
1 part rotted cow manure

Cymbidium potting mixture no. 2
1 part osmundine
1 part rotted cow manure
½ part rotted oak leaves
fine charcoal, bonemeal and sand sprinkled in as mixed

Paphiopedilum potting mixture no. 1
2 parts shredded osmundine
1 part chopped sodded loam
1 part sharp coarse sand
Add a 12.5 cm (6 inch) pot of dry cow manure to each wheelbarrow of the medium

Paphiopedilum potting mixture no. 2
2 parts shredded osmundine
1 part turfy loam
1 part live sphagnum moss

Phaius potting mixture
1 part rotted cow manure
1 part sandy loam
1 part peat or shredded osmundine
Mulch cow manure on the pots

Calanthe potting mixture no. 1
1 part chopped sod loam
1 part rotted cow manure
1 part sharp coarse sand

Calanthe potting mixture no. 2
1 part fibrous loam
½ part composted leaf mold
½ part rotted cow manure

No information is given about some of the terms, e.g. sodded loam, turfy loam, loam. Also there is no indication as to how much charcoal, bone meal, and sand "is sprinkled in" in *Cymbidium* mix no. 2, making it difficult to prepare these media.

For 30 years (1930s to 1950s) the book *Orchids for Amateurs* by Briscoe (1950) was popular in England. In it the author recommended a number of substrates for growing orchids. He stated "Of late years osmunda and A1 fibers have become exceedingly popular – –." *Polypodium* fern root, a finer fiber was popular for seedlings and small plants, whereas the use of sphagnum

moss was declining. Depending on the genus being grown, additions of leaf mold, peat, silver sand or fibrous loam was added to potting mixes. As an example, for *Cypripedium* and similar plants the medium should consist of "fibrous loam which will form the staple, to which is added a small portion of sphagnum moss and peat. Here again the sphagnum may be omitted except for a few live heads, which may be arranged with the last layer of soil." The author does not mention amounts of any of the ingredients to be used in preparing the potting mix, yet the book remained popular for over 30 years, indicating once again that orchids can tolerate a wide variety of potting media.

New mixes evolve: 1950–1970

The 1950s and 1960s saw some interesting changes as far as potting mixes were concerned. Interest in orchids blossomed after World War II, but sources of osmunda, the medium of choice, were rapidly diminishing. Consequently, interest in finding replacement media was high. In the early 1950s Vacin (1952) working with *Cymbidium*, and testing a variety of media, concluded that any medium containing 50% redwood fiber would give the best growth. Kono (1956) and Miyamoto (1952), working with *Vanda* and *Dendrobium*, respectively, found tree fern to be a good medium alone or as an additive. Miyamoto (1952) determined that dendrobiums grew just as well on tree fern logs as they did in osmunda. However, Kono (1956) found that a combination of tree fern chips and either charcoal or cinders was a fine medium for vandas. The search for new media was beginning to evolve.

Cymbidium orchids will grow and struggle along in most any type of soil, but results will be slow, according to Boyle (1950). However, Boyle noted that in their native habitat *Cymbidium* orchids are not accustomed to growing in soil. Their roots are more or less exposed and are free to travel without obstructions. Therefore, it would be logical to say that the soil they are planted in should be loose. Consequently, the medium used and recommended by Boyle consisted of:

$\frac{1}{4}$ good soil
$\frac{1}{4}$ #5 pea gravel (about the size of a pea)
$\frac{1}{4}$ peat moss
$\frac{1}{8}$ coarse oak leaves
$\frac{1}{8}$ well rotted steer manure

He also mentioned using 'decomposed granite' in his mixes (this was also included in potting mixes by Schirmer and Schirmer, 1953, which see), but had ceased to use it because it decomposed too rapidly and soon looked like mud, and as such impeded drainage.

During the 1950s composts for *Vanda* plants seemed to revolve around two materials. Writing between 1948 and 1956, Summer (1948), Bowman (1954) and Kono (1956) all listed tree fern and either cinders or charcoal as a medium

for vandas in Hawaii. At that time mainland growers were also using a high percentage of charcoal in their mixes. Miyoshi (1953) suggested that the best medium for *Phalaenopsis* growing in baskets was cinders (washed through hardware cloth) and tree-fern chips. At the same time osmunda was still the medium of choice on the mainland.

Osmunda was the only medium for epiphytic orchid mentioned by Noble (1951). She did note that some orchid growers were experimenting with gravel culture for orchids, but results were not sufficient to recommend it at that time. In mentioning terrestrials Noble pointed out that they were planted in 'dirt' in the same manner as other potted plants. No definition was given for 'dirt.' Northen (1950) suggested the following medium for *Cymbidium* plants and other terrestrials:

$\frac{1}{3}$ loam
$\frac{1}{3}$ shredded osmunda
$\frac{1}{6}$ sand
$\frac{1}{6}$ cow manure

This is yet another mixture with almost 50% organic matter. This percentage of organic matter proposed by Vacin (1952) seems to prevail for *Cymbidium* mixes.

Composts for *Paphiopedilum* plants were the subject of controversy in the 1950s because the published potting mixes varied greatly as far as their components were concerned. Takahashi (1952) stated that straight osmunda was the best material, while fellow Hawaiian Yamada (1953) could find no differences in growth when he grew *Paphiopedilum* in 100% 'dirt' sifted through a 0.3 cm by 0.3 cm ($\frac{1}{8}$ inch by $\frac{1}{8}$ inch) screen or a compost of cinders and shredded tree fern or osmunda fiber. Mott (1955b), working with a variety of media at Cornell University, found that moss peat was the best medium for *Cypripedium*. Once again it appears that, like many other genera, *Cypripedium* plants will grow in a wide variety of media.

As was typical of that time, Schirmer and Schirmer (1953) stated "Osmundine, a fern root, is most commonly used as a potting material." In this case they were referring to basket culture. They did note that redwood bark fiber, cedar hay (shredded cedar bark) and green sphagnum were also used. In addition they recommended osmundine for epiphytes being grown in pots, with the fiber tightly packed vertically in the pots. The mixes recommended by Schirmer and Schirmer (1953) for terrestrials also proved to be interesting. In the case of *Cymbidium*, they used a mixture consisting of:

2 parts leaf mold
1 part top soil
1 part ground redwood fiber
1 part decomposed granite or crushed rock

In addition, to each wheelbarrow of the above mix they added:

One pound (500 g) coffee can of fine crushed charcoal, one pound (500 g) coffee can of bonemeal, four one-pound (500 g) coffee cans of steer manure.

Although the amount of each ingredient is given, terms such as 'decomposed granite' are somewhat vague. An earlier writer (Boyle 1950) claimed it decomposed too fast. A grower might wonder just how decomposed the granite should be before it can be used successfully. The mixture recommended for *Paphiopedilum* was slightly different. It consisted of:

1 part top soil
1 part leafy leaf mold
1 part peat moss
$\frac{1}{2}$ part sharp sand
$\frac{1}{2}$ part fine charcoal

Since *Paphiopedilum* species are often found growing near limestone rocks, Schirmer and Schirmer recommended adding 1 cup of agricultural lime to each wheelbarrow of the above mix. They recommend leaf mold for *Cymbidium* and 'leafy leaf mold' for *Cypripedium* but do not tell the reader how to distinguish between the two leaf molds. Also fine charcoal could be considered to be dust by some growers. Information about the particle size in such cases would be most helpful. Ratios of ingredients and particle sizes seem to be the two parameters that are most often overlooked in describing media. Consequently, duplicating another grower's medium is not easy and those attempting to emulate their competitors were not always successful. Furthermore, differences in control regimens (watering, humidity, light intensity, air movement) and the plants themselves will not produce the same results even when using the same medium.

In a very extensive discussion of *Cymbidium* composts, Matkin (1953) noted the requirements of a good growing medium and the various materials that should or should not be used. Manure of all kinds, leaf mold, composts and charcoal, according to Matkin, were unacceptable because they lack uniformity[8].

Matkin (1953) stated that a good *Cymbidium* compost must anchor the plant and support it physically. It must hold moisture in an available state for a reasonable period of time, and offer a source of mineral nutrients for plant growth. After establishing these basic requirements he suggested a typical compost with the following ingredients by volume:

3 parts sandy loam or fine sand
4 parts loose brown peat moss

[8] Since the advent of orchid growing we have seen numerous articles recommending these ingredients as parts of various orchid composts. This is the first report I have come across which lists components which should not be used, but I must agree with Matkin that these materials do lack uniformity. However, if a component (e.g., manure) is obtained from the same source and cultural practices are adjusted to it, I see no harm in using it.

1 part #5 crushed rock (about pea gravel size)

He also included a fertilizer mix to incorporate when preparing the compost which consisted of:

Hoof and horn	2 ounces (65 g) per bushel (35 liters) or $2\frac{1}{2}$ pounds (1.1 kg) per cubic yard
Single superphosphate	2 ounces per bushel or $2\frac{1}{2}$ pounds per cubic yard
Sulfate of potash	$\frac{1}{2}$ ounce (15 g) per bushel or 10 ounces (350 g) per cubic yard
Dolomite lime	2 ounces per bushel or $2\frac{1}{2}$ pounds per cubic yard
Gypsum	2 ounces per bushel or $2\frac{1}{2}$ pounds per cubic yard

Care should be taken to make the mix uniform (Matkin, 1953).

Smith (1953) reported good results with *Phaius grandifolius* (*P. tankervilleae*) grown in a mix consisting of 3 parts garden loam and 1 part finely chopped osmunda fiber. He attributed his success to the addition of one level 10 cm (4″) pot of 4-12-4 fertilizer to each wheelbarrow of mix ($2\frac{1}{2}$ bushels; 85 l). He also recommended annual repotting in this mix.

Yamada (1953) had some very interesting comments on growing *Paphiopedilum* plants in Hawaii. He noted that "Books on orchid culture classify the *Cypripedium* (*Paphiopedilum*) as a cool house orchid requiring a night temperature of 60° F. From such reading most amateurs in the Hawaiian Islands took it for granted that cypripediums (paphiopedilums) could not be flowered in Hawaii." However, this was proven wrong. Since most *Paphiopedilum* species are terrestrials found growing in the ground with leaf mold and pine needles scattered at their roots (the author cited *Cypripedium acaule*, a true *Paphiopedilum*), a terrestrial mix is necessary. Yamada successfully grew *Paphiopedilum* plants in 100% 'dirt' sifted through a $\frac{1}{8}$″ by $\frac{1}{8}$″ screen (approx. 0.3 cm × 0.3 cm) and using only the coarse grains[9]. To test the medium, Yamada suggested pouring water on the 'dirt' and if it passed through rapidly, as if through a wire screen, the mix could be used. He also noted that in Hilo some growers were using a mixture of cinders and shredded hapuu (tree fern) fibers. Cinders $\frac{1}{2}$ inch (1.25 cm) or larger are used to anchor the plant, and the shredded hapuu, 1″ (2.5 cm) long, is intermixed with the cinders to fill the pot. Later, Warne (1958) recommended osmunda with a little leaf mold for *Paphiopedilum* leads and straight osmunda for back growths, whereas Merkel (1958) called for straight osmunda with a little bone meal added for paphiopedilums.

