Figure 1. Who is this sleeping beauty? (Growers, n.d.)

Sleeping Beauty of the Plant World?

Xerophyta elegans: A rare flowering perennial resurrection plant

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EXECUTIVE SUMMARY

Updated studies need to be done for the successful propagation and production of *Xerophyta elegans* (Balf.) Baker, creating more germplasm to ensure this rare genetic gem is preserved for possible future breeding efforts. The incredible desiccation-tolerance genetics could possibly be of great agricultural value and utilized in breeding climate-smart food crops. The plant clearly has biopharmaceutical value, and it would be valuable information to know whether in fact it does contain the anti-cancer bioflavonoid amentoflavone, as most of its related species do. The plant tolerates a wide range of environmental extremes, bearing phenotypic attributes more distinctive than any in its family, and may yet hold secrets we would benefit from unlocking. Propagation can be tricky, but under the right conditions this plant slowly develops an impressive resurrection capability, and even bears beautiful flowers. Horticultural distribution chains do not currently exist for *X. elegans* but can be developed, and this plant may be suitable for a market niche similar to that of orchids. *Xerophyta elegans* (Balf.) Baker is nonetheless a unique, beautiful, and resilient species which can perform graciously in many landscape or potted plant settings.

I. INTRODUCTION

A. Study Species Overview.

Vascular plants make up a relatively small portion of desiccation-tolerant species, with angiosperms being even less common, making *Xerophyta* *elegans* a rare survivor from before Pangea split apart. Hardy in warm, partly shady, wet and rocky places, this evergreen perennial may have a lot to offer for climate-adapted breeding efforts, xeric landscape groundcover, houseplant specimens, and striking in hanging baskets. Officially recorded as a South African native by namesake John Gilbert Baker in 1875, this paper will further explore the secrets of this flowering beauty, which has gone by many other names during its taxonomic journey, and still lacks a permanent common name.

B. A Unique *Xerophyta*.

Previously known as False Dracaena and synonymous with *Talbotia elegans and Vellozia elegans, Xerophyta elegans* (Balf.) Baker is a rare desiccation-tolerant monocotyledonous angiosperm native to eastern South Africa (Braun, 2017). For shady areas, rocky slopes, or containers, *X. elegans* is a hardy beauty adapted to survive drought and propagated easily by seed or vegetative stem cuttings (Nichols, 2005). The extreme desiccation tolerance of *Xerophyta elegans* allows it to withstand 0% relative humidity for six months, then rehydrate and begin photosynthesis within two days (Hallam, N. D.; Gaff, 1978). Being the only member of the *Xerophyta* genus to retain chlorophyll and chloroplast structure after complete desiccation (homioichlorophyllous), it also displays protective purple coloration on upfolding leaf undersides due to increased anthocyanin production (Hallam & Luff, 1980).

Xerophyta elegans is also unique morphologically in that the leaves are mesophytic and contain xylem primarily composed of tracheids, allowing for quicker water movement into and throughout the vasculature in comparison to its relatives (Smith & Ayensu, 1974). Plants displaying such desiccationtolerance and the ability to rehydrate and resume functioning are colloquially termed 'resurrection plants', and *X. elegans* is an amazing exemplar of this.

II. TAXONOMIC CLASSIFICATION AND GEOGRAPHIC DISTRIBUTION IN THE WILD

A. Taxonomical History.

Etiology of the specific epithet reveals that the Ancient Greek words 'xeros' (dry) and 'phyta' (plant), are accurate descriptors for this unique specimen, while 'elegans' claims it as elegant. Regarding genetics, all *Xerophyta* species have bisexual flowers and are hexaploid, having six sets of homologous chromosomes (Mello-Silva et al., 2011). The *Xerophyta* genus name was first given by Jussieu in his 1789 "Genera Plantarum", describing a single species collected in Madagascar 232 years ago (International Plant Names Index (IPNI), n.d.). Currently without a common name, *Xerophyta elegans* (Balf.) Baker is the most recent name given to this ancient African plant, which was once called False Dracaena while bearing the official term *Talbotia elegans* (Braun, 2017).

Figure 2. (Royal Botanic Gardens, n.d.)

