Phytotaxa 487 (3): 185–194
https://www.mapress.com/j/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.487.3.1

A new species of *Osteospermum* subgen. *Tripteris* (Asteraceae: Calenduleae) from the Namib Desert, Namibia

WESSEL SWANEPOEL[1,2,5*], VERA DE CAUWER[3,6] & ABRAHAM E. VAN WYK[2,4,7]

[1] *Independent Researcher, P.O. Box 21168, Windhoek, Namibia.*
[2] *H.G.W.J. Schweickerdt Herbarium, Department of Plant and Soil Sciences, University of Pretoria, Pretoria, 0002 South Africa.*
[3] *Biodiversity Research Centre, Faculty of Natural Resources and Spatial Sciences, Namibia University of Science and Technology, Private Bag 13388, Windhoek, Namibia.*
[4] *South African National Biodiversity Institute, Private Bag X101, Pretoria, 0001 South Africa.*
[5] *wessel@kaokosafari.com; https://orcid.org/0000-0002-0181-3543*
[6] *vdecauwer@nust.na; https://orcid.org/0000-0003-3383-7758*
[7] *braamvanwyk@gmail.com; https://orcid.org/0000-0002-0437-3272*
**Author for correspondence*

Abstract

Osteospermum namibense, here described as a new species, is known only from the northern part of the Namib Desert in the Kaokoveld Centre of Endemism, northwestern Namibia. Within a broad generic concept for *Osteospermum* (tribe Calenduleae), the new species is a member of subgen. *Tripteris*. These dwarf shrubs grow on rocky outcrops under harsh desert conditions. Diagnostic characters for *Osteospermum namibense* include the perennial, woody habit, di- or trichotomous branching, succulent leaves arranged in rosettes, and capitula with 12–14 rays. A comparison of some of the more prominent morphological features to differentiate between *O. namibense* and its possible nearest relative, *O. microcarpum* (=*Tripteris microcarpa*), is provided. Based on IUCN Red List categories and criteria, a conservation assessment of Vulnerable (VU D1) is recommended for the new species.

Keywords: endemism, flora, Kaokoveld Centre of Endemism, *Osteospermum* sect. *Trifenestratae*, sand armour, succulent, taxonomy, *Tripteris*

Introduction

In the recent past, twenty described species of *Tripteris* Lessing (1831: 95), narrowly defined following Nordenstam (2006, 2007), were recognized in the Flora of southern Africa [FSA] region (South Africa, Namibia, Botswana, Eswatini, and Lesotho), ten of which occur in Namibia (Germishuizen & Meyer 2003, Klaassen & Kwembeya 2013). The generic name *Tripteris* derives from the Greek *tri* = three and *pteron* = wing, referring to the fruit (achenes) that are three-winged (Clarke & Charters 2016).

Although members of *Tripteris* can easily be recognized by the three-winged, apically fenestrated achenes that are dispersed by wind, available molecular analysis of the tribe Calenduleae suggests that even when narrowly defined, *Tripteris* as a genus may well be polyphyletic (Nordenstam & Källersjö 2009). Because few synapomorphies are available to recognize segregate genera, and pending further phylogenetic studies on the Calenduleae, Manning & Goldblatt (2008, 2012) proposed the provisional recognition of *Osteospermum* Linnaeus (1753: 923) in a broad sense for the monophyletic clade sister to *Dimorphotheca* Moench (1794: 585) in the phylogenetic tree of Nordenstam & Källersjö (2009). This approach has since been widely adopted by herbaria in the FSA region (e.g. South African National Biodiversity Institute 2020) and is also followed in the present contribution. Such a broad circumscription of *Osteospermum* is in line with the earlier treatment of the Calenduleae by Norlindh (1943), with members of *Tripteris* s.str. being classified under *Osteospermum* subgen. *Tripteris* (Lessing 1831: 95) Norlindh (1943: 263) sect. *Trifenestratae* Norlindh (1943: 270).

