



A revised generic classification for *Aloe* (Xanthorrhoeaceae subfam. Asphodeloideae)

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Abstract

The predominantly southern African Xanthorrhoeaceae subfam. Asphodeloideae (Asphodelaceae subfam. Alooideae) has long been regarded as comprising seven so-called alooid genera (*Aloe*, *Astroloba*, *Chortolirion*, *Gasteria*, *Haworthia*, *Lomatophyllum*, *Poellnitzia*). A reassessment of the classification of the traditionally broadly circumscribed genus *Aloe*, a charismatic Old World group of leaf succulents, has necessitated nomenclatural adjustments. We propose a narrower generic concept for *Aloe* s. str. and the recognition of segregate genera to reflect accumulating evidence for monophyletic groups: here, the genus *Kumara* is reinstated and the new genera *Aloidendron* and *Aloiampelos* are established. New combinations are made in *Aloe* for the three species of *Chortolirion*.

Introduction

The predominantly southern African Xanthorrhoeaceae subfam. Asphodeloideae [following APG III (APG 2009); alternatively Asphodelaceae, following Nyffeler & Eggli (2010)] comprise over 700 species in 15 genera, including the charismatic leaf succulent genus *Aloe* Linnaeus (1753: 319) and related alooid genera. A traditionally broad circumscription of *Aloe* and considerable infrageneric diversity (about 560 species) have been accommodated by traditional classifications at sectional, subsectional and series levels, or as informal infrageneric groups (Berger 1905, 1908, Reynolds 1950, 1966, Carter *et al.* 2011). A reassessment of the classification of *Aloe* (Grace & Rønsted in prep.) supports previous studies that have highlighted the need for taxonomic changes to reflect phylogenetic relationships between the core aloes and sister groups (Adams *et al.* 2000, Treutlein *et al.* 2003a, Klopper *et al.* 2010, Grace & Rønsted 2012).

As the first step towards a revised classification of *Aloe*, we propose a new generic circumscription to address the previous lack of monophyly in the genus and provide a nomenclatural framework for future studies of the biology and evolution of the alooids. Two distinct lineages comprising the tree aloes and

scrambling aloes are elevated to generic rank as *Aloidendron* (Berger 1905: 48, 59) Klopper & Gideon F.Sm. (tree aloes) and *Aloiampelos* Klopper & Gideon F.Sm. (scrambling aloes), respectively. The distinctive Cape endemic *Aloe plicatilis* (Linnaeus 1753: 321) Miller (1768: 7) is reinstated in the genus *Kumara* Medikus (1786: 69) as *Kumara disticha* Medikus (1786: 70, t. 4). New names are proposed in *Aloe* for the three species of *Chortolirion* Berger (1908: 72), a genus of bulbous plants closely related to *Aloe* sect. *Graminialoe* Reynolds (1947: 104) and florally resembling members of the genus *Haworthia* Duval (1809: 7). The resemblance of *Chortolirion* to *Haworthia* is interpreted as being due to a shared pleisiomorphic insect pollination syndrome (Hargreaves *et al.* 2008) and / or early hybridisation events.

The proposed changes reduce the heterogeneity of *Aloe s. str.* and resolve the problem of paraphyly in the genus. An alternative approach, mooted by Treutlein *et al.* (2003b), is an expanded, near-Linnaean generic concept of *Aloe*. This approach would require broad generic concepts to be applied throughout the expanded Xanthorrhoeaceae, resulting in a larger number of nomenclatural changes and, possibly, further taxonomic instability. The associated loss of taxonomic information to the users of plant names could have negative consequences for biodiversity conservation and horticulture, since several southern African alooid genera would be ‘lost’ and over a hundred species added to the CITES appendices, affecting the substantial trade in these collectible succulent plants. The popularity of Asphodeloideae in horticulture contributes to their *ex situ* conservation, yet pressing *in situ* conservation concerns affect several genera, particularly those characterised by high endemism and habitat transformation—notably *Aloe*, *Gasteria* Duval (1809: 6), *Haworthia* and *Kniphofia* Moench (1794: 631). A generic concept within the alooids that reflects evolutionary relationships and strengthens predictive classification is needed to support their conservation and sustainable use as well as future research.

The purpose of the present contribution is to provide the required nomenclatural adjustments and a morphological key to support the proposed new classification of *Aloe s. str.* and its segregate genera.

Key to *Aloe s. str.* and its segregate genera

1. Dichotomously branched trees or large shrubs; leaves unspotted; dried leaves not persistent; flowers cylindrical to cylindrical-ventricose, without a pronounced constriction above a bulbous basal swelling; perianth segments connate in lower half to almost free; mainly southern Africa, with an outlier species in Somalia **2**
 - Not dichotomously branched trees or large shrubs; leaves variously spotted to unspotted; dried leaves persistent or not; flowers variously shaped, with or without a pronounced constriction above a bulbous basal swelling; perianth segments variously connate to free; widespread in sub-Saharan Africa, Arabia, Madagascar and western Indian Ocean Islands **3**
2. Leaves rosulate, apex tapering; inflorescence branched; southern Africa, with an outlier species in Somalia *Aloidendron*
 - Leaves distichous, apex rounded; inflorescence simple (unbranched); Western Cape, South Africa (Cape Floristic Region)..... *Kumara*
3. Plants several-stemmed, shrubby or climbing; leaves spirally arranged, cauline dispersed, sheathing, separated by distinct internodes, unspotted; inflorescence usually simple; flowers cylindrical to slightly clavate or subventricose, sometimes slightly narrowed above the ovary, but without a pronounced constriction above a bulbous basal swelling; perianth segments ± connate; South Africa (mainly Western and Eastern Cape), with one species just entering Swaziland *Aloiampelos*
 - Plants acaulescent or with simple or branched stems; leaves rosulate or distichous, seldom cauline dispersed, usually not separated by distinct internodes, variously spotted to unspotted; inflorescence variously branched or simple; flowers variously shaped, with or without a pronounced constriction above a bulbous basal swelling; perianth segments variously connate to almost free; widespread in sub-Saharan Africa, Arabia, Madagascar and western Indian Ocean Islands *Aloe*

New generic descriptions and nomenclatural adjustments

For complete lists of synonyms for the genera and species dealt with here, see Grace *et al.* (2011).

1. *Aloidendron* (A.Berger) Klopper & Gideon F.Sm., *comb. et stat. nov.*

Basionym: *Aloe* section *Aloidendron* Berger (1905: 56). **Type:**—*Aloidendron barberae* (Dyer) Klopper & Gideon F.Sm. *Aloe* section *Dracoaloe* Berger (1905: 56). Type:—*Aloe dichotoma* Masson (1776: 310).

Description:—Dichotomously branched [Model of Leeuwenberg (Hallé *et al.* 1987, Van Wyk *et al.* 2008)] shrubby to arborescent, sub-woody to woody succulent perennials, with bark smooth to often longitudinally fissured. Leaves rosulate, narrowly lanceolate or ensiform, erectly spreading to reflexed, unspotted, margins minutely dentate, apex tapering; exudate absent or minimal, watery, pale yellow, not strong smelling. Inflorescence a branched panicle with cylindric, dense to sublux racemes. Pedicels not articulated. Flowers cylindric to cylindric-ventricose, segments connate in lower half to almost free; yellow, orange or pink to red. Stamens and style straight, usually long-exserted; filaments glabrous. Fruit a loculicidal capsule; seeds numerous.

Chromosome number:— $2n = 14$ (Brandham 1971).

Chemistry:—Roots containing chrysophanol, asphodeline and aloechryson, 1-methyl-8-hydroxyanthraquinone pathway lacking, hence the absence of aloesaponarin, aloesaponarin II, laccaic acid D-methyl ester, aloesaponol I, aloesaponol II and isoeleutherol (Van Wyk *et al.* 1995). Leaf exudate containing anthrones but not flavonoids (Viljoen *et al.* 1998; Viljoen 1999). Included in chemotype B (anthrones) by Dagne *et al.* (2000).

1.1. *Aloidendron barberae* (Dyer) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe barberae* Dyer (1874: 566). Type:—Cultivated at Kew, no date, *Anonymous s.n.* (holotype K000256753!).

1.2. *Aloidendron dichotomum* (Masson) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe dichotoma* Masson (1776: 310). Type:—SOUTH AFRICA. Cape of Good Hope, no date, *C.P. Thunberg* 8587 (holotype UPS, photo PRE).

1.3. *Aloidendron eminens* (Reynolds & P.R.O.Bally) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe eminens* Reynolds & Bally (1958: 187). Type:—SOMALIA (formerly Somaliland Protectorate). Erigavo District: Surud ravine, west side of Tabah Pass, 9 September 1957, *G.W. Reynolds* 8435 (holotype PRE0683971-0!, isotypes EA000000408!, K000256425!).

1.4. *Aloidendron pillansii* (L.Guthrie) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe pillansii* Guthrie (1928: 15). Type:—SOUTH AFRICA. Northern Cape: Cornell's Kop, west of Annisfontein, October 1926, *N.S. Pillans* 5012 (holotype BOL140227! & BOL140228!, isotype K000256752!).

1.5. *Aloidendron ramosissimum* (Pillans) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe ramosissima* Pillans (1939: 66). Type:—SOUTH AFRICA. Northern Cape: Richtersveld, between Helskloof and Annisfontein, 25 July 1937, *G.W. Reynolds* 2547 (holotype BOL140225! & BOL140226!, isotypes K000256751!, PRE0111456-0!).

1.6. *Aloidendron tongaense* (Van Jaarsv.) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe tongaensis* Van Jaarsveld (2010: 71). Type:—SOUTH AFRICA. KwaZulu-Natal: Sand forest southeast of Kosi Bay, 25 January 1992, *E.J. van Jaarsveld & L. Powrie 12202* (holotype PRE).

2. *Aloiampelos* Klopper & Gideon F.Sm., *gen. nov.*

Diagnosis: Differs from *Aloe* L. in the following suite of characters: plants shrubby or climbing; leaves cauline dispersed, sheathing, separated by distinct internodes, unspotted; exudate absent or minimal; inflorescence usually simple; flowers cylindrical to slightly clavate or subventricose, sometimes slightly narrowed above the ovary, but lacking a pronounced constriction above a bulbous basal swelling; perianth segments \pm connate.

Type:—*Aloiampelos ciliaris* (Haw.) Klopper & Gideon F.Sm.

Aloe series *Macrifoliae* Haworth (1825: 280). *Aloe* section *Macrifoliae* (Haw.) Glen & Hardy (2000: 92). Type:—*Aloe ciliaris* Haw. [= *Aloiampelos ciliaris* (Haw.) Klopper & Gideon F.Sm.].

Aloe series *Striatulae* Berger (1905: 47). Type:—*Aloe ciliaris* Haw. [= *Aloiampelos ciliaris* (Haw.) Klopper & Gideon F.Sm.].

Description:—Shrubby or climbing, herbaceous or sub-woody succulent perennials. Leaves spirally arranged, sheathing, separated by distinct internodes, linear-lanceolate, thin, flat, unspotted, margins dentate to denticulate, apex tapering; exudate absent or minimal, watery, clear to pale yellow, not strong smelling. Inflorescence a simple (seldom 1- or 2-branched) lateral panicle with lax to subdense cylindric, or dense capitate racemes. Pedicels not articulated. Flowers cylindric, slightly trigonous, sometimes subventricose or with a constriction in the middle; segments \pm connate; yellow, orange, red or greenish. Stamens and style straight, included or exerted; filaments glabrous. Fruit a loculicidal capsule; seeds numerous.

Distribution:—Occurs in South Africa (mainly Western and Eastern Cape), with one species found on the Swaziland border.

Etymology:—From *Aloe* and the Greek word for a climbing plant, *ampelos*. This refers to the general climbing habit of the scrambling aloes.

Chromosome number:— $2n = 14$, $4n = 28$ and $6n = 42$ (Brandham 1971).

Chemistry:—Roots usually containing chrysophanol and asphodeline, rarely aloechryson; 1-methyl-8-hydroxyanthraquinone pathway lacking, hence the absence of aloesaponarin, aloesaponarin II, laccaic acid D-methyl ester, aloesaponol I, aloesaponol II and isoeleutherol (Van Wyk *et al.* 1995). Leaf exudate absent or minimal, containing flavonoids as flavones (isovitexin), but lacking dihydroflavonols and flavanones (Viljoen *et al.* 1998). Included in chemotype A2 (flavones, anthrones and chromones) by Dagne *et al.* (2000).

2.1. *Aloiampelos ciliaris* (Haw.) Klopper & Gideon F.Sm., *comb. nov. var. ciliaris*

Basionym: *Aloe ciliaris* Haworth (1825: 281). Lectotype (designated by Glen & Hardy 2000: 93, as 'iconotype'):—SOUTH AFRICA. Eastern Cape: cultivated at Kew, *J. Bowie s.n.* (unpublished Duncanson plate K!).

2.2. *Aloiampelos ciliaris* var. *redacta* (S.Carter) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe ciliaris* var. *redacta* S.Carter in Brandham & Carter (1990: 643). Type:—SOUTH AFRICA. Eastern Cape: Qolora Mouth, flowered 12 February 1973 in Cape Town, *W. Wisura 2640* (holotype K000256669!).

2.3. *Aloiampelos ciliaris* var. *tidmarshii* (Schönland) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe ciliaris* var. *tidmarshii* Schönland (1903: 41). Type:—SOUTH AFRICA. Eastern Cape: Grahamstown, garden of Lark's Hotel, Stone's Hill, November 1900, *S. Schönland 1487* (holotype GRA0000434-0!, isotype BOL140194!).

2.4. *Aloiampelos commixta* (A.Berger) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe commixta* A.Berger (1908: 260). Type:—SOUTH AFRICA. Western Cape: Simonstown, no date, *C. Wright s.n.* (holotype K!).

2.5. *Aloiampelos decumbens* (Reynolds) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe gracilis* var. *decumbens* Reynolds (1950: 358). Type:—SOUTH AFRICA. Western Cape: Riversdale Division, rocks on summit of Kleinberg at Platteklouf, June 1909, *J. Muir 5383* (holotype PRE0090651-0!).

2.6. *Aloiampelos gracilis* (Haw.) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe gracilis* Haworth (1825: 280). Lectotype (designated by Glen & Hardy 2000: 96, as 'iconotype'):—SOUTH AFRICA. Eastern Cape: Plate by F. Bauer (K) [reproduced in Reynolds (1950: 357)].

2.7. *Aloiampelos juddii* (Van Jaarsv.) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe juddii* Van Jaarsveld (2008: 4). Type:—SOUTH AFRICA. Western Cape: Rocky outcrop, southeast-facing sandstone ridge, 7 November 2007, *E.J. Van Jaarsveld, P. Nel & Xaba 18295* (holotype NBG).

2.8. *Aloiampelos striatula* (Haw.) Klopper & Gideon F.Sm., *comb. nov. var. striatula*

Basionym: *Aloe striatula* Haworth (1825: 281). Lectotype (designated by Glen & Hardy 2000: 97, as 'iconotype'):—SOUTH AFRICA. Eastern Cape: Plate by F. Bauer (K) [reproduced in Reynolds (1950: 362)].

2.9. *Aloiampelos striatula* var. *caesia* (Reynolds) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe striatula* var. *caesia* Reynolds (1936: 633). Type:—SOUTH AFRICA. Eastern Cape: Near Hofmeyr, slopes of Bamboesberg, flowered November 1935 in Pretoria, *G.W. Reynolds 1607* (holotype PRE0090488-1! & PRE0090488-2!, isotype BOL140195!).

2.10. *Aloiampelos tenuior* (Haw.) Klopper & Gideon F.Sm., *comb. nov.*

Basionym: *Aloe tenuior* Haworth (1825: 281). Lectotype (designated by Glen & Hardy 2000: 92, as 'iconotype'):—SOUTH AFRICA. Eastern Cape: Plate by F. Bauer (K) [reproduced in Reynolds (1950: 347)].

3. *Kumara* Medikus (1786: 69)

Type:—*Kumara disticha* Medik.

Aloe section *Kumara* (Medik.) Baker (1880: 155). Type:—*Aloe plicatilis* (L.) Mill. [= *Kumara disticha* Med.].

Description:—Dichotomously branched [Model of Leeuwenberg (Hallé *et al.* 1987; Van Wyk *et al.* 2008)] shrubby to arborescent, sub-woody succulent perennials, with corky bark. Leaves distichous, broadly linear to lorate, erectly spreading, unspotted, margins minutely dentate in upper third or almost entire, apex rounded; exudate copious, watery, yellow with unpleasant odour, soon coagulating and becoming sticky. Inflorescence simple with cylindrical, slightly acuminate, lax raceme. Pedicels not articulated. Flowers cylindrical, slightly trigonous, segments connate in lower third; scarlet. Stamens and style straight, shortly exerted; filaments glabrous. Fruit a loculicidal capsule; seeds numerous.

Chromosome number:— $2n = 14$ (Brandham 1971).

Chemistry:—Roots containing chrysophanol, asphodeline and aloechryson; 1-methyl-8-hydroxyanthraquinone pathway lacking, hence the absence of aloesaponarin, aloesaponarin II, laccic acid D-

methyl ester, aloesaponol I, aloesaponol II and isoeleutherol (Van Wyk *et al.* 1995). Leaf exudate containing the naphthalene derivative plicatiloside but lacking chromones and anthrones (Viljoen 1999, Viljoen *et al.* 1999). Included in chemotype C (plicatiloside) by Dagne *et al.* (2000).

3.1. *Kumara disticha* Medikus (1786: 70, t. 4)

Aloe plicatilis (Linnaeus 1753: 321) Miller (1768: 7). Lectotype (designated by Wijnands 1983: 125):—*Aloe africana arborescens montana non spinosa, folio longissimo plicatili, flore rubro* (Commelijn 1701: 5, t. 3).

New names in *Aloe*

For complete lists of synonyms for the species dealt with here, see Zonneveld & Fritz (2010).

1. *Aloe welwitschii* Klopper & Gideon F.Sm., *nom. nov.*

Haworthia angolensis Baker (1878: 263). *Chortolirion angolense* (Baker) Berger (1908: 73). Type:—ANGOLA. Huilla District: flowered November 1859, *F.M.J. Welwitsch 3756* (holotype BM000911693!).

Etymology:—Since the name *Aloe angolensis* Baker (1878: 263) already exists, this combination is not available for *Chortolirion angolense*. The new name commemorates Friedrich Martin Josef Welwitsch (1806–1872), who collected the type specimen and is estimated to have made over 10,000 botanical collections in Angola, representing around 5,000 species (Albuquerque *et al.* 2009).

2. *Aloe barendii* Klopper & Gideon F.Sm., *nom. nov.*

Haworthia tenuifolia Engler (1889: 2, t. 1). *Chortolirion tenuifolium* (Engl.) Berger (1908: 73). Type:—SOUTH AFRICA. Northern Cape: Kalahari Region, near Kuruman, *R. Marloth 1049* (holotype B100165765!, isotype PRE0037837-0!).

Etymology:—Since the name *Aloe tenuifolia* Lamarck (1783: 87) already exists, this combination is not available for *Chortolirion tenuifolium*. The new name commemorates Barend [Ben] Hermanus Groenewald (1905–1976), who described several new aloes from South Africa during the 1930s and wrote the first book on the aloes of southern Africa that represented an up-to-date treatment for the subcontinent (Groenewald 1941). Despite his valuable contributions towards our understanding of aloes in southern Africa, he did not receive the recognition he deserves and has never been commemorated in the genus *Aloe* (Anonymous 2010, Figueiredo & Smith 2010).

3. *Aloe jeppeae* Klopper & Gideon F.Sm., *nom. nov.*

Chortolirion latifolium Zonneveld & Fritz (2010: 32). Type:—SOUTH AFRICA. Free State: Bloemfontein near airport, 24 April 2009, *G.P.J. Fritz 1025* (holotype PRE!).

Etymology:—Since the name *Aloe latifolia* (Haworth 1804: 7) Haworth (1812: 82) already exists, this combination is not available for *Chortolirion latifolium*. The new name commemorates Barbara Joan Jeppe (1921–1999), who wrote and illustrated a book on the aloes of South Africa (Jeppe 1969) that is now considered to be valuable historical literature on the genus (Smith & Steyn 2000). Despite her contributions to illustrating the aloes of South Africa, she has never been commemorated in the genus *Aloe*.

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