It is unknown when the common name was dropped, but the assignment of genus and repeated reassignment of species took precedent based on morphology and genetics in most recent times, categorizing it far from the *Dracaena* genus. Rediscovered and renamed in 1868 by Talbot and renamed again in 1875 by Baker, Xerophyta elegans (Balf.) Baker has at least eight synonyms according to the most recent cladistic analysis: Talbotia elegans Balf., Barbacenia elegans (Balf.) Pax, Hypoxis barbacenioides Harv. ex Baker, Vellozia elegans Balf. Talbot ex Hook.f, Vellozia elegans var. minor (Baker)

Baker, Talbotiopsis elegans, Vellozia talbotii Balf, and Xerophyta minuta Baker (Royal Botanic Gardens, n.d.). In a private 1971 communication from Dr. Gaff to Dr. Ayensu, Gaff stated:

"All the *Xerophyta* species that I examined lose the chlorophyll, except *Xerophyta elegans* which retains it . . . there is a suggestion that *X. elegans* be transferred to a distinct genus, *Talbotia*, of its own; perhaps the difference in chlorophyll reaction to water stress gives some support to this." (Ayensu, 1973).

So, it is after more than 200 years that our species of study is in the family Velloziaceae under the order of Pandanales, as seen in Table 1.

Kingdom	Plantae
Phylum	Magnoliophyta
Class	Angiospermae
Category	Basal monocotyledons
Order	Pandanales
Family	*Velloziaceae*
Genus	*Xerophyta*
Species	*Elegans*
Sub Species	(Balf.) Baker

Table 1. Taxonomic categorization of the taxon under study (Behnke et al., 2013).

B. Geographical Distribution.

Xerophyta elegans is endemic to mountainous subtropical areas in north and northeastern South Africa, with provincial distribution from the eastern Mpumalanga range, KwaZulu-Natal and Marieskop to the southern Drakensberg foothills of the KwaZulu-Natal (Royal Botanic Gardens, n.d.). As seen in Figure 1, this area is at -26 latitude, ranges from 23 to 33 longitudinally, and much of it is at an elevation of 1500 feet above sea level with a medium to high relative humidity.

Figure 3. Native area for *Xerophyta elegans* (Royal Botanic Gardens, n.d.).

Of the large *Velloziaceae* family, 250 species are spread among four genera spanning a handful of continents including both South America and Africa, with *Xerophyta* being endemic to south and southeast areas on the African continent (Braun, 2017). The *Xerophyta* genus is the only one currently considered to be African, with forty-five species recognized in Africa, twentyfive in Madagascar, and one on the Arabian Peninsula (Behnke et al., 2013). DNA studies of the entire *Velloziaceae* family point to a Gondwanan source for the *Xerophyta* genus and a South American source for the *Vellozia* genus, as the temporal demarcation between African and South American species corresponds to about 100 million years ago when the two continents split apart (Mello-Silva et al., 2011). This means *Xerophyta elegans* originated from South Africa according to genetic analysis.

III. HABITAT AND MORPHOLOGICAL CHARACTERISTICS

A. Native Habitat.

Conditions favorable to *X. elegans* include xeric, mountainous niches near water sources, commonly in rocky areas and cliff faces near waterfalls (Braun, 2017). *Xerophyta elegans* has adapted to rock-based growth substrates like quartzite found in such inselberg locations, with a slightly acid to neutral soil pH (Association, n.d.; Behnke et al., 2013). Field data states that the plant does well at the wet edges of forests in southern Africa and humid, mesophytic environments as well as xeric, arid ones (Ayensu, 1973).

The plant prefers partial or dappled shade but can survive in full sun, making a good container and landscape groundcover plant, providing many uses (Association, n.d.). A nursery in California, USA categorizes *X. elegans* as a Zone 8b-10b plant requiring shade to part sun, adding that clay substrates may be tolerated if well-drained. They also shared that in 1990, their specimens planted outside in the garden were cold hardy down to about -7°C, surviving these temperatures without visible damage (Growers, n.d.).

Figure 4. *Xerophyta elegans* habitat, growth pattern and flowering in the wild (EPPO Global Database, 2010).

Writing for the South African Botanical Diversity Network (SABONET), Nichols states that it needs a dormant period during the dry winter months to rest, but is otherwise an excellent container plant he has not repotted in decades, as it does not respond well to disturbing transplanting (Nichols, 2005). With such a wide range of suitable habitat conditions, one may wonder if these cases are all, in fact, *Xerophyta elegans* (Balf.) Baker or instead a tropical, Brazilian relative. Additional research on the growth of this specific cultivar would be beneficial considering its valuable uses as a hardy beauty.