In this paper, a new species of *Osteospermum* subgen. *Tripteris* endemic to the Kaokoveld Centre of Endemism, a biogeographical region rich in range-restricted plants and animals in northwestern Namibia and adjacent southwestern

Accepted by Ronell Klopper: 5 Feb. 2021; published: 26 Feb. 2021

Angola (Van Wyk & Smith 2001), is described. In May 2018, during a scoping expedition to the Skeleton Coast National Park aimed at monitoring biodiversity in the new Iona Skeleton Coast Transfrontier Park, two of us (WS & VDC) encountered an unfamiliar but sterile perennial dwarf shrub with succulent leaves on a rocky hill between the Nadas and Sechomib rivers. During a follow-up visit in February 2019 the plants were in flower and fruit, enabling fertile material to be collected and the plants to be identified as an undescribed species of *Osteospermum*. Similar plants have since been recorded from various localities between the Engo and Khumib rivers, all within the boundaries of the Skeleton Coast National Park.

The new species seems to be closely related to *Osteospermum microcarpum* (Harvey 1865: 427) Norlindh (1943: 295), especially to *O. microcarpum* subsp. *septentrionale* Norlindh (1943: 300) [=*Tripteris microcarpa* subsp. *septentrionalis* (Norl.) Nordenstam 1994: 48] with which its distribution overlaps (Norlindh 1943, 1965). Such an affinity is suggested by similarities in indumentum, leaf, flower and fruit morphology (dense glandular hairs on stems, leaves and inflorescences; leaves narrow with small teeth; rays yellow; achenes 3-winged, relatively small). A study of the *Osteospermum* s.l. holdings in the National Herbarium of Namibia (WIND) revealed three other collections of the new species, all filed under *O. microcarpum* (herbarium acronym follows Thiers 2020).

Methods

Diagnostic features for the new species and *Osteospermum microcarpum* were determined through examination of live material. For *O. microcarpum* high resolution images (including images of the type specimens) available on the internet through JSTOR Global Plants (https://plants.jstor.org/) were also examined. This was supplemented by study of relevant literature (including the protologue) and herbarium collections (Harvey 1865, Norlindh 1943, 1960, 1965). The National Herbarium of Namibia in Windhoek was consulted for possible collections of the new species. As imaging equipment, a 6.5–45.0 magnification stereo microscope was used for determining morphological features. Descriptive terminology follows Beentje (2016). The distribution map was compiled from specimen data using ArcView 3.1 software. For all collections, quarter degree grid squares are supplied according to the Degree Reference System proposed by Edwards & Leistner (1971). Conservation assessment follows IUCN (2012) recommendations.

Taxonomic treatment

Osteospermum namibense Swanepoel, *sp. nov.* (Figs 1–3)

Diagnosis:—Dwarf shrub up to 0.5 m high, related to *O. microcarpum,* but differing by being perennial (*vs*. annual in nature, although reported as a short-lived perennial in cultivation); branches initially succulent becoming woody (*vs*. branches succulent, remaining herbaceous), branching di- or trichotomous, zig-zag in appearance (*vs*. alternate, virgate); leaves distinctly succulent (*vs*. not or only slightly succulent), distal leaves arranged in rosettes (*vs*. alternate and spirally), lamina oblanceolate or narrowly obovate, trigonous in transverse section, sessile (*vs*. oblanceolate, lanceolate, sublinear or ligulate, crescent-shaped in transverse section, sessile or petiolate); ray florets per capitulum 12–14 (*vs*. 16–20); achenes dimorphic (*vs*. achenes monomorphic).

Type:—NAMIBIA. Kunene Region: Skeleton Coast National Park, basalt ridge, 8 km east of Agaatberg Mountain along track to stone circles, 1812AC, 63 m a.s.l., 25 September 2020, *Swanepoel 396* (holotype WIND!; isotypes PRE!, PRU!).

Perennial dwarf shrub up to 0.5 m high with di- or trichotomous branching; younger vegetative growth and some reproductive parts glandular hairy and sticky, with adherent sand grains. *Branches* densely covered with tapering glandular hairs of variable length, glabrescent, initially succulent, becoming woody with prominent leaf scars, short, 13–100 mm long before rebranching. *Leaves* succulent; older proximal cauline leaves ligulate, semi-amplexicaul, soon withering; younger distal leaves alternate and spirally arranged, appearing as rosettes at branch apices, sessile, lamina oblanceolate or narrowly obovate, in transverse section halfway between base and apex trigonous or vertically compressed trigonous, apex acute or obtuse, base gradually tapering; margins entire, crenate or crenate-serrate towards apex with 2 or 3 teeth each side, midrib slightly prominent abaxially, 10–25 × 5–8 mm, pale green, densely covered by tapering glandular hairs of variable length, usually with additional simple hairs towards base adaxially; withered leaves persistent, sometimes completely covering stem and branches. *Inflorescences* axillary or terminal, all parts