Like many writers of this era, Butterfield (1955) listed the major materials used in potting mixes for orchids. He included such items as osmunda, *Polypodium* fern, sphagnum moss and charcoal but did not list any specific mixes

[9] Unfortunately a definition of the word 'dirt' is not given. Therefore since soils are highly variable it would be difficult to duplicate the medium exactly. At one time Cypripedium included species which are now part of *Paphiopedilum*. This creates confusion at present when the older literature does not include the names of species.

or give any recommendations for epiphytic orchids. He did list two mixes for terrestrial orchids: mix 1 comprised $\frac{2}{3}$ coarse oak-leaf mold and $\frac{1}{3}$ small gravel; mix 2 consisted of $\frac{1}{2}$ fibrous loam, $\frac{1}{4}$ leaf mold and $\frac{1}{4}$ sharp sand or small gravel. Also for some terrestrials (no genera given) rich loam may be sufficient as a medium.

The end pages of Watkins' (1956) book had an 'Orchid Growers Reference Table' (Fig. A-2) listing 21 genera, potting media, etc. Like many of the early British books (e.g. Burberry 1900; Fig. A-1) potting ingredients were listed for each genus, but if more than one ingredient was listed no ratios were provided. Even at that time growers were still reluctant to share 'growing secrets' with their competitors. This made it safe to list the number of ingredients in a mix, without indicating the amount.

The early 1950s witnessed the introduction of fir bark and its coming into vogue in the USA. One of the earliest accounts of its successful use was by Hubert (1955) who reported on his trials in which he compared growing cattleyas in bark, osmunda and compost. After one year he eliminated the compost and after the second year his results with bark were so satisfying he potted everything in it. At first he used large chunks of bark (1″ to $\frac{1}{2}$″; 1.25–25 cm) but later changed to $\frac{1}{4}$″ (0.6 cm) and smaller. He preferred the chopped to the shaved material as the former contained less fines (minute particles). He also reported success growing *Epidendrum*, *Odontoglossum*, *Dendrobium* and *Vanda* in bark. McLellan (1956) reported that as a medium bark was easier to handle, cost less than osmunda, and produced excellent root growth. At that time the so called 'fir bark' contained 80% white fir (*Abies concolor*) and 20% ponderosa pine (*Pinus ponderosa*). Bacher (1956) also reported success using bark and confirmed the reports of both Hubert and McLellan. During this period a wide variety of barks appeared on the market (e.g., Ivory Bark, Vita Bark, Wonder Bark, Naturgro and Ease). Only those containing fir bark or redwood survived until the oil crisis in the late 1970s when many lumber mills resorted to burning bark in response to the shortage and rapidly increasing prices of crude oil. Hence barks lost some of their original luster and have yet to regain their place of prominence as an orchid medium. However, many of the potting mixes on the market today have bark as one of the components.

It should be noted that even though bark became very popular during this era not everyone was satisfied with their results after changing to it. Forman's (1957) experience with bark was not good. He claimed that; "1) the buds failed to open; 2) the stems are too short for proper blooming; 3) the inflorescences fail to mature; 4) the color of the flower is not quite so intense as previous when the plants were grown in osmunda and 5) there is a deficiency of nectar on the new growths with resulting paper thin sepals."[10]

[10] This experience was typical of many growers during that period. In such cases the growers did not change their fertilizing and watering practices when they changed from osmunda to bark. The fir bark was blamed for poor performance of the plants which was due to the lack of nitrogen in most cases.

ORCHID GROWERS'

KIND OF ORCHID	USUAL TIME IN BLOOM	WHEN TO POT
Cattleya	Hybrids, the year around	Right after flowering
Calanthe	Winter	Spring, when eyes swell
Chysis	Spring	Just before growth starts
Coelogyne	Late winter, early spring	Infrequently, after flowering
Cycnoches	Winter	Before growth starts
Cymbidium	Winter, early spring	Spring
Dendrobium (evergreen)	Winter	Small, after flowering
Dendrobium (deciduous)	Spring	Small, after flowering
Diacrium	Winter	After flowering
Epidendrum	Winter, spring, summer	After flowering
Laelia	Variable with species	After flowering
Lycaste	Winter, spring	Before growth starts
Miltonia	Summer	July-August, small
Odontoglossum	Variable, usually summer	September
Oncidium	Mostly springtime	After flowering
Paphiopedilum (green leaf)	Mostly spring	After flowering
Paphiopedilum (mottled leaf)	Mostly spring	After flowering
Peristeria	Summer	Before growth starts
Phaius	Spring	When basal eyes start
Phalaenopsis	Variable with lineage	After flowering
Sophronitis	Winter, variable	After flowering
Stanhopea	Warm months	After flowering, in rafts
Vanda (strap)	Variable with lineage	When needed
Vanda (terete)	Warm months	Bed grown
Vanilla	Summer	Bed grown

Figure A-2. Two of the end pages from the *ABC of Orchid Growing* 3rd ed., by J. V. Watkins 1956. In the column 'potting medium' only ingredients are listed with no ratios or clues given as to how much of each ingredient goes into each mix.

REFERENCE TABLE

POTTING MEDIUM	MIN. NIGHT TEMP.	% OUTDOOR SUMMER LIGHT	WHEN TO FERTILIZE
Osmundine	60°	20-30	When root action starts
Loam, manure and sand	65°	15-20	Summer, when foliage expands
Osmundine	60°	15-20	Summer, lightly
Black osmundine	55°	10-15	Summer, lightly
Osmundine	60°	15-20	Summer, lightly
Loam, peat, manure and sand	50°	half-shade	May-September
Black osmundine	65°	half-shade	May-September
Black osmundine	50°	half-shade	When foliage is expanding
Osmundine	60°	20-30	Usually not fertilized
Osmundine or tree fern plank	55°	20-30	When foliage is expanding
Osmundine	50°	20-30	When roots are growing
Osmundine	55°	15-20	Usually not fertilized
Black Osmundine	50°	15-20	Usually not fertilized
Black Osmundine	48°	15-20	Usually not fertilized
Osmundine	55°	20-30	Usually not fertilized
Osmundine or loam and peat	55°	10-15	Warm months
Osmundine or loam and peat	60°	20-30	Warm months
Loam, manure and sand	60°	15-20	When foliage is expanding
Loam, manure and sand	55°	half-shade	When flower scapes appear
Black osmundine	65°	10-15	Warm months only
Osmundine	60°	20-30	Usually not fertilized
Osmundine	60°	15-20	Usually not fertilized
Charcoal or osmundine	60°	20-30 or more	When roots are growing
Charcoal or earth beds	50°	full sun	During summer
Osmundine or earth	50°	half-shade	During summer

Figure A-2. Continued

Cymbidiums received their share of attention during the fifties as far as potting media were concerned. Vacin (1952) listed six different composts for *Cymbidium* and described their nutritive qualities and the type of growth he obtained with each compost. His best compost contained 50% redwood fiber and consisted of the following ingredients:

50% (by volume) finely shredded redwood bark fiber
50% (by volume) of the following mix:
12 parts leaf mold (usually oak leaves),
3 parts partially decomposed bean straw,
3 parts well rotted cow manure,
3 parts fresh osmunda screenings,
4 pounds of bone meal,
3 pounds of vermiculite,
3 handfuls ferrous sulphate,
(each part in this formula refers to a wheelbarrow load).

Sherman (1955) suggested a slightly different compost containing redwood shavings, peat moss and fine sand or sandy loam. He stated that originally in England the typical compost consisted of osmunda and sphagnum with perhaps a few beech leaves. This mix was still being used by some, but during the evolution of composts the trend was toward using redwood fibers. Mott (1955a,b) experimented with 10 potting mixes for *Cymbidium* and *Paphiopedilum insigne*. Included in the mixes were 100% peat, 100% soil and 100% manure and a variety of combinations of these materials. After two years, he had his best results when the plants were grown in 100% peat moss. Growth in this potting medium was better than in any of the other media tried. Mott stated that peat moss in addition to producing the best growth resists decay, retains its physical condition for 2–3 years, holds water and yet is well aerated and is practically free of diseases. In addition, the low pH of the peat moss hinders bacterial decay. Later studies by Powell (1957) suggested that a 1-1-1 mix containing peat, shavings and fine sand produced good plants. This compost is similar to the one mentioned by Northen (1950). Again it is evident that *Cymbidium* plants can grow in a variety of media as long as organic matter is a major component.

"There have been many different attempts to develop a potting medium which will approximate conditions allowing for quick drainage as well as maximum circulation of air around the roots. Disregarding the odd types of media (the author knows of one *Cattleya* plant growing in a keg of nails and doing remarkably well), most media fall within these groups: osmunda, bark or chips and gravel" (Bateman, 1957). Bateman noted that bark and chips (fir, spruce, cedar, pine, etc.) had come into wide use in the two years prior to his article (1955–1956) and that claims for bark usage had ranged from utter failure to it being considered the ultimate potting mix. However, Bateman contended that gravel came closer to approximating natural conditions than

other potting mixes (e.g., osmunda, bark). He listed three types of gravel he had used – Haydite, poultry grit (granite) and river-bottom gravel. He found river-bottom gravel to be the best. The roundness of the stones allows for better drainage, and it was the least costly of the three. He recommended three sizes to use:

1. For plants out of flasks	$\frac{1}{16}$–$\frac{1}{8}$″ (0.15–0.3 cm)
2. For plants in $1\frac{1}{2}$–2″ (3.5–5 cm) pots	$\frac{1}{8}$–$\frac{1}{4}$″ (0.3–0.6 cm)
3. For plants in 3″ (7.5 cm) pots and up	Use unscreened gravel

In discussing orchid potting media at the Second World Orchid Conference, Sheehan (1958) gave a brief history of the evolution of potting mixes. He noted that during the 1950s there was a large influx of barks with trade names such as Ivory Bark, Wonder Bark, Ease and Naturgro being offered as potting media. Included in this group were fir, redwood, cedar and southern pine. There was also one mix containing hardwood barks from New England, but unfortunately this material had two problems: it rotted too rapidly, and the type of bark varied from shipment to shipment. Consequently, it was withdrawn from the market. Ease, a byproduct of the cedar tan bark industry, was a very clean, sterilized product that not only served as a good medium but also added a touch of cedar aroma to the greenhouse. Unfortunately, the supply of Ease was very limited and not sufficient to supply the market[11]. Only the fir barks proved to be worthy candidates and survived for a number of years.