B. Morphology.

Xerophyta elegans (Balf.) Baker typically grows about 20-30 cm tall by 3045 cm wide, its linear-lanceolate leaves arch up and out are deeply pleated down the center length, and taper to a point at about 25 cm long (Behnke et al., 2013). Showy white 5-15 cm single blooms drape from long, delicate stems beyond the leathery foliage, bearing a long, yellow center style as long as the six stamens. The bloom has a six-furrowed, cylindrical stigma which rises above the anthers but is smaller than the style, and an obovate, triangular, naked ovary (Behnke et al., 2013).

Often after heavy rains, *X. elegans* blooms from December to March in the southern hemisphere, bearing light purple buds becoming white, star-shaped flowers, and turning light green upon senescence (Ayensu, 1973). After blooming, tiny black hooked seeds can be harvested from dry, tough fruit capsules, naturally dispersing via animals, wind, or water (The Indigenous Gardener, n.d.).

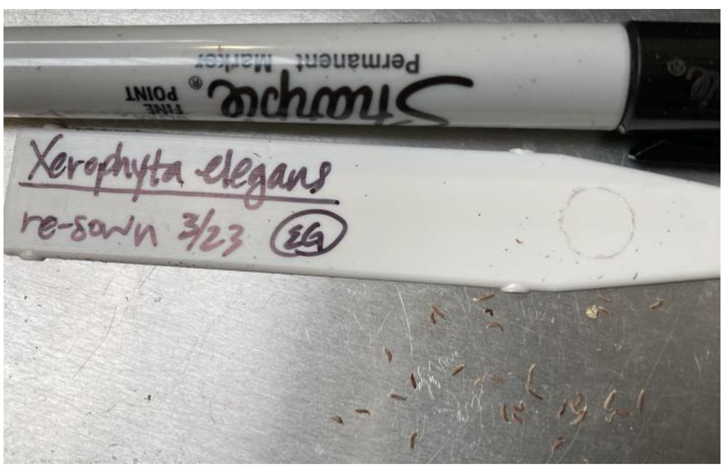

Figure 5. Tiny seeds require sowing with tweezers (Author image) .

The perennial forb grows upright in spreading clumps, its leaves circling around the length of a branching main stem, leaving ‘bract-like’ sheaths upon abscission (Retief & Herman, 1997). Species in the *Xerophyta* genus specifically bear an abscission line between the lamina and sheath, while anthers have apical appendages. These diagnostic traits aid in the distinction between *Xerophyta* and *Talbotia* (Braun, 2017).

As the plant ages, the most mature leaves form a stiff basal rosette, growing up and out, possibly to catch more water and light (The Indigenous Gardener, n.d.). The apical edges of the bright evergreen leaves also have serrations, functioning to gather and hold more water (Braun, 2017). The main stem also has long, aerial roots which rapidly grow downward to provide anchorage and moisture retention, surrounded by dry leaf sheaths which create a microclimate sufficient to soak the roots to dripping (Ayensu, 1973). It is unknown whether the plant officially roots adventitiously, but it has been stated that it spreads via 'stem creep' (The Indigenous Gardener, n.d.).

Continuing to explore the xerophytic morphology of *X. elegans,* it is likely no accident that most resurrection plants are herbaceous and about 10 cm tall, as capillary rise from roots to shoots is more easily accomplished in a shorter plant with efficient xylem such as this subject (Gaff, 1977). Specific leaf physiology unique from others in its genus, *X. elegans* has a thinner cuticle, an epidermis dominated by large sclerenchyma cells, many more strands of subepidermal sclerenchyma, extra furrows on the leaf underside, and the laminal midsection houses small lateral bundles (Behnke et al., 2013). The furrowed texture of the leaves, specifically on the bottom or abaxial side, reduces transpiration rates by protecting stomata from drying air and temperatures (Ayensu, 1973).

Figure 6. Taxonomic drawing of *Xerophyta elegans* (Royal Botanic Gardens, n.d.).

Upon desiccation, leaves crease lengthwise considerably, folding upwards to reveal purple undersides due to increased anthocyanin production, and purple or brown coloration increases as drying continues, while leaf size shrinks by roughly half the hydrated width (Braun, 2017). Gaff found that the dry weight of leaves after desiccation was only 27% of the total hydrated fresh weight, meaning that 73% of the plant's weight is water when fully turgid (Gaff, 1977).