densely covered by tapering glandular hairs of variable length. *Peduncle* 3–25 mm long, 1.2–2.3 mm diam. *Bracts* narrowly triangular or clavate, 4–7 × 1–3 mm long. *Capitula* solitary, radiate, flat, 3.7–4.2 mm diam. (16–18 mm diam. including rays), yellow-flowered, radiate, heterogamous with female ray florets and cylindrical hermaphrodite (female sterile) disc florets. *Receptacle* convex or flat, foveate, when dry flat or convex, verrucose. *Involucre* soft, cupuliform to campanulate, reflexing when in fruit, 8.6–9.8 mm long, 6.0–6.6 mm diam., phyllaries 18–20 in three rows, inner ones longest, narrowly elliptic or lanceolate, 5.0–6.5 ×1.7–2.1 mm long, acute, pale green, with glandular hairs except towards base adaxially, margins membranous, ciliate. *Ray florets* (12–)13(–14), yellow, ligulate, corolla 6.3–8.3 × 2.5 mm long (including ray), tube cylindrical or slightly widening towards limb, 1.2–2.0 mm long, 0.3–0.4 mm diam.; rays yellow, lanceolate or narrowly elliptic with 4 longitudinal pale yellow-green lines, 5.1–6.3 mm long, apex obtuse, with 3 denticulate teeth; outside of tube and abaxially towards base of limb villose. Ovary oblong or narrowly elliptic, triquetrous pale green, 1.5–1.8 mm long, 0.6 mm diam., glabrous or with short conical hairs towards base and apex, often one ovary densely glandular-hairy. Style terete, ca. 3.3 mm long, 0.2 mm diam.; branches ca. 1.6 mm long, flattened, grooved. *Achenes* 3-sided, narrowly obovate, winged, smooth or slightly verrucose in places, glabrous or with few short conical hairs, black, 4.7–6.2 mm long, 3.7–4.3 mm wide including wings, apical air-chamber 3-fenestrate, fenestrae ovate, ca. 1 mm long, ca. 20% the length of achene, often one achene lacking wings and with remains of dense glandular hairs. *Disc florets* 21–38, pale yellow, corolla ca. 3.3–4.0 mm long; tube cylindrical or slightly widening towards limb, ca. 0.8 mm long, 0.4 mm diam. glabrous or villose outside; limb cylindrical or slightly widening towards apex, 2.5–3.2 mm long, 0.8–1.1 mm diam., outside villose towards base; lobes 5, ovate, 0.8 mm long, densely papillate outside. Anthers ca. 1.8 mm long including the ovate apical appendage and sagittate base; filaments terete, ca. 1 mm long. Style simple, sterile, ca. 3.4 mm long, 0.2 mm diam., tipped with a rounded appendage 0.3 mm diam., with short papillae. Ovary sterile, narrowly oblong, laterally flattened, glabrous, 0.7–1.3 mm long.

Phenology:—Flowers and fruit were recorded from January to September.

Distribution, habitat and ecology:—At present *Osteospermum namibense* is known only from the northern part of the Skeleton Coast National Park, Namibia (Fig. 4) where it occurs in small colonies of a few plants each. This part of the Skeleton Coast National Park falls within the Namib Desert zone of the Kaokoveld Centre of Endemism, a biogeographical region known for its many restricted-range plants and animals, and extending from northwestern Namibia to southwestern Angola (Van Wyk & Smith 2001). *Osteospermum namibense* occurs approximately 5–20 km from the coast at elevations of 60–200 m a.s.l. between the Engo and Khumib rivers.

Environmental conditions in the general distribution area of *Osteospermum namibense* are extremely harsh, with low rainfall, high temperature variation and strong winds. Average annual rainfall in the area is less than 57 mm, occurs in summer and is highly erratic. Annual mean temperature is 19°C (Fick & Hijmans 2017). However, the area regularly receives fog from the bordering Atlantic Ocean with relative occurrence of fog and low clouds varying from approximately 40% to 12% (mean 25%) (Andersen & Cermak 2018) from west to east in the distribution area. Fog occurrence is seasonal and at this latitude (18°–19°S), with minimum occurrence during December and January and maximum occurrence during August and September (Andersen *et al*. 2019). The wind is nearly always blowing and calm for only 14% of the time as measured at Möwe Bay to the south of the new species' range (Mendelsohn *et al*. 2002).

