



Kalanchoe ×*sogae* (Crassulaceae subfam. Kalanchooideae) derived from *Kalanchoe lateritia* × *K. sexangularis*, with notes on the inheritance of hairiness and resistance against phytophagous insects in *Kalanchoe* hybrids

GIDEON F. SMITH^{1,2*} & ESTRELA FIGUEIREDO^{1,3}

¹ Ria Olivier Herbarium, Department of Botany, Nelson Mandela University, P.O. Box 77000, Gqeberha, 6031 South Africa.

² smithgideon1@gmail.com; <https://orcid.org/0000-0002-5417-9208>

³ epnfigueiredo@gmail.com; <https://orcid.org/0000-0002-8511-8213>

*Author for correspondence

Abstract

The hybrid between *Kalanchoe lateritia* and *K. sexangularis* (Crassulaceae subfam. Kalanchooideae) is described as *K. ×sogae*. Like *K. lateritia*, virtually all plant parts of *K. ×sogae* are covered in a fine indumentum, but with the indumentum being less substantial in the case of this nothospecies. The leaves and stems of material of *K. ×sogae* are bright red-infused, especially when growing in full sun. This hybrid shows considerable horticultural potential and is more resistant against phytophagous insects than *K. sexangularis*.

Keywords: breeding; character inheritance; *Kalanchoe* subg. *Kalanchoe*; nothospecies; south-tropical Africa, southern Africa

Introduction

From a horticultural perspective, the most successful recently described nothospecies in *Kalanchoe* Adanson (1763: 248) is *K. ×estrelae* Smith (2020a: 225) [Crassulaceae subfam. Kalanchooideae Berger (1930: 383) emend. Gideon F.Sm. in Smith & Monro (2022a: 247–248)] (see Smith & Monro 2022b for the nomenclature to be used for this subfamily). The parents of *K. ×estrelae* are *K. luciae* Hamet (1908: 256) (see Smith & Figueiredo 2023a), included in *K.* [subg. *Kalanchoe*] sect. *Raveta* Raym.-Hamet ex Smith (2022a: 210) (see Raymond-Hamet 1916: 83–84), and *K. sexangularis* Brown (1913: 120), also included in *K.* subg. *Kalanchoe*. The vegetative organs, especially the leaves, of both species can be strongly reddish purple- or crimson red-infused (Smith 2020b: 7–12, c, d, 2021a). In addition, the peduncles and inflorescence branches of material of *K. sexangularis* are also usually bright to crimson red or at least substantially red-infused (Figueiredo *et al.* 2016, Smith *et al.* 2019a: 226–232).

Recent breeding work in which the virtually entirely pubescent *K. lateritia* Engler (1894: 19) (see also Engler 1895: 189) (Fig. 1A–B) from south-tropical and eastern Africa was combined with *K. sexangularis* (Fig. 1C–D) has yielded attractive material that is distinctly suited to outdoor cultivation in mild climates. In addition to being visually striking, material is also more resistant to attacks by a range of insects that feed and breed on, inter alia, the horticulturally popular *K. sexangularis* (Smith 2022b: 177–178).

To enable communication about this hybrid, including about character inheritance in *Kalanchoe* nothospecies, in this instance with specific reference to hairiness, resistance against phytophagous insects, as well as the enhancement of horticulturally desirable characters, such as a strong red infusion, it is here described as *K. ×sogae* Gideon F.Sm. & Figueiredo (Fig. 2A–F).

Material and methods

Classification:—*Kalanchoe* is here regarded as consisting of four subgenera: the geographically widespread autonymic one; as well as *K.* subg. *Alatae* (Raymond-Hamet 1933: 547) Gideon F.Sm., Shtein & D.-P.Klein in Smith *et al.* (2021a:

255) (see also Smith 2021b), *K.* subg. *Bryophyllum* (Salisbury 1805: t. 3) Koorders (1919: 170) (see Smith 2022c), and *K.* subg. *Kitchingia* (Baker 1881: 268) Smith & Figueiredo (2018: 169) (see Smith *et al.* 2021b), the last three mentioned being endemic to Madagascar. *Kalanchoe* subg. *Fernandesiae* Smith (2020e: 5) from southern and south-tropical Africa is here treated at the rank of section, in *K.* subg. *Kalanchoe*, as *K.* sect. *Raveta*.

Taxonomy:—The description of *K.* \times *sogae* is based on detailed, comparative morphological studies of living material of this nothospecies and its parents, *K. lateritia* and *K. sexangularis*. Material of *K.* \times *sogae* was derived from cross-breeding of *K. lateritia*, which was obtained from cultivated material originally from south-tropical Africa, with *K. sexangularis*, which originated from South Africa's eastern and northern Mpumalanga and Limpopo provinces. Measurements were taken by hand using a ruler, except for floral measurements below 4 mm, which were taken using hand-held magnifying equipment.

Nomenclature:—Unless more up-to-date information is available, author attribution of scientific plant names cited follows IPNI (2022 [continuously updated]) albeit in the notation required by *Phytotaxa*, i.e., by citing the protologues of the names as full bibliographic references.

Herbarium codes follow Thiers (2022 [continuously updated]).

Nomenclatural issues accord with the Shenzhen *Code* (Turland *et al.* 2018).

Terminology:—For the sake of clarity, the following terminology is adopted here for the hairiness of the *Kalanchoe* material examined: 'pubescent' [*K. lateritia*] refers to dense, fine, short, soft hairs (Lawrence 1970: 767, Beentje & Williamson 2010: 95); 'puberulous' [*K.* \times *sogae*] refers to a rather dense covering of very short, soft hairs (Beentje & Williamson 2010: 95); and 'tomentose' is used for a surface densely covered in somewhat matted, short, soft hairs (Lawrence 1970: 773, Beentje & Williamson 2010: 121). Collectively, 'hairy' is used to refer to an indumentum type where individual hairs are visible (Beentje & Williamson 2010: 55).



