Synonymization - A Threat to Plant Conservation

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Abstract

Plant conservation aims to include the full genetic diversity of a given species (Abrego-López et al. 2025) in particular and of a given genus more broadly. However, the preservation of plant genetics is not often on authors minds when they rearrange the taxonomy within a given genus, especially when thorough nuclear DNA analysis of the taxa is unavailable or even prohibited by the lack of sufficient plant material, as is especially the case for dwarf succulents with very small populations (10 -100 individuals). Here we give examples of approaches for rearranging the taxonomy within a genus that are singularly destructive in preserving the genetic diversity of a given genus – simplification of a genus by synonymization, especially when done without giving any reason or by willfully discounting the traits that set taxa apart. The changed status may falsely imply that *in situ* protection is no longer needed and may lead to a breakdown of *ex-situ* conservation efforts because of creeping hybridization of formerly separate taxa. We propose simple guidelines to be applied before new taxonomic changes are "accepted", in order to prevent harm to genetic diversity when valid taxa disappear into obscurity as synonyms.

Introduction

Taxonomic changes occur all the time, often to the chagrin of succulentophiles, who might feel that they need to learn yet another name and relabel their plants. Taxonomic changes come in different flavors, and some are more invasive than others.

A simple name change is harmless from the point of view of conservation. When one tries to maintain tabs on all known plants it does not make any difference, if a given name has changed as long as the taxon itself has not been deleted. For example, when we stop referring to *Aloe dichotoma* Masson and call it instead *Aloidendron dichotomum* (Masson) Klopper & Gideon F.Sm. the plant has not changed, only its name, and the number of taxa remains unchanged. In Figs. 1 and 2 we show an unusual summer-blooming form of Aloidendron dichotoma.

Fig. 1. *Aloidendron dichotoma* (**Aloe dichotoma*) at Haalenberg, Namiba, getting ready to flower in late summer (March 2, 2025), which is the "wrong" time of year for *A. dichotoma*, but it is not unusual time for plants at Haalenberg.

Fig. 2. Close-up of inflorescence of the tree shown in Fig. 1.

Problems for plant conservation, however, can arise when one or more validly described species, subspecies, or varieties are merged by synonymizing them with the "accepted" species leftover from the merger. Synonymization reduces the number of taxa, because the synonymized taxon is said to being one and the same as the accepted species and is no longer needed to account for all distinct taxa in the plant kingdom.

In practice synonymization means one has to keep track of fewer plant names - and for those of you who want to keep only one plant per taxon, it means that you can throw out one of the two plants, creating much needed space for a new acquisition. The more synonymizing the more space is created. Or put another way, for each synonym there is one fewer plant to buy. And for plant conservation there is one fewer taxon to worry about. The urge and need to conserve the synonymized species goes away.

If two taxa that are synonymized are not fully identical, then the unique trait(s) of one of the taxa are no longer recognized and may be lost. There is no more reason for propagators to not mix seeds and no more reason to not cross-pollinate among the synonymized species.

We can learn from zoology what happens when distinct traits are not recognized: Although there are more tigers (*Tigris panthera*) in private US captivity than in all of nature, the gene pool of these captive tigers is useless for species conservation. After many decades of private breeding without regard for taxonomy these are a thorough mix of the six remaining subspecies (Armstrong et al. 2024). Once interbreeding of synonymized plant species has started, it is just as irreversible as it is for animals. The hybrids or mutts created by interbreeding are as useless for plant conservation as they are for tiger conservation.

Falsely synonymized plant species may also be excluded from future botanic studies and thus may stay in perpetual oblivion. For example, when Earlé and Young (2020) studied the morphology of "all" taxa of the genus *Lithops*, they excluded synonymized taxa, thus omitting the wrongly synonymized *L. opalina* Dinter and *L. summitatum* Dinter (Beiersdorfer et al. 2024, 2025).

With synonymization an entire species disappears with the stroke of a pen, often in the name of "simplification": no bulldozers, poachers, or climate change are needed to remove a taxon from botanical existence. In the following we discuss merger scenarios that should raise flags. Was due diligence exercised so that the synonymized plants don't have unique traits not found in the "accepted" species and, therefore, deserve to be kept as a separate taxon from the conservation perspective?

True Taxonomic Twins

Many "accepted" plant species are the result of merging multiple, validly described species, subspecies, or varieties by synonymizing them with the accepted species. No genetic loss occurs when it is found that two or more authors independently described the same population of plants, but accorded them different names. In that case, clearly the original name has priority and subsequently names are simply synonyms of the original name. No harm is done.

Dubious Taxonomic Twins

It should raise immense doubt, when authors synonymize taxa without giving a reason. And it is equally dubious when authors give a reason for their choice, but that reason does not address all the points made by the previous authors who originally described the taxon.

It may seem odd that this happens, but it is more common than one would think. Skipping a thorough reason or giving none at all seems common when reorganizing the taxonomy of an entire genus. Sometimes it seems a species is synonymized as an afterthought, perhaps to simplify a complicated world. The reader is to think that simplification is reason enough to abolish a few taxa or perhaps all subtaxa of a given species. Let us give some examples below.