The new species grows on basalt, gneiss and latite in soil-filled rock fissures. The persistent withered leaves on the stems are probably an adaption to protect the fleshy younger branches against the elements until these have been lignified. The potential role, if any, of these leaves in the collecting of water from fog or dew as a source of additional water (e.g. Henschel & Seely 2008) needs investigation. Gland-covered parts of the plants are sticky and trap sand grains (Fig. 3B, C). This capture of sand grains by especially desert plants has been proposed as a potential defence (so-called "sand armour") against larger herbivores. Sand should wear down the teeth of larger herbivores, thus discouraging browsing of the plants (Farmer 2014). Despite the presence of gemsbok and springbok in the range of the new species, we have never encountered any signs of the plants being eaten by these antelope, but more observations are needed to test the validity of this defence hypothesis. The only potential pollinators recorded were flies of the family Mythicomyiidae (A. Kirk-Spriggs pers. com.; Fig. 3A).

Osteospermum namibense and *O. microcarpum* both occur at Okau Spring in the Skeleton Coast National Park, the morphological distinction between the two species being quite obvious when the two are compared. They also occupy different habitats; *O. namibense* grows on the rocky ridges, and *O. microcarpum* on the sandy areas adjacent to the spring.

FIGURE 1: *Osteospermum namibense*: Habit and habitat. A. Plant, ca. 0.4 m high, with dead leaves persisting on older stems. B. Plant partially buried by windblown sand; note leaves arranged in rosettes. Photographs by W. Swanepoel.

FIGURE 2. *Osteospermum namibense*: di- and trichotomous branching. A. Live plant. B. Woody remains of a dead plant. Photographs by W. Swanepoel.

FIGURE 3. *Osteospermum namibense*: flower and fruiting heads, as well as leaves. A. Flower head viewed from above, with two visiting flies in the family Diptera: Mythicomyiidae. B. Leaves and side view of flower head; note succulence of leaves and sand grains sticking to gland-covered surfaces. C. Fruiting head with mature achenes. Photographs by W. Swanepoel.

Conservation status:—Although rare and known from a small area, *Osteospermum namibense* is probably not threatened at present as the entire known population occurs within the boundaries of the Skeleton Coast National Park, a remote and protected area with limited access by humans. No signs of damage caused by animals or humans could be found on any of the *in situ* specimens examined. It should be considered as Vulnerable (VU D1) due to the small known population size (IUCN 2012).

Etymology:—The specific epithet refers to the Namib Desert which, in its broadest definition, stretches along the Atlantic Ocean from San Nicolau in Angola through Namibia to the Olifants River in the Western Cape, South Africa (Seely 2004, Goudie & Viles 2015).