FIGURE 1. *Kalanchoe lateritia* (A–B) and *K. sexangularis* (C–D), the parents of *K.* \times *sogae* (see Fig. 2). **A.** Leaves of *K. lateritia* are pubescent and light green to yellowish or brownish green. **B.** Flowers of *K. lateritia* have bright yellow to strongly bright orange-infused corolla lobes. **C.** Leaves of *K. sexangularis* turn a bright crimson red when exposed to high levels of solar irradiation. **D.** Flowers of *K. sexangularis* have a greenish yellow corolla tube and generally bright yellow corolla lobes that could be faintly brown-tipped. All photographs taken by Gideon F. Smith.

Results

Material described here as *K. ×sogae* is intermediate between its parents (Table 1), the pubescent *K. lateritia* (Fig. 1A–B) and glabrous *K. sexangularis* (Fig. 1C–D). Plants of *K. ×sogae* are puberulous with the hairiness less pronounced than in *K. lateritia* (Fig. 2A), but very much apparent without magnification. Colour-wise, *K. ×sogae* is as bright red-to crimson red-infused as *K. sexangularis*, but never light green to yellowish or brownish green as in *K. lateritia* (Fig. 2A–B).

TABLE 1. Morphological differences among *Kalanchoe lateritia*, *K. ×sogae*, and *K. sexangularis*. *K.* = “*Kalanchoe*”.

#	Character	<i>K. lateritia</i>	<i>K. ×sogae</i>	<i>K. sexangularis</i>
1.	Vestiture	Pubescent	Puberulous	Glabrous
2.	Plant colour	Light green to yellowish or brownish green	Mid-green, often red or strongly crimson red-infused	Mid-green, often red or strongly crimson red-infused
3.	Peduncle in cross-section	Round	Round	Angled
4.	Flower bud tip colour	Orange	Bright orange-red	Yellow
5.	Sepal colour	Light green	Light green, strongly orange-infused throughout	Light green, red-infused
6.	Sepal size (l × w) (mm)	3.5–7.0 × 2.0–2.5	7–9 × 2.0–2.5	ca. 2 × 1
7.	Corolla tube colour	Light green, orangey yellow-infused	Light green especially in basal swollen part; angles higher up distinctly and strongly orange-infused to yield striped appearance	Yellowish green
8.	Corolla lobe shape	Obovate to lanceolate-obovate	Obovate to nearly round	Ovate to subcircular
9.	Corolla lobe colour	Bright yellow to strongly bright orange-infused	Bright yellow to strongly bright orange-infused	Bright yellow, faintly brown-tipped

The corolla lobes of *K. ×sogae* have the shape, size, and colour of those of *K. lateritia*; the sepals, while also prominent, as in *K. lateritia*, are strongly orange-infused throughout, a character inherited from *K. sexangularis* (Fig. 2C–F). When in bud, the flowers of *K. ×sogae* are bright orange-red, more so than those of *K. lateritia*.

Kalanchoe ×sogae Gideon F.Sm. & Figueiredo, *nothospec. nov.* (Fig. 2A–F)

Type:—SOUTH AFRICA. Gauteng province—2528 (Pretoria): Tshwane, (–CA), ex hort., 28 June 2022, *G.F. Smith 1185* (holotype PRU).

Parentage:—*Kalanchoe lateritia* Engler (1894: 19) × *Kalanchoe sexangularis* Brown (1913: 120).

Diagnosis:—Like one of its parents, *K. sexangularis*, *K. ×sogae* has strongly red-infused leaves, so differing from the other parent, *K. lateritia*, which has light green to yellowish or brownish green leaves. *Kalanchoe sexangularis* is completely glabrous, while *K. lateritia* has a pubescent vestiture; *K. ×sogae* is puberulous and intermediate between its two parents. In *K. ×sogae* the sepals are prominent and ± as long as those of *K. lateritia*, while the sepals of *K. sexangularis* are very small. The corolla tube of *K. lateritia* is light green and orangey yellow-infused, that of *K. sexangularis* is uniformly yellowish green, while that of *K. ×sogae* is light green with strongly orange-infused angular sections. The corolla lobes of *K. ×sogae* are obovate to nearly round while those of *K. lateritia* are obovate to lanceolate-obovate and those of *K. sexangularis* are ovate to subcircular.

Description:—Perennial through sprouting from the base, but individual rosettes annual or biennial, dying after flowering, rather few-leaved, unbranched, puberulous throughout, succulent, to 0.5–1.0 m tall when in flower. *Stems* one to several, erect or leaning, light to intensely dark red, densely puberulous above, reddish brown, less puberulous lower down especially where leaves shed, often ± leafless at fruiting, round in cross-section throughout, leaf scars

