ALSTERWORTHIA INTERNATIONAL

THE SUCCULENT ASPHODELACEAE JOURNAL

Gasteria batesiana var. *batesiana* 'Sifula' in cultivation.

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Aloe hereroensis Engl. in Botswana

Bruce J. Hargreaves

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I had never been to the southwest corner of Botswana at Bokspits when Torben Larsen went there in March of 1991. He was collecting butterflies for his book on them (still unpublished). He brought back a few plants which were unexpected for Botswana. These included *Aloe hereroensis, Tridentea marientalensis* and *Ruschia cononotata*. Although these are widespread in South Africa and Namibia, they are limited to this SW area in Botswana. I organized a trip for December when plants should be at their best. (In fact it rained and we had to abandon the Nosob River Bed road when the river began flowing!) We found a number of plants of *Aloe hereoensis* as well as *Euphorbia bergii*, another plant limited to this part in Botswana. More recent trips have found *Hoodia gordonii* and *Stapelia flavopurpurea*.

This was not the first report of *Aloe hereroensis* in Botswana. Leistner, 1967, has a photo of the plant on the east bank of the Nosob. I have seen plants at Olifantshoek and Strydenburg in South Africa. At Strydenburg there are hybrids with other species. Reynolds, 1974, lists these as *A. hereroensis* x *A. claviflora* and *A. hereoensis* x *A. grandidentata*. He also reported two other hybrids from elsewhere. No such hybrids are known for Botswana and no other species of *Aloe* is found in the Bokspits area. *Aloe grandidentata* has been reported for eastern Botswana.

Another trip ten years later found most of the aloes dead. No obvious cause was seen. We managed to find one live plant which was unusual in having twelve heads and a well-developed stem. We took one head back to the botanic garden in Gaborone where it not only rooted, but formed an offset. This is contrary to the description of *Aloe hereroensis* as "plants solitary, stemless or short stemmed…" (Glen & Hardy, 2000). A trip in 2005 found aloes still surviving, but *Hoodia gordonii* had succumbed to the heavy rains of the previous season.

References

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Fig. 1.
Aloe hereroensis habitat - Olifantshoek

Fig. 2.
Aloe hereroensis hybrid - Strydenburg

Fig. 3.
Aloe hereroensis inflorescence - Bokspits

Taxonomic implications of genome size for all species of the genus *Gasteria* Duval (Aloaceae)

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Abstract. Nuclear DNA content (2C) is used as a new criterion to investigate all species of the genus *Gasteria* Duval including the three recently described species *Gasteria polita* van Jaarsv., *G. pendulifolia* van Jaarsv. and *G. glauca* van Jaarsv. The 122 accessions investigated have the same chromosome number (2n=2x=14), with exception of three tetraploid plants found. The nuclear DNA content of the diploids, as measured by flow cytometry with Propidium Iodide, is demonstrated to range from 32.8–43.2 pg. This implies that the largest genome contains roughly 1010 more base pairs than the smallest. Based on DNA content the species could be divided in five groups: *G. rawlinsonii* Oberm. with 32.8 pg, 13 mostly inland species with 34.3–36.0 pg, five coastal species with 36.5–39.0 pg and *Gasteria batesiana* Rowley with 43.2 pg. The thirteen species with 34.3–36.0 pg could be divided further, in a group of eight species occupying mainly very restricted areas with 34.3–35.1 pg and a second group of five species with 35.2–36.0 pg mainly occupying large areas. These five groups did not coincide very well with the two sections and four series of *Gasteria* based on a cladistic analysis by van Jaarsveld et al. (1994). Based on its long leafy branches, location in the centre of *Gasteria* species distribution and its by far lowest DNA content, *G. rawlinsonii* might be the most primitive member of the genus.

Nuclear DNA content as measured by flow cytometry is shown to be relevant to provide additional information on the relationships between Gasteria species.

Key words: Gasteria, taxonomy, DNA content, flow cytometry.

Introduction. The genus *Gasteria* Duval (Aloaceae) consist of succulent perennials, endemic in southern Africa. It is widely distributed along the coastal margin of South Africa, forming a horsehoe distribution. *Gasteria* is mainly confined to the coastal plain and adjacent inland region below the great escarpment from south-western Namibia to northern KwaZulu-Natal. Its distribution is extended northwards to Swaziland (Lebombo Mountains) and as far north as Mpumalanga and the Northern Province (Drakensberg foothills) of South Africa (van Jaarsveld et al. 1994, van Jaarsveld 1995). The highest species concentration is in the southeastern part of South Africa between Grahamstown and Uniondale with rain throughout the year. *Gasteria* are aloe-like, drought resistant and easily grown plants often occurring in shade. They range from dwarf *Gasteria bicolor* var. *liliputana* (Poelln.) van Jaarsv. 25 mm to large robust rosettes of *Gasteria acinacifolia* (J. Jacq.) Haw. of up to 700 mm high. The majority are small rosulate succulents with spotted leaves and ideal for horticulture. Most species occur at low altitudes. However, *G. vlokii* van Jaarsv. occurs over a 1000 m in altitude (Groot Swartberg) and *G. excelsa* has been collected at altitudes of 1500 m in the southern Drakensberg. *G. carinata* Duv. and *G. disticha* L. were probably the first species grown outside Africa, reaching Holland at the end of the seventeenth century.

Gasteria taxonomy is generally considered as difficult, as there are few unique characters and these vary considerably depending on growing circumstances and geographical areas. Moreover, flowering already as juvenile plants, they can look very different from the mature specimens. As van Jaarsveld stated (1994): ''The extreme variability and chameleon-like nature of the species have resulted in the publication of about 100 names''. He found that these names were extremely difficult to apply to plants as the original habitat was rarely mentioned and it is difficult to prepare dried specimens. The major revisions of van Jaarsveld et al. (1994) and van Jaarsveld, (1992, 1994) are a landmark in the investigations of *Gasteria.* They have brought the number of species back to 16, but in the meantime three more species have been described bringing the total number at 19.

Gasteria is a well-defined natural and monophyletic group within the Aloaceae (van Jaarsveld et al. 1994). It is clearly distinguished from the other members by its pendulous pedicels and basically gasteriform perianth. All plants investigated have a uniform bimodal chromosome complement and, apart from a few tetraploids, the same chromosome number, 2n=2x=14 (Vosa and Bennett 1990). Genome size Cx (Greilhuber 1979) and C-value (C) are receiving more attention during recent years (Bennett 1972, Ohri 1998). Flow cytometry was successfully used to investigate the genera Helleborus L. (Zonneveld 2001), Hosta Tratt. (Zonneveld and Van Iren 2001), Galanthus (Zonneveld et al. 2003) and Agapanthus (Zonneveld and Duncan 2003). When all species in a genus have the same chromosome number, as in *Gasteria* (Vosa and Bennett 1990) differences in nuclear DNA content have proven to be very effective in delimiting infrageneric divisions in a number of taxa (Ohri 1998). Moreover it is shown (Greilhuber 1998) that species vary less than often assumed and the so-called 'fluid genome' seems not very well founded. In this study the total amount of nuclear DNA as measured by flow cytometry is introduced as a novel criterion in *Gasteria.* It shows that total amount of nuclear DNA is very useful to delimitate the species. Based on the amount of nuclear DNA found and all other relevant taxonomic criteria as published (van Jaarsveld et al. 1994; van Jaarsveld 1992, 1994) the number of species is now estimated at twenty.

Materials and methods

Plant material. Plant material was obtained from the Kirstenbosch Botanical Garden via E. van Jaarsveld, from B. Breckenridge, from C. Grootscholten and from the collection of the author. These are maintained as a living collection in the Kirstenbosch Botanical Garden and vouchers are deposited in the Compton Herbarium (NBG) at Kirstenbosch, Cape Town, RSA.

Flow cytometric measurement of nuclear DNA content. For the isolation of nuclei, about 0.5 cm^2 of the green part of the leaf, or occasionally scape or root (see below) was chopped together with a piece of *Agave americana* L. as internal standard. The nuclear DNA content (2C-value) of *A. americana* is 15.9 picogram (pg) per nucleus as measured with human leucocytes (=7 pg, Tiersch et al. 1989) as the standard (Zonneveld and Van Iren 2001). The chopping was done with a new razor blade in a Petri dish in 0.25 ml nuclei-isolation buffer, with 0.01 % RNAse added, as described by Johnston et al. (1999). After adding 2 ml Propidium Iodide

(PI) solution (50 mg PI/l in isolation buffer) the suspension with nuclei was filtered through a 30 microm. nylon filter. The fluorescence of the nuclei was measured, 30 and 60 min. after addition of PI, using a Partec CA-II flow cytometer. The more DNA is present in a nucleus, the higher is the intensity of the fluorescence. The 2C DNA content of the sample was calculated as the sample peak mean, divided by the Agave peak mean, and multiplied with the amount of DNA of the Agave standard. In most cases, five different samples, and at least 5000 nuclei, were measured twice for each clone. Gasteria nuclei are difficult to isolate as the leaves have a tough outer skin and the inside of the leaf is rather slimy. The green layer in-between was carefully excised, but in some difficult cases we had to resort to other material like scapes or roots. The CVs were in most cases between 2 and 8 (see Fig. 1) and above a CV of 10 new samples were prepared.