This author also found that upon desiccation and following rehydration, about 50% of seedlings with almost no true leaves still develop anthocyanin pigmentation, as seen below in images taken after days of desiccation, then 24 hours after rehydration.

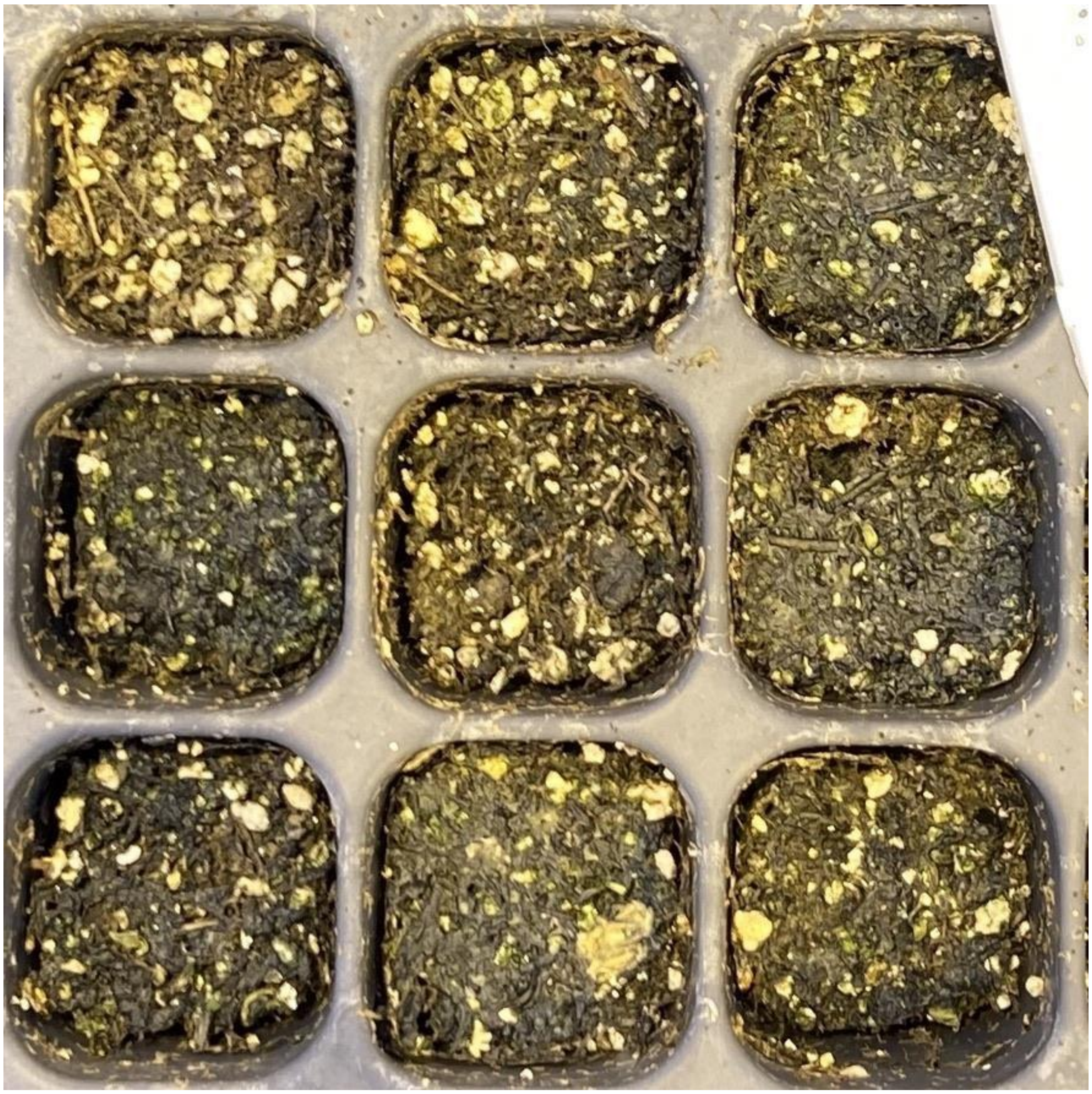

Figure 7. Seed germination studies involving *Xerophyta elegans,* 3/23/21: After 1 week of desiccation (Author image).

Figure 8. Seed germination studies involving *Xerophyta elegans,* 3/24/21: 24 hours after watering (Author image).