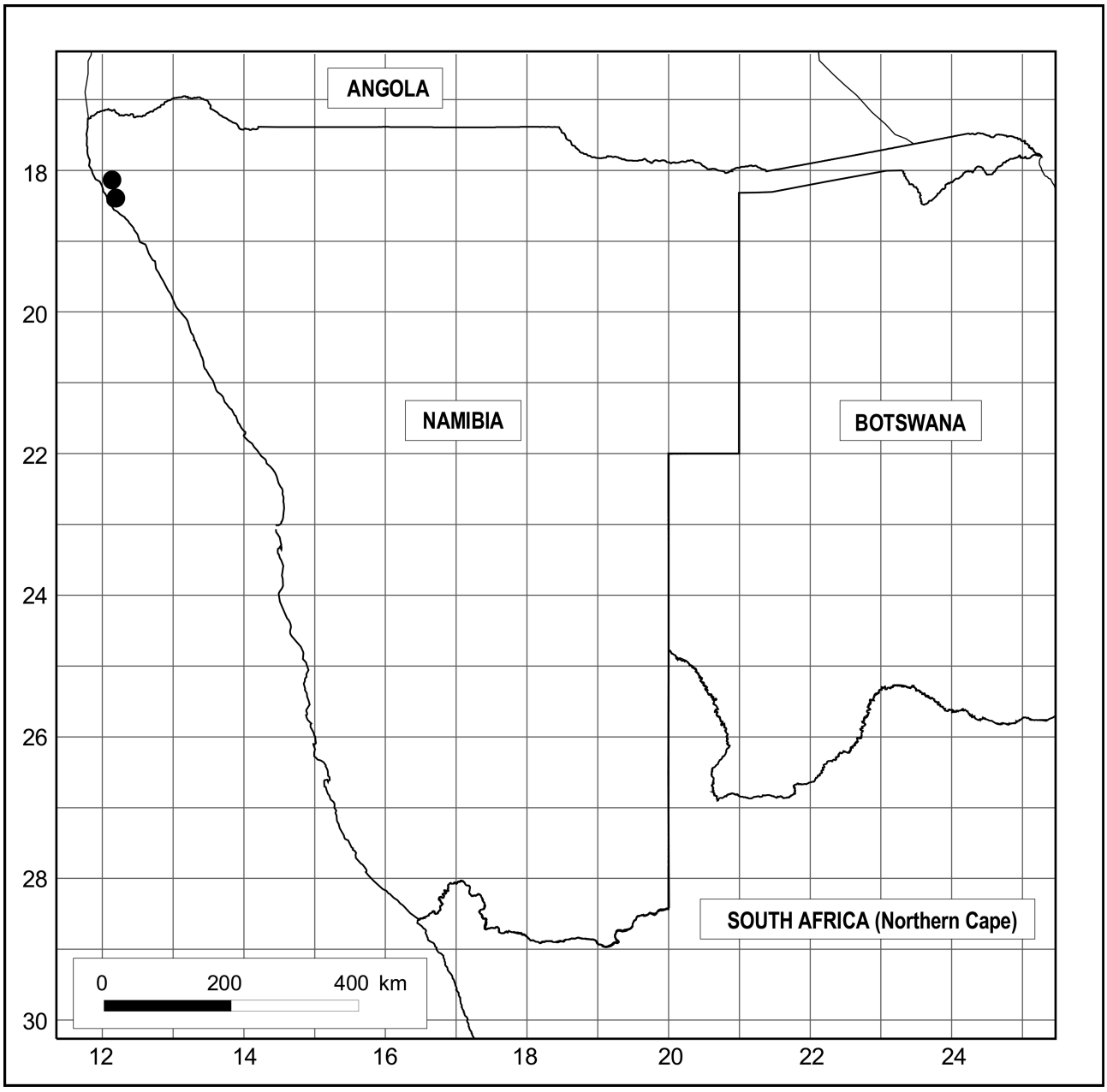

FIGURE 4. Known distribution (black dots) of *Osteospermum namibense.*

Notes:—The nearest relative of *Osteospermum namibense* appears to be *O. microcarpum*, a widespread species from which it differs in habit, branches, leaf and floral characters. Distribution ranges of the two species overlap in the northern Namib. However, they utilize different habitats with *O. namibense* occurring in rocky areas, whereas in the area of overlap *O. microcarpum* occupies sandy washes along drainage lines and the beds of ephemeral rivers. Elsewhere *O. microcarpum* is found from southwestern Angola throughout arid western Namibia to the Northern and Western Cape Provinces of South Africa (Norlindh 1943). Some of the more prominent morphological features to distinguish between the two species are provided in Table 1.

Additional collections (paratypes):—NAMIBIA. Kunene Region:—1812: Opuwo District, (–AA), 16 June 1997, *Burke 97155* (WIND!); Strandloper settlement on road from Cape Fria to Sanitatas, (–AC), ca. 200 m, 18 April 1985, *Moss & Jacobsen* (WIND!); Agaatberg omgewing, Kaap Fria, (–AC), 15 April 1986, *Schoeman s.n.* (WIND!).

TABLE 1. Prominent morphological differences between *Osteospermum namibense* and *O. microcarpum*.