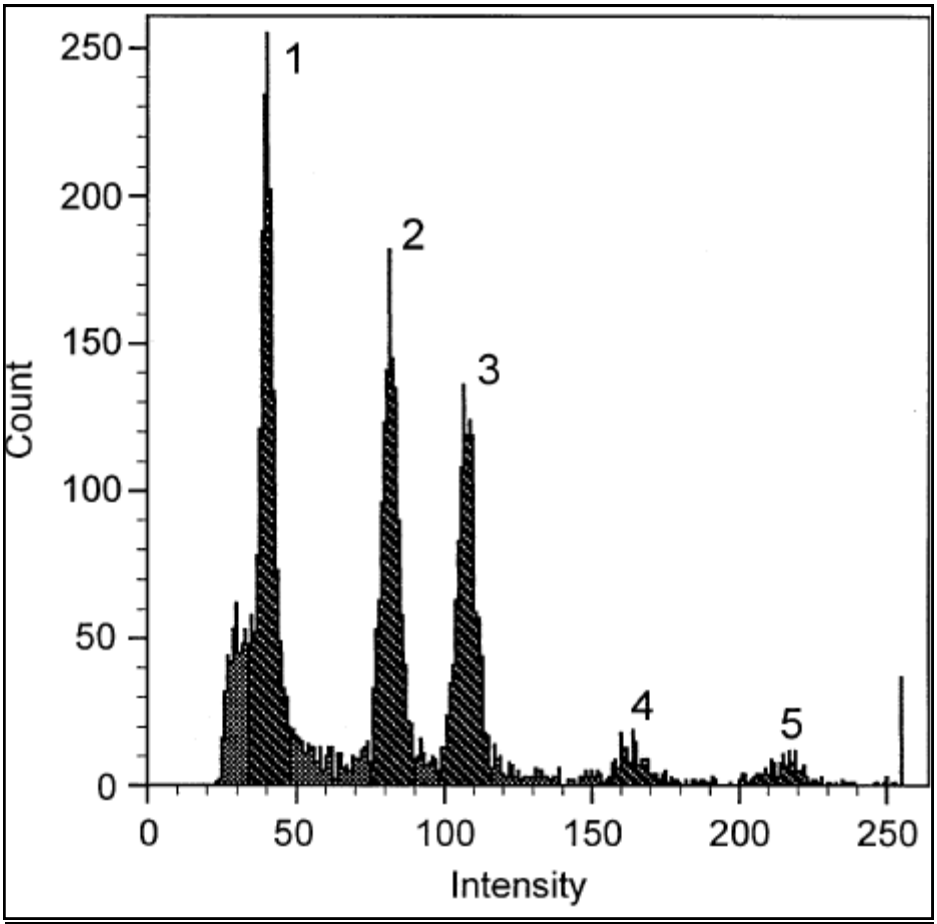
Results and discussion

Nuclear DNA content of the species. The species were classified based on their morphology (Van Jaarsveld 1992, 1994). A fair number are clonally propagated plants used also by Van Jaarsveld for his invest-igations. Flower size, length of stem, flower dimensions and leaf shape were considered by him as important characters.

The amount of DNA per somatic nucleus (2C) and earlier morpho-logical and geographical arguments van (van Jaarsveld et al. 1994; van Jaarsveld 1992, 1994) determined our number of 20 accepted species. In most cases 10 to 20% of the nuclei of Gasteria leaves showed endopolyploidy (Fig. 1).

In Table 1, page 6, the results are shown of the nuclear DNA measurements (2C) of 122 accessions for the species *Gasteria*, arranged alphabetically. Three species, *G. polita* van Jaarsv., *G. pendulifolia* van Jaarsv. and *G. glauca* van Jaarsv. were described after the major revision (van Jaarsveld et al. 1994; van Jaarsveld 1992, 1994). The nuclear DNA content varied from 32.8 pg in *G. rawlinsonii* Oberm. to 43.2 pg in *G. batesiana* Rowley. This difference of about 10 pg is equivalent to 1010 base pairs, so indicates a fair evolutionary distance. Vosa and Bennett (1990) found that the relative chromosome length of the eight long chromosomes measured in 37 *Gasteria* accessions, compared with relative total genome length, ranged from about 33 to 44 microm., whereas the length of the 6 short chromosomes stays constant. Brandham (1976) suggested earlier that the increase in chromosome length (and consequently in nuclear DNA content) is due to numerous small duplications in the long chromosomes.

In Table 2 the results for the species are summarized and arranged with increasing amounts of nuclear DNA. They are divided in five Groups, each with similar amounts of DNA. These Groups differ in several respects from the two Series and four Sections of the cladogram of *Gasteria* species from van Jaarsveld et al. (1994) (Table 3). Yet these five different Groups seem to have also a firm geographical basis. *G. rawlinsonii* is most distinctive, both in floral and vegetative characters (van Jaarsveld 1994). It is the only *Gasteria* with up to 2 meter long, leafy and pendent stems and the leaves are often armed with prickles. The absence of regeneration from detached leaves and of leaf maculation were considered reversions in their cladogram. Noting also the low amount of nuclear DNA of *G. rawlinsonii* and its occurrence in the centre of *Gasteria* species diversity, it is suggested that it could be the most primitive member of the genus. This is contrary to the opinion of van Jaarsveld (1994, p.40) who suggests that G. acinacifolia, G. croucheri and *G. batesiana* (with the highest amounts of nuclear DNA!) to be the most primitive species. If the latter was true, it would mean that *Gasteria* is the first genus where nearly all species did arise by a decrease in DNA. The second and third groups are hardly different in DNA content.



Peak	Index	Mode	Mean	Area#	Area%	CV%
1	0.41	41	40	1575	30.36	5.00
2	0.82	82	82	1220	23.52	3.05
3	1.07	107	108	1084	20.90	2.31
4	1.64	164	164	171	3.30	1.83
5	2.17	217	215	131	2.53	2.79

Fig. 1. Histogram of fluorescense intensity of 5187 nuclei, isolated and stained simultaneously with Propidium Iodide.
1. *Agave americana* (standard). 2. and 4. *Gasteria rawlinsonii*. 3. and 5. *Gasteria batesiana*. (4. and 5. are nuclei with a tetraploid amount of DNA of 2 and 3 resp.

Table 1. Alphabetical list of *Gasteria* species with accession number, locality cq source, nuclear DNA content (2C) with standard deviation, and average for the species with standard deviation

Gasteria species	acc #	locality/source	2C DNA, pg	st dev	sp. average	st dev
acinacifolia (Jacq.) Haw.	BZL 001	Malgas	38.7	0.6	38.0	0.5
acinacifolia (Jacq.) Haw.	FGB 141	Willows	38.1	0.7		
acinacifolia (Jacq.) Haw.	FGB 192	Hort.	37.8	1.0		
acinacifolia (Jacq.) Haw.	FGB 190	Hort	38.1	1.0		
acinacifolia (Jacq.) Haw.	FGB 141	Willows	38.4	0.4		
acinacifolia (Jacq.) Haw.	FGB 141b	Willows	37.8	0.5		
acinacifolia (Jacq.) Haw.	FGB 001	Birt clone	37.4	0.6		
acinacifolia (Jacq.) Haw.	EvJ16802	The Heads,Krysna	37.6	1.4		
acinacifolia (Jacq.) Haw.	EvJ480/86	Port Elizabeth	37.1	0.3		
acinacifolia (Jacq.) Haw.	EvJ9123	Natures Valey	38.5	0.8		
acinacifolia (Jacq.) Haw.	J.duToit	Storms River	38.4	0.9		
acinacifolia 'Grandiflora'	FGB 134	Hort.	76.6	1.6		
batesiana Rowley	BZL 005	Nurs. Bos	44.0	0.8	43.2	0.6
batesiana Rowley	BZL 006	Nurs.Whitestone	43.6	0.6		
batesiana Rowley	EvJ 007	light leaf form	43.7	0.7		
batesiana Rowley	EvJ 008	Barberton	43.2	1.3		
batesiana Rowley	FGB 009	Hort.	42.2	0.7		
batesiana Rowley	FGB 153	Pongola Dam	43.7	0.6		
batesiana Rowley	18239	Sifula, Mzimnyati	43.2	1.3		
batesiana var. dolomitica	FGB 154	Penge	42.4	0.6		
batesiana var. dolomitica	GRC 9	Penge	42.6	0.7		
batesiana var. dolomitica	GRC 11	Penge small form	43.1	0.5		
species nova?	18354	Tukhela river	42.7	1.2		
baylissiana Rauh	BZL 042	Suurberg	35.3	1.1	35.8	0.4
baylissiana Rauh	BZL 009	Nurs.Grootscholten	35.5	0.6		
baylissiana Rauh	EvJ 002	type plant	36.1	0.8		
baylissiana	Rauh	CGS 003 Oudekraal	36.1	0.6		
baylissiana Rauh	EvJ16046	Witterivier,Oudekraal	35.9	0.7		
bicolor var. bicolor Haw.	BZL 012	Hort. large form	35.2	0.4	35.3	0.5
bicolor var. bicolor Haw.	EvJ 014	Mortimer 412	35.0	0.3		
bicolor var. bicolor Haw.	EvJ 015	Oakhill farm	35.6	0.5		
bicolor var. bicolor Haw.	GRC 14	Oakhill farm	34.9	0.6		
bicolor var. bicolor Haw.	BZL 059	BG Groningen	34.8	0.2		
bicolor var. bicolor Haw.	BZL 063	Nurs. Obesa	34.4	1.6		
bicolor var. bicolor Haw.	BZL 011	N.of Jansenville	35.0	0.7		
bicolor var. bicolor Haw.	FGB 169	Gamtoos river	34.9	0.6		
bicolor var. bicolor Haw.	FGB 128	Hort.	36.0	0.4		
bicolor var. bicolor Haw.	FGB 016	MacKay Bridge	35.2	1.0		
bicolor var. bicolor Haw.	FGB 020	Haw. Soc. seed	35.2	0.5		
bicolor var. bicolor Haw.	FGB 018	Hort.	36.1	1.0		
bicolor var. liliputana	BZL 062	Hort.	35.1	0.4		
bicolor var. liliputana	BZL 016	Hort. short leaf	35.9	0.8		
bicolor var. liliputana	EvJ 017	Stonedale	35.5	0.4		
bicolor var. liliputana	BZL 018	medium size leaf	36.1	0.3		
bicolor var. liliputana	BZL 019	long leaf	34.9	0.6		
bicolor var. liliputana	BZL 069	Hort.	35.6	0.4		
bicolor var. liliputana	FGB 014	Grahamstone	34.9	0.7		
bicolor var. liliputana	FGB 022	NE Grahamstone	34.8	0.3		
bicolor var. liliputana	FGB 024	Hort.	35.1	0.9		
bicolor var. liliputana	R. Bayliss	Swartwaterspoort	35.8	1.0		
bicolor var. liliputana	D. Court	Swartwaterspoort	35.7	0.9		
brachyphylla	GRC 23	Barrydale	35.3	0.6	35.2	0.8
brachyphylla cf	FGB 145 3		6.1	0.5		
brachyphylla	BZL 010	Hort.	34.2	0.9		
brachyphylla var. bayeri	EvJ 013		35.2	0.6		
carinata var. carinata Duv.	CGS 05		40.4	0.3	39.0	0.8
carinata var. verrucosa	BZL 024	Hort.	39.9	1.0		
carinata var. verrucosa	BZL 025	Nurs. Bos	39.2	0.9		