Some fungal activity occurred in this first trial, so transplanting was done, but this seemed to further hamper growth relative to the fungal growth. In fact, the seedlings did not seem to be negatively affected by the surface growth. Additional information on studies done by author is discussed in following sections.

IV. CROP SPECIES FUNCTIONAL USES

A. History and Potential Uses.

More information on historical use was found for a different species, *Xerophyta retinervis,* though the traditional uses may be quite similar. Johnson (2008) from SANBI states that the plant has numerous cultural applications in South Africa, including smoking the roots for asthma relief, inhaling smoke from whole plant parts to relieve nosebleeds, and using preparations of the hardened stem 'bark' for analgesic and anti-inflammatory properties. She also explains that the tough, stringy stems were commonly used to make brushes, mats, rope, and European settlers cut chunks of stem to use as scouring pads (Johnson, 2008). It has also been common in South Africa for *Xerophyta* species to be collected illegally for use as bases for epiphytic orchids, though this decreases the endemic populations that much more and is not a sustainable practice (Johnson, 2008).

In Brazil, a historical use of *Velloziaceae* species includes using the gummy stem sap on skin sores, the chemical compounds of which were purportedly analyzed by a pharmaceutical company decades ago; while an unknown species of African *Xerophyta* supposedly contains potential anticancer compounds (Ayensu, 1973). In fact, other *Xerophyta* species are known to contain a powerful therapeutic compound known as amentoflavone, or didemethyl ginkgetin, which is also found in *Ginkgo biloba* and *Hypericum perforatum*, or St. John's Wort (PubChem, n.d.). Originally isolated from the moss-like selaginella plant, amentoflavone is a biflavonoid with antiviral, antibacterial, antioxidant, antidiabetic and neuroprotective properties, is able to induce apoptosis in human cervical cancer cells (in vitro), inhibit melanoma tumor development, and prevent and reduce epileptic seizures (in vivo) (Selleck Chemicals, 2013). It has also been studied as a topical antiinflammatory to treat psoriasis and has similar antidepressant properties as St. John's Wort (Bonesi, Loizzo, Menichini, & Tundis, 2017).

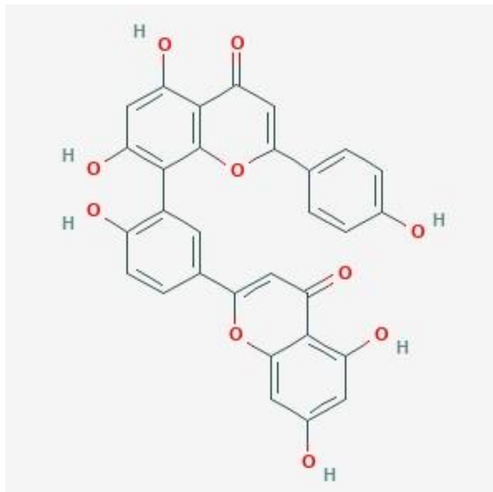

Figure 9. Amentoflavone chemical structure (PubChem. (n.d.)).

It is likely that *Xerophyta elegans* (Balf.) Baker also contains this biflavonoid since most of its relatives do, but no literature has been found confirming this, providing yet another reason to research the potential uses of this unique plant. Most medicinal compounds originate from plants, and the continued study of nutraceuticals in plant foods is a timely and necessary field of study in today's health-conscious world.

Due to *Xerophyta elegans* being a rarity in the horticultural industry, no current distribution chain exists, though a potential one is illustrated in Figure 10.