obvious, white. *Leaves* decussate, petiolate, light to intensely dark red, succulent, spoon-like longitudinally folded upwards, erectly-spreading to spreading to often floppy, caducous when inflorescence develops, somewhat papery when dry, densely puberulous throughout, hairs whitish or very light brownish white; *petiole* 10–20 mm long, slightly grooved above, puberulous, somewhat stem-clasping; *blade* (50–)60–90(–100) × 30–50 mm, elongated-elliptic to ovate to ovate-spathulate; *base* attenuate to cuneate; *apex* obtuse, round, not indented, rarely somewhat acute; *margins* variably crenate or dentate in upper $\frac{3}{4}$ – $\frac{7}{8}$, entire towards petiole. *Inflorescence* consisting of contracted cymes forming dense corymbs, 0.30–0.75 m tall, terminal, erect, many- and apically dense-flowered, generally rounded, sometimes flat-topped, branches opposite, growing upwards at a $\pm 30^\circ$ angle, subtended by small leaf-like bracts, small leafy shoots in axils usually absent, puberulous throughout; *peduncle* light green to strongly red-infused; *pedicels* 1–2 mm long, stout. *Flowers* 17–18 mm long, erect to slanted sideways, never pendent, bright orange-red in bud apically, conspicuously to densely puberulous throughout except adaxial corolla lobe surface; *calyx* consisting of 4 sepals, prominent, light green, strongly orange-infused throughout, slightly fleshy; *sepals* 7–9 × 2.0–2.5 mm, basally fused into a short tube 1.0–1.5 mm long, separate above, narrowly triangular-lanceolate, acute, \pm clasping the corolla, obscuring and contrasting against light green, swollen portion of corolla tube where covered by calyx, drying reddish brown; *corolla* (16–)17–18 mm long, distinctly enlarged basally, slightly twisted apically after anthesis; *tube* (15–)16–17 mm long, light green especially basal swollen part, distinctly 4-angled-fluted, rounded when viewed from below, gradually narrowly cylindrical apically, angles distinctly and strongly orange-infused to yield striped appearance; *lobes* 5–6 × 4–5 mm, bright yellow to strongly bright orange-infused towards margins and apical $\frac{1}{3}$, obovate to nearly round, gradually acuminate towards apex, apiculate-mucronate. *Stamens* 8, inserted in \pm two ranks at about the middle of the corolla tube, well included; *filaments* 2.5–3.0 mm long, thin, flimsy, light yellow; *anthers* 0.5–1.0 mm long, yellowish grey, oval to oblong. *Pistil* consisting of 4 carpels; *carpels* 5–6 mm long, light green; *styles* 1–2 mm long; *stigmas* very slightly capitate, whitish; *scales* (2.0–)2.5(–3.0) mm long, linear to linear-ribbon-like to very slightly linear to oblong to tapering to apex, yellowish green. *Follicles* not seen. *Seeds* not seen. *Chromosome number*: unknown.

Eponymy:—*Kalanchoe* × *sogae* is named for Dr Jotello Festiri Soga (born near Stutterheim, Eastern Cape province, South Africa, 1865–died Amalinda near East London, Eastern Cape province, South Africa, 6 December 1906), the first South African to have qualified as a veterinary surgeon. He studied in Scotland and thereafter worked for the then Cape Department of Agriculture (Hammel 2020: 54). He had an interest in ethnobotany and is known to have liaised with his botanical contemporaries Peter MacOwan and Andrew Smith (Gunn & Codd 1981: 327, Figueiredo & Smith 2021: 291–292). He inter alia studied krimpsiekte, also called nenta poisoning, a chronic form of heart glycoside poisoning, especially among small livestock (Soga 1891). Krimpsiekte is caused by a range of representatives of the Crassulaceae, including by kalanchoes (Smith *et al.* 2019a: 43, 52, 108), with nentabos being one of the Afrikaans vernacular names of *K. rotundifolia* (Haworth 1824: 188) Haworth (1825: 31).

Flowering time:—*Kalanchoe* × *sogae* flowers mainly in the mid-winter months, June to August in the southern hemisphere.

Notes:—Several biennial, multiannual, and perennial species of *Kalanchoe* are variously and virtually throughout pubescent or tomentose, or are squamulose (finely scale-like covered). This applies especially to the medium-sized to large shrubs and small trees with woody stems that are included in the ‘woody clade’ of *K.* subg. *Kalanchoe* that is naturally restricted to Madagascar (see for example Smith *et al.* 2021c, d and Smith & Figueiredo 2019, 2022a, b, 2023b).

Species that have most of the external surfaces of their organs so adorned include the widely cultivated *K. beharensis* Drake del Castillo (1903: 41) (see Smith *et al.* 2021d), *K. millotii* Hamet & Perrier de la Bâthie (1912: 374) (see Smith & Figueiredo 2019, Smith *et al.* 2019b, Smith 2020f, and Smith *et al.* 2021e), and *K. tomentosa* Baker (1882: 110) (see Smith 2020g). Similarly, nothospecies of which these species are variously the parents, for example *K. ×edwardii* Smith & Shtein (2020: 120) [*K. beharensis* × *K. tomentosa*] (see Smith 2022d); *K. ×gildenhuysii* Smith & Figueiredo (2020: 43) [*K. millotii* × *K. tomentosa*]; and *K. ×hummeliae* Smith (2020f: 91) [*K. beharensis* × *K. millotii*] (see Smith 2022d: 155), are variously hairy. Therefore, where two variously pubescent- or tomentose-leaved species hybridise, the offspring is invariably hairy to varying degrees. The opposite also holds true: where two glabrous *Kalanchoe* species are hybridised, the offspring is glabrous (see *K. ×gunniae* Gideon F.Sm. & Figueiredo in Smith *et al.* 2019c: 147).

A hairy vestiture is not restricted to some Malagasy *Kalanchoe* species; species from Africa and other parts of the distribution range of the genus also show this trait [see for example Smith *et al.* 2019a: 170–176 with reference to *K. lanceolata* (Forsskål 1775: CXI & 89) Persoon (1805: 446), where onset of the reproductive phase yields hairy peduncles, bract-like leaves, and flowers].