Character	*O. namibense*	*O. microcarpum*
Habit	Perennial, up to 0.5 m tall	Annual, up to 1 m tall; reported as a short-lived perennial under cultivation (Norlindh 1965)
Branching	Di- or trichotomous, appearing zig-zag	Alternate, virgate
Leaves		
Arrangement	Terminal; rosettes and older, soon withering cauline leaves	Alternate and spirally
Lamina shape and attachment	Proximal cauline leaves ligulate, semi-amplexicaul, distal leaves in rosettes, oblanceolate or narrowly obovate, sessile; trigonous or vertically compressed trigonous in t/s halfway between base and apex	Proximal cauline leaves broad, rhomboid to ovate or elliptic, tapering cuneate to a petiole, semi-amplexicaul, minutely auriculate. Distal leaves much narrower, oblanceolate, lanceolate, sublinear or ligulate, sessile or inconspicuously petioled, with or without distinct auricles; crescent-shaped in t/s halfway between base and apex
Lamina margin	Entire, crenate or crenate-serrate	Cauline leaves sinuate-dentate to inciso-pinnatisect; distal leaves distantly denticulate to subentire
Lamina size	10–25 × 5–8 mm	10–80 × 10–50 mm
Peduncle	Simple; 3–25 mm long, 1.4–2.2 mm diam.	Simple or 2- to 4-branched, laxly corymbose; 40–200 mm long, 1.0–1.5 mm diam.
Involucre	8.6–9.8 mm long, 6.0–6.6 mm diam.; number of phyllaries: 18–20	4.7–7.5 mm long, 5.2–6.0 mm diam.; number of phyllaries: 18–30
Ray florets per capitulum	12–14	16–20
Disc florets per capitulum	21–38	30–56
Achenes	Dimorphic; most achenes winged, usually one achene wingless and paler in colour	Monomorphic; all achenes winged
Distribution	Namibia in northern Namib Desert between Engo and Khumib rivers	Northern Namib Desert, from southwestern Angola to Namibia through the central and southern Namib, southern Namibia to the Northern Cape and Western Cape Provinces of South Africa

Acknowledgements

We would like to thank Dr Hester Steyn, SANBI (Pretoria), for preparing the distribution map, and Dr. Ashley Kirk-Spriggs, Natural History Museum (London), for the identification of flies that visited the new species. The curator and staff of the National Herbarium of Namibia (WIND) are thanked for their support during visits to this institution. For assistance and companionship during field trips, the first author is especially grateful to his wife, Hannelie. The constructive comments of two anonymous reviewers are greatly appreciated. We are grateful to the University of Pretoria and the SCIONA project funded by the European Union (EuropeAid/156423/DD/ACT/Multi) for financial support.

References

Andersen, H. & Cermak, J. (2018) First fully diurnal fog and low cloud satellite detection reveals life cycle in the Namib. *Atmospheric Measurement Techniques* 11: 5461–5470.
https://doi.org/10.5194/amt-11-5461-2018

Andersen, H., Cermak, J., Solodovnik, I., Lelli, L. & Vogt, R. (2019) Spatiotemporal dynamics of fog and low clouds in the Namib unveiled with ground and space-based observations. *Atmospheric Chemistry and Physics* 19: 4383–4392.
https://doi.org/10.5194/acp-19-4383-2019

Beentje, H. (2016) *The Kew plant glossary: an illustrated dictionary of plant terms*, 2nd ed. Kew Publishing, Kew, 184 pp.

Clarke, H. & Charters, M. (2016) *In:* Moll, E. (Ed.) *The illustrated dictionary of southern African plant names.* Jacana Media, Sunnyside, Auckland Park, 482 pp.

Edwards, D. & Leistner, O.A. (1971) A degree reference system for citing biological records in southern Africa. *Mitteilungen der Botanischen Staatssammlung München* 10: 501–509.

Farmer, E.E. (2014) *Leaf defence*. Oxford University Press, Oxford, 216 pp.
https://doi.org/10.1093/acprof:oso/9780199671441.001.0001

Fick, S.E. & Hijmans, R.J. (2017) WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology* 37: 4302–4315.
https://doi.org/10.1002/joc.5086

Germishuizen, G. & Meyer, N.L. (Eds.) (2003) Plants of southern Africa: an annotated checklist. *Strelitzia* 14. South African National Biodiversity Institute, Pretoria, 1231 pp.