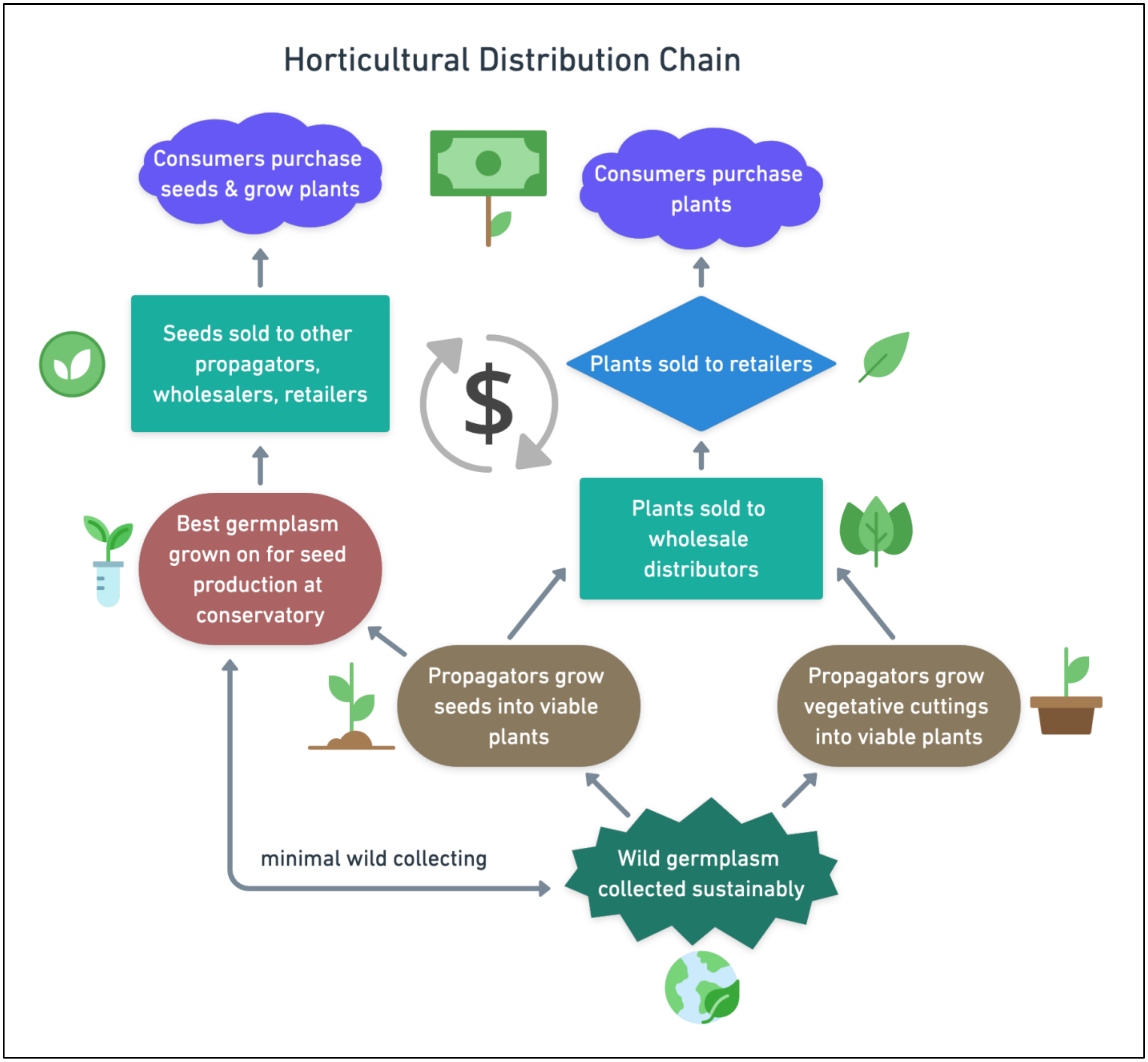

Figure 10. Diagram of the proposed horticultural distribution chain for *Xerophyta elegans*, created using Whimsical.com (Author image)

V. PRODUCTION INFORMATION

A. Anticipated Cultural Requirements.

In 1973, Ayensu found that seeds germinate in warm, moist environments with fourteen hours of light and ten hours of dark, germinating in ten days with cotyledon emergence a few days later, showing an average germination time of 10-12 days at a consistent 30˚C (Ayensu, 1973). Other than this, minimal data exists for the germination and propagation of the ancient plant, as most literature and research focus on the morphology, unique vasculature, and determination of the correct taxonomic clade. Nichols (2005) writes that propagating from seed is the best way to grow species in the *Velloziaceae* family, having collected and germinated seed in South Africa after the fruit capsules have split open, and encourages growers to allow seedlings to become rootbound for a full season before planting out prior to the next summer rains (Nichols, 2005).

Mature plants harvested from the wild have proved difficult to maintain after transplanting, according to some horticulturists (Ayensu, 1973), and this author has found similar results after transplanting seedlings. Some growers have had luck with vegetative propagation using stem cuttings in sand, and growing on in shallow containers with a sandy substrate (Nichols, 2005). Others have encouraged the use of soil rich in compost and regular watering when growing *Xerophyta elegans*, stating that as long as it drains well, it will thrive in shade garden conditions ("Talbotia elegans," n.d.).