Gasteria species	acc #	locality/source	2C DNA, pg	st dev	sp. average	st dev
carinata var. verrucosa	BZL 026	Hort.	38.4	1.2		
carinata var. verrucosa	BZL 070	Hort.	38.3	0.7		
carinata var. verrucosa	BZL 028	Hort.	38.8	0.7		
carinata var. retusa	CGS 04 N.	Worcester	39.0	0.5		
carinata var. retusa	EvJ 029		39.9	0.6		
carinata var. retusa	CGS 01	Nurs.Grootscholten	39.8	0.0		
carinata var. glabra	FGB 033	Groot Brak	38.2	0.3		
carinata var. glabra	FGB 031	Klein Vlei	37.6	1.0		
carinata var. thunbergii	CGS 013	Herbertsdale	38.4	0.2		
carinata var. thunbergii	EvJ 023	N Gouritz river	39.1	0.6		
croucheri (Hook.f.) Bak.	GRC 032	Izothsha	37.1	0.7	37.7	0.6
croucheri (Hook.f.) Bak.	FGB 118	Oribi Gorge	37.5	0.3		
croucheri (Hook.f.) Bak.	GRC 38a	Mtentu river	37.3	0.5		
croucheri (Hook.f.) Bak.	FGB 191	Hort.	37.3	0.8		
croucheri (Hook.f.) Bak.	BZL 057	Oribi Gorge 1	8.1	0.7		
croucheri (Hook.f.) Bak.	EvJ 9204	Oribi Poort	38.2	0.8		
croucheri (Hook.f.) Bak.	JXH28	Mzimvubu river	38.7	0.5		
disticha (L.) Haw.	CGS 009	Brand river	35.7	0.4	35.4	0.5
disticha (L.) Haw.	EvJ 001	Beaufort west	35.0	0.5		
ellaphieae van Jaarsv.	BZL 034	Alicedale	34.8	0.6	34.9	0.2
ellaphieae van Jaarsv.	EvJ 035	Kouga dam	34.7	0.5		
ellaphieae van Jaarsv.	BZL 036	Kouga dam	35.1	1.5		
excelsa Bak.	EvJ1997	Cala pass	37.4	1.3	36.5	0.5
excelsa Bak.	EvJ 061		37.0	0.2		
excelsa Bak.	EvJ 17877	Keibolo	36.6	1.2		
excelsa Bak.	EvJ 7622	Cala Pass	36.4	1.2		
excelsa Bak.	EvJ 778/58	Cala pass	36.3	1.2		
excelsa Bak.	BZL 033	Nurs.Grootscholten	72.0	3.3		
glauca van Jaarsv.	CGS 02	Kouga river	35.5	0.6	35.1	0.6
glauca van Jaarsv.	BZL 064	Kouga river	34.7	0.8		
glomerata van Jaarsv.	EvJ 037	Kouga dam	35.3	0.5	34.8	0.4
glomerata van Jaarsv.	BZL 039	Kouga dam	34.6	0.2		
glomerata van Jaarsv.	EvJ 038	small form 1	34.6	1.0		
glomerata van Jaarsv.	EvJ 038a	small form 2	34.6	0.8		
nitida (Salm-Dyck) Haw.	BZL 046 coll.	G Barad 1983	35.6	0.8	35.1	0.6
nitida (Salm-Dyck) Haw.	BZL 066	Taaibos laagte	34.5	0.3		
nitida 'Beckeri'	BZL 045	Whitestone	35.3	0.3		
nitida var. armstrongii *	BZL 043	Hort.no 1	33.6	0.2	34.3	0.6
nitida var. armstrongii *	BZL 043a	Hort. no 2	34.6	0.7		
nitida var. armstrongii *	BZL 068	Hort.no 3	34.0	1.0		
nitida var. armstrongii *	FGB 54a	ex Japan	35.2	0.5		
nitida var. armstrongii *	EvJ	Jeffreys Bay	34.0	0.6		
pendulifolia van Jaarsv. *	FGB 043	Shongweni	37.3	1.5	37.8	0.7
pendulifolia van Jaarsv. *	GRC 035	Mamba Valley	37.6	1.1		
pendulifolia van Jaarsv. *	EvJ 17305	Shongweni Dam	38.6	0.9		
pillansii var. pillansii Kensit	BZL 047	Bloukranspas	35.6	1.2	36.0	0.7
pillansii var. pillansii Kensit	EvJ 048	pale leaf form	36.6	0.9		
pillansii var. pillansii Kensit	BZL 049	as 'neliana'	35.7	0.8		
pillansii var. ernesti-ruschii	BZL 050	Gemsbokvlei	35.2	0.5		
pillansii var. ernesti-ruschii	BZL 051	Oranje river	35.8	0.6		
pillansii var. ernesti-ruschii	BZL 052	Lekkersing	37.0	0.4		
polita van Jaarsv.	GRC 007	Whiskey Creek	35.4	0.6	34.7	1.0
polita van Jaarsv.	EvJ 003	type plant	34.0	0.2		
pulchra (Ait.) Haw.	BZL 053	Hankey	35.0	0.6	34.8	0.2
pulchra (Ait.) Haw.	BZL 040	Pratensie	34.8	1.1		
pulchra (Ait.) Haw.	CGS 092	N Hankey	34.9	0.8		
pulchra (Ait.) Haw.	KVD 004	Gamtoos	34.7	0.4		
pulchra (Ait.) Haw.	EvJ13814	Keurkloof, Hankey	34.5	1.0		

Gasteria species	acc #	locality/source	2C DNA, pg	st dev	sp. average	st dev
rawlinsonii Oberm.	BZL 054	Baviaans kloof	32.2	1.3	32.8	0.7
rawlinsonii Oberm.	EvJ 055	Bav. kloof, spiny leaf	32.6	0.3		
rawlinsonii Oberm.	GRC 067	Geelhoutbos kloof	33.6	0.8		
vlokii van Jaarsv.	EvJ 056		35.4	1.0	35.0	0.3
vlokii van Jaarsv.	FGB 132a		34.9	0.7		
vlokii van Jaarsv.	CGS 011	Zwartberg	34.8	0.4		
Poellnitzia rubriflora	BZL 067		35.0	0.8	35.0	

Table 2. Gasteria species arranged according to increasing nuclear DNA content (2C) and divided into Groups accordingly. In bold are added species newly described since van Jaarsveld 1994

		2C DNA in pg
Group A	*G. rawlinsonii* Oberm.	32.8
Group B	***G. armstrongii* Schonl.**	**34.3**
	***G. polita* van Jaarsv.**	**34.7**
	G. glomerata van Jaarsv.	34.8
	G. pulchra (Ait.) Haw.	34.8
	G. ellaphiae van Jaarsv.	34.9
	G. vlokii van Jaarsv.	35.0
	***G. glauca* Van Jaarsv.**	**35.1**
	G. nitida (Salm-Dyck) Haw.	35.1
Group C	*G. brachyphylla* (Salm-Dyck) van Jaarsv.	35.2
	G. bicolor Haw.	35.3
	G. disticha (L.) Haw.	35.4
	G. baylissiana Rauh	35.8
	G. pillansii Kensit	36.0
Group D	*G. excelsa* Bak.	36.5
	G. croucheri (Hook.F.) Bak.	37.7
	***G. pendulifolia* van Jaarsv.**	**37.8**
	G. acinacifolia (Jacq.) Haw.	38.0
	G. carinata (Mill.) Duv.	39.0
Group E	*G. batesiana* Rowley	43.2
	G. sp. nov.?	**42.7**

Table 3. Gasteria species divided into Sections and Series according to van Jaarsveld et al., (1994) with their nuclear DNA content (2C) added (this article). In bold are added species newly described since van Jaarsveld 1994.

	2C DNA in pg
A. Section Longiflorae	
I. Series Longifoliae	
G. batesiana Rowley	43.2
G. sp. nov.?	**42.7**
G. croucheri (Hook.F.) Bak.	37.7
***G. pendulifolia* van Jaarsv.**	**37.8**
G. acinacifolia (Jacq.) Haw.	38.0
***G. polita* van Jaarsv.**	**34.7**
II. Series Multifariae	
G. excelsa Bak.	36.5
G. pulchra (Ait.) Haw.	34.8
G. carinata (Mill.) Duv.	39.0
G. nitida (Salm-Dyck) Haw.	35.1
G. ellaphiae van Jaarsv.	34.9
***G. glauca* van Jaarsv.**	**35.1**
G. vlokii van Jaarsv.	35.0
B. Section Gasteria	
IV. Series Gasteria	
G. bicolor Haw.	35.3
G. disticha (L.) Haw.	35.4
G. brachyphylla (Salm-Dyck) van Jaarsv.	35.2
G. rawlinsonii Obermeyer	32.8
G. glomerata van Jaarsv.	34.8
G. baylissiana Rauh	35.8
III. Series Namaquana	
G. pillansii Kensit	36.0

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They are mainly separated with respect to the size of their growing areas. Group B with eight species ranging from 34.4 to 35.1 pg are all species with restricted distributions (habitat not overlapping) except the variable *G. nitida*, occurring in grassland (Fig. 2). Group C with five species with 35.2 to 36.0 pg, consist of more southeastern and westerly growing species, each with large growing areas (Fig. 3). The exception is G. *baylissiana* Rauh with 35.7 pg, which is in Group C the only one with a very restricted area (Fig 3). Going from the south to the west of South Africa the amount of DNA increases in this Group C. The five species of Group D (Fig. 4, page 10), having higher amounts of DNA from 36.5 to 39 pg, consist also of species with a large growing area but all are confined more or less to the southern and northeastern coast. Interestingly there is an increase in nuclear DNA from north (*G. pendulifolia* 37.8 pg, *G. croucheri* 37.7 pg both in Kwa Zulu-Natal) to the south (*G. excelsa* 36.5 pg, *G. acinacifolia* 38.0 pg) and west (G. carinata 39.0 pg). Our Group D partly coincides with the series Longifoliae of van Jaarsveld et al. (1994), (Table 3). However, *G. polita* van Jaarsv. with only 34.7 pg clearly does not belong in this Series. Also, *G. excelsa* (36.5 pg) and G. *carinata* (39.0) do not fit in Series Multifariae where the other six species have nuclear DNA contents of 34.8 – 35.2 pg and are here added to Group D. The variable *G. batesiana* Rowley forms a fifth group. It is not only the most northerly growing *Gasteria* with a very wide and scattered distribution, but it has also at least four pg more DNA than any other *Gasteria*.

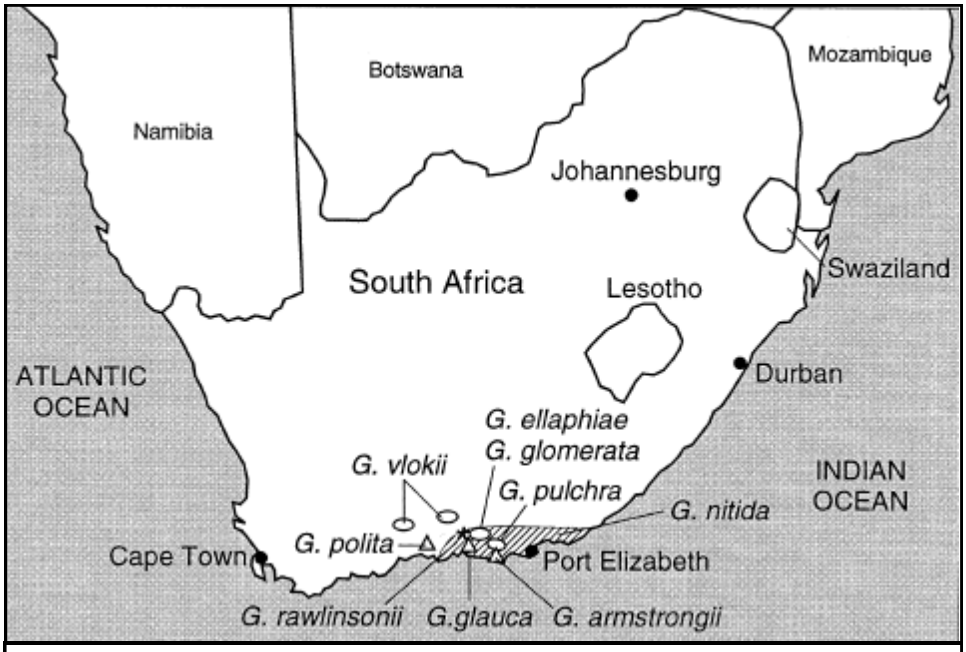

Fig. 2. The main localities of the species of Gasteria of Group A and B, altered after van Jaarsveld et al. (1994) with the additional species given as triangles.

Group A. *G. rawlinsonii* van Jaarsv. (Asterisk)
Group B. *G. armstrongii* Schonl., *G. polita* van Jaarsv., *G. glomerata* van Jaarsv., *G. pulchra* (Ait.) Haw. *G. ellaphieae* van Jaarsv., *G. vlokii* van Jaarsv., *G. glauca* van Jaarsv., *G. nitida* (Salm-Dyck) Haw

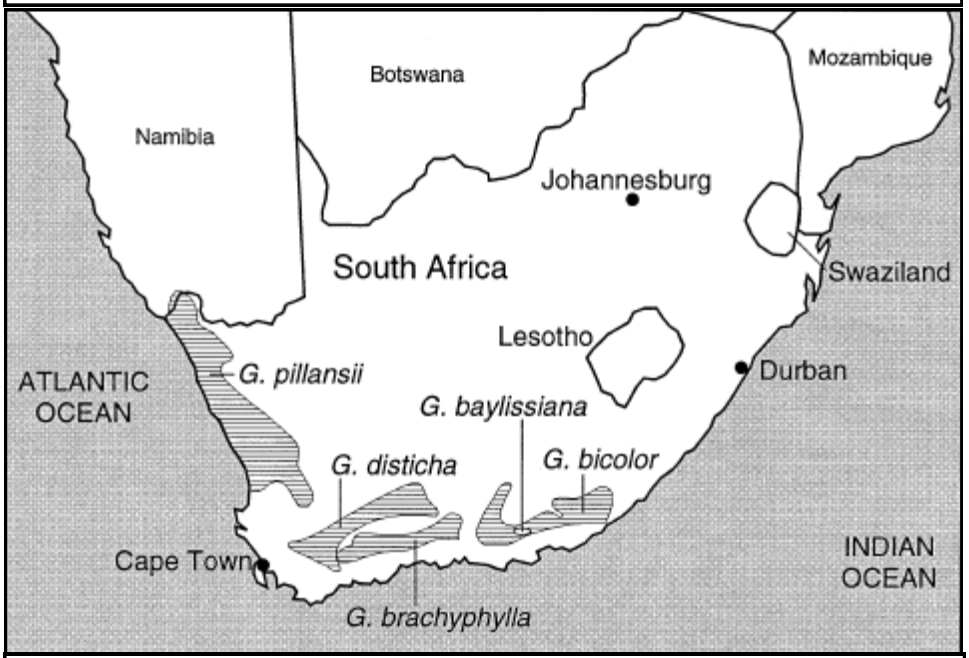

Fig. 3. The main localities of the species of Gasteria of Group C, altered after van Jaarsveld et al. (1994).

Group C. *G. bicolor* Haw., *G. brachyphylla* (Salm-Dyck) van Jaarsv., *G. disticha* (L.) Haw., *G. baylissiana* Rauh, *G. pillansii* Kensit.

Especially in Group B and C the values of the nuclear DNA content are very close (Table 2). Different values usually indicate different species, identical values do not necessarily indicate the same species, and it might just be coincidence. Still, the question arises if some of the species of Group B and C are separate species or only subspecies. E.g. van Jaarsveld states that *G. ellaphieae*, *G. vlokii*, *G. nitida*, and *G. glauca* can be added, (*as they* Ed.) have very similar flowers. As their DNA content is nearly identical may be it is just one variable species.

The new species

G. glauca van Jaarsv. is stated to be close to *G. ellaphieae* van Jaarsv. and that it is here confirmed with nearly identical amounts of DNA. The same is true for *G. pendulifolia* van Jaarsv. described as close to *G. croucheri* (Hook.f.) Bak. both are having the same amount of DNA. On the other hand, *G. polita* van Jaarsv. is described as closely related to *G. acinacifolia* (Jacq.) Haw. (van Jaarsveld 2001). However there is a four pg difference in DNA content making this connection unlikely. Recently, a so far undescribed taxon was discovered with glabrous leaves like *G. croucheri* but

growing closer to the warty leaved *G. batesiana* (Table 1 as sp. n.). It might be a new species but as its nuclear DNA content is very close to that of *G. batesiana*, it could be just a glabrous variety of the latter.

G. pendulifolia van Jaarsv. differs from *G. croucheri* (Hook.f.) Bak. by its smaller size, prolific cluster forming nature, glaucous leaf coloration, narrow pendulous leaves and an entire leaf margin only. It is therefore better described as *G. croucheri* subsp. *pendulifolia* (van Jaarsv.) Zonn.
Basionym: *G. pendulifolia* van Jaarsv. Cactus and Succulent J. (US) 2001. 73–2:68–70.

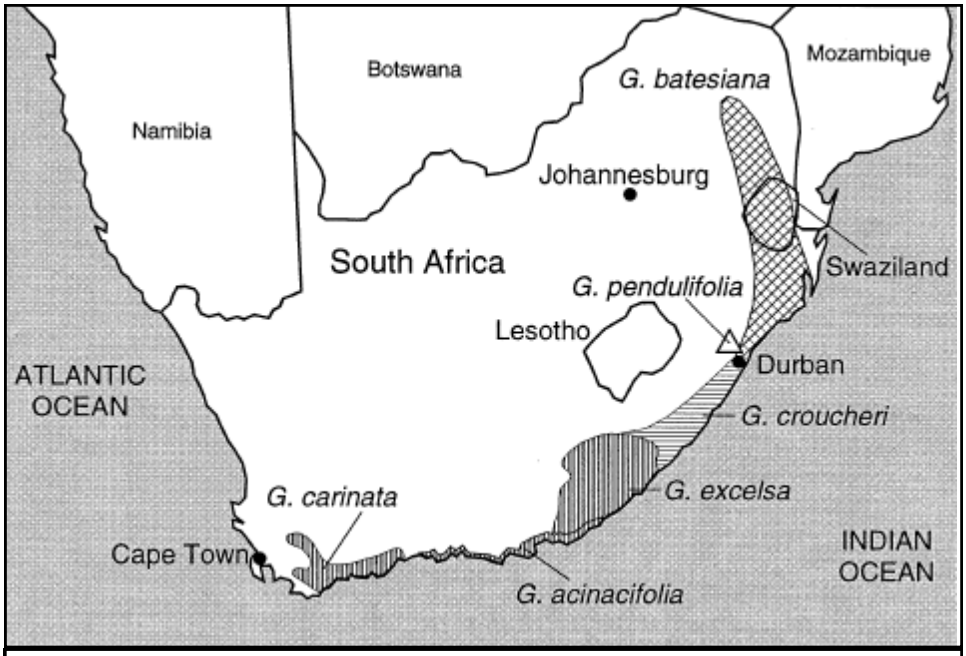

Fig. 4. The main localities of the species of *Gasteria* of Group D and E. altered after van Jaarsveld et al. (1994) with the additional species (in bold) given as a triangle.

Group D. *G. croucheri* (Hook.F.) Bak., *G. croucheri* ssp. *pendulifolia* (van Jaarsv.) Zonn., *G. excelsa* Bak., *G. acinacifolia* (Jacq.) Haw., *G. carinata* (Mill.) Duv. (whole Group striped).
Group E. *G. batesiana* Rowley

The varieties.

Van Jaarsveld describes nine plants at a rank below species. They are: *G. batesiana* var. *dolomitica*, *G. bicolor* var. *liliputana*, *G. brachyphylla* var. *bayeri*, *G. carinata* vars. *verrucosa*, *retusa*, *glabra* and *thunbergii*, *G. nitida* var. *armstrongii* and *G. pillansii* var. *ernesti-ruschii*. Eight of these coincide with the nominate species in their DNA content confirming their placement by van Jaarsveld. The exception is *G. nitida* var. *armstrongii*. It has short, distichous and retuse leaves and it also differs in its DNA content of 34.3 pg from *G. nitida* var. *nitida* with 35.1 pg. Therefore *G. nitida* var. armstrongii is reinstated as a separate species: *G. armstrongii* Schonl.

Tetraploidy and other deviations.

In the 122 plants investigated only three tetraploids were found: *G. acinacifolia* 'Grandiflora', with 76.7 pg; *G . excelsa* ? with 72.0 pg and *G. disticha* ? 'Nigricans' with 75.8 pg. *G. nigricans* var *crassifolia* (syn. of *G. disticha*), *G. spiralis* (syn. of *G. bicolor*) and *G. subverrucosa* (syn. of *G. carinata*) were earlier decribed as having a tetraploid chromosome number (Brandham 1976) and in the list of Kew DNA C-values a *G. brachyphylla* is mentioned as tetraploid. It is not known if some of these are the same plants and it cannot be excluded that they are hybrids. An artificial made hybrid between *G. batesiana* and *G. brachyphylla* was with 38.8 pg, as expected, about halfway between the parents in nuclear DNA content. Two forms of ''atypical'' *G. bicolor* var. *liliputana* from Swartwaterspoort were measured, as illustrated by van Jaarsveld (1994, p. 73). Their nuclear DNA content is very similar to typical *G. bicolor* so they indeed belong to that species. *Poellnitzia rubiflora* Uitew., used as an outgroup in the cladogram by van Jaarsveld et al. (1994) has 35.0 pg of nuclear DNA.

Evolutionary considerations

Kalender et al. (2000) suggested that in dry, growth-limited situations species adapt over evolutionary time with an increase in DNA content and a decrease in permanently wet situations. This was confirmed for *Hosta* (Zonneveld and van Iren 2001), and seems also to be true for *Gasteria* but not for *Galanthus* (Zonneveld et al. 2003). Phylogenetic trees cannot be derived from nuclear DNA contents, but it can provide clues in elucidating relationships among species. Assuming an increase only in DNA content, the following can therefore be envisioned (Figs. 2 and 3). From the most primitive species *G. rawlinsonii*, Group B arose. Except for the widely distributed G. *nitida*, which clearly belongs to this group being also summer flowering, the remainder are now confined to very restricted areas (Fig. 2). Two grow on inaccessible cliffs (*G. glomerata*, *G. glauca*), *G. vlokii* is distributed on mountain tops in the west and *G. ellaphieae*, a chasmophyte well camouflaged in its thicket habitat, is restricted to the Kouga River near Hankey and might be considered a relict species. Subsequently species of Group D arose. Their three pg higher DNA content suggested that they had a long time to get adapted to a more coastal habit and to get larger flowers. Within this Group D the spread to the south shows an increase in DNA content. The most northerly species *G. batesiana* shows a strong increase in DNA to 43.2 pg, maybe as an adaptation to a hotter climate. Based on only a slight increase in DNA, culminating so far in *G. pillansii* Kensit with 36.0 pg, a more recent wave of species resulted in those of Group C. Nearly all occupy a far more extensive area (Fig. 3) than those of the Group B (Fig. 2) with similar amounts of nuclear DNA. The exception is *G. baylissiana* that has, contrary to the other species of Group D (Fig. 3), a restricted territory. We are the first to admit that the above evolutionary considerations are rather speculative, to say the least. However, they might form a basis for further thoughts about these matters. The above considerations are based on the available data collected. The DNA content confirms several relationships that were already suggested by van Jaarsveld et al. (1994) and van Jaarsveld (1992, 1994) based on morphological and geographical arguments. Each species has a certain amount of DNA, which is of systematic value. However the results, if based on nuclear DNA content, suggests partly other relationship than found in the cladistic analysis of van Jaarsveld et al. (1994). This contrary to the nuclear DNA content in the 16 species of *Helleborus* (Zonneveld 2001) that coincided exactly with the subgenera and sections devised by Mathew (1989). DNA sequencing could bring

further light in this discrepancy and also throw more light on the evolutionary aspects. Flow cytometry provides a valuable extra set of data. It is shown, combined with morphological and geographical characters, to be able to provide new insights in the species relationships between members of the genus *Gasteria.*

I (BJMZ) would like to thank F. van Iren who kept the flow cytometry apparatus going, J. F. Veldkamp of the National Herbarium Nederland, Leiden Branch, for nomenclatural advice and P. Hock for redrawing Figs. 2, 3 and 4.

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Editor's Note.

For ease of reference tables 4 to 7 on page 12, which are not part of the above article, list the taxa accepted by Ernst van Jaarsveld in his book Gasterias of South Africa and subsequent publications up to and including his "The genus *Gasteria*: a synoptic review (new taxa and combinations)" published in Aloe 44:4(2007). This latter takes into account the results of the "Taxonomic implications of genome size for all species of the genus *Gasteria* Duval (Aloaceae)" by Ben Zonneveld and Ernst van Jaarsveld.

"The genus *Gasteria*: a synoptic review (new taxa and combinations)" is published on pages 17-28 with some slight modifications and the opportunity has been taken to include van Jaarsvled's published cultivars.

Acknowledgements.

I am deeply indebted to Ben Zonneveld and Ernst van Jaarsveld for permission to publish their paper "Taxonomic implications of genome size for all species of the genus *Gasteria* Duval (Aloaceae)". It was originally published in Plant Systomatics and Evolution 251: 217–227 (2005) and on line February 24, 2005 Springer-Verlag 2005.

It is basic to Ernst's synoptic review and invaluable reading for interested members.

Table 4.
Species listed in Gasterias of South Africa - A new revision.

Gasteria acinacifolia (Jacq.) Haw. + three cultivars 'Knysna', 'Tsitsikamma' & 'Algoa'

Gasteria batesiana Rowley + four cultivars 'Pongola', Golela', 'Barberton', 'Penge' & 'Klipwal'.

Gasteria baylissiana Rauh.

Gasteria bicolor Haw. + four cultivars 'Pearston', 'Mackay 'Bridge', 'Committes Drift' & 'Bowie'.
Gasteria bicolor v. *liliputana* (V. Poelln) v. Jaarsveld + two cultivars 'Swartwater' & 'Pluto's Vale'.

Gasteria brachyphylla (Salm-Dyck) E.J. v. Jaarsveld v. *brachyphylla* + four cultivars 'Brandriver', 'Cango', Willowmore' & 'Gamka'
Gasteria brachyphylla v. *bayeri* E.J. v. Jaarsveld..

Gasteria carinata (Mill.) Duval v. *carinata* + five cultivars 'Kykoedie', Gourits', 'Mossel Bay', 'Great Brak' & 'Klein Brak'.
Gasteria carinata v. *retusa* E.J. v. Jaarsveld.
Gasteria carinata v. *verrucosa* (Mill.) E.J. v. Jarrsveld + five cultivars 'Malgas', 'Infanta', 'Port Beaufort', 'Albertina' & 'Herbertsdale'.

Gasteria croucheri (Hook f.) Bak. + three cultivars 'Oribi', 'Shongweni' & 'Umgeni'.

Gasteria disticha (L.) Haw. + three cultivars 'Nuy', 'Pieter Meintjies' & 'Beaufort West'.

Gasteria ellaphieae E.J. v. Jaarsveld.

Gasteria excelsa Bak. + two cultivars 'Gaika' & 'Nqancule'

Gasteria glomerata E.J. v. Jaarsveld.

Gasteria nitida (Salm-Dyck) Haw. v. *nitida*.
Gasteria nitida v. *armstrongii* (Schonl.) E.J. v. Jaarsveld.

Gasteria pillansii Kensit v. *pillansii* + four cultivars 'Clanwilliam', 'Krakadou', 'Vredendal' & 'Rosyntjiesberg'.
Gasteria pillansii v. *ernesti-ruschii* (Dinter & V. Poelln.) E.J. v. Jaarsveld.

Gasteria pulchra + one cultivar 'Studtis'.

Gasteria rawlinsonii Oberm.

Gasteria vlokii E.J. v. Jaarsveld.

Table 5.
Taxa published since Gasterias of South Africa.

Gasteria *carinata* v. *glabra* (Salm-Dyck) van Jaarsveld. C&SJ US 70(2)70.
Gasteria carinata v. *thunbergii* (N.E. Brown) van Jaarsveld. C&SJ US 70(2)4. (in Gasterias of South Africa included under *Gasteria carinata* v. *verrucosa* with a note that *Gasteria carinata* v. *verrucosa* 'Herbertsdale' "..corresponds very well with Thumberg's specimen (UPS) described by N.E. Brown as *Gasteria thunbergii*".)

Gasteria batesiana v. *dolomitica* van Jaarsveld & E.A. van Wyk. Aloe 36(4)74 (2000)

Gasteria doreeniae van Jaarsveld & A.E. van Wyk. Aloe 41 (4)81-82.

Gasteria glauca van Jaarsveld Flowering Plants of Africa 58:16-21 Aloe or C&SJ US 70(2)65-66 {IOS}

Gasteria pendulifolia van Jaarsveld C&SJ US73(2)68-70 (2001). Reclassified as *Gasteria* ssp. *pendulifolia* in Plant Systematics and Evolution 251:217-227 (2005).

Gasteria polita van Jaarsveld C&SJ US 73(3)127-129 (2001)

Gasteria tukhelensis van Jaarsveld. Bothalia 35(2)154-165.

Gasteria croucheri v. *pendulifolia* (van Jaarsveld) Zonneveld Pl. Syst. Evol 251:225 2005).

Table 6.
New species & cultivars in Aloe 44:4

Gasteria armstrongii Recorded as *Gasteria nitida* v. *armstrongii* in Gasterias of South Africa. Table 1. Reverts to species status.

Gasteria batesiana 'Mzimduzi' & 'Sifula'.

Gasteria bicolor v. *fallax* (Included in G. *bicolor* v. *bicolor* in Gasterias of South Africa.) Reverts to variety status.

Gasteria disticha v. *leangebergensis* new variety.
Gasteria disticha v. *robusta* new variety.

Gasteria pillansii v. *hallii* New variety.

Gasteria retusa formerly *G. carinata* v. *retusa*

Gasteria thunbergii formerly *G. carinata* v. *thunbergii*

Table 7. ***Gasteria*** **species accepted by van Jaarsveld in Aloe 44:4.**

Gasteria acinacifolia
Gasteria armstrongii
Gasteria batesiana var. *batesiana*
Gasteria batesiana var. *dolomitica*
Gasteria baylissiana
Gasteria bicolor var. *bicolor*
Gasteria bicolor var. *fallax*
Gasteria bicolor var. *liliputana*
Gasteria brachyphylla var. *brachyphylla*
Gasteria brachyphylla var. *bayeri*
Gasteria carinata var. *carinata*
Gasteria carinata var. *glabra*
Gasteria carinata var. *verrucosa*
Gasteria croucheri subsp. *croucheri*
Gasteria croucheri subsp. *pendulifolia*
Gasteria disticha var. *disticha*
Gasteria disticha var. *langebergensis*
Gasteria disticha var. *robusta*
Gasteria doreeniae
Gasteria ellaphieae
Gasteria excelsa
Gasteria glauca
Gasteria glomerata
Gasteria nitida
Gasteria pillansii var. *pillansii*
Gasteria pillansii var. *emesti-mschii*
Gasteria pillansii var. *hallii*
Gasteria polita
Gasteria pulchra
Gasteria thunbergii
Gasteria viokii
Gasteria retusa
Gasteria rawlinsonii
Gasteria tukhelensis

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Corrigenda.

Alsterworthia International 7(1)7.
Bruce Hargreaves requests that the following amendments should be made to
Fig. 20. Replace "*Aloe cameronii* Botswana" with "*Aloe christianii* Botswana".
Fig. 21. Add to the caption "Zimbabwe".
Fig. 22. Add to the caption "Malawi".
Fig. 23. Replace "Nyangwe …7 May 1969" with "Dedza Mountain, Malawi".

Alsterworthia International 8(1)10.
Gordon Rowley writes "I am indebted to Terry Smale for pointing out a nomenclatural error in my list of *Haworthia* cultivar names in the March 2008 issue of Alsterworthia International page 10. Von Poellnitz's *H. zantneriana* was not, after all, taken up as a cultivar name, thus leaving the way clear for the epithet to be used for a variety of different species. Hence please delete my substitute name 'Alfred Zantner' and replace it with 'Zantneriana', to accord with the ICNCP."

Membership Renewal 2009.

The enclosed form gives full details of Alsterworthia International representatives for 2009, methods of payment and details of books available to members at favourable terms.
Non-members should preferably obtain books direct form local booksellers.

I should like to place on record my sincere appreciation of the support that Petr Pavelka has given to Alsterworthia International since its inception. The Czech Republic has one of the highest recorded Alsterworthia International memberships of any non-English speaking country, thanks to the efforts of Petr. Petr has now handed over the representation to Jakub Jilemicky, who has been a long standing subscriber to Alsterworthia International.

Did you know that 2010 is the 10th anniversary of Alsterworthia International?

Earnst van Jaarsveld's the Genus *Gasteria*

Ernst van Jaarsveld's book **Gasterias of South Africa - A new revision** (1994) is the standard for naming gasterias throughout the hobby and scientific circles. 16 species were accepted in that book. Subsequently, further work on the genus, both in the field and in the laboratory, has prompted new thoughts on *Gasteria* classification. These have recently been published in Aloe 44:4 (24 pages) raising the number of species recognised to 23. This article summarises the new taxa, combinations and Van Jaarsveld's cultivars. Photographs used in the original article have been kindly supplied by Kotie Retief, South African Succulent Society. Other photographs Harry Mays.

***Gasteria* Duval**.

Section *Longifoliae* Haw. Series *Longifoliae* (Haw.) van Jaarsveld (four species).

1. *Gasteria acinacifolia* (J. Jacq.) Haw.

A large, 200-600 x 650 mm solitary or cluster-forming plant with a flat topped, paniculate inflorescence appearing in spring and early summer. It prefers coastal sandy conditions and is distributed Knysna to near East London, occurring on vegetated dunes (dune thicket, shade or full sun) close to the sea. Rainfall in winter and summer.

2. *Gasteria batesiana* G.D. Rowley.

Gasteria batesiana* var. *batesiana.

Plants usually 30-100 mm tall and 80-300 mm in diameter, proliferating from the base to form small to large groups. It is very variable, with many beautiful forms ranging from plants with dark, almost black leaves from Barberton to narrow-leaved plants from Pongola.

***Gasteria batesiana* var. *batesiana* 'Barberton'.** Very dark, blackish-green leaves with an obtuse apex. Source population Barberton.

***Gasteria batesiana* var. *batesiana* 'Golelea'**. Linear leaves from Pongola Dam.

***Gasteria batesiana* var. *batesiana* 'Klipwal'.** The largest form with leaves up to 260 mm long and about 70 mm broad at the base. The perianth at 45 mm long. is also larger than normal. The source population is sheer cliff faces near the Klipwal gold mine.

***Gasteria batesiana* var. *batesiana* 'Mzimduzi'.** Differs from the variety by having almost smooth leaves. Kubeyini along the Mzimdusi River is the source population for this cultivar.

***Gasteria batesiana* var. *batesiana* 'Penge'.** Leaves attractive, mottled, linear-lorate, almost terete. Source population Penge district.

***Gasteria batesiana* var. *batesiana* 'Pongola'**. Mostly solitary with very striking, triangular, often recurved, mottled, dark green leaves. Believed to have originated in the Pongola valley.

***Gasteria batesiana* var. *batesiana* 'Sifula'**. Differs from the variety by having particularly fine tubercles. Sifula on the Buffalo River is the source population for this cultivar.

***Gasteria batesiana* var. *dolomitica* Van Jaarsv. & A.E. van Wyk.** Forms small to large groups. Long, slender, linear leaves 100 x 10-20 mm becoming subterete in the moist summer season and spontaneously proliferating (from the leaves) to form new plantlets. Attractive leaf makings. Will rot with too much moisture. This variety has the northernmost distribution of the genus. It grows on shear south-facing dolomite cliffs, Olifants River, Mpumalanga.

3. *Gasteria croucheri* (Hook.f.) Baker.

Gasteria croucheri* subsp. *croucheri.

Plants typically large 250mm x 600 mm proliferating from the base, forming clusters. Leaves dark green with dense white spots in transverse rows. Variable. In habitat summer rainfall, plants prefer moist, acidic sandy soil rich inorganic matter.

***Gasteria croucheri* subsp. *croucheri* 'Oribi'.** Leaves spreading, triangular to triangular-lanceolate. Paniculate inflorescence has a flat top, spreading racemes are often drooping. The source population for this cultivar is the Oribi George region.

***Gasteria croucheri* subsp. *croucheri* 'Shongweni'**. Smaller plants with linear, lanceolate leaves which are somewhat glaucous. Inflorescence is a simple raceme, occasionally with a pair of side branches. Plants divide to form dense clusters. The source of this cultivar is in Durban and towards Zululand.

***Gasteria croucheri* subsp. *croucheri* 'Umgeni'** Leaves long, linear-lanceolate to 470 mm long and 45 mm broad at the base droop over the cliff face. Divides to form dense clusters. The source of this cultivar is the Umgeni valley.

***Gasteria croucheri* subsp. *pendulifolia* Van Jaarsveld.**

Caulescent, decumbent, up to 15cm high, up to 30cm in diameter. Proliferating from the base to form dense clumps. Leaves rosulate, spreading, pendulous, linear lanceolate to strap shape, 30-45.3 cm long, up to 45 mm broad, triangular in cross section curving downwards, green, slightly glaucous, mottled with white spots, margin entire. Summer rainfall. Prefers an acid, sandy soil rich inorganic matter. Feed regularly with an organic fertilized in spring and summer.

***Gasteria croucheri* subsp. *pendulifolia* 'Shongweni'.** This cultivar has particularly glaucous leaves. The source plants are from Shongweni.

4. *Gasteria tukhelensis* Van Jaarsveld.

Large open rosette. Leaves glossy, glabrous except young ones which are tuberculate, 120-250 x 30-50 mm. Known only from the Tukhela Valley in central KwaZulu-Natal, dry bushveld.

Section *Longifoliae* Haw. Series *Multifariae* (Haw.) van Jaarsveld (ten species).

5. *Gasteria armstrongii* Schonland.

Leaves distichous, very well camouflaged and difficult to spot in habitat. The bright pin-red flower closely resemble those of *G. nitida. G. armstrongii* has been reinstate as a species in the light of nuclear DNA work (Zonneveld & Van Jaarsveld 2005). It occurs in Renosterveld on dark soil derived mainly from conglomerate and on flat ground from west of the Gamtoos River to near Port Elizabeth. At the edge of distribution area it grades into *G. nitida*, for example at Jeffrey Bay, where plants occur on sandstone rocks. Rainfall in habitat occurs in winter and summer but with a tendency to winter dryness. The species suffers from *Fusarium* root rot.

6. *Gasteria carinata* (Mill) Duval.

Gasteria carinata* var. *carinata

Plants decumbent to erect, 30-180 mm high, proliferating from the base forming dense groups 150-160 mm in diameter. Leaves triangular to triangular-lanceolate or lorate with a more or less distinct keel. Adaxial surface channelled. Epidermis with raised or immersed white tubercles. Apex acute or obtuse. Over watering encourages *Fusarium* root rot.

***Gasteria carinata* var. *carinata* 'Great Brak'**. Smooth, lorate, very faintly spotted, triangular-lanceolate leaves 70-100 x 20-25 mm. Apex obtuse. Prolific. Van Jarrsveld

records that his plant was originally named *G. schweickerdtiana* v. Poelln.

***Gasteria carinata* var. *carinata* 'Gourits'.** Small form with smooth, broad, triangular, lorate leaves 30 mm long. Apex obtuse. The source population for this cultivar is the Gourits River.

***Gasteria carinata* var. *carinata* 'Klein Brak'.** Smooth, faintly spotted, triangular-lanceolate leaves, 80-110 x 40-45 mm. It occasionally produces offsets from the base.

***Gasteria carinata* var. *carinata* 'Kykoedie'.** A small form with short, broad, triangular, tuberculate leaves 60 mm long. The source population for this cultivar is Kykoedie.

***Gasteria carinata* var. *carinata* 'Mossel Bay'**. Smooth linear-lorate, leaves 90-120 x 15-20 mm with dense spotting in attractively arranged transverse bands. Apex obtuse. The source of this cultivar is Mossel Bay. See *Gasteria carinata* v. *glabra*

***Gasteria carinata* var. *glabra* (Salm-Dyck) Van Jaarsveld.**

Leaves smooth varying in size and shape from short and triangular to large and lanceolate-triangular. Rain at any time of year. Eastern end of distribution rage of *G. carinata* from Mossel Bay to Gouritz River. *Gasteria carinata* var. *carinata* 'Gourits', described before the variety, appears to be a selected form of the variety.

***Gasteria carinata* var. *verrucosa* (Mill.) Van Jaarsveld.**

Leaves usually distichous, densely tuberculate with white spots. Proliferous. Distinction between v. *verrucosa* and v. *carinata* not always clear as there are many intermediate forms. Note: descriptions of v. *carinata* and v. *verrucosa* are for plants at the extreme ranges of variation. Plants in between have many intermediate forms. See cultivars below.

***Gasteria carinata* var. *verrucosa* 'Albertina'**. Leaves lorate triangular with acute apices, 60-90 mm in length and 25 mm broad, tubercles greenish-white in obscure transverse bands. The source of this cultivar is Albertinia.

***Gasteria carinata* var. *verrucosa* 'Herbertsdale'**. Leaves erectly spreading, linear, acuminate, deeply channelled, 90-140 mm long and 25 mm broad at the base, dense green and whitish tubercles in obscure transverse bands. This cultivar corresponds closely with Brown's *Gasteria thunbergii.*

***Gasteria carinata* var. *verrucosa* 'Infanta'.** A very large form with leaves up to 280 mm long and 35 mm broad at the base. Densely covered with white tubercles. The source of this cultivar is Infanta.

***Gasteria carinata* var. *verrucosa* 'Malagas'.** Leaves lorate up to 40 mm long. The source of this cultivar is Malagas.

***Gasteria carinata* var. *verrucosa* 'Port Beaufort'**. A small form with lorate leaves up to 30 mm long. tubercles greenish-white, leaf apex obtuse. The source of this cultivar is Port Beaufort.

7. *Gasteria ellaphieae* Van Jaarsveld.

Rosettes small. Leaves at first distichous, becoming rosulate spreading, 20-40(50) mm long, 10-20 mm broad, triangular and falcate, densely tuberculate. Inflorescence an erect, spreading raceme slender, flowers small, orange-pink. Flowers in summer. In habitat rainfall winter and summer. In cultivation too much water results in *Fusarium* root rot.

8. *Gasteria excelsa* Baker.

Solitary robust species, acaulescent, 300-600 tall x 600-750 mm wide. Leaves 100-400 mm x 100-180 mm broad, smooth with particularly sharp edges and a sharp apex (juvenile leaves tuberculate). Inflorescences are large panicles appearing in summer.

***Gasteria excelsa* 'Cala'**. Leaves short with wrinkled margins and pronounced keel.

Gasteria excelsa 'Gaika'. Leaves with striations. Originates from Gaika Fort near Stutterheim.

***Gasteria excelsa* 'Nqancule'.** A large form from Nqancule in Transkei. The margins of the leaves are extremely sharp and dangerous.

9. *Gasteria glauca* Van Jaarsveld.

G. glauca forms dense rosettes with triangular, lanceolate, glaucous leaves with the texture reminiscent of *G. glomerata* (especially in juvenile, distichous specimens). Flowers December. On sheer cliff faces below Guernakop, Kouga River Valley

10. *Gasteria nitida* Salm-Dyck) Haw.

Solitary or proliferous from the base forming small groups 60-200 x 50-280 mm. Leaves short triangular, distinctly keeled, erect to erectly spreading, dark green with faint to dense white spots in irregular transverse bands. Requires full sun but will grow in dappled shade. In habitat rain in winter and summer. Susceptible to *Fusarium* root rot.

11. *Gasteria polita* Van Jaarsveld.

Fairly large plant 12 x 250 mm, usually solitary. Leaves 6 -12 x 3-4 cm, spotted white, apex obtuse, large marginal tubercles to 1.5 mm long in adults. Soil must be sandy, acidic and well drained. It is susceptible to *Fusarium* root rot.

12. *Gasteria pulchra* (Aiton) Haw.

Leaves 240-360 tall, 25-40 mm broad at the base, erectly spreading, often falcate, linear-ensiform to linear-acuminate, dark green with white spots in transverse bands, margins serrulate. Leaf size, colour and shape is variable. Inflorescence erectly, spreading, lax panicle rarely simple. Prefers a sandy, well-drained, slightly acidic soil.

***Gasteria pulchra* 'Studtis'** shorter and more succulent leaves. Inflorescence simple.

13. ***Gasteria thunbergii* (N.E. Br.) Van Jaarsveld.**

Mat-forming. Leaves channelled, distichous, acerose-subulate, 33-200 x 15-30 mm, apex acuminate, tubercles arranged in distinct transverse rows. Stoloniferous, branching prolifically from the base. Flowers autumn.

14. *Gasteria vlokii* Van Jaarsveld.

Small plants usually proliferating from the base, forming small groups up to 140 mm in diameter. Leaves distichous becoming rosulate, 50-90 mm long, 20-30 mm broad at the base, patent, lorate. lanceolate to triangular, falcate, surface asperulous, excentric marginiform keel in upper third. Grows in acidic, well-drained, sandy soil. Rainfall summer and winter. Flowering midsummer.

Section Gasteria Duval (8 species). Series *Namaquana* Van Jaarsveld. (one species).

15. *Gasteria pillansii* var. *pillansii* Kensit.

Vary variable in size. Leaves distichous, broad, strap shaped, spreading up to 200 x 50 mm, spotted with immersed tubercles in obscure transverse rows. Dry in summer. Flowers midsummer. Seed ripens in autumn in time for the autumn and winter rains.

***Gasteria pillansii* var. *pillansii* 'Clanwilliam'**. The largest form from the Clanwilliam region where plants attain their largest size. Leaves up to 200 mm long, perianth up to 50 mm long.

***Gasteria pillansii* var. *pillansii* 'Krakadou'**. A natural mutation with an amalgamation of the leaf spots found in a normal population south of Clanwilliam.

***Gasteria pillansii* var. *pillansii* 'Ramkop'.** Broad leaves 30-40 x 28-33 mm. Source of plants Ramkop Farm, eastern Khamiesberg.

***Gasteria pillansii* var. *pillansii* 'Rosyntjiesberg'**. Short broad leaves. This cultivar is from the top of the Rosyntjiesberg.

***Gasteria pillansii* var. *pillansii* 'Vredendal'** Aberrant form with tuberculate leaves.

***Gasteria pillansii* var. *ernesti-ruschii* (Dinter& Poelln.)**

Van Jaarsveld. Dwarf stature, leaves shorter than v. *pillansii* 20-70 mm long.

***Gasteria pillansii* var. *ernesti-ruschii* 'Lekkersing'**. Short, broad, truncate leaves with rugulose margins.

***Gasteria pillansii* var. *hallii* Van Jaarsveld.**

Distinguished from *Gasteria pillansii* var. *ernesti-ruschii* by its ascending, spreading, smaller, lorate leaves 20-40 x 15 -20 mm. Grow in slightly acid, sandy soil, well drained. Keep dry in summer. Prone to *Fusarium* root rot. Originally published as *Gasteria pillansii* var. *ernesti-ruschii* 'Oograbies', a now superfluous name.

Section Gasteria Duval Series *Gasteria* Duval.

16. *Gasteria baylissiana* Rauh.

Plants acaulescent, decumbent to erect 15-40 mm high forming dense groups to circa 80 mm in diameter. Leaves distichous, densely tuberculate. Flowers reddish-pink. Occurs in Albany Thicket vegetation in a deep gorge along the Witterivier in the Addo Elephant National Park.

17. *Gasteria bicolor* Haw.

***Gasteria bicolor* var. *bicolor*.**

Variable. Widespread in the Eastern Cape. Height to 500 mm. Leaves longer than 60 mm, firm spirally arranged or distichous, greyish green without makings. Forms clusters. Inflorescence paniculate. Summer rainfall species.

***Gasteria bicolor* var. *bicolor* 'Pearston'.** Leaves remain distichous but the perianth is more inflated than that of the plants further south. Pearston is the source locality for this cultivar.

***Gasteria bicolor* var. *bicolor* 'Mackay Bridge'**. Shorter leaves arranged in an attractive spiral. Van Jaarsveld records that it was once described as *G. chamaegigas*.

***Gasteria bicolor* var. *bicolor* 'Committees Drift'.** A very large robust form previously known as *G. marmorata.*

***Gasteria bicolor* var. *bicolor* 'Bowie'.** This is based on Bowie's original clonotype which has never been found in habitat. The plants are slow to grow and have attractive, faintly-spotted, green leaves with an entire margin.

***Gasteria bicolor* var. *fallax* (Haw.) Van Jaarsveld.** Distinguished from v. *bicolor* by having long, narrow, linear, mottled leaves, 130-150 x 10-12 mm. Requires dappled shade and a sandy soil rich in organic matter. Dry in winter.

***Gasteria bicolor* var. *liliputana* (Poelln) Van Jaarsveld.**

Smaller than v. *bicolor.* Leaves under 60 mm long, variable in shape and size grading into *G. bicolor* v. *bicolor.* Inflorescence racemose.

***Gasteria bicolor* var. *liliputana* 'Pluto's Vale'.** A very small form, 15-30 mm tall. Plant source Pluto's Vale.

18. *Gasteria brachyphylla* (Salm-Dyck) Van Jaarsveld.

Gasteria brachyphylla* var. *brachyphylla.

Widespread in the Little Karoo and variable. Plants stemless, cluster-forming generally with smooth, shiny, distichous leaves, 90-230 mm long, spotted white in horizontal bands, acute apices.

***Gasteria brachyphylla* var. *brachyphylla* 'Brandrivier'**. Short, dark green acute leaves 120 mm long. Flowers in November. The source population for this cultivar is Brandrivier.

***Gasteria brachyphylla* var. *brachyphylla* 'Cango'**. Leaves linear, lorate up to 200 mm long with acute apices. Inflorescence often branched. The source population for this cultivar is Cango Caves, Oudtshoorn.

***Gasteria brachyphylla* var. *brachyphylla* 'Willomore'**. Leaves very short, faintly spotted, dark green. Apices often truncate. Flowers Oct.-Nov. The source population for this cultivar is Willomore District South Africa.

***Gasteria brachyphylla* var. *brachyphylla* 'Gamka'.** 110 mm tall with leaves that have broad, truncate margins 10 mm in diameter giving the appearance of a double keel.

***Gasteria brachyphylla* var. *bayeri*. Van Jaarsveld.**

Dwarf plants with usually patent (widely spreading) leaves 15-50 mm long, 22-28 mm broad. Obtuse. Grows on hilltops in Succulent Karoo vegetation.

19. *Gasteria disticha* (L.) Haw.

Gasteria disticha* var. *disticha.

Acaulescent with distichous leaves, 60-120 x 30-45 mm, often undulating and with a wrinkled margin. Surface mat minutely asperulous (*G. brachyphylla* leaves smooth). Cultivate in dappled shade and in a sandy soil.

***Gasteria disticha* var. *disticha* 'Nuy'**. Undulating lorate leaves, flowers from Aug. to September.

***Gasteria disticha* var. *disticha* 'Pieter Meintjies'.** This cultivar has shiny flowers. Source of plants Pieter Meintjies, west of Matroosfontein.

***Gasteria disticha* var. *langebergensis* Van Jaarsveld.**

Leaves small, 30-50 x 10-12 mm, margins denticulate. Endemic to the dolomite region of Langvlei quarry between Worcester and Robertson on the lower Langeberg.

***Gasteria disticha* var. *robusta* Van Jaarsveld.**

Leaves firm, short, robust, 55-100 x 45-65 mm. Flowers midsummer. Plants occur in the mostly summer rainfall region of the Beaufort West region. This plant was apparently published in "Gasterias of South Africa" as *Gasteria disticha* var. *disticha* 'Beaufort West', a now superfluous name.

20. *Gasteria doreeniae* Van Jaarsveld.

It resembles *Gasteria baylissiana* but the leaves are smooth, mottled and broader, 35-80 x 14-25 mm, erectly spreading, often becoming patent in the dry season. In "Gasterias of South Africa" it was referred to as *Gasteria bicolor* var. *liliputana* 'Swartwater', now a superfluous name.

21. *Gasteria glomerata* Van Jaarsveld.

Resembles *G. baylissiana* but the plants grow in rounded cluster. Leaves distichous, compact, lorate to widely ovate, recurved, glaucous. Epidermis minutely asperulous-tuberculate. Flowers bright reddish-pink 20-25 mm long. Proliferate from the base to form dense clusters.

22. *Gasteria retusa* Van Jaarsveld.

Leaves distichous, 50-90 mm long, 25-35 mm broad at base, lorate, distinctly undulating, truncate or notched at the apex, surface distinctly tuberculate. Gasteriform portion of its perianth is more swollen than in *G. carinata.* Rainfall in habitat mainly in winter with dry summers. Prone to *Fusarium* root fungus.

23. *Gasteria rawlinsonii* Oberm.

Pendulous to 1 m long, prolific from the base. Leaves short, occasionally subterete, distichous or spiral, margins with prickles. A cliff dweller. Rainfall mainly summer.

***Gasteria rawlinsonii* 'Geelhoutboskloof'** has leaves which spiral with age and with large prickles that turn black with age. Inflorescence lax. Plant source Geelhoutboskloof.

***Gasteria rawlinsonii* 'Gert Smitskoof'** has compact distichous leaves with few prickles. Inflorescence compact. Plant source Gert Smitskloof.

***Gasteria rawlinsonii* 'Staircase'** has spirally arranged distichous leaves almost like a staircase. Plants from an unknown location in the Baviaanskloof.

Acknowledgement.

I am deeply indebted to Kotie Retief, Succulent Society of South Africa and Ernst van Jaarsveld, SANBI for their invaluable assistance in making it possible for Alsterworthia International to publish this updated information on the genus *Gasteria* and for the use of the illustrations. The excellent detailed paintings are by Jeanette Loedolff.

1

Gasteria batesiana var. *dolomitica*.

2

***Gasteria batesiana* var. *dolomitica* - large clump on dolomite cliffs.**

Gasteria batesiana var. *batesiana* 'Sifula' in habitat.
Gasteria batesiana var. *batesiana* in habitat at Mzinduszi. Photo: David Gwynn-Evans.

5

Gasteria croucheri subsp. *pendulifolia* . Cliffs, Umgeni River Valley.

6

Gasteria tukhelensis. Cliffs, tugela River, KwaZulu-Natal.

7 *Gasteria armstrongii.* A stone plant. Conglomerate flats in renosterveld. Gamtoos River.

8

9 *Gasteria carinata* var. *glabra.*

10 *Gasteria glauca*

11 *Gasteria glauca*

12 *Gasteria glauca.*

13

Gasteria excelsa 'Cala'

14

Gasteria carinata var. carinata.

15

Gasteria brachyphylla var. *brachyphylla.*

16

Gasteria pulchra.

Gasteria ***baylisiaana***

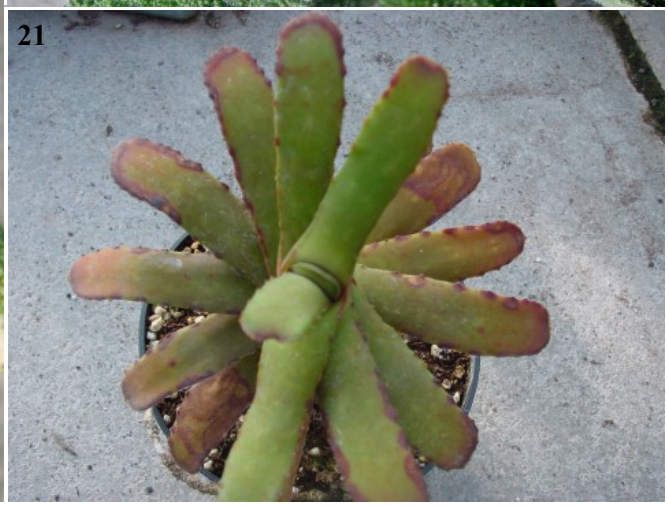
Gasteria rawlinsonii

Fig. 19.
Gasteria batesiana var *batesiana* 'Barberton'
This plant has been grown under the staging and therefore lack the black colouration. Prior to removal to under the staging it was blackish-green.

Fig. 20
Gasteria batesiana var. *batesiana* 'Pongola'
Young plant in cultivation

Fig. 21
Gasteria rawlinsonii 'Stair Case'
Plant growing in cultivation in strong light.

Photos. Harry Mays



Gasteria polita. Whisky Creek, near Plettenberg Bay
Photo: Gregory Nicolson.

Gasteria thunbergii

Gasteria pillansii var. *pillansii* 'Ramkop'

Gasteria disticha var. *robusta* near Beaufort West.

Gasteria pillansii var. *eresti-ruschii*. Sonberg.

Gasteria bicolor var. *fallax.* South of Swartwaterspoort.

Gasteria pillansii var. *hallii.*
Oograbies Mts.

Gasteria doreenieae

Gasteria retusa. Breede River Valley.

Gasteria disticha var. langebergensis.

Gasteria retusa. Orange Grove.