While barks were becoming popular in the United States traditional media were still prevalent elsewhere. Ann (1958) pointed out that growers in Singapore preferred perforated pots, ranging in size from 4″ to 20″ (10 to 45 cm) in diameter for *Dendrobium*, *Phalaenopsis*, *Cattleya* and strap-leaf *Vanda*. She stated that they did not use sphagnum moss, osmunda or tree fern but relied entirely on "broken bricks and charcoal brought down to the size of walnuts." The charcoal was thought to be necessary to 'sweeten' the medium (Ann, 1958). The 'brick–charcoal' mix was also recommended by Soysa (1943) for Sri Lanka (then Ceylon) and other tropical areas where there is heavy rainfall and organic media tend to decompose very rapidly.

McLellan (1958), in discussing the commercial aspects of growing orchids in bark, stated that barks were not new as far as orchid cultivation was concerned. In the late nineteenth century in England and France barks were tested as growing media but with little success. He attributed the present-day success to the use of soluble fertilizers with the correct pH and laboratory equipment which facilitated proper monitoring. At that time no one had tried *Abies concolor* (white fir), *A. magnifica* or *A. grandis*, which were not only acceptable but also according to McLellan "a perfect medium for growing orchids." The results of their first test were ". . . mainly astounding root action with notice-

[11] Had 'Ease' become a reality it might have been a great deterrent to insects in the greenhouse.

ably heavier sturdier roots, about 30% more leads, not to mention the purely business advantage of something like a 10% savings in production costs . . . ." McLellan was aware that there was some skepticism about growing in bark (Forman, 1957). He noted that after six months in bark plants started to turn yellow. After consulting Matkin (University of California) and Davidson (Rutgers University) the problem (nitrogen level) was corrected, and McLellan switched everything to bark.

According to Fennell (1959) "osmunda fiber, a coarse black fiber, is the traditional potting material for most orchids." He also noted that in the previous few years a revolution in the methods and materials of orchid potting had taken place. Barks replaced osmunda, and pine and fir barks were widely used. Although Fennell had stated that osmunda was a suitable potting material for most orchids, it was obvious that in 1959 barks were already replacing it as the medium of choice. He cited both the advantages and disadvantages of using barks, but the best advantage, according to Fennell, was summed up in one of the slogans of a bark supplier; "If you aren't potting with bark, you're working too hard." This was undoubtedly a reference to the tedious process of potting in osmunda.

No matter how much a medium is extolled there always seem to be areas where it fails to work. A good case in point was made by Ghose (1959). He stated that "sphagnum moss is no good for the plains of India or other hot countries where it soon rots and turns slimy, but fern roots (e.g., osmunda, *Polypodium* and *Asplenium*) and tree fern blocks are good." One interesting aspect discussed by Ghose was the dressing applied to the top $\frac{1}{3}''$ (0.8 cm) when potting. It consisted of 5 parts broken bricks, charred or well-cleaned bones and one part *Polypodium* fiber. The top dressing was added to assist in holding moisture and prevent the compost from becoming hard. It is worth noting that Ghose recommends the use of sphagnum moss as a top dressing when earlier he advised against it. However, he recommended that if sphagnum moss were used as a top dressing it should be removed in the advent of rain. This could present problems if the plants were grown out-of-doors or in shade houses as one would be constantly putting the moss on and taking it off. Ghose also noted that leaf mold should not be used as it deteriorates rapidly in the tropics and causes disease problems. However, in the case of terrestrials, Ghose recommends a mixture of leaf mold and a little dry cow dung, charred if possible[12].

Even as bark was increasing in popularity other media were still being evaluated. Australian tree fern (*Cyathea arborea*) was the best material found by Bayley (1958) for growing orchids in Barbados. She stated that it lasted longer than osmunda and was similar to Hawaiian tree fern (*Cibotium*) but appeared to have finer fibers. As did other authors, she noted that the fiber's

[12] Ghose is not consistent in his recommendations, as he states in one paragraph that a material is not good and then suggests its use in another paragraph.

longevity made repotting less of a chore: it was not imperative to repot on time since rot was not a problem for several years.

Davidson (1960) also was trying new combinations of ingredients. As a result of his studies he recommended the following mixture as a medium for epiphytic orchids:

$\frac{1}{3}$ peat (poultry grade),
$\frac{1}{3}$ oak leaves (dried but not decomposed),
$\frac{1}{3}$ redwood fiber (insulation grade, Palco Pete's mulch)

This medium became known as New Jersey No. 1.

"Virtually every orchid genus – and often almost every species within a given genus – has its own requirement for compost and potting" (Hawkes, 1961)[13]. He then went on to state "most present day growers grow the bulk of their epiphytic orchids in straight osmunda fiber," noting that in Europe *Polypodium* is a substitute for osmunda. For *Paphiopedilum*, *Masdevallia*, *Pleurothallis* and *Bulbophyllum* as well as the majority of orchid seedlings a mixed compost of osmunda with some sphagnum moss added is used. Tree fern is also mentioned as a medium used by many orchid growers. It should be pointed out that barks, which were very popular at that time were not discussed in the section on composts but mentioned elsewhere. Hawkes starts out his discussion of barks with a brief description of changes that have taken place with composts over time (much of which had been covered by earlier writers). According to Hawkes, barks that were used included Douglas fir, white fir and several types of pine and cedar and were becoming very popular. Although no details were given it was noted that the barks came in different particle sizes and that the material should be sifted before use to remove the fines.

An era of potential change in potting media began in the early 1960s when a variety of materials were being tried, many with success. Ackerson (1961) compared coke with osmundine and bark and found it to be as efficient as osmundine in moisture-holding capacity. Coke is sterile, and there is no danger of overpotting in it. Ackerson also included used osmundine and bark in his trials since these partially decomposed materials had higher water-holding potential than either product in the fresh state. Coke proved to be as good a medium as the others, and it also had an added plus – it was cheaper. Although coke was readily available and in plentiful supply in that era it never became the medium of choice for the majority of the growers. At the same time Hawkinson (1961) noted that eight years had elapsed since fir bark had become widely used for orchids. Its continual use was fostered by the fact that knowledge of how to use it was developed rapidly and backed by scientific evidence.

[13] This is an interesting statement, when osmunda had been the medium of choice, and numerous species from a great variety of genera and many hybrids did grow extremely well in one medium.

The advantages of tree fern fiber as a potting medium was discussed by Neilson (1961), Brown (1964) and others. "There are other fine media for growing orchids of course," but after using tree fern for 20 years Brown (1964) found that no matter what other media he tried he always returned to hapuu, the Hawaiian tree fern. He noted that hapuu came in three grades of fibers (coarse, medium and fine), as slabs, in chunks or as totem poles. The range of sizes and shapes makes it suitable for a wide variety of orchid genera. Hapuu is an ideal medium because it meets all these requirements: "durability; moisture-holding capacity; drainage and aeration; ability to withstand nutrients but still make them available to the plant: minimum salt accumulation; and last but not least cost." (Brown, 1964). Brown noted that he had a plant in California that had been in coarse tree fern fiber for 16 years with no dieback, and the fiber was still good. In this respect Brown was like many others who praised hapuu as a medium. Longevity has always been a high point in discussions of its value. Tree fern (hapuu), for many years a popular medium in the Hawaiian Islands, became increasingly more popular worldwide as the decline in bark supplies set in (Holguin, 1976; Chang, 1976; Little, 1964).

When looking for new media for epiphytic orchids, several basic requirements must be met in order to develop a good potting mixture. Factors to consider (Little, 1964) are availability, ease of handling, lasting qualities, nontoxicity, and aeration. The material that impressed Little most was Mexican tree fern as he felt that it came closer to meeting all the requirements than any other medium he tried. He felt the main problem with Mexican tree fern was its longevity and the tendency for growers to overpot. This can be overcome, (Little, 1964) by selecting containers that will accommodate growth for only 2 years and repotting after that. Even though the Mexican tree fern can last longer he felt this was the best way to handle it.

Unlike many researchers looking for a new potting medium composed of a single ingredient, Davidson (1965) was continually studying combinations of a variety of materials. After testing a number of formulations his research indicated that the following medium was good for *Cattleya* plants:

6.5 parts fir bark
1.5 parts coarse peat moss
1–1.5 parts redwood fiber
0.5–1.0 part perlite

No particle sizes were given for the various ingredients. However, this potting mixture was a forerunner for mixes that would be developed in the 1980s and 1990s.

Silva (1966) listed a number of materials that were being used in Brazil in the 1960s. Basically they were tree fern (*Dicksonia sellowiana*), *Polypodium* fern, osmunda (*Osmunda regalis*) and coconut fiber. There were no recommendations as to mixes or genera for which the materials should be used.

A new material 'solite' emerged in the 1960s. Solite is a lightweight alu-

minum slag aggregate that is used to make concrete blocks. Wilkins (1968) showed that this material was an excellent medium for epiphytic orchids. It is a mix that will hold up indefinitely and can be reused. Although the material is basically inert, it should be sterilized before reuse. In his article Wilkins explained how to prepare the "little clods of baked mud" to be sure that all the fines and impurities had been removed. Wilkins used solite for 5 years and found it to be very satisfactory under his conditions.

Present-day potting mixes: 1970 to date

From the late 1970s there was a steady but gradual decline in the use of barks only as potting media. Supplies of tree fern fiber also declined since this plant was considered by many to be an endangered species. Thus, this period saw an upsurge in the area of prepared potting mixes for orchids, many of which still contained bark as one of their ingredients. Other materials, such as New Zealand sphagnum moss, were introduced into the market along with synthetic materials such as Oasis blocks. The evolution of potting mixes continued.