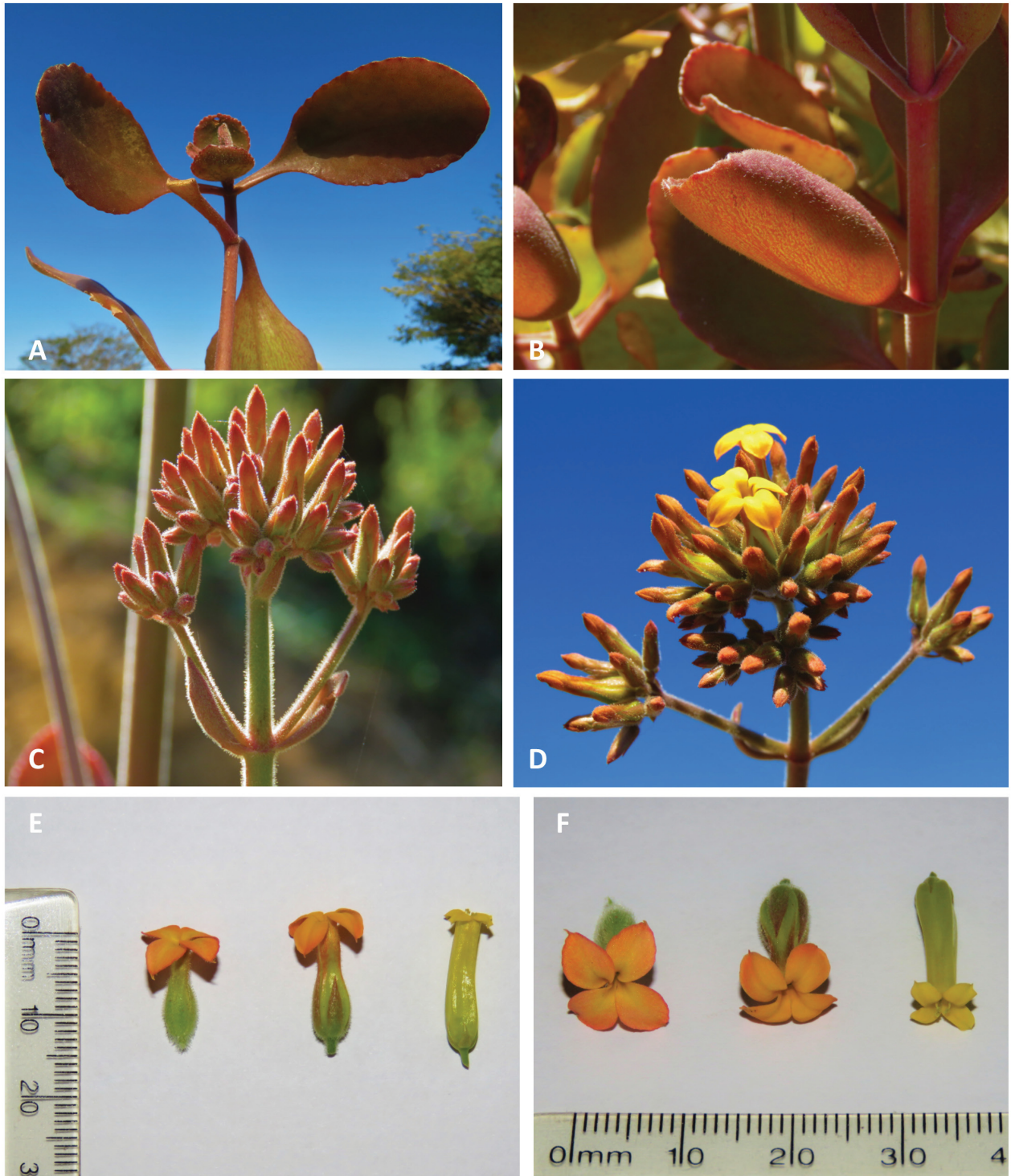


FIGURE 2. *Kalanchoe* *x sogae*. **A.** At flowering maturity plants of this shrubby nothospecies reach a height 0.5–1.0 m. **B.** Leaves are puberulous and mid-green to most often distinctly red or strongly crimson red-infused. **C.** Apart from being intensely reddish-infused, virtually all the plant parts are puberulous. In bud, the flowers are bright orange-red apically. Flowers are borne erectly to slanted sideways—never pendent. Excepting the adaxial surface of the corolla lobes, the flowers, too, are conspicuously puberulous throughout. **D.** Especially the basal swollen part of the corolla tube is light green and distinctly 4-angled-fluted. **E.** Flowers, here in lateral view, of *K. x sogae* (centre) are intermediate between those of *K. lateritia* (left, one of the parents of *K. x sogae*) and *K. sexangularis* (right, the other parent of *K. x sogae*); rounded when viewed from below; gradually narrowly cylindrical above; and with the angles distinctly and strongly orange-infused to yield a green-orange-striped appearance. **F.** Corolla lobes of *K. x sogae* (centre) are bright yellow to strongly bright orange-infused, rather similar to those of *K. lateritia* (left) but differs from the bright yellow, faintly brown-tipped ones of *K. sexangularis* (right). All photographs taken by Gideon F. Smith.

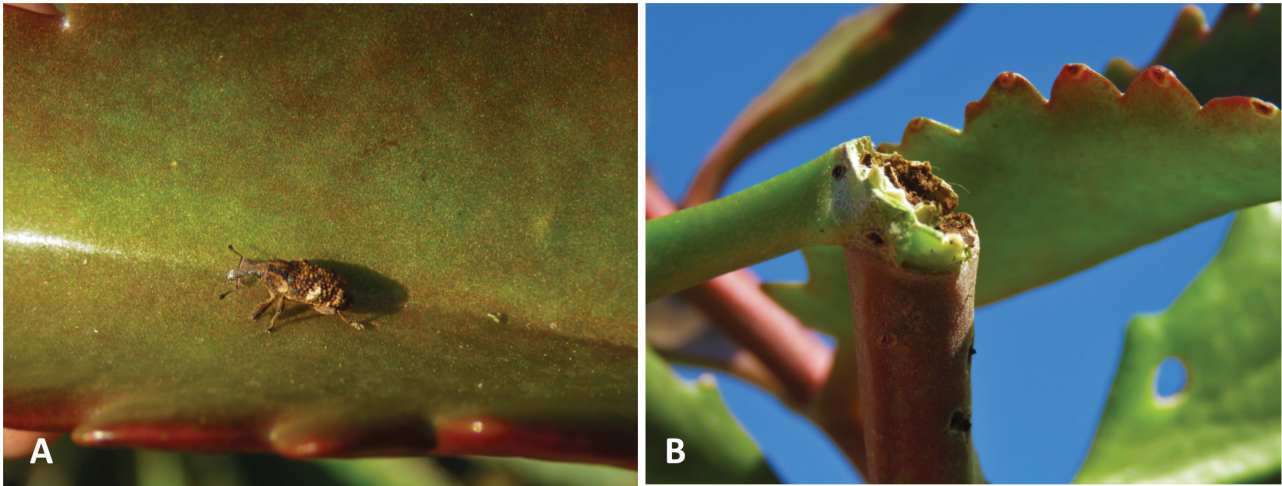


FIGURE 3. **A.** The indigenous South African weevil *Sternuchopsis sedi* (Coleoptera: Curculionidae: Molytinae: Mecysolobini) on a leaf of *K. sexangularis*. The weevil is 7 mm long. **B.** The weevil deposits its eggs in the stems of kalanchoes where the hatched larvae feed on the internal tissues, usually leaving only a hollowed out and very much weakened tube that will easily snap off. Both photographs taken by Gideon F. Smith.