A. *Opuntia cacan*apa Griffith & Hare

The recent article in the *Cactus and Succulent Journal* by Shaw and Fergusson (2024) on *Opuntia cacanapa* Griffith & Hare provides a case in point for plants that are synonymized without reason. Shaw and Fergusson tell that *Opuntia cacanapa* was synonymized and pushed to purgatory many times during its taxonomic journey since its original description in 1906. They state that "In the way of so many opuntias, it was rechristened several times, apparently without supporting evidence," and "none of these assertions is supported by behavior, morphology, nor cytology of the plants."

Luckily, *Opuntia cacanapa's* contribution to the botanical gene pool has resurfaced as *O. engelmannii* var. *cacanapa* (Griffith & Hare) D.Weniger in the plant database at the Royal Botanic Garden Kew (Plants of the World Online, or POWO for short), although other authorities still deny its genetic contributions to the plant kingdom and thus give it no status that deserves conservation. It appears that *O. cacanapa* should be reinstated as a species in its own right.

Reading Shaw and Fergusson's article we wonder how many other opuntias are currently missing from the "accepted" plant lists because of such botanical malpractice. Clearly, authors, who want to synonymize a taxon, should be required to give a detailed rebuttal to the original diagnosis as to why they think that taxon is the same as another and why it does not contribute to the gene pool of the genus.

B. Dipcadi crispum

We had our own encounters with plants that may have been synonymized in doubtful ways, when we were trying to determine the names of various geophytic plants (Beiersdorfer & Lepson 2025). Here we describe some of our doubts when we were looking at plants in the genus *Dipcadi* Medik.

Two of our *Dipcadi* plants in question are shown in Figs. 3 and 4. These plants are separated by more than 200 km. They look different yet close enough to recognize them as *Dipcadi*. The plants at Haalenberg (Fig. 3) were perhaps an inch (25 mm) across, while the plants at

Maltahöhe (Fig. 4) were ten times longer. Perhaps the growth form is different because the leaves may change from being curly to linear as they age and elongate in the rainy weather we encountered near Malthöhe. But there are other differences that cannot be explained by age: All plants we encountered at Haalenberg have two leaves, but the plants south of Maltahöhe have merely one leaf. In the end we settled on **Dipcadi tortile* R.A.Dyer for the Haalenberg plant shown in Fig. 3 (the asterisk denotes the name to be officially a synonym), which is now synonymized with *D. crispum* Baker. We settled on *D. platyphyllum* Baker for the Maltahöhe plant shown in Fig. 4. The other choice for the plant in Fig. 4 was **D. unifolium* Baker. However, it is now unfortunately part of a whopping 36 synonyms for *D. viride* (L.) Moench. But unlike **D. unifolium* and despite the reasonable expectation that synonyms should look the same, *D. viride* with its multiple thin, tall, erect leaves looks nothing like the plant in Fig. 4. This creates doubt about the validity of all the 36 synonyms.

Fig. 3. Typical double-leaved Dipcadi crispum photographed in the morning sun at Haalenberg (July 9, 2023).

A mere six species were synonymized with *Dipcadi crispum*, and we decided to look at this list in a bit more detail. The list of synonyms from POWO is given in Table 1. There seems to be no easy way to determine why they have been synonymized. Inspection of the "short" list of *D. crispum* synonyms should give one pause. Did the original authors who described the now-synonymized species err in thinking that theirs was a good species?

The first striking observation, when we look at Table 1, is that three of the six entries come from the same author, John Gilbert Baker. He is also the author of the accepted species *Dipcadi crispum*. In fact, in his 1870 treatise on *Liliaceae* he described both *D. crispum* and *D. setosum*, whereby he put each of the two into a different division. When he did so, he certainly did not think that the two were one and the same species. Clearly, this is not a case where two different authors publish the same species independently of each other.

Fig. 4. Typical single-leaved *Dipcadi platyphyllum* photographed on March 2025 south of Maltahöhe, Namibia.

Baker published two additional species 17 and 31 years later, respectively, which were later also deemed to be identical (see Table 1).

It is hardly likely that Baker did not know the detailed differences between his own four species. This raises some questions. Why would Baker describe four separate species if all are the same, as they are now considered? Was he less competent than the subsequent authorities and therefore the noted differences are simply delusions? Or did subsequent authors simply ignore Baker's qualifications when they synonymized his species?

We do not know why all of Baker's species are now considered to be identical. We know, however, that merely studying plants in habitat, including those mounted on herbarium sheets, gives an insufficient picture of the taxonomic differences. Perhaps subsequent authors grew the plants *ex situ* side by side to rule out environmental influences that may have changed their appearances and found that all seven species listed in Table 1 become indistinguishable. We can only hope so, although it is our experience (see next section) that raising plants ex situ can reveal new characteristics, such as growth habits, that go unnoticed in field or herbarium studies and thus increase taxonomically important differences.

Table 1. *Dipcadi crispum* Baker and its six heterotypic synonyms according to POWO.