When considering potting mixtures for epiphytic orchids "a light but rough mixture must be chosen," according to Oplt (1970). He mentioned that in experiments with many mixtures the best results were obtained using the roots of *Osmunda regalis* and *Polypodium vulgare* fern species, the moss *Sphagnum squarrosa*, and decayed beech leaves. These were usually mixed at the rate of $\frac{1}{3}$ each of *Polypodium* or *Osmunda*, *Sphagnum* and beech leaves with a few pieces of charcoal added. Oplt further stated that in the aforementioned mixture the moisture content could be regulated by varying the amount of *Sphagnum* and fern root. He noted that for *Dendrobium*, *Phalaenopsis* and *Vanda* the mixture should contain a larger amount of *Osmunda* or *Polypodium*, whereas for *Cattleya*, *Bulbophyllum*, *Epidendrum*, *Oncidium* and *Odontoglossum* the mixture should contain a larger amount of *Sphagnum*. Unfortunately, no amounts were given for either modification, leaving it up to the grower to determine the content of the mix. Oplt indicated that in recent years in Europe dead pine bark was being used as a supplement to the aforementioned medium[14]. The new medium consisted of:

1 part *Osmunda* or *Polypodium*
1 part *Sphagnum*
1 part beech leaves
1 part pine bark

He noted that good results were obtained in all cases and that terrestrial orchids could be grown in the same mixture if 1 part compost or clods of loam was added.

[14] This statement would indicate that the original mixture mentioned by Oplt was probably developed in the 1950s or 1960s. Unfortunately, no dates are given in his book.

Growers in Venezuela, (Luciano, 1970) were becoming concerned about the high cost of their favorite potting mix – Mexi-fern and fir bark (3-1 v/v). In searching for local materials that might be readily available and reasonably priced, Luciano found a potential material in the waste product of the oil palm (*Elaeis guineenis*) industry. The broken pieces of the palm fruits, when washed free of any oil residue and graded, proved to be a very fine medium for orchids. Luciano listed three grades: coarse, for *Cattleya* and *Vanda*; medium, for *Phalaenopsis* and fine, for seedlings. No size range was given for the different grades. Coconut husks have been used as media components in many tropical areas and orchids grow on a variety of palm species in the wild. Therefore it would seem logical that the fruits of the oil palm as well as other palm fruits might prove to be a good medium or ingredient.

In describing a potting mix for *Lycaste*, Fowlie (1970) wrote "There is little doubt that the roots luxuriate in Loamite mix, partially due to the purifying effects of the charcoal contents, and keep in excellent condition." He listed the ingredients as:

3 cu ft (85 liters) Lomite (moist) 1-0-0 (the subcharcoal chips)
3 cu ft (85 liters) fine fir bark
2 gal (8 liters) sand blasting sand
11 oz (350 ml) single superphosphate
18 oz (550 ml) oyster shell (available at feed stores)
30 oz (1 liters) dolomite lime
2 oz (60 ml) saltpeter (drug store)

The Lomite (which consisted of subcharcoal kiln roasted bark chips) mix which proved successful had to be replaced annually, as once it began to deteriorate it broke down rapidly. Fowlie also noted that he had also successfully used palco wool (red wood fiber) as a medium for *Lycaste*.

At the Sixth World Orchid Conference Hetherington (1971) stated that "there are no ideal basic ingredients for a *Cymbidium* mix. Any *Cymbidium* mix will be found to have common properties with almost any other. Precisely what is used in a given area is determined by what local materials best meet the specifications for the compost." He listed the physical and chemical properties sought for in a basic mix:

1. High organic content, like that provided by wood barks, leaf mold, redwood bark, horticultural peat, etc.
2. Good moisture retention.
3. Excellent drainage. There must be no stagnation.
4. Good supply of nutrients through slow decomposition and retention of 'food' on the mix particles.
5. An acid pH, 5.5–6.0 being optimal.

6. Body. Sufficient physical body to hold the plant firmly.
7. Durability. The mix must not break down or wash away.

These are much more exacting than the three basic media requirements listed by Matkin (1952). Hetherington further stated that most American mixes are chosen in varying proportions from the following basic ingredients: redwood bark, coarse German peat moss, fir barks, coarse leaf mold, clay-free silt sand and redwood shavings. He also observed that additional nutrients were added to these mixes to ensure good growth.

The more popular kinds of potting materials are osmunda, tree fern (both of which are fibrous, spongy-like roots) and fir bark broken into various particle sizes according to Johnston (1974). He also noted that many of the potting mixes being used contained some bark and that fir bark enjoys popularity because it is easy to use, consistent in quality and long lasting. Other advantages of fir bark were that it was hard to overwater and had large air spaces, allowing good aeration and drainage. Fir bark (the bark of red and white fir or Douglas fir) came in a variety of particle sizes and was graded as 'fine' ($\frac{1}{8}$–$\frac{1}{4}$"; 0.3–0.6 cm), 'medium' ($\frac{1}{4}$–$\frac{1}{2}$"; 0.6–1.2 cm) and 'coarse' ($\frac{1}{2}$–1"; 1.2–2.5 cm). Seedlings and fine-rooted orchid plants (e.g. *Miltonia*) grew best in fine bark, which also had the highest moisture content. *Vanda* and *Phalaenopsis* plants with large roots should be grown in the coarse, whereas *Cattleya* and other orchids with similar roots should be potted in medium. Johnston did not recommend using very fine or dusty bark particles as they tended to clog pore spaces, increasing water-holding capacity and reducing aeration.

The use of artificial media was mentioned by Schoser (1974). He and his colleagues were searching for six years for a convenient potting material. They found a foam material, polystyrene, in the form of chips, scraps or shreds to be suitable. The material is completely inert, takes up less than 2% moisture, is neutral, cheap, nearly impervious to decomposition and releases no harmful ions. They suggested that this new material was satisfactory and convenient for orchids. This is one of the earlier reports regarding the use of plastic as orchid media.

Burkey (1975) surveyed potting mixes used by *Paphiopedilum* growers around the world. He found a wide variety of materials being used including sphagnum moss, fir bark, cork, Styropor (expanded polystrene), beech leaves, perlite, charcoal, shell grit and milled peanut hulls. According to Burkey this indicates that *Paphiopedilum* plants are quite versatile as far as media were concerned. He listed 11 composts used by firms around the world. Two of these are given below to show some of the variations he found.

A. Ratcliffe – England

16 parts by bulk, coarse fir bark (sifted to remove dirt and fine particles)
1 part by bulk, roughly chopped sphagnum moss
1 part by bulk, charcoal.

B. Rand – California

400 ml (ca 1 pint) of #60 silica sand
$1\frac{1}{2}$ cups of hoof and horn
$\frac{1}{2}$ cup of single super phosphate
$\frac{1}{2}$ cup of sulphate of potash

To this one added enough small, seedling grade fir bark to make 2 cu ft (60 l) of mix. Some redwood fiber (about 32 oz; 1 kg) can also be added to enhance the stability of the mix[15].

One of the most popular potting materials for *Phalaenopsis* in the Philippines, (Valmayor, 1975) was the basal portion of *Asplenium nidus* (bird's-nest fern), locally known as 'paslak.' The fibers of this medium are dark, durable and absorb a lot of moisture; they are similar to the black wiry fibers of osmunda. During the same period, tree fern (called snake wood in Taiwan), longan (*Euphoria longana*) bark and sphagnum moss were the three main ingredients used in Taiwan (Su, 1975) for potting materials. He stated that longan[16] was still under evaluation and the results were being awaited.

In 1975, Penningsfeld reported at the Eighth World Orchid Conference on 15 years of research using peat and a plastic foam (Styromull; 1/1 v/v) as a medium for growing orchids. He also conducted nutritional studies to determine the best fertilizer for this mix. In addition he reported on studies of media for terrestrial orchids and recommended the following mix for *Cymbidium*:

3 parts *Pinus sylvestris* bark chips
3 parts crushed dry oak leaves
3 parts milled peat moss
1 part old cow manure
1 part sphagnum moss
1 part coarse sand.

One of the favorable aspects of this medium, according to Penningsfeld, was the fact that plants grown in this mix needed to be repotted every three years. Since the work was done in Europe, the medium might not last as long in warmer climates like California where *Cymbidium* is widely grown. Also some of the components may not be available everywhere.

Chang (1976) was one of many writers who listed Hawaiian tree fern, hapuu, as an excellent medium for orchids. He pointed out that the long life of this product reduced the need for repotting as it remained stable for many years. The value of hapuu was also extolled by Brown (1964). Tree fern was still readily available at that time in Hawaii.

[15] These mixes were selected at random from the 11 listed and do not necessarily show the extremes as far as differences are concerned.
[16] Longan is a fruit similar to lychee.

In 1976, writing in England, Wilma and Brian Rittershausen reported basing their composts mainly on osmunda and live sphagnum moss. Sphagnum moss helped in the retention of moisture and kept the acidity in the compost in balance. The moss must be green and freshly collected, so it will grow over the surface of the compost and aid in watering. Osmunda fiber keeps the compost open and well drained. Both ingredients can also supply nutrients for the growth of orchid plants. They also stated that osmunda was becoming harder to obtain and more costly, forcing growers to seek an alternative material. Some growers were substituting a mixture of peat and coarse sand or grit. In order to ensure that the mix would stay open (i.e. remain aerated) a small amount of chopped bracken (fern) was added. Some growers substituted plastic chips or granulated polystyrene for sand. Further, they noted that a number of non-resinous barks could be used as additives or on their own as a complete compost.

Holguin (1976) briefly reviewed the history of various media used for *Cattleya* plants, pointing out that a mixture of chopped osmunda and sphagnum moss was popular in the 1930s. He noted that this medium often remained too moist and caused root rotting. Ashton's mix (redwood and oak leaves) appeared in 1945 as an orchid medium, and in the 1950s barks were introduced. The popularity of barks soared in the late 1950s and early 1960s according to Holguin. Barks were later modified by adding redwood fibers, perlite and German peat moss. The latter was a forerunner of some of the potting mixes available today.

"The great adaptability and vitality of orchids is evident in their ability to show excellent growth when grown in any number of different composts!" (Richter, 1977)[17]. He goes on to describe the characteristics of good components for media, but before listing the materials he notes that "the ratio of different materials used is a point hotly debated by all orchid growers." Osmunda topped Richter's list of ingredients, but he bemoaned the fact that it was costly and hard to obtain. This was also true of *Polypodium* fiber, his second most important ingredient. Sphagnum, although short-lived, was readily available and cheap. It, too, presented problems as freshly collected material often contained contaminants such as snails and slugs. Beech leaves, tree fern, fir bark and peat rounded out his list of organic materials. Inert materials mentioned as possible additives were plastics (flakes and cut pieces), broken brick, pumice granules and broken coke. Some of the latter could be used with a little sphagnum in an almost hydroponic culture.

