

## CHENOPODIACEAE

*CHENOLEA CONVALLIS*, A NEW SPECIES FROM WESTERN CAPE PROVINCE, SOUTH AFRICA

Generic circumscriptions in Chenopodiaceae have still to be fully resolved but modern treatments recognize four subfamilies, with subfamily Chenopodioideae segregated into six tribes (Kuhn *et al.* 1993). Keys to the genera of tribe Camphorosmeae in current use (Scott 1978; Kühn *et al.* 1993) rely heavily on fruit and seed characters to distinguish taxa, but the limited value of these characters for generic delimitation within the tribe has become increasingly apparent (Kadereit & Freitag 2011). This applies particularly to the form of appendages on the fruits that are likely to experience strong and variable selection for dispersal (Chu & Sanderson 2008). The most recent taxonomic conclusions of Kadereit & Freitag (2011) indicate that several genera, particularly *Bassia* All. and *Kochia* Roth, are highly polyphyletic and that the taxa fall within three clades corresponding with three informal groups, the *Chenolea* Thunb., *Sclerolaena* R.Br. and *Bassia* All./*Camphorosma* L. groups. The *Chenolea* group comprises five species of dwarf shrubs, perennial and annual plants placed in four widely disjunct genera, spread between Eurasia, western North America, southern Italy, and southern Africa. The *Sclerolaena* group, the largest of the three, incorporates a strictly perennial Australian group plus three annual species from Central Asia. The *Bassia*/*Camphorosma* group has a predominantly Eurasian geographic range but includes *B. dinteri* and *B. salsoloides* within southern Africa. The formal subtribal classification and supporting morphological data of these groups have not yet been published. Nevertheless, Kadereit & Freitag (2011) stress the importance of the internal morphology of leaves in providing phylogenetically informative characters. The *Bassia*/*Camphorosma* group has various types of Kranz anatomy indicative of C<sub>4</sub>-photosynthetic pathways, whereas the *Chenolea* and *Sclerolaena* groups have non-Kranz anatomy, reflecting C<sub>3</sub>-photosynthesis.

Plants of the monotypic *Chenolea* and the moderately sized genus *Bassia*, with which it has previously been combined (Scott 1978), are subshrubs or herbs with small bisexual, sometimes pistillate flowers, and slightly accrescent fruiting perianths. In common with other members of tribe Camphorosmeae, the seeds contain an annular or horseshoe-shaped embryo and moderately developed perisperm, the flowers lack bracteoles, and the stigmas are entirely papillose (Kadereit & Freitag 2011). Scott (1978) circumscribed *Bassia* to encompass both *Kochia* Roth and *Chenolea*, each with one species

in southern Africa, as well as the monotypic, Eurasian *Londesia* Fisch. & C.A.Mey. In contrast, the most recent molecular-based classification of Kadereit & Freitag (2011) treats *Bassia* as a strictly Afro-Eurasian genus of ± 20 species that includes *Londesia* and the major part of *Kochia*. *Chenolea*, which resolved separately in their analysis, was reinstated as a genus endemic to southern Africa's coast.

Recent plant checklists for southern African Chenopodiaceae (Makgaka 2003; Klopper *et al.* 2006) list four species of *Bassia* in the region, including *B. diffusa* (Thunb.) Kuntze, which is now treated in *Chenolea* as *C. diffusa* Thunb. Only two of the remaining three species are native to southern Africa: *B. dinteri* (Botsch.) A.J.Scott, a local endemic in the southern Namib of Namibia, and *B. salsoloides* (Fenzl) A.J.Scott, widespread in South Africa's Nama Karoo, extending from northern Bushmanland eastwards to the southern Free State and southwards through the Great Karoo. The third species, *B. indica* (Wight) A.J.Scott, appears to have been introduced from an area between North Africa and India (Scott 1978; Kadereit & Freitag 2011).

In 2011, Mrs A. le Roux, an ecologist undertaking a long-term study of the vegetation in the valley and hills surrounding the Greater Brandvlei Dam near Worcester, Western Cape, encountered several unusual plants of Chenopodiaceae in the area. Based on a study of the leaf anatomy in particular, notably the non-Kranz anatomy, we recognize them as representing an undescribed species belonging to the *Chenolea* group of Camphorosmeae with a fruiting perianth quite unlike any other species in the group. We discuss our interim decision to place this new species in the genus *Chenolea* with the name *C. convallis*, in reference to the secluded Brandvlei Valley where the plants are found.

For anatomical investigation, fresh material was fixed in FAA and then embedded in wax before sectioning and double-staining with alcian blue and safranin following Rudall (1995).

## TAXONOMY AND CONSERVATION STATUS

***Chenolea convallis* Snijman & J.C.Manning, sp. nov.**

Like taxa in the *Chenolea* group *sensu* Kadereit & Freitag (2011) in its succulent, ± opposite leaves with

non-Kranz anatomy of the  $C_3$  *Neokochioid* or *Eokochoioid* type, but differing by the combination of a woody habit and the fruiting perianth with a prominent, succulent, rugose, pale brown, glistening dorsal tubercle below the apex of each lobe.

TYPE.—South Africa, Western Cape, **3319** (Worcester): Worcester District, Greater Brandvlei Dam area, slopes on E side of Dam, 212 m, (–CD), 23 February 2012, *D. Snijman & A. le Roux* 2368 (NBG, holo.; KASSEL, MO, PRE, iso).

Succulent-leaved, branching subshrub, up to 300 mm tall, resprouting from a