Name	Year	Publication
Dipcadi crispum Baker	1870	J. Linn. Soc., Bot. 11: 399 (1870).
**Dipcadi setosum* Baker	1870	J. Linn. Soc., Bot. 11: 398 (1870).
**Dipcadi volutum* Baker	1897	Fl. Cap. (Harvey) 6(3): 448 (1897).
**Dipcadi dinteri* Baker	1901	Bull. Herb. Boissier, sér. 2, 1: 788 (1901).
**Dipcadi undulatifolium* Schinz	1912	Vierteljahrsschr. Naturf. Ges. Zürich 57: 534 (1912).
**Dipcadi tortile* R.A.Dyer	1944	Fl. Pl. South Africa 24: t. 956 (1944)
**Dipcadi crispo-ciliatum* Suess.	1950	Mitt. Bot. Staatssamml. München 2: 51 (1950)

Finally, in 1944 and 1950 "modern" descriptions were made of two new species, *Dipcadi tortile* R.A.Dyer and *Dipcadi crispo-ciliatum* Suess. The author of *D. tortile* states that it "shows a strong superficial resemblance to *D. volutum*" and then describes characteristics of the flower and hairiness of the flower stalk that "satisfactorily distinguish these two species" (Dyer 1944). Today, *D. volutum* and *D. tortile* are considered one and the same, despite Dyer's diagnosis, and both have disappeared into synonymy with *D. crispum*.

Interestingly, the isotype of *Dipcadi crispo-ciliatum* Suess. was based on a collection made by Dinter (#6830) in Namibia in 1934. Dinter's herbarium sheet is shown in Fig. 5. At one point the determination "*Dipcadi platyphyllum* Baker" was added to the herbarium sheet. In other words, it once was thought that *D. crispo-ciliatum,* and ultimately perhaps even *D. crispum*, could be a synonym of *D. platyphyllum*. In that case, our two plants in Figs. 3 and 4 would have been one and the same species! Will their appearance truly morph into each other when grown *ex situ*?

Calling every plant *D. crispum* certainly simplifies the genus. But it seems that the input of many competent minds was discarded in the process, and, most important for plant conservation, it appear that genetic traits of the genus were suppressed during simplification. The spirit that allows only for tigers but not their subspecies may still be wafting through botanical taxonomy.

Fig. 5. Herbarium sheet of Dinter's collection #6830 from January 10, 1934. The plant is now listed as *Dipcadi crispum*.

When the status of a taxon is changed or a new combination is made, the name of the author(s) is attached. Unfortunately, this is not done when an author creates a synonym. This makes it very difficult to uncover the reasons, if any, that resulted in synonymy.

Synonymy by Decree

In the case of Dipcadi, we can only suspect that genetic information is lost, but we cannot be sure, because we do not know what informed the modern authorities. By contrast, we are more intimately familiar with the history of synonymy in the genus *Lithops* N.E.Br., and the story is a definitive loss for plant conservation.

A. If I don't see it, it doesn't count

It is quite pernicious for conservation when an author declares that a species does not exist because he himself did not find a known population in nature, even though there is documentation that authors before him did so successfully. Cole employed that argument in 1973 when he declared that *Lithops opalina* Dinter and *L. summitatum* Dinter to be synonyms of *L. karasmontana* Dinter & Schwantes (Cole 1973) simply because he did not himself find pure populations of the plants in nature. He then falsely treated both *L. opalina* and *L. summitatum* as cultivars.

Cole issued this diktat in willful disregard of the documented descriptions of their respective populations in nature and of the abundant offspring disseminated since their original collections. For about 50 years this declaration stood until the original pure populations of both species were revisited and documented to be in exactly the locations described by the discoverer of the species a hundred years earlier (see Beiersdorfer et al. 2024, 2025).

Recently, the same argument was again employed (Jainta 2019) to declare that *L. schwantesii* subsp. *gebseri* (De Boer) Cole is the same as *L. schwantesii* Dinter. The author states "The only locality [of *L. schwantesii* subsp. *gebseri*] was discovered in 1960 by Gebser and visited by the Coles in 1968. No further sighting is reported, hence the taxon's validity cannot be confirmed." As Cole did 50 years earlier, this argument is made in willful disregard of the documented descriptions of the respective population of *L. schwantesii* subsp. *gebseri* in nature and of the abundant offspring disseminated since their original collection (Cole's seed collection C165). We may add that no one was waiting for yet another validation of the accepted evidence of a well established taxon.

If no new information can be added to the facts about a well known taxon, it is standard procedure to keep the taxon at its current status. In the case of *L. schwantesii* subsp. *gebseri* extinction in the wild was used to abolish the taxon by claiming that no new information could be added (Jainta 2019). Thus, the taxon's status was changed without providing any reason other than that no reason could be given. A rather circular argument indeed!

From the point of view of conservation, this argument is appalling in more ways than one. Not only does it deny the unique status of the taxon, but it also means that any vanished species can be reclassified as being abundant simply by synonymizing it with an abundant taxon: First you state that you cannot find the taxon and, therefore, cannot confirm its "validity." Then you assess the taxon, which therefore cannot be assessed, to be the same as some common taxon, and, voilà, the taxon is no longer extinct!

Seemingly this logic was convincing in the sense that POWO now states that based on Jainta's 2019 article, *L. schwantesii* subsp. *gebseri* is no longer a valid taxon but is a synonym of *L. schwantesii*. It does not convince us.