Poole and Sheehan (1977) studied the effects of media and supplementary microelement fertilization on growth and chemical composition of *Cattleya*. They worked with four media (tree fern, tree fern + redwood (80-20 v-v), fir bark, and peat and perlite (50-50 v-v)) and seven different fertilizer rates. After

[17] The lead-in sentence to his discussion on composts (potting mixes) supports what the author and others have been saying over the years. Epiphytic orchids can be grown in any medium except soil as long as watering and fertilizer practices are adjusted to the medium being used.

one year they found that media significantly affected all growth responses. Plants grown in peat and perlite were superior to all others.

In 1977, Davidson also proposed several new orchid potting media. Here again, Davidson was working on combinations of materials. These new mixtures were also given the prefix NJ (New Jersey) to signify the state where Davidson was working. After considerable study, Davidson found his NJ #1 (1960) to still be a good medium. He added his NJ #6 as another good medium. Both were recommended to growers for use. The NJ #6 mix contained the following ingredients:

1 part peat moss
1 part oak leaves
1 part redwood fibers
1 part coarse clean sand

Davidson recommended the two mixes for epiphytic orchids. These mixtures were considered as replacements for both osmunda and fir bark, which were becoming scarce at that time.

There is a brief section on culture in *The Brazilian Bifoliate Cattleyas and Their Color Variants* by Fowlie (1977) in which he made some interesting comments on composts. He started with a brief discussion on osmunda, noting its long (3–6 year) life but pointed out that it was difficult to obtain[18]. He felt that osmunda had been a good medium and one not subject to fungus problems. Hapuu, used by Hawaiian growers, was also a good fibrous medium. Although, according to Fowlie, hapuu lasted only 2–3 years, most orchids thrive in it, especially for those hobbyists whose orchids are being cultivated outdoors in tropical climates depending on local rainfall[19]. Fowlie felt that hobby growers in temperate or subtropical climates particularly, who must water his/her plants artificially (with a hose), there was no better medium than fir bark[20]. He felt that the myriad of fungal hyphae growing in bark represented a decided disadvantage, rather than a cause for not using bark. Redwood wool was also a good medium but had a short, one-year, life, according to Fowlie. Since bifoliate cattleyas, the subject of the book, are all epiphytes he suggested using cork slabs or limbs as a medium. *Cattleya* plants grow very well on cork slabs hung at a 45° angle. He stressed that only one plant should be planted on a slab as two different plants will grow together and be hard to separate after several years of growth on the slab. Fowlie felt that species that were difficult to grow were best cultured on slabs.

A very interesting medium was not only successful for *Brachypetalum* paphiopedilums but also for a number of other genera (Heuer, 1977). Basically, the medium components were 2 cubic feet (60 liters) of fine fir bark (seedling grade)

[18] The effects of urban sprawl on the east coast of the United States were being felt.
[19] Brown (1964) reported that tree fern lasted 16 years in California. It would be interesting to learn if there was any difference between the fern used in 1964 and that used by Fowlie in 1977.
[20] This was the period when fir bark was in its prime.

and 1 pound can (450 g) of silica sand (#60). To this he added a number of other ingredients:

1 cup of dolomite
½ cup of bone meal
¾ cup of hoof and horn
½ cup of aluminum sulfate
1 tablespoon of single superphosphate (powdered form)
⅝ cup of potassium sulfate
1 tablespoon of ferrous sulfate
1 teaspoon of manganese sulfate
¼ teaspoon each of zinc, copper and molybdenum

Heuer based his potting mix on the fact that the *Brachypetalum Paphiopedilum* species are found growing on linestone outcroppings and that cold water breaks down calcium faster than hot water. He also stated growers often tend to use excess calcium due to the fact it is plentiful in the native habitat of these plants.

Production of *Dendrobium* cultivars for cut flowers in Sri Lanka (Ceylon) relied on a medium composed of charcoal (derived from mango wood) and tile pieces. According to Hagen (1976), in the wetter areas of the country the mix was 20% charcoal and 80% tile, whereas in the hotter, drier areas the proportion of charcoal was raised to 40%. He also noted that some growers were mounting their plants on tree fern pieces. Similar brick and charcoal media are used (personal observation) by some growers in the Caribbean area for *Dendrobium* cut flower production.

Sessler (1978) listed a number of potting materials for orchids including osmunda, bark, tree fern logs, hapuu (shredded tree fern) and orchid mixes. She stated that the latter now come in a great variety of combinations of the aforementioned materials. No suggested combinations are given.

In New Guinea many orchids are grown as garden plants, and according to Millar (1978) frangipanni (*Plumeria rubra* and *P. obtusifolia*) and calabash (*Crescentia cujete*) trees are excellent hosts for epiphytic orchid plants[21]. She noted that both of these trees were easy to grow and that cuttings up to 2 m (6 feet) tall could be rooted to produce instant trees for orchids to grow on. *Antidesma ghaerembilla* and *Tectona grandis* (teak) as well as many other local trees can also be used as hosts. Tree-fern slabs and coconut husks are used as well as plaques for orchids grown in New Guinea. Tree fern and brick and charcoal are used as potting mixes for container-grown plants[22].

[21] Little has been mentioned in the literature to date about culturing epiphytic orchids on trees, yet calabash trees in their native habitats are excellent hosts for epiphytic orchids (personal observation). Also citrus trees in tropical areas that have not been sprayed are often festooned with a wide variety of epiphytic genera (personal observation).

[22] Brick and charcoal mixes are often dominant in tropical rainy areas because they are well drained yet hold moisture. (Broken bricks are used with great success by Flora Sari Orchids near Jakarta, Indonesia – J.A.).

Leonardt (1980) discussed some of the potting mixes used for various orchid genera in Hawaii. The materials varied depending on genera. For example, under *Cattleya* he listed a variety of media any of which would produce satisfactory results: redwood, fir bark, tree fern (hapuu), osmunda fiber, as well as gravel and sand mixes, including volcano cinders. He stated that bark was the easiest to use and with proper watering and fertilization would produce good plants. Terrestrial mixes were composed of three parts coarse material and one part medium-grade material. Although a variety of materials were listed including macadamia nut hulls and wood chips, there was no indication as to which were the coarse ingredients or the medium ingredients nor were any particle dimensions given.

Odontoglossum plants in Australia were grown in equal parts of bark and charcoal according to McGraith (1980). The particles had to pass through a $\frac{3}{4}''$ (2 cm) screen but not through a $\frac{1}{4}''$ (3 cm) screen. The fines were also removed and the mixture soaked in a fungicide for one week before using. The specific type of bark used was not named.

One medium tried as a substitute for the dwindling supply of fir bark was red lava rock. According to Arp (1980) red lava rock had several advantages over fir bark. The rock does not change over time and can be reused; the root environment is the same for two or more years after repotting. A grower can easily overpot to produce specimen plants without fear that the medium will rot and root injury will occur. Further, red lava rock cannot be overwatered, and the plant is fertilized, not the medium. Red lava rock does hold moisture on its surface. The only genus with which Arp had problems growing in red lava rock was *Phalaenopsis*. *Cattleya* alliance plants, dendrobiums, and vandaceous species produced excellent growth in this medium. Arp did not mention whether other colors of lava rock could produce similar results.

The Complete Book of Orchid Growing (Black, 1980) had an engaging section on orchid potting mixes. Black began with a brief but interesting discussion of the history of orchid potting mixes to date. In this discussion he mentioned the use of Corsican pine, which is the hardest of all barks. It is slow to break down and can be used several times[23]. Since orchids are grown in various localities and need different treatments, Black felt it was necessary to be adaptable. Consequently, he listed a number of media combinations for different genera (Table A-1). He suggested that these mixes should be general guides for orchid growers rather than be 'the medium.'

"All the above orchids require a little coarse (not the powdered) bone meal and crocks or polystyrene at the bottom of the pot, up to 5 cm (2') depending on the size of the pot." Black did not give any suggestions as to what materials might be considered when adapting the potting mixes listed above. Apparently that was left to the grower.

[23] This was the first mention of Corsican pine I have come across, and if it lasts as long as stated it is strange that there is not more in the literature about its use. As a matter of fact Black does not mention it in his mixes.

Table A-1. Mixes for different species

Species	Ingredient	Ratio (by volume)
Cattleya	Medium bark or chopped osmunda fiber	$\frac{1}{2}$
	Sphagnum moss	$\frac{1}{4}$
	Charcoal	$\frac{1}{8}$
	Perlite or perlag	$\frac{1}{8}$
Cymbidium	Harvested bracken fern, chopped coarsely, or medium bark or osmunda fiber	$\frac{1}{2}$
	Sphagnum moss	$\frac{1}{4}$
	Charcoal and perlite or perlag	$\frac{1}{4}$
Miltonia, Odontoglossum and intergenerics	Fine bark or finely chopped osmunda fiber	$\frac{1}{2}$
	Sphagnum moss (live)	$\frac{1}{4}$
	Fine charcoal and perlite or perlag	$\frac{1}{4}$
Paphiopedilum and other terrestrials	Medium bark or chopped osmunda fiber	$\frac{1}{4}$
	Sphagnum moss (fine) or moss peat,	$\frac{3}{4}$
	Sprinkling of charcoal and perlite or perlag (a cup full per 4.55 l (1 gal)	
Phalaenopsis	Chopped live sphagnum moss	$\frac{3}{4}$
	Perlite or perlag and charcoal	$\frac{1}{4}$
Vanda	Chopped live sphagnum moss	$\frac{3}{4}$
	Charcoal and perlite or perlag	$\frac{1}{4}$

In a discussion of orchid growing media, Batchelor (1981) starts out by addressing alternative media, mainly sticks and stones. "Sticks – naturally enough, parts of trees and other plants, in the form of branches, plaques (cork or tree fern) come closer to duplicating conditions of epiphytic orchids in the wild. And stones – at the other end of the media spectrum, gravel culture for potted orchids has its share of advocates" (Arp, 1980). Having noted the potential of these media, Batchelor then discussed conventional potting mix ingredients. "By far the growing medium most commonly used for orchids is a mixture of organic and frequently synthetic materials. Gone are the days when osmunda fiber was used almost to the exclusion of every other possible medium." Batchelor gave in-depth summations on fir bark, tree fern, peat moss and perlite. He included a table, 'Guidelines in selecting growing media', but unfortunately was not specific with items in the potting mix column. As an example all it stated in the column was 'coarse grade – porous', which is of little help to an amateur seeking a potting mix.