This author has had luck germinating seeds with a 40% germination rate at 21˚C, surface-sown in germination mix 1-2 seeds per cell in a 288-plug tray, within a mist house environment. Tiny cotyledons were barely visible with the naked eye after a two-week period, and slow growth yielded 0.5 cm tall plants after three months of growth. Out of three trials using various germination media, moisture, and temperatures, best results were found using half germination mix (SunGro brand) in the cells with the top half being fine vermiculite, and surface-sowing the tiny seeds with a tweezers. It was also advantageous to grow seedlings covered on a capillary mat, as growth seemed to slow down with too much moisture. General propagation methods are included in Table 2 below, using seeds of unknown age and origin.

Trial	Date Sown	Germ. Date	Germ. %	Media Used	Temp	Moisture for germination	Desiccation stress?	Total Viable Plants	Issues
1	2/9/21	2/24/21	39.5% (19/48 seeds)	Germ mix	21°C	High	Yes: completely dried out 3/163/23; watered 3/23, 14/19 fully rehydrated 3/24	12 (25%); transplanted 3/30 d/t surface mold in cells; total viable as of 4/5 = 3 (6.25%)	Surface mold on germ mix
2	3/2/21	3/23/21	35% (21/60 seeds)	Germ mix covered w/ vermiculite	21°C	High but decreased quickly after germ; increased temperature by covering	None or minimal	15 (25%); no transplant	No issues at all with mold, etc
3	3/23/21	4/5/21	4% (1/25 seeds)	Mixed half germ mix, half vermiculite	21°C	High but decreased quickly after germ; increased temperature by covering	Some: allowed to dry out a little	0; 1 died	0% germ. rate in mixed media

Table 2. Propagation trials of *Xerophyta elegans* and data by author, UMN, 2021.

This data shows that the germination media plays a large role in successful germination and growth of *Xerophyta elegans* seeds, likely due to how moisture levels are maintained. The most robust growth was observed in Trial #2, which also yielded the most viable plants since there was no mold or transplant stress. Interestingly, Trials #1 and #2 both yielded 25% viable plants of the total seeds sown, though Trial #1 plants declined due to transplanting more so than the week-long desiccation. It seems that the tiny root system being disturbed causes more loss than any surface mold or days of drought.

B. Market Niche.

This ‘resurrection plant’ could become a popular landscape novelty in warm, neglected areas, and the delicate white flowers dangling over the foliage create a stunning look in a hanging basket. Since it thrives in partly shady, wet, and rocky areas it might do well in a landscape near a natural pool or waterfall, or even in a semi-arid landscape. As a slow-growing potted plant, a possible retail market niche would be orchid lovers, as they have some similar growth requirements and often act as host plants to orchids in the wild (Johnson, 2008). The uses of this plant may be numerous, possibly including using hardy *X. elegans* rootstock for grafting of other plants in need of drought tolerance. Another use may be as a nurse plant for delicate orchids to flourish and set seed rather than being attached to a piece of wood, since this function has already been shown as effective, albeit discouraged in wild areas. There are no known varieties of *Xerophyta elegans* on the market at this point, but some online retailers offer a related aforementioned plant, *Xerophyta retinervis,* though this has very different morphology than our subject species. This may be a market opportunity for keen propagators to try their hand at producing and multiplying this ancient and beneficial resurrection plant.

Figure 11. Flowering potted plant of *Xerophyta elegans* (Wikipedia, n.d.).

VI. PRODUCT INFORMATION GUIDE & CROP SCHEDULE

Light: 14-hour days/10-hour nights

Temperature: >21˚C constant, 30˚C ideal

Moisture: medium, consistent; from bottom

Relative Humidity: medium to high

Substrate: half germination mix on bottom and half fine vermiculite on top provides best results

Planting: surface-sow, lightly pressing into soil

Days to Germinate: 15-20, germination and growth may be faster if covered/temperature increased

Recommended Plug Tray: 288, or broadcast on top of open tray

Crop Schedule: This crop can be propagated anytime in a protected environment such as a greenhouse with temperature and moisture controls. It can also be propagated in the springtime of the southern hemisphere, after rains in November or December, as it does in the wild. There is no set schedule for this rare crop other than what has been included in this paper, and more information may be gleaned from future trials propagating *X. elegans.*

VII. ACKNOWLEDGEMENTS

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