We agree with de Boer, who wrote the original diagnosis of *L. schwantesii* var. *gebseri* de Boer as a new variety (de Boer 1964); we agree with Cole and Cole, who elevated the variety status to that of a subspecies (Cole and Cole 2005); and we agree with Earlé and Young (2020), who reconfirmed the status of *L. schwantesii* var. *gebseri* by studying the seed structure of *ex-situ* plants. In other words, *L. schwantesii* subsp. *gebseri* is not an identical twin of *L. schwantesii*, as Jainta (2019) decreed.

And, by the way, a few more plants have been found in nature since its untenable relegation to synonymy (Mouton and Mouton 2021). We show pictures of one of the rediscovered plants in Figs. 6 and 7. Unsurprisingly, the plant looks like those first described by de Boer (1964); there are no mysteries that require confirmation of the "taxon's validity." We, therefore, reinstate the taxon in Table 2.

Table 2. New taxonomy of *Lithops schwantesii* Dinter.

New Classifications	Previous Classifications by H. Jainta (2017,2019)
Lithops schwantesii Dinter subsp. *gebseri* (de Boer) D.T. Cole **stat. nov**. Basionym: *Lithops schwantesii* Dinter var. *gebseri* de Boer 1964. Succulenta 43: 109	*Lithops schwantesii* Dinter Südwestafrikansiche Lithopsarten: 14 (1928)

Fig. 6. Photograph of *Lithops schwantsesii* subsp. *gebseri* taken in habitat on November 17, 2021.

Fig. 7. Photograph of *Lithops schwantsesii* subsp. *gebseri* taken in habitat on October 23, 2025. (Same plant as in Fig. 6.)

B. If you restrict yourself to a hammer everything looks like nail

Nature is very complex, and to account for the observed variation in different plant populations, botanists have added new species, subspecies, and varieties. A complex taxonomy can be simplified if one decrees that most of the traits that have been used by past botanists to distinguish different taxa are irrelevant. In one swoop we can solve the problem of genetic mixing of captive tigers in the US: We simply decree that the traits that define subspecies are irrelevant. (By using the word "decree" we mean to emphasize that there is no good scientific reason to discard well established traits and characteristics.)

For plant conservation restricting taxonomically relevant characteristics is another disastrous approach, because it suppresses the genetic differences among plant taxa expressed in those characteristics. In the genus *Lithops,* diversity is expressed in traits such as seed morphology and seed weight, growth habit as juveniles and adults, flower structure, tanniferous idioblast distribution, seed capsule shape, etc. These criteria have been established by *Lithops* researchers over a century of research. In the 1920s Dinter first grew newly discovered plants for several years at the farm Liechtenstein before he would write a diagnosis of a new taxon so he could discern plant specific characteristics from environmental influences and be sure that what he describes as a new species is truly different from what he or others had described before. Dinter emphatically pointed out that it was impossible to tell anything from dried Lithops mounted on herbarium sheets. Subsequently, from the middle to the end of the 20th century, first de Boer and then Cole continued this scientific approach of combining *in situ* and *ex situ* studies to inform their taxonomic decisions. One of the results was Cole's thoughtfully compiled taxonomy which was summarized in his monographs (Cole 1988, Cole & Cole 2005).

By the time of his death Cole's list included 91 taxa, all of which he grew not only *ex situ* for comparative studies but all of which he also photographed in habitat and showed in his book. This list, however, did not include taxa he mistakenly omitted.

Cole's 91 *Lithops* taxa were reduced to just 38 taxa a dozen years later (Jainta 2017, 2019). This was done by considering only the plants' surface patterns and, furthermore, restricted to only those visually observed in nature. As the author says "*Lithops* are mainly identified by the shape, colour and pattern of the topmost visible parts […] Other attributes such as flower size and structure, seed capsule and seed as well as plant size are considered less relevant by the author." By disallowing the specific traits and characteristics that were carefully developed through many decades of research and which distinguished Cole's 91 taxa, it was easy to relegate 53 *Lithops* taxa to oblivion. When you restrict yourself to a hammer, all plants look like nails, and "simplification" of a genus becomes easy.

Indeed the goal of eliminating 53 *Lithops* taxa was not to provide a more accurate list of taxa; the goal was simplification. "In the present revision the taxonomy of the genus is further simplified," so the author states (Jainta 2019). However, from a conservation perspective these kinds of synonymizations are abhorrent.

Using the case of Lithops dinteri as an example, we show in the following that "simplification" seriously undermines the goal of plant conservation because the remaining taxon no longer contains the genetic information necessary to recreate the lost taxa.

The history of *Lithops dinteri*

Citing Jainta (2019) POWO currently lists *L. marthae* Loesch & Tischer, *L. brevis* L.Bolus, *L. dinteri* subsp. *frederici* (D.T.Cole) D.T.Cole, L. dinteri subsp. *multipunctata* (de Boer) D.T.Cole, and *L. dorotheae* Nel as synonyms of *L. dinteri*. In order to understand how the author (Jainta

2017, 2019) arrived at this level of synonymization, let us first give some history to show that the *Lithops* taxa that were lost in the new, simplified taxonomy have a long and carefully established scientific history.