In 1981 the medium of choice in Hawaii for *Paphiopedilum* was fir bark mixed with small amounts of charcoal chips and perlite to maintain good drainage (Fujiwara, 1982). Marble chips and/or ground oyster shells were added to help maintain a uniform pH.

Not all media recommendations are the results of published research papers. Sometimes they are the results of clever ideas by individuals. An example appeared in the *American Orchid Society Bulletin* in 1981 in the form

of an advertisement. It stated "At last the potting material that gives you the six benefits you want ... ORCHID BLOCKS." This was an advertisement for polystrene blocks cut to fit into 15 cm (6 in) pots and would give you all the benefits you wanted. The blocks would not decompose like bark and did not require repotting every two years. This would be fine for orchids that did not like to be disturbed. Little information has surfaced on the longevity of these 'blocks'[24].

In 1984 Henderson discussed orchid culture in the United States observing that the most widely used potting material at that time was fir bark or the many bark-based mixes. He also mentioned 'Off Mix' – a combination of fir bark, peat, and perlite developed at Rutgers University. Tree fern was also very popular at this time but was becoming more expensive and less readily available as some species had been declared endangered. Charcoal was also being used widely, especially for vandas. He noted that Florida growers were switching to charcoal because some barks decomposed too rapidly. A simple mix of charcoal, peat and Styrofoam was proving to be a satisfactory medium for virtually all orchids. Servo, a byproduct of the sugar industry, was finding localized use[25]. Solite, a fired clay product, was being used by some south Florida growers in locations where plants were exposed to high amounts of rainfall. Henderson also indicated that in some areas of the United States potting ingredients included shredded coconut fibers, walnut and rice hulls. He concluded by saying that potting mixes are limited mostly by imagination. Developing a medium is often determined by the type and availability of organic materials found in any given area.

Noble (1987) addressed the need to consider particle dimension in relation to root size when developing a medium. Orchid plants with large roots such as *Vanda* need "a very open medium of chunky materials so air is available. *Phalaenopsis* have roots of medium thickness and can use a medium grade of tree fern or bark, for example. Orchids with fine roots, such as, miltonias and most seedlings do better in a finer medium"[26]. The author also delineated the advantages and disadvantages of tree fern osmunda and bark mixes (usually combinations of these ingredients), rocks and sphagnum moss. She gave no specific recommendations, however. Only three lines were devoted to terrestrial orchids, stating that they are grown in mixes consisting of "soil; compost; dehydrated dairy manure and other elements to make a rich garden loam."

Stewart (in Cribb, 1987) listed a number of compost ingredients used in varying combinations by growers for *Paphiopedilum*. She mentioned that peat from Finland and Germany was best and that bark from various types of

[24] To my knowledge these orchid blocks are not sold at present.
[25] Bagasse-like materials tend to decompose rapidly and become soggy in the bottom of the pot.
[26] It is interesting to see that potting mixes in Noble's book are based more on root size than genera. Most authors do not mention roots in their discussions of media. Prior to this time only Johnson (1974) had mentioned root size in relation to bark particle size.

European pines and redwood from the United States were used as components. The compost used successfully at the Royal Botanic Gardens at Kew, England, consisted of:

3 parts medium grade moss peat
3 parts supercoarse grade perlite
2 parts medium grade pine bark (7–13 mm size)
1 part charcoal (7 mm grade).
To each liter of this mix 4 g of dolomitic lime are added.

She further stated that a more 'open' growing medium with larger grades of bark and charcoal is used for epiphytes and lithophytes.

Rentoul (1987) mentioned that "Most potting mediums can be changed to suit a number of genera. The ideal is to make up those which need the least modification to suit both specialist genera and the compatibles which may be benched with them." He further cautioned that every combination should be related to the environment in which it is used and that the dislike of any ingredient should be based on experience. Rentoul disliked charcoal because he felt it could be toxic[27]. Bark is cited as a good medium but should be the best available and in sizes or grades to suit the various genera. Rentoul suggested imported bark (source unknown) because it gave better results and had better water-holding capacity.

Pleione, according to Cribb and Butterfield (1988), will grow in a variety of media, but they limit their recommendations to two which have been very successful. Their preferred medium consists of (by volume):

6 parts of ungraded orchid bark with dust and fine particles (up to 5 mm) sieved out,
1 part coarse perlite
1 part sphagnum moss chopped into 6 mm lengths
1 part sphagnum moss peat which has been thoroughly broken up.

"This coarse medium is used in the bottom two-thirds of the pan. A similar less coarse grade is used above . . . ." In their second mix charcoal, beech and oak leaves are used. The leaves are collected as soon as they fall and shredded before using. They further state that fibrous loam can be substituted for bark, but garden soil is most unsuitable.

Richards et al. (1988) describe some of the media used in the cultivation of Australian native orchids. They recommend a very simple mix for epiphytes consisting of two parts bark chips (fir or pine) and one part charcoal[28]. The

[27] When perusing the literature, in this case orchid development, it is not uncommon to find an article in which the author degrades or eliminates an ingredient (e.g., charcoal) that is widely used and highly praised by growers around the world.

[28] The use of common names for the bark chip sources is often confusing as pine in Australia will not necessarily be the same as a pine in the United States or Europe. In Australia *Casuarina* species are called pine, whereas in the United States and Europe the genus *Pinus* is commonly called pine. Therefore duplicating the exact medium is not always possible. It would be better to use the Latin (generic and specific) name of the tree.

basic mix for terrestrials is much more complicated. It consists of:

2 parts coarse sand
1 part rich loam
1 part buzzer chips (shavings from woodworking machines)
1 part leaf mold
1 dessert spoonful blood and bone per 9 liters bucket of mix
1 dessert spoonful of garden lime or dolomite per 9 liters bucket of mix

The mixture for tropical terrestrials is different and consists of:

2 parts leaf mold
1 part coarse sand
1 part aged pine bark (approx. 10 mm size)
A little blood and bone meal

According to Stewart (1988) orchid composts play a dual role, in both supporting the plant in the container and providing a well aerated, moist medium. She also noted that composts used today (in England) are mixtures of natural materials, such as pine or fir bark, coarse grit, fibrous peat, chopped dry leaves or sphagnum and inert materials like perlite, perlag, pieces of horticultural grade charcoal and sometimes pieces of polystyrene. Mixtures vary among growers, but "two tried and tested compost mixes are given below."

Basic epiphyte mix:
3 parts washed bark chips, medium grade
1 part coarse perlag
1 part charcoal, horticultural grade
1 part fibrous peat or broken leaves or chopped sphagnum

Basic mix for terrestrial orchids:
3 parts fibrous peat
2 parts coarse perlite
2 parts coarse grit
1 part charcoal, horticultural grade

Although these two mixes were 'tried and tested', Stewart suggests that they could be modified to suit individual orchids and/or grower situations. Genera or substitute ingredients were not listed. Suggestions for modifying the mixes were not provided.

As late as 1988, Fanfani and Rossi in a brief section on fertilization stated that "The growing medium most commonly used today is bark, with the addition of more or less inert materials (peat, sphagnum moss, foam rubber)[29] or of making it lighter (polystyrene, cork, pebbles) but none of these provides the plant with any food"[30]. Although bark was the component of a number of

[29] Peat and sphagnum are far from inert.
[30] Peat and sphagnum moss do supply some nutrients as they decompose.

commercial potting mixes when this was written, it was used in smaller amounts than those employed during its heyday in the 1950s and 1960s.

Hennessy and Hedge (1989) made several interesting comments before they listed growing media for *Paphiopedilum* plants. They researched the native habitats of *Paphiopedilum* species and found that there was ". . . one [obvious] aspect common to all. Their roots penetrate a light well-aerated substrate; they are never found growing in hard compact soils. There is always perfect drainage at their roots . . ." They also pointed out that a variety of potting media used in cultivation came close to equaling the number of *Paphiopedilum* growers and ranged from live sphagnum moss to complete formulae with numerous ingredients. Here again is a case where, despite the uniformity of growing conditions in their native habitat, *Paphiopedilum* species will grow in a wide variety of media. Hennessy and Hedge listed three formulas for growing *Paphiopedilum* plants:

General medium for mature plants:
5 parts conifer bark[31] (medium grade) 10–15 mm size
3 parts coarse peat
2 parts perlite (coarse grade)
1 part charcoal, 5–7 mm size
To each 5 liters add 20 g dolomitic lime

Seedling medium
4 parts conifer bark (fine grade), 4–7 mm size
2 parts coarse peat
1 part perlite (medium grade)
1 part charcoal, 5–7 mm size
To each 5 liters add 20 g dolomitic lime

Medium for epiphytes and some lithophytes
3 parts conifer bark (coarse grade), 15–25 mm size
3 parts conifer bark (medium grade), 10–15 mm size
1 part coarse peat
1 part super coarse perlite
2 parts charcoal, 10–20 mm size
To each 5 liters add 20 g dolomitic lime

Writing on the culture of *Dendrobium* and other sympodial orchids grown in Asia, Teoh (1989) stated that the most widely used medium for plants in pots was broken charcoal, either alone or with broken bricks[32]. Their ratio is not

[31] Although no specific conifer bark is delineated in any formula, Hennessy and Hedge mention American redwood (*Sequoia sempervirens*) and some European *Pinus* species as the types of conifer barks used.

[32] Brick and charcoal have been the standard medium for almost 50 years in southeast Asia, a relatively long usage for any medium.

critical but is usually 4 to 1. The medium would depend on the location of the pots in the growing area. For example, if the pots were hanging from a lath frame, only charcoal would be used as the medium to lighten the load on the structure. In Thailand, according to Teoh, the bottom $\frac{3}{4}$ of the pot is filled with crock. Vertical fibers of tree fern are placed in the remaining $\frac{1}{4}$ of the pot[33]. *Dendrobium* plants are placed on the medium after it has been trimmed flush with the top of the pot. The new roots can easily grow down among the vertical fibers. Monopodial orchids of the "*Vanda-Arachnis* Tribe" growing in pots were also covered by Teoh (1989). These robust plants should be grown in large clay pots (12″ or 30 cm) to provide proper support for the plants. Broken bricks fill up to $\frac{1}{2}$ of the bottom of the pot (adding support) and then charcoal is added to within $\frac{3}{4}$″ (2 cm) of the top of the pot. He also noted that Styrofoam, tree fern chunks, and redwood bark have been used as alternative media but have not been widely accepted in southeast Asia. Under the local climate conditions Styrofoam does not retain sufficient moisture, but the other two materials tend to become waterlogged[34].