Goudie, A. & Viles, H. (2015) *Landscapes and land forms of Namibia*. Springer, Dordrecht, 173 pp.
https://doi.org/10.1007/978-94-017-8020-9

Harvey, W.H. (1865) Compositae Juss. *In:* Harvey, W.H. & Sonder, O.W. (Eds.) *Flora Capensis; being a systematic description of the plants of the Cape Colony, Caffraria & Port Natal* 3. Hodges, Smith & Co. Dublin; I.C. Jutta, Cape Town, pp. 44–529.
https://doi.org/10.5962/bhl.title.821

Henschel, J.R. & Seely, M.K. (2008) Ecophysiology of atmospheric moisture in the Namib Desert. *Atmospheric Research* 87: 362–368.
https://doi.org/10.1016/j.atmosres.2007.11.015

IUCN (2012) *IUCN red list categories and criteria*: Version 3.1. 2nd edn. Gland, Switzerland and Cambridge U.K., iv + 32 pp.

Klaassen, E. & Kwembeya, E. (2013) A checklist of Namibian indigenous and naturalised plants. *Occasional Contributions No. 5*. National Botanical Research Institute, Windhoek, Namibia, 591 pp.

Lessing, C.F. (1831) Synanthereae Rich. *Linnaea* 6: 83–170.

Linnaeus, C. (1753) *Species plantarum*. Salvius, Stockholm, 1200 pp.
https://doi.org/10.5962/bhl.title.59734

Manning, J.C. & Goldblatt, P. (2008) Asteraceae: *Tripteris calcicola*, a new calciphilous species from Western Cape, South Africa (Asteraceae). *Bothalia* 38: 85–88.
https://doi.org/10.4102/abc.v38i1.272

Manning, J.C., Goldblatt, P. & Helme, N.A. (2012) Asteraceae: *Osteospermum norlindhianum* and *O nordenstamii*, two new species of *Osteospermum* sect. *Fenestratae* (Calenduleae) from the Greater Cape Floristic Region. *Bothalia* 42: 59–66.
https://doi.org/10.4102/abc.v42i1.32

Mendelsohn, J., Jarvis, A., Roberts, C. & Robertson, T. (2002) *Atlas of Namibia*. Philip, Cape Town, 200 pp.

Moench, C. (1794) *Methodus plantas horti botanici et agri Marburgensis, a staminum situ describendi.* Nova Libraria Academiae, Marburg, 780 pp. + Index.
https://doi.org/10.5962/bhl.title.304

Nordenstam, B. (1994) New combinations in the Calenduleae. *Compositae Newsletter* 25: 46–49.

Nordenstam, B. (2006) Generic revisions in the tribe Calenduleae (Compositae). *Compositae Newsletter* 44: 38–49.

Nordenstam, B. (2007) Tribe Calenduleae Cass. *In:* Kadereit, J.W. & Jeffrey, C. (vol. Eds.); Kubitzki, K. (series Ed.) *The families and genera of vascular plants. VIII Flowering plants–Eudicots–Asterales*. Springer, Berlin, pp. 241–245.
https://doi.org/10.1007/978-3-540-31051-8

Nordenstam, B. & Källersjö, M. (2009) Calenduleae. *In:* Funk, V.A., Susanna, A., Stuessy, T.F. & Bayer, R.J. (Eds.) *Systematics, evolution and biogeography of Compositae*. International Association for Plant Taxonomy, Vienna, pp. 527–538.

Norlindh, T. (1943) *Studies in the Calenduleae 1. Monograph of the genera Dimorphotheca, Castalis, Osteospermum, Gibbaria and Chrysanthemoides*. C.W.K. Gleerup, Lund, 430 pp.

Norlindh, T. (1960) Additions to the monograph on *Osteospermum*. *Botaniska Notiser* 113: 385–399.

Norlindh, T. (1965) Zur kenntnis der Calenduleae in Südwestafrika. *Mitteilungen der Botanischen Staatssammlung München* 5: 645–651.

Seely, M. (2004) *The Namib: natural history of an ancient desert*. Desert Research Foundation of Namibia, Windhoek, 110 pp.

South African National Biodiversity Institute (2020) Botanical database of southern Africa (BODATSA) [dataset]. Available from: https://newposa.sanbi.org/ (accessed 20 October 2020)

Thiers, B. (2020) *Index Herbariorum: a global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. Available from: http://sweetgum.nybg.org/science/ih/ (accessed 20 October 2020)

Van Wyk, A.E. & Smith, G.F. (2001) *Regions of floristic endemism in southern Africa: a review with emphasis on succulents*. Umdaus Press, Hatfield, Pretoria, 199 pp.