Fifty-five years ago Fearn published a key for identifying plants in the genus *Lithops* (Fearn 1970). He took the opportunity to include a few new combinations. One of them was to combine *Lithops marthae* with *L. dinteri*, which yielded *Lithops dinteri* var. *marthae* (Loesch. & Tisch) Fearn. This new combination, of course, did not reduce the genetic pool, but it is just the beginning of our story.

Simply judging *Lithops* by their appearance in habitat, it is easy to see why Fearn combined *Lithops marthae* with *L. dinteri*, although Fearn does not state the basis for his choice. In Fig. 8 we compare specimens of *L. dinteri* subsp. *dinteri* var. *dinteri*, *L. brevis*, and *L. marthae* photographed in habitat at or very near their respective type localities. They undoubtedly look similar, although differences can be noted upon close examination. Fearn acknowledges those differences, when he keeps the taxon as a variety of the nominate species; he does not synonymize one with the other by claiming they are the same.

Three years later, Cole criticizes Fearn's new combination, when he writes that "Fearn offers neither reasons nor explanations for his new combinations" (Cole 1973). Cole states that there is some superficial resemblance of some *Lithops marthae* specimens with *L. brevis*, "but there the similarity ends. In all other respects, e.g. facial markings, flower and capsule structure, *L. marthae* manifests a clear relationship to *L. schwantesii* Dint." (Cole 1973). Cole also points out the geographical closeness to *L. schwantesii* and a 160 km distance to *L. dinteri*. He proceeds to combine *L. marthae* with *L. schwantesii* to yield L*. schwantesii var. marthae* (Loesch & Tischer) D.T.Cole.

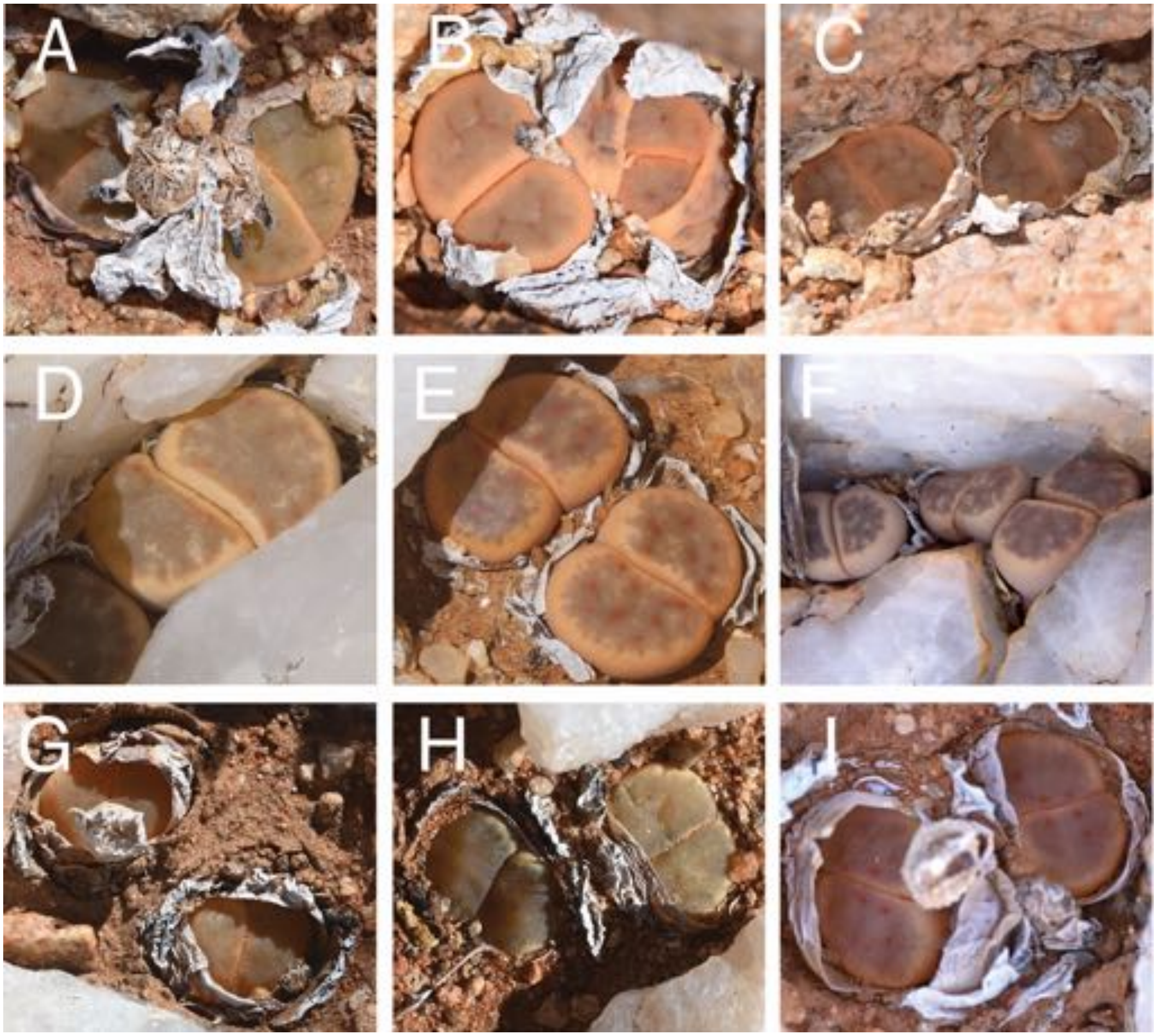

Fig. 8. Photographs of *Lithops marthae* (A-C), *Lithops dinteri* subsp. *dinteri* var. *dinteri* (D-F), and *Lithops brevis* (G-I). The first two taxa were photographed at their type localities (C249 and C206, respectively) on Nov. 5, 2021 and Feb. 24, 2022, respectively; the last taxon was photographed 5 miles from Bolus's type locality on Jan. 14, 2024.