"Epiphytic orchids need excellent drainage and plenty of aeration around their roots. For this reason they cannot be grown in soil and must be potted in a coarse mix free of soil and other fine, clogging particles" (Jones, 1990). Having made that opening statement, Jones proceeded to list ingredients used for potting mixes in Australia. Softwood barks like pines, redwood and firs (the best bark is obtained from mature trees and is "nuggety or flaky"), osmunda, tree fern and *Polypodium* fern fibers, staghorn peat, sphagnum, peanut shells and leaf mold were the organic materials listed. Charcoal was listed as also being widely used. Inorganic ingredients listed were coarse sand, gravel, grit, blue metal (no description given as to what the material was), scoria, stone chips, terracotta and brick shards. Limestone chips were suggested as a material to incorporate in *Paphiopedilum* mixes, as these plants are often found growing on limestone in their native habitat. Jones did not provide the reader with a list of mixes, but noted that "there are nearly as many mixes as there are orchids." He did note, as a guide only, one useful mix for epiphytes. It consisted of:

4 parts bark
2 parts charcoal
$\frac{1}{2}$ part peanut shells or tree fern fiber

[33] I have personally observed chopped pieces of coconut husks used in Thailand with their fibers vertical.

[34] Since tree fern and redwood have been used successfully elsewhere in the world it appears that adjusting watering practices might solve the problems with tree fern and redwood. If the plants are grown in the open, increasing the drainage capacity of the containers should solve the problem as both materials drain readily.

Jones listed two mixes for terrestrial orchids[35]:

	Mix 1	Mix 2
loam	1 part	–
sand	3 parts	1 part
leaf mold	1 part	1 part
fern fiber	1 part	1 part
sphagnum moss	–	1 part

"New Zealand sphagnum moss has long been known as an ideal medium into which deflasked orchids can be planted, for propagation of back-bulbs, and for developing roots on orchids" (Murphy, 1990). He considered it superior to Australian sphagnum moss, and reported it was widely used in Hawaii, Taiwan and Japan. Murphy expresses concern over the high cost and problems of storing quantities of New Zealand sphagnum moss. He was concerned that there might be contamination after the bales had been opened and also that the light weight of the material would make it hard to keep it under control. His concerns were modified when a pelletized form of the moss was developed. These tightly compressed pellets were easier to ship, required less storage space and made the moss less costly to import. They were not as messy in storage. All that was necessary was to rehydrate the pellets, and the moss reacted as normal sphagnum. His studies with orchid potting mixes showed New Zealand sphagnum moss to be a superior medium[36].

In a detailed article on orchid media judywhite[37] (1990) stated that "The two things a potting material must do after giving an orchid plant support in a pot are to 1) allow plenty of air to the roots and 2) allow water to run past the roots freely rather than let it stand around them to suffocate and rot, while still retaining enough moisture for the plant's needs." The author also describes in depth 15 commercially available potting materials, namely fir bark, redwood bark, tree fern, sphagnum moss, osmunda, cork, peat moss, charcoal, Styrofoam, rockwool, perlite, stones, lava rock, expanded shale and vermiculite. In the descriptions properties such as water-holding capacity and pH were given for some of the materials. Only in the description of rockwool is there any mention of genera that could or should be grown in any of the components. No component mixtures were mentioned. judywhite pointed out that the Eric Young Foundation bases their potting mix particle on the root diameter of the plant to be potted. This method of basing mix particle size on root diameter was described earlier by Johnson (1974) and Noble (1987) and still is not commonly used.

[35] There was no indication whether different terrestrial genera require different mixes or whether both mixes are good for all genera.

[36] New Zealand sphagnum moss is an excellent, clean, long-fiber moss when compared with sphagnum moss from many other locations.

[37] *Sic.* The author, whose name is Judy White should be cited as 'White (1990)', but she insists on this unique citation format. The format 'judywhite, 1990' is also used in the references.

Hodgson et al. (1991) were very specific about the size of the particles of the potting ingredients for epiphytic orchid species, details lacking in many articles on potting mixes. They also pointed out that "Epiphytic orchids require adequate ventilation and drainage around their roots." Therefore, they proposed that the medium for *Cattleya*, *Dendrobium*, *Phalaenopsis* and *Vanda* plants should be composed of chunks of potting material 2.5 cm (1″) thick for 10–15 cm (4–6″) pots. In smaller pots the particles should be smaller and for larger pots they recommended 3–4 cm ($1\frac{1}{2}$–2″) chunks. The mix they recommended consisted of:

5 parts 'sterilized' pine bark
1 part rock
1 part charcoal

"Terrestrial species require much more moisture around the roots." Here, too, the potting mixture is much heavier. They recommended a mixture of "sterilized conifer bark or artificial, coarse compost medium, sphagnum and rice hulls or fine grade bark." Unfortunately no amounts were given for the various components in the medium nor were there descriptions of the sterilized conifer bark and fine grade bark. Hence duplicating this medium would be difficult, and the results might not be as gratifying as one might expect, but at least they discussed particle size.

Interesting comments on potting media were made by Leroy-Terquem and Parisot (1991) in their book on orchid cultivation. In it they noted that some growing media are still as popular today as they were in Lindley's time (approx. 1860). They recommended the use of fragments of terracotta and pieces of charcoal for growing vandas. The authors stated that this compost . . . "one of the best possible for such plants (provided they are well fertilized), has recently caused the death of orchids potted in it. This happened because the charcoal had been treated to render it more flammable for barbecues and the roots reacted to the chemical used. So great care still has to be exercised in choosing and purchasing ingredients." The authors then listed the characteristics to consider in preparing a good orchid compost. They included:

1. There should be free air movement.
2. Components should have good drainage yet hold sufficient moisture for good growth.
3. They should withstand decomposition as long as possible.
4. It must offer the roots good opportunity to adhere.
5. It should promote ionic exchange between the water and roots.
6. It should deter the development of fungi and microbes.

These are similar to guidelines given by other authors but expressed somewhat differently. They do not list specific mixtures, only ingredients, and state that "the composition of the compost, although important, is not the sole determining factor in the successful cultivation of orchids. Success depends much

more on a sensible balance and combination of all these factors." In addition to the standard ingredients mentioned by most authors they added a 'polyurethane moss.' This material is "a fairly new ingredient, this moss is quite resistant to decomposition, retains water well and only releases it slowly to the exterior, so it helps to ensure an adequate moisture content within the compost." Nothing is mentioned about the size, shape or color of the 'moss'[38].

Bechtel et al. (1992) stated "Orchids are relatively versatile plants and will tolerate a wide variety of growing media. Often local conditions dictate the composition of the growing medium used." Further they stated that epiphytes are more tolerant than terrestrials, adding that "a few epiphytes (no names given) will grow quite happily suspended in air on a piece of string while others will grow attached by thread or wire to a slab of cork bark." They listed three basic composts and noted that if a grower had difficulty locating some of the ingredients "with a little thought, an effective local substitute can easily be found." The composts were:

A. Basic mix for all epiphytes and some terrestrials.
   6 parts of coniferous bark
   1 part perlag or pumice
   1 part coarse peat
   1 part charcoal

   This medium can be made up in three grades of bark: particle size 1–3 mm, 4–6 mm and 7–12 mm depending on pot size.

B. For terrestrial orchids.
   1 part peat
   1 part loam
   1 part sand

C. A fine version of Compost A.
   3 parts peat
   6 parts bark
   Live sphagnum moss can be added (when available).

No genera were listed in the section on composts. However, throughout the book after most generic descriptions, one of the three composts was listed (e.g., *Acacallis* – Compost A, *Disa* – Compost C and *Phaius* – Compost B or C).

Schoser (1993) suggested that the substrate must allow air and water to move through but also should be able to retain moisture. He further states that "all natural substrates can be used: dried fern roots, peat moss and shredded bark. People also use artificial fibers, perlite of different origins, sandy

[38] It is possible that this moss might have been similar to the small Oasis blocks offered in the United States as a possible growing medium. These small green plastic blocks were similar to those used in the florist industry and held water. Unfortunately, like many potential media components, they did not develop into a much sought-after medium.

loam, charcoal and fall leaves." Schoser listed five potting mixes:

1. Fern root as base:
   3 parts fern root
   3 parts fibrous moss
   3 parts rigid foam beads
   1 part charcoal (3–8 mm in diameter)

   This is modified for epiphytes by adding additional fern roots and beads (no amounts mentioned). For terrestrials the fibrous moss is replaced by sandy loam or peat moss.

2. Peat moss as base:
   3 parts peat moss
   3 parts pumice stone
   3 parts rigid plastic foam beads
   1 part charcoal.
   Add a teaspoon (2 g) of calcium carbonate for each quart (liter) of mix.

3. Fir bark as base is heavy in fir bark:
   5 parts fir bark (small chips for orchids)
   2 parts pumice stone
   2 parts peat moss
   1 part charcoal
   A teaspoon (2 g) of calcium carbonate per quart (liter) is added to this mix.

4. Lumpy, commercial peat moss as base:
   1 part lumpy peat moss
   1 part rigid plastic foam beads.

5. Orchid chips:
   This text states that the beads or chips are made by a special process that uses steam. The surface of the beads or chips is rough, and all kinds of orchids can be grown in it. Several advantages are listed for this material, but no information is given as to its chemical background. A picture accompanying the text shows thin white strips which one assumes are the 'chips'[39].

Schoser states that mix 1 is good for *Paphiopedilum*, but it is necessary to add 2 teaspoons (2 g) of calcium carbonate for every 2 quarts (liters) of mix. *Phalaenopsis*, *Oncidium* and *Lycaste* grow well in mix 2. Mix 3 is ideal for epiphytes growing in flower pots. The fourth is recommended for *Phalaenopsis*. No specific genera are listed for mix 5. There is only a general statement that all kinds of orchids can be grown in it. From this one would assume that both epiphytes and terrestrials can be grown in mix 5.