Further, a hairy vestiture is not restricted to the vegetative parts of these, and some other, species of *Kalanchoe*; in many instances the stem-peduncle continuum, inflorescence branches, and flowers (usually excepting the adaxial corolla lobe surface) too can be variously and often very densely hairy (Weryzko-Chmielewska & Chernetsky 2005).

Horticultural material of the intensely red-infused *K. sexangularis*, an endemic southern and south-tropical African species, has for long been popular in outdoor cultivation in mild-climate regions of the world. This species has also been combined with reddish purple-leaved forms of *K. luciae* to yield horticulturally successful, strikingly red- to purplish red-leaved material that was described as *K. ×estrelae*, as well as giving rise to orange-leaved material described as *K. ×leistneri* Smith (2021c: 250), following combination with *K. winteri* Gideon F.Sm., N.R.Crouch & Mich. Walters in Crouch *et al.* (2016: 219).

Kalanchoe sexangularis, as well as *K. ×estrelae*, can act as hosts of, and are sometimes severely attacked by, the kalanchoe weevil, *Sternuchopsis sedi* (Marshall 1938) (Coleoptera: Curculionidae: Molytinae: Mecysolobini) (Fig. 3A–B). The weevil deposits its eggs in the stems where the hatched larvae feed on the internal tissues, usually leaving only a hollowed out and very much weakened and tube-like stem that will easily snap off. The weevil can also incite stem galls and both larvae and adults can cause substantial damage to kalanchoe populations. However, to date, likely given its puberulous vestiture, *K. ×sogae* has not been observed as acting as a host of *S. sedi*. It has been long-known that variously hairy representatives of the Crassulaceae are less prone to attacks by phytophagous insects than glabrous species [see for example Smith *et al.* 2019a: 80 on the hairy form of *Cotyledon barbeyi* Schweinf. ex Baker (1893: 624)].

Kalanchoe ×sogae responds well to cultivation and once material propagated through stem cuttings is rooted very little aftercare is required. With red, yellow, and orange, the predominant leaf and flower colours of *K. ×sogae*, which are so-called related colours on the landscaping colour wheel (Calhoun 2009: 118), this nothospecies, material of which has thus far entered the horticultural trade in limited volumes, is an excellent addition to material suitable for waterwise, even no-irrigation, gardening in mild climates (Smith 2020a–d, 2021a, Smith & Hankey 2021, Smith & Shtein 2021).

References

- Adanson, M. (1763) *Familles des Plantes. Seconde Partie. Etat actuel de la Botanique*. Chez Vincent, Imprimeur-Libraire de M^{gr} le Comte de Provence, Paris, 640 pp. [<https://www.biodiversitylibrary.org/item/6958#page/794/mode/1up>]
- Baker, J.G. (1881 [21 February]) Notes on a collection of flowering plants made by L. Kitching, Esq., in Madagascar in 1879 (Plates VII. & VIII.). *Journal of the Linnean Society, Botany* 18: 264–281. [<https://www.biodiversitylibrary.org/item/8373#page/271/mode/1up>]