A few years later Jump (1981) published a thorough study of *Lithops* seed morphology. His microscopy pictures demonstrated that the seeds of *Lithops marthae* are similar to seeds of *L. schwantesii* but differ greatly both in size and structure from seeds of *L. dinteri* (see Fig. 9). Jump states "The association by Fearn of this variety with *L. dinteri* appears unjustified. The seeds of *dinteri* are smaller (0.53 mm.) and markedly tuberculate compared with the larger (0.78 mm.) and smooth coats of *schwantesii* and *marthae*" (Jump 1981). Jump's investigation laid the question to rest. Or, at least, so it seemed.

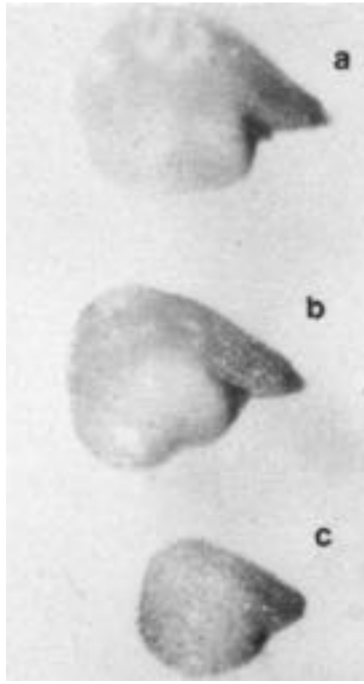

Fig. 9. Comparison of seeds from (a) Lithops schwantesii var. schwantesii (C077) with (b) *L. schwantesii* var. *marthae* (C146) and (c) *L. dinteri* (C206) as shown by Jump (1981). The seed from *L. dinteri* is not only considerably smaller than those from *L. schwantesii* and *L. marthae*, but its globe is also noticeably rough with tuberculate protrusions, while the other two seeds are smooth.

A few years later Wallace (1988) studied the tanniferous idioblast pattern. He determined that idioblasts, which are a specific kind of cell found in *Lithops* and other mesembs, are situated only on the top surfaces of *L. marthae*. By contrast, idioblasts can also be found on the side of *L. dinteri* plants. Wallace (1988) concludes that "The affinities of *Lithops marthae* to either *L. dinteri* or *L. schwantesii* have been questioned, and placement of the species as a variety of *L. schwantesii* by Cole (1973) is generally supported by idioblast pattern character." This provided yet another scientific confirmation that *L. marthae* should not be placed with *L. dinteri*. If Jump's seed investigations were not enough, surely Wallace's cell patterns provided independent evidence that *L. marthae* is more closely related to *L. schwantesii* than to *L. dinteri*.

Almost 40 years later history repeated itself. Restricting himself solely to the facial patterns seen in habitat Jainta (2017, 2019) places *Lithops marthae* once again with *L. dinteri*. In doing so Jainta writes that *L. marthae* "has greater morphological affinities to the *dinteri* complex when compared with *L. schwantesii*, despite the significant geographical distance between *marthae* and *brevis* (see also Fearn)" (Jainta 2017). Because only a hammer is allowed, no mention is made of the evidence to the contrary provided by Jump's studies of seed morphology, by Cole's determinations of differences in flower and seed capsule structure, or by Wallace's tanniferous idioblast distribution.

As we mentioned before, there is no genetic loss if a given taxon is simply moved and renamed. The loss occurs when a taxon with different genetics is falsely eliminated by relegating it to synonymy. Unfortunately, Jainta (2017, 2019) proceeded to do just that. First, he subsumed all well established *L. dinteri* subspecies and varieties into *L. dinteri*. To these he adds Fearn's *Lithops dinteri* var. *marthae*, which he had resurrected. Then he goes another step further and subsumes *L. dorotheae* into *L. dinteri*. In doing so, he labels *L. dorotheae* and *L. dinteri* var. *marthae* as "extreme forms" of *L. dinteri*. We can only guess that invoking "extreme" means that the differences are so large that a wide stretch of the imagination is needed to accept them as identical to *L. dinteri*.