The present situation of potting media was summarized briefly by Pridgeon (1992) when he stated that for epiphytes in the past, osmunda was

[39] Other authors have used the term 'orchid chips' to denote larger plastic slabs (Bomba, 1957).

the medium of choice, but when supplies ran out other media were sought, both organic and inorganic. Today, tree fern and fir bark are the basic ingredients of most media. They are found in a wide variety of combinations with perlite or pumice, charcoal, redwood bark, sphagnum, lava rock, and cork. These are not the only ingredients because depending on the locale native ingredients may be substituted for those mentioned above. When considering terrestrials, Pridgeon cited loam, coarse sand and leaf mold, with traces of bone and blood meal as the basic constituents of media. Throughout the book he or various contributors give specific media recommendations for a variety of genera (e.g., *Calypso*: "the plants need an open mix of leaf mold with crushed quartzite grit or alternately, living sphagnum moss to survive").

From Australia, Jim and Barbara McQueen have given interesting insights on media being used there for miniatures (1992). They pose the question "And what materials should be used for potting and mounting? It really doesn't matter too much. It is obviously sensible to use materials which are cheap and readily available locally." In their conditions and locality, they use tree fern mounts for most miniatures. A mixture of tree fern and fresh sphagnum is used for plants grown in pots. They also employ sheoak (*Casuarina*) needles and seed capsules. This material is ideal for coarse rooted plants, such as *Vanda* and *Aerides*, as the material holds some moisture and is well aerated. Paper bark (*Melaleuca*) limbs and limbs sawed in sections, although slightly heavy, make some of the finest mounts for growing orchids. The McQueens found paper bark to be an ideal mount for *Sophronitella violacea*, a plant that is considered hard to grow outside its native habitat. In the case of those epiphytes that "prefer drier conditions" (e.g., *Cattleya*) cork bark is the preferred material. Their adaptation and use of local materials is commendable and also indicates the wide array of materials that have proven to be successful media for epiphytic orchids. In 1993, The McQueens listed similar components to be used in growing Brazilian orchids.

Rhodehamel (1993) "suggests that the grower employ basically the same type of potting mix for all masdevallias in the collection (and for other genera as well)." He suggests two bark mixes:

Mix 1:
- 4 parts fine fir bark
- 2 to 3 parts tree fern
- 2 to 3 parts charcoal
- 1 part perlite
- 1 part chopped sphagnum moss

Mix 2:
- 4 parts fine fir bark
- 3 parts tree fern
- 3 parts charcoal
- 1 part perlite

Rhodehamel found these to be good media for plastic pots but stated that they dried out too fast in clay pots. He also recommended a straight sphagnum moss medium and a mixture of sphagnum moss and tree fern (3 : 1) which can produce good plants. The latter works well in clay pots. He found New Zealand sphagnum moss to work particularly well.

During the past few years, a new potting medium, rockwool, has been making inroads in the orchid potting medium market. Rockwool has been used for a long time as an insulating material for buildings. At present there are two types, one that repels moisture and one that holds it. Consequently, a grower can control the amount of moisture in the pot by mixing various amounts of the two types of rockwool. Even more recently an almost pelleted form of rockwool has been developed (personal observation). The pellets are about the size of pea gravel. So far root development has been excellent, and only time will tell whether rockwool or rockwool pellets will become a common medium for orchid growing. Since rockwool is inert it can be sterilized and reused. New Zealand sphagnum moss has also proven to be a very fine potting medium. It has been an excellent medium for *Phalaenopsis* in our greenhouse. It is the best sphagnum moss on the market, but unfortunately its high cost has deterred widespread use. Recently I was given two bags of shredded automobile tires, which were being used as an orchid medium. Only time will tell how this material will work or what other interesting innovations in potting mixes will arise.

Final thoughts

Despite the trials and tribulations of many orchid growers and researchers the 'one best medium for epiphytic orchids continues to elude us'. It becomes very obvious that despite the variety of media tried and successfully used over the decades no single material is as widely used today as osmunda was during its heyday from the 1920s through the 1950s. Each grower has a special ingredient or ingredients added to personalize the medium. Throughout this review on orchid potting a large number of different media have been described which contained an equally large number of components. These media have all been successfully used in many areas of the world. This tends to emphasize a point stated earlier by this author that "epiphytic orchids will grow in any medium except soil as long as you adjust your watering and fertilizing practices to the medium in hand." Also, as far as terrestrials are concerned, an equally broad statement can be made. Terrestrials can be grown in any medium that contains at least 40% or more organic matter. The picture as far as orchid potting mixes are concerned will continue to evolve. New and possibly more interesting combinations of ingredients will appear. Perhaps another 'osmunda' (some synthetic material) will be found to which growers will flock.

There will be times when a grower will try to develop his/her own potting mixture, and if he/she does there are certain points to keep in mind. In order to

produce a good potting mix the following considerations must be taken into account:

1. It must hold moisture yet be well drained.
2. It should contain some organic matter.
3. It should supply some nutrients.
4. It should support the plant.
5. It should maintain its physical structure for at least two years.

The availability and cost of the material is also important. There is no sense putting a mix together and then finding out that one or more of the components is no longer available. Granted, inert materials can also be used, but they require adjustments as far as fertilization is concerned as they do not always have the same buffer capacity as organic materials.

Glossary

Bark. A by-product of the lumber industry. Mostly the bark of fir trees collected during the debarking of logs at the saw mill.
Charcoal. A black, very lightweight substance made by partially burning wood.
Coke. A bituminous coal product, lighter in weight and more porous than standard hard coal.
Dirt. The common name applied by nonagriculturists to most soils.
Fiber. Thread-like parts of plant tissue.
Fibrous loam. Loam soil containing fibers or partially decomposed plant parts.
Fibrous peat. Peat moss wherein fibrous material is still evident.
Fines. Dust-like or small particles that will pass through a $\frac{1}{8}''$ by $\frac{1}{8}''$ screen.
Fish manures. Any manure or fertilizer derived from the waste products of the fishing industry.
Hapuu. Hawaiian name for tree fern.
Haydite. A lightweight inert aggregate that holds water.
Leaf mold. The common name applied to partially decomposed leaves.
Living sphagnum moss. Live plants of species of *Sphagnum* moss often collected from stream banks and used in the living state as a potting medium or top dressing.
Loam. A type of soil composed of sand and clay, usually containing some organic matter. Considered a good garden soil.
Lomite. Subcharcoal kiln roasted bark chips.
Mold. An early term used to describe leaf mold.
Moss. The common term used for peat moss, sphagnum moss and any other moss.
Osmunda. A fern native to eastern United States. The black wiry or soft brown roots of this plant were used by orchid growers as the medium of choice for many years.
Osmunda fiber. The roots of the *Osmunda* fern.
Osmundine. Another term for the roots of the *Osmunda* fern.
Peat. A common name for peat moss.
Peat moss. The soft brown substance formed when plants partially decay, usually under water. The more decayed the plant material the more water it holds.
Perlite. A lightweight, white, inert, aluminum silicate aggregate used in potting mixes to lighten the mix and increase aeration and drainage.
Pot shards. Broken pieces of clay pots. Also often used to describe small pieces of broken bricks.
Sharp sand. Small sand particles with sharp edges. Also known as builders sand.

Shell grit. Ground-up shells, mainly oyster, a product used by the poultry industry.
Silver sand. Any white sand, often pure quartz, used by some as another term for sharp sand.
Sod. Squares or rectangles of lawn or pasture grass usually with an inch (2.5 cm) of soil attached.
Sodded loam. Loam soil obtained from a sodded field where the sod has been plowed under a week or two before the soil was collected.
Solite. A lightweight, inert aggregate used in the cement industry. Used as a potting medium by some growers.
Sphagnum moss. Mosses of the genus *Sphagnum*, used either live or dried as a potting mix.
Soot. The fine black, often somewhat oily, material obtained when cleaning chimneys. This material was more available in Europe when soft coal was the main source of heating.
Styropor. A form of expanded polystyrene (plastic).
Turfy loam. Another term for sodded loam.

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Index of Persons

Boldface numerals denote illustrations.

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Index of Organism Names

This index contains common, scientific, and regional names of orchids and other organisms. Scientific names (e.g., *Gastrodia elata*) and terms in languages other then English (examples: Mandarin, *Chin shih-hu*; Latin, *icones*; etc) are *italicized.* Other entries are in roman type. Taxonomic groupings above the generic level are in CAPITAL LETTERS (ORCHIDACEAE, for instance). **Boldface numerals** denote illustrations. The mycorrhizal fungi of orchids entries in Table 4-1 (pages 18–25) are not indexed in this index because they are already alphabetized. Spellings, nomenclatural combinations, terms, orchid names, taxonomic designation, and organism names that may seem erroneous, inconsistent, archaic, and/or unusual are historic, as they appear in the original literature, and/or represent preferences by the authors. This index was prepared with *Kindex*, a Shareware indexing program by Professor Emeritus A. Phillips Griffiths, 6 Brockley Rd., West Bridgford, Nottingham, NG2 5J4, U. K.; Telephone: 44-5-981-0319; e-mail: griff@apg.u-net.com. The program can be downloaded from several WWW Shareware sites or obtained from Prof. Griffiths for a registration fee of at least £10.00 (US$15–20, depending on the exchange rate).

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Index of Subjects

This index was prepared with Indexer 2.0, a program written in 1977 by Joshua Rehman, an undergraduate student at the University of California, Irvine. The program is actually a macro for Excel97. Copies are available free of charge from Professor J. Arditti. Requests must be accompanied by a 3.5 inch IBM-formatted disk and a self-addressed stamped mailer and no money, or US$ 25.00 (please note the word "or"). Indexer I was written by Kevin J. Hackett, also an undergraduate student at UCI, in 1983–1984 and revised in 1989–1990 by two other undergraduates. It was used to prepare the indices for OB III–VI.

Glossary entries are not included in this index because all terms in the glossaries are already in alphabetical order. Page numbers for all glossaries are included in the index.

Some parts of this index were prepared by J. A. in the Los Angeles International Airport and in the Mexico City Airport, as well as on flights to Mexico on Mexicana de Aviacion and United Airlines. Other parts were prepared in the home of Professor Helen Nair and her husband James Bonney in Kuala Lumpur, Malaysia, and in a suite at a beach resort hotel in Melaka, Malaysia provided by them. The last half was prepared in the offices of Jill and Chin-on Mak's Maryland orchids in Singapore and the home of Mr. Soediono (some Indonesians use only one name), his wife Noes and their daughter Luki, also in Singapore. J. A. thanks the individuals mentioned for their help, generosity and hospitality, and his son, Jonathan, for spotting a few typographical errors. The editors hope that the index is adequate despite all that globetrotting.

J. Arditti and A. M. Pridgeon (eds.), Orchid Biology: Reviews and Perspectives, VII, 381–394.