- Baker, J.G. (1882) Contributions to the flora of central Madagascar (to be continued). *Journal of Botany, British and Foreign*. London 20: 109–114. [<https://www.biodiversitylibrary.org/item/35873#page/125/mode/1up>]
- Baker, J.G. (1893 [27 May]) New or noteworthy plants. *Cotyledon barbeyi*, Schweinf. ined.* *The Gardeners' Chronicle*. [A weekly illustrated journal of Horticulture and Allied Subjects], 3rd ser., XIII(No. 335): 624–625. [<https://www.biodiversitylibrary.org/item/83804#page/646/mode/1up>]
- Beentje, H. & Williamson, J. [illustrations] (2010) *The Kew plant glossary: an illustrated dictionary of plant terms*. Kew Publishing, Royal Botanic Gardens Kew, Richmond, Surrey, 160 pp.
- Berger, A. (1930 [Mai]) Crassulaceae. Unterfam. II. Kalanchoideae [sic, Kalanchooideae]. 6. *Kalanchoe* Adanson. 7. *Kitchingia* Baker. 8. *Bryophyllum* Salisb. In: A. Engler & K. Prantl (eds.) *Die natürlichen Pflanzenfamilien*. edn 2, 18a. Verlag von Wilhelm Engelmann, Leipzig, pp. 378–386, 402–412.
- Brown, N.E. (1913) 1436. *Kalanchoe sexangularis*. In: XVII—Diagnoses Africanæ LIII. *Bulletin of Miscellaneous Information, Kew* 1913 (3): 120–121. [<https://www.biodiversitylibrary.org/item/43726#page/125/mode/1up>]
- Calhoun, S. (2009) *The hot garden. Landscaping design for the desert southwest*. Rio Nuevo Publishers, Tucson, Arizona, 192 pp.
- Crouch, N.R., Smith, G.F., Walters, M. & Figueiredo, E. (2016) *Kalanchoe winteri* Gideon F.Sm., N.R.Crouch & Mich.Walters (Crassulaceae), a new species from the Wolkberg Centre of Endemism, South Africa. *Bradleya* 34: 217–224. <https://doi.org/10.25223/brad.n34.2016.a9>
- Drake del Castillo, E. (1903) Note sur les plantes recueillies par M. Guillaume Grandidier dans le sud de Madagascar, en 1898 et 1901. (A suivre). *Bulletin du Muséum d'Histoire Naturelle* 9: 35–46. [<https://www.biodiversitylibrary.org/page/42893852#page/45/mode/1up>]
- Engler, A. (1894) Über die Gliederung der Flora Usambaras und der angrenzenden Gebiete. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin*. Berlin. 1894: 1–86. [<https://www.biodiversitylibrary.org/item/92793#page/55/mode/1up>]
- Engler, A. (Ed.) (1895) Verzeichniss der bis jetzt aus Ost-Afrika bekannt gewordenen Pflanzen. *Die Pflanzenwelt Ost-Afrikas und der Nachbargebiete*. Theil C. Geographische Verlagshandlung Dietrich Reimer, Berlin, pp. 1–433 [Crassulaceae on pp. 188–189]. [<https://www.biodiversitylibrary.org/item/10523#page/193/mode/1up>]
- Figueiredo, E. & Smith, G.F. (2021) Women in the first three centuries of formal botany in southern Africa. *Blumea* 66 (3): 275–307. <https://doi.org/10.3767/blumea.2021.66.03.10>
- Figueiredo, E., Smith, G.F. & Crouch, N.R. (2016) The taxonomy and type of *Kalanchoe sexangularis* N.E.Br. (Crassulaceae). *Bradleya* 34: 92–99. <https://doi.org/10.25223/brad.n34.2016.a24>
- Forsskål, P. (1775) *Flora Ægyptiaco-Arabica. Sive descriptiones plantarum, Quas per Ægyptum inferiorem et Arabiam felicem detexit* [...]. Ex officina Mölleri, aulæ Typographi. Prostat apud Heineck et Faber, Hauniae, 220 pp. <https://doi.org/10.5962/bhl.title.6625>
- Gunn, M.[D.] & Codd, L.E.[W.] (1981) *Botanical exploration of southern Africa. An illustrated history of early botanical literature on the Cape flora. Biographical accounts of the leading plant collectors and their activities in southern Africa from the days of the East India Company until modern times*. A.A. Balkema, Cape Town, 400 pp.
- Hamet, R. (1908) *Kalanchoe luciae* sp. nov. *Bulletin de l'Herbier Boissier*, sér. 2, 8: 254–257. [<https://www.biodiversitylibrary.org/item/104945#page/290/mode/1up>]
- Hamet, R. & Perrier de la Bâthie, J.M.H.A. (1912) Contribution à l'étude des Crassulacées malgaches. *Annales des Sciences Naturelles. Botanique*, sér. 9, 16: 361–377. [<https://www.biodiversitylibrary.org/item/24564#page/771/mode/1up>]
- Hammel, T. (2020) African farmers and medicinal plant experts. In: Drayton, R. & Dubow, S. (eds.) *Shaping natural history and settler society. Mary Elizabeth Barber and the nineteenth-century Cape* [corrected]. Cambridge Imperial and Post-Colonial Studies Series. Palgrave Macmillan, and imprint of Springer Nature, Cham, Zug, Switzerland, pp. 39–74, the whole work 360 pp. https://doi.org/10.1007/978-3-030-22639-8_2
- Haworth, A.H. (1824 [September]) XXXI. Decas novarum Plantarum Succulentarum. (“Mr Haworth’s *Decade of new Succulent Plants*.”). *The Philosophical Magazine and Journal*[: comprehending various branches of science, the liberal and fine arts, agriculture, manufactures, and commerce] 64: 184–191. <https://doi.org/10.1080/14786442408644582>
- Haworth, A.H. (1825 [06 July]) III. Decas quarta novarum Plantarum Succulentarum (“Mr Haworth’s *Fourth Decade of new Succulent Plants*.”). *The Philosophical Magazine and Journal*[: comprehending various branches of science, the liberal and fine arts, agriculture, manufactures, and commerce] 66: 27–33. <https://doi.org/10.1080/14786442508673917>
- IPNI. (2022 [continuously updated]) *The International Plant Names Index*. Available from: <https://www.ipni.org/> (accessed 2022).
- Koorders, S.H. (1919 [Mai] [24 October 1918]) Beitrag zur Kenntniss der Flora von Java No. 18. Beschreibung von *Kalanchoë Schumacheri* vom Idjen-Plateau und Revision der Crassulaceae von Java. (Mit 2 lithographischen Tafeln.). *Bulletin du Jardin Botanique de*