Jainta (2017) only gives "overlapping morphological patterns" as his reason for synonymizing the six established taxa, including the two "extreme" forms. "Overlapping morphological patterns" is not further explained. However, in his follow-on paper Jainta (2019) states that his synonymization focused solely on the red dots exhibited by *Lithops dinteri*: "In particular [plants] are recognised by their red markings ("rubrications"), seen in all taxa. A differentiation between subspecies *frederici* and *multipunctata* is not appropriate. This is also true for the extreme forms of *L. dorotheae* and *marthae* that were formerly either considered as a variety of *L. schwantesii* or of *L. dinteri.*"

Of course, the fact that subtaxa within the same species have common characteristics, such as red dots, is not a surprise; relying on these common characteristics to subsume the subtaxa while ignoring the many well established differences, however, is a stretch. And one needs to stretch even further to include the "extreme forms." Surely, Cole would strongly disagree with the statement that "a differentiation between *L. dinteri* subsp. *frederici* and *L. dinteri* subsp. *multipunctata* is not appropriate," as both taxa were carefully established by Cole.

The keepers of the plant database at POWO have accepted Jainta's "arguments." As a result, *Lithops dinteri* subsp. *frederici*, *L. dinteri* subsp. *multipunctata*, *L. dinteri* subsp. *dinteri* var. *brevis*, *L. schwantesii* var. *marthae* and *L. dorothea*, which were valid taxa before Jainta (2019) are no longer accepted and are now listed by POWO as being one and the same as *L. dinteri*.

The visual clues used by Jainta to synonymize the taxa can also be used to disprove such synonymy. We already showed that there are visual differences between the taxa photographed *in situ*, as illustrated in Fig. 8. These visual differences become very apparent when we photograph the same taxa *ex situ*. In Fig. 10 we show three-year-old seedlings of *Lithops dinteri* subsp. *frederici*, *L. dinteri* subsp. *multipunctata*, *L. brevis*, and *L. schwantesii* var. *marthae*. It is immediately apparent that the four taxa look nothing alike and should never be treated as being one and the same.

Fig. 10. Comparison of seedings from (a) *Lithops dinteri* subsp. *frederici* C180, (b) *L. dinteri* subsp. *multipunctata*, C326 (c) *L. dinteri* subsp. *brevis* C268, and (d) *L. schwantesii* var. *marthae* C249. The plants are from seeds sown in April 2022 and were photograph *ex situ* in California.

We show a comparison of adult plants of *L. dinteri* subsp. *dinteri*, *L. brevis*, *L. schwantesii* var. *marthae,* and *L. dorotheae* in Fig. 11. Again, it is clear as day that the four taxa are totally different. No one would think that these taxa are identical to each other and should be synonymized. The presence of red dots clearly does not make them equal to each other. Even superficial inspection shows that these *ex-situ* plants differ from each other in more than one way. Seeing these profound visual differences, it is no wonder that there are similarly profound differences in other taxonomic markers such as seed structure, idioblast distribution, or growth habits.

Figures 10 and 11 make it clear that it is untenable to focus solely on visual clues of plants in nature (which is often difficult due to their physical condition, depending on varying environmental conditions) while ignoring the large body of established scientific data before assigning these plants to synonymy. These plants are simply not identical with each other.

Fig. 11. Comparison of adult plants of (a) *L. dinteri* subsp. *dinteri* C206, (b) *L. brevis* C084, (c) *L. schwantesii* var. *marthae* C249*,* and (d) *L. dorotheae* C124 photographed *ex situ* in California.

Another way to assess the question of whether synonymization is justified is to answer the following question. Does the nominate taxon remaining after synonymization still encompass all the genetic material necessary to rebuild all the taxa that were synonymized with it? In other words, if one population is wiped out, can we use another population as a substitute? Surely, if the synonymized taxa are all equal, the answer is 'yes,' and synonymization was appropriate. If the answer is 'no,' synonymization reduces genetic diversity.

When we look at Figs. 8-11, we can see that keeping just one of the six taxa is not sufficient to maintain genetic diversity. In other words, if a bulldozer were to wipe out the entire *in situ* populations of *L. dorotheae*, it is not sufficient to repopulate the sites by replanting *L. marthae*. Nor can we sow out seeds of *L. dinteri* subsp. *multipunctata* and hope they will turn into *L. dorotheae*. Neither can we replace *L. dorotheae* by sowing seeds of *L. brevis*.

No matter how we pose the question above, the answer is 'no.' Simplification of the genus *Lithops* based on a restricting scientific evidence to merely visual clues in habitat leads to a miscarriage of botany and does great harm to plant conservation.

The corrected taxonomy of *Lithops dinteri*

We would be negligent in our duty to preserve the natural gene pool, if we were to merge all these taxa into one and allow them to be interbred *ex situ*. We would end up with mutts like the aforementioned tigers. Except that we would have to add a striped house cat to the tiger gene pool as one of the aforementioned "extreme forms". We, therefore, have reinstated all the taxa that have vanished in Jainta's "simplified" taxonomic concept of *L. dinteri*, as summarized in Table 3.

In compiling Table 3 we have also corrected the status of *Lithops brevis.* Fearn had made *L. brevis* a variety of *L. dinteri*. According to Cole, who agreed with Fearn's new combination, the surface area of *L. brevis* is about 65% that of *L. dinteri,* and *L. brevis* rarely as many as 5 red dots, compared to 5-12 for the nominate species (Cole 1973). However, *L. brevis* differs from *L. dinteri* in other significant ways. In fact, it differs in as many or more ways than do subspecies *multipunctata* and subspecies *frederici*, as we show below, and we think its status should be elevated from a variety to a subspecies of *L. dinteri*.

Unlike any of the other subspecies of *L. dinteri*, plants of *L.* brevis lose their red dots with age. Adult plants, therefore, often become dotless within a few years. In fact, many of the three-year old plants shown in Fig. 10 (c) have already lost their red dots. This change during plant maturation was first shown in two elegant studies *in situ* and *ex situ* by Earlé and Mouton (2013) and Earlé (2016), respectively. This growth habit is not duplicated by *L. dinteri* nor by any of its other subspecies and, therefore, constitutes a very unique distinguishing characteristic.

Subspecies *brevis* can also be distinguished from the other subspecies of *L. dinteri* by the fact that its window is essentially fully open and not obscured by buff-colored dots. The nominate species is known to exhibit buff-colored dots (see Fig. 11), which can aggregate in some cases to a dozen or more and partially block the window's transparency. Such aggregates are essentially absent in *L. dinteri* subsp. *brevis* (see Fig. 11), where at most two or three dots form a cluster. Together with the lack of red dots, the lack of aggregate buff dots makes for a striking difference between *L. dinteri* subsp. *brevis* and the nominate species as well as the other subspecies, as shown in Fig. 11.

Table 3. New taxonomy of taxa formerly synonymized with *Lithops dinteri* Schwantes.

New Classifications	Previous Classifications by H. Jainta (2017,2019)
Lithops dinteri Schwantes subsp. *dinteri* **stat. nov**. Basionym: *Lithops dinteri* Schwantes 1927. Z. Sukkulentenk. 3: 97	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)
Lithops dinteri Schwantes subsp. *brevis* (L.Bolus) Beiersd. & Lepson **comb. nov.** Basionym: *Lithops brevis* L.Bolus 1932. Notes Mesembryanthemum 2: 344.	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)
Lithops dinteri Schwantes subsp. *frederici* (D.T.Cole) D.T.Cole **stat. nov**. Lithops Flowering Stones: 220 (1988) Basionym: *Lithops dinteri* Schwantes var. *frederici* D.T.Cole 1973. Madoqua 7: 34	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)
Lithops dinteri Schwantes subsp. *multipunctata* (de Boer) D.T.Cole **stat. nov**. Lithops Flowering Stones: 227 (1988) Basionym: *Lithops dinteri* Schwantes var. *multipunctata* de Boer 1966. Succulenta 45: 21	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)
Lithops dorotheae Nel **stat. nov**. Succulenta (Netherlands) 21: 71 (1939). Basionym: *Lithops dorotheae* Nel 1939. Succulenta 21: 71	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)
Lithops schwantesii Dinter var. *marthae* (Loesch & Tischer) D.T.Cole **stat. nov** Madoqua 7: 35 (1973). Basionym: *Lithops marthae* Loesch & Tischer 1936. Sukkulent.: 148 (1933)	*Lithops dinteri* Schwantes Z. Sukkulentenk. 3: 97 (1927)

Finally, in *L. dinteri* subsp. *brevis* is separated by more than 100 km from *L. dinteri*. This makes it difficult to argue that it is only a "local variety". The geographical separation means that brevis has been on a separate evolutionary path from the nominate species and that there has been no gene flow between two taxa for eons.

Suggested steps to maintain genetic diversity in light of synonymization

Three simple rules can aid plant conservation and prevent the loss of genetic diversity from inappropriate synonymization.

(1) Authors who want to synonymize species should be required to rebut the original diagnoses point by point to show why the differences that were established to keep taxa separate are mistaken or superseded by better data.

We point out that at present there is an untenable asymmetry between describing new species and extinguishing them via synonymy. An author describing a new species is required to provide a diagnosis that explicitly points out what traits distinguish the new taxon from (the closest) existing ones and why it deserves separate taxonomic status. Clearly, if this asymmetry is not removed, valid species painstakingly described and delineated from other species might vanish in obscurity and the associated genetic differences may go extinct without proper scientific evaluation and justification.

(2) A discussion should be included that addresses the question whether genetic diversity is maintained, if one or more of the synonymized taxa were to vanish from Earth. If the synonymized taxa were cross-bred *ex situ*, would this hamper efforts to reintroduce an extinct population?

To use one of our examples, is it proper to replace the nearly extinct *L. schwantesii* subsp. *gebseri* in the wild with the nominate species or, say, with *L. urikosensis, which has also been synonymized with the nominate species (Jainta 2017, 2019)? Or should we strive to preserve the existing populations of *L. schwantesii* subsp. *gebseri,* which exist *ex situ*, to maintain their gene pool for possible future reintroduction in the wild?

(3) The name(s) of the author(s) who synonymized given taxa should be appended to the synonym. This is already done when an author changes the taxon's status. Using the above example, when Jainta (2019) synonymized *L. dorotheae* Nel with *L. dinteri* the synonym might be listed as **L. dorotheae* Nel(*Jainta).

This rule would have made it a lot easier to figure out, for example, what happened to the many *Dipcadi* species in Table 1 that became synonyms of *D. crispum*.

If these three rules were generally adopted, it would be a leap forward in plant conservation.

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