- Buitenzorg* sér. 3, 1 (3): 169–180, Figures 14 and 15. [<https://www.biodiversitylibrary.org/item/27173#page/205/mode/1up> (text); <https://www.biodiversitylibrary.org/item/27173#page/243/mode/1up> (figures)]
- Lawrence, G.H.M. (1970) *Taxonomy of vascular plants*, 11th printing. The Macmillan Company, New York and Toronto, Ontario, 823 pp.
- Marshall, G.A.K. (1938) XX. New Curculionidae (Col.) from southern Africa. *Annals and Magazine of Natural History* ser. 11, 1 (2): 178–195. [<https://www.tandfonline.com/doi/abs/10.1080/00222933808526755>]
- Persoon, C.H. (1805 [1 April–15 June]) *Synopsis plantarum, seu enchiridium botanicum, complectens enumerationem systematicam specierum hucusque cognitorum*. Pars prima. Apud Carol. Frid. Cramerum, Parisiis lutetiorum [Paris] et apud J.G. Cottam, Tubingæ [London].
<https://doi.org/10.5962/bhl.title.638>
- Raymond-Hamet. (1916) Sur un groupe de transition reliant le genre *Kalanchoe* au genre *Cotyledon*. *Revue Générale de Botanique, Paris* XXVIII: 80–84. [<https://www.biodiversitylibrary.org/item/45180#page/83/mode/1up>]
- Raymond-Hamet. (1933) Observations sur le *Kalanchoe uniflora* (Stapf) Raymond-Hamet. *Bulletin de la Société Botanique de France* 80 (4): 542–548.
<https://doi.org/10.1080/00378941.1933.10833878>
- Salisbury, R.A. (1805 [1 June 1805]) *The Paradisus Londinensis: or coloured figures of plants cultivated in the vicinity of the metropolis* 1. Published by William Hooker, No. 6, Frith Street, city not stated, presumably London, 157 pp. & 117 plates.
<https://doi.org/10.5962/bhl.title.53520>
- Smith, G.F. (2020a) *Kalanchoe* × *estrelae* (Crassulaceae subfam. Kalanchooideae): a new nothospecies for the hybrid between *K. luciae* and *K. sexangularis*. *Phytotaxa* 441 (2): 225–228.
<https://doi.org/10.11646/phytotaxa.441.2.11>
- Smith, G.F. (2020b) Character inheritance in *Kalanchoe* ‘Vivien’ Bischofberger (Crassulaceae subfam. Kalanchooideae), a cultivar derived from an interspecific hybrid between two southern African species (*K. luciae* Raym.-Hamet × *K. sexangularis* N.E.Br.). *Bradleya* 38: 3–13.
<https://doi.org/10.25223/brad.n38.2020.a1>
- Smith, G.F. (2020c) Zwei Neuzugänge im *Kalanchoe*-Gartenbau: *K. ×estrelae* and *K. ×gunniae*. / Two recent additions to *Kalanchoe* horticulture: *K. ×estrelae* and *K. ×gunniae*. *Avonia* 38 (4): 322–327.
- Smith, G.F. (2020d) Plant smart. The big easy. Gardening with *Kalanchoe*. *Veld & Flora* 106 (3): 40–43.
- Smith, G.F. (2020e) *Kalanchoe* Adans. subg. *Fernandesiae* Gideon F.Sm. (Crassulaceae subfam. Kalanchooideae), a new subgenus from southern and south-tropical Africa. *Haseltonia* 27: 2–7.
<https://doi.org/10.2985/026.027.0101>
- Smith, G.F. (2020f) *Kalanchoe* × *hummeliae* Gideon F.Sm.: the hybrid between *K. beharensis* Drake and *K. millotii* Raym.-Hamet & H.Perrier (Crassulaceae subfam. Kalanchooideae). *Bradleya* 38: 89–93.
<https://doi.org/10.25223/brad.n38.2020.a12>
- Smith, G.F. (2020g) Nomenclature of the partial infrageneric classification proposed for *Kalanchoe* (Crassulaceae subfam. Kalanchooideae) by René C.J.E. Maire in 1976. *Phytotaxa* 468 (2): 231–235.
<https://doi.org/10.11646/phytotaxa.468.2.8>
- Smith, G.F. (2021a) Meet the kalanchoe people. New South African kalanchoe hybrids have been named in honour of key figures in our botany and horticulture. *Veld & Flora* 107 (2): 40–43.
- Smith, G.F. (2021b) Reinstatement of *Kalanchoe* [subg. *Bryophyllum*] sect. *Alatae* (Crassulaceae subfam. Kalanchooideae) for *K. porphyrocalyx* and *K. uniflora*, two Madagascan endemics. *Bradleya* 39: 177–181.
<https://doi.org/10.25223/brad.n39.2021.a17>
- Smith, G.F. (2021c) *Kalanchoe* × *leistneri* (*K. sexangularis* × *K. winteri*) (Crassulaceae subfam. Kalanchooideae), a new southern African nothospecies. *Phytotaxa* 509 (2): 248–254.
<https://doi.org/10.11646/phytotaxa.509.2.8>
- Smith, G.F. (2022a) *Kalanchoe* sect. *Raveta* (Crassulaceae subfam. Kalanchooideae) of Raymond-Hamet (1916): a long-overlooked name in *K.* subg. *Kalanchoe*. *Phytotaxa* 550 (2): 208–212.
<https://doi.org/10.11646/phytotaxa.550.2.10>
- Smith, G.F. (2022b) A review of the ecology and natural history of *Kalanchoe* (Crassulaceae subfam. Kalanchooideae) in southern Africa. *Bradleya* 40: 161–184.
<https://doi.org/10.25223/brad.n40.2022.a15>
- Smith, G.F. (2022c) Notes on *Kalanchoe* subg. *Bryophyllum* (Crassulaceae subfam. Kalanchooideae) and the kalanchoes of Sijfert H. Koorders (1919). *Phytotaxa* 549 (1): 87–96.
<https://doi.org/10.11646/phytotaxa.549.1.7>

- Smith, G.F. (2022d) Identity of *Kalanchoe* ‘Fang’ and *K.* ‘Rose Leaf’, two cultivars derived from *K. ×edwardii* (Crassulaceae subfam. Kalanchooideae), with notes on aspects of interspecific hybridisation in the genus. *Bradleya* 40: 151–160.
<https://doi.org/10.25223/brad.n40.2022.a14>
- Smith, G.F. & Figueiredo, E. (2018) The infrageneric classification and nomenclature of *Kalanchoe* Adans. (Crassulaceae), with special reference to the southern African species. *Bradleya* 36: 162–172.
<https://doi.org/10.25223/brad.n36.2018.a10>
- Smith, G.F. & Figueiredo, E. (2019) Taxonomic and nomenclatural notes on *Kalanchoe millotii* Raym.-Hamet & H.Perrier and the cultivar *Kalanchoe* ‘Fern Leaf’ (Crassulaceae). *Bradleya* 37: 79–86.
<https://doi.org/10.25223/brad.n37.2019.a30>
- Smith, G.F. & Figueiredo, E. (2020) *Kalanchoe ×gildenhuysii* (Crassulaceae subfam. Kalanchooideae), a new nothospecies derived from *K. millotii* and *K. tomentosa*. *Phytotaxa* 442 (1): 43–46.
<https://doi.org/10.11646/phytotaxa.442.1.8>
- Smith, G.F. & Figueiredo, E. (2022a) Clarifying the typification of the name *Kalanchoe orgyalis* (Crassulaceae subfam. Kalanchooideae). *Phytotaxa* 543 (1): 99–102.
<https://doi.org/10.11646/phytotaxa.543.1.11>
- Smith, G.F. & Figueiredo, E. (2022b) Nomenclatural and taxonomic notes on the names published in *Kalanchoe* (Crassulaceae subfam. Kalanchooideae) by Drake del Castillo in 1903. *Phytotaxa* 547 (2): 158–166.
<https://doi.org/10.11646/phytotaxa.547.2.3>
- Smith, G.F. & Figueiredo, E. (2023a). *Kalanchoe luciae*. Crassulaceae subfam. Kalanchooideae. Southern and south-tropical Africa (South Africa, Swaziland, Mozambique, Zimbabwe). *Flowering Plants of Africa* 68: in press.
- Smith, G.F. & Figueiredo, E. (2023b) *Kalanchoe orgyalis*. Madagascar. *Flowering Plants of Africa* 68. [in press]
- Smith, G.F., Figueiredo, E. & Bernhard, S. (2019b) Notes on the taxonomy and nomenclature of *Kalanchoe brevisepala* (Humbert) L.Allorge and its basionym, *K. millotii* Raym.-Hamet & H.Perrier subsp. *brevisepala* Humbert, and *Kalanchoe dinklagei* Rauh (Crassulaceae). *Bradleya* 37: 87–96.
<https://doi.org/10.25223/brad.n37.2019.a31>
- Smith, G.F., Figueiredo, E. & Crouch, N.R. (2021e) *Kalanchoe millotii*. Crassulaceae: Kalanchooideae. Madagascar. *Flowering Plants of Africa* 67: 80–89, plate 2368.
- Smith, G.F., Figueiredo, E., Loureiro, J. & Crouch, N.R. (2019c) *Kalanchoe ×gunniae* Gideon F.Sm & Figueiredo (Crassulaceae), a new South African nothospecies derived from *Kalanchoe paniculata* Harv. × *Kalanchoe sexangularis* N.E.Br. *Bradleya* 37: 141–150.
<https://doi.org/10.25223/brad.n37.2019.a9>
- Smith, G.F., Figueiredo, E. & Van Wyk, A.E. (2019a) *Kalanchoe* (Crassulaceae) in southern Africa. *Classification, biology, and cultivation*. Academic Press, an imprint of Elsevier, London, San Diego, Cambridge (USA), and Oxford, 328 pp.
<https://doi.org/10.1016/B978-0-12-814007-9.00003-7>
- Smith, G.F., Figueiredo, E. & Walker, C.C. (2021d) *Kalanchoe beharensis*. Crassulaceae subfam. Kalanchooideae. Madagascar. *Flowering Plants of Africa* 67: 50–59, plate 2365.
- Smith, G.F. & Hankey, A. (2021) *Kalanchoe ×forbesiae* (Crassulaceae subfam. Kalanchooideae) derived from *K. lubangensis* × *K. sexangularis*: towards improved horticultural material. *Phytotaxa* 528 (5): 290–300.
<https://doi.org/10.11646/phytotaxa.528.5.3>
- Smith, G.F., Klein, D.-P. & Shtein, R. (2021b) A revision of the Malagasy *Kalanchoe* subg. *Kitchingia* (Crassulaceae subfam. Kalanchooideae): history, taxonomy, and nomenclature. *Phytotaxa* 507 (1): 67–80.
<https://doi.org/10.11646/phytotaxa.507.1.3>
- Smith, G.F. & Monroe, A.M. (2022a) The nomenclature and taxonomy of Crassulaceae subfam. Kalanchooideae resolved. *Phytotaxa* 555 (3): 241–251.
<https://doi.org/10.11646/phytotaxa.555.3.3>
- Smith, G.F. & Monroe, A.M. (2022b) (2908) Proposal to reject the name Crassulaceae subfam. Cotyledonoideae (Crassulaceae). *Taxon* 71 (4): 910–911.
<https://doi.org/10.1002/tax.12778>
- Smith, G.F. & Shtein, R. (2020) *Kalanchoe ×edwardii* (Crassulaceae subfam. Kalanchooideae), a nothospecies derived from *K. beharensis* and *K. tomentosa*. *Phytotaxa* 475 (2): 117–124.
<https://doi.org/10.11646/phytotaxa.475.2.6>
- Smith, G.F. & Shtein, R. (2021) A review of horticulturally desirable characters in *Kalanchoe* (Crassulaceae subfam. Kalanchooideae): variable and deviating vegetative and reproductive morphologies useful in breeding programmes. *Haseltonia* 28: 106–119.
<https://doi.org/10.2985/026.028.0110>
- Smith, G.F., Shtein, R. & Klein, D.-P. (2021a) *Kalanchoe* subg. *Alatae* (Crassulaceae subfam. Kalanchooideae), a new rank for *K.* sect.

Alatae. Phytotaxa 509 (2): 255–258.

<https://doi.org/10.11646/phytotaxa.509.2.9>

Smith, G.F., Shtein, R., Klein, D.-P., Parihar, B., Almeida, A., Rodewald, S. & Kadereit, G. (2021c) Sexual and asexual reproduction in *Kalanchoe* (Crassulaceae): a review of known and newly recorded strategies. *Haseltonia* 28: 2–22.

<https://doi.org/10.2985/026.028.0101>

Soga, J.F. (1891) Disease ‘Nenta’ in goats. *Agricultural Journal of the Cape of Good Hope* 3: 140–142.

Thiers, B. (2022 [continuously updated]) *Index herbariorum: a global directory of public herbaria and associated staff*. New York Botanical Garden’s Virtual Herbarium. Available from: <http://sweetgum.nybg.org/ih/> (accessed 2022).

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F. (2018) *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Koeltz Botanical Books, Glashütten. [Regnum Vegetabile 159], 254 pp.

<https://doi.org/10.12705/Code.2018>

Weryzko-Chmielewska, E. & Chernetsky, M. (2005) Structure of trichomes from the surface of leaves of some species of *Kalanchoë* Adans. *Acta Biologica Cracoviensia Series Botanica* 47 (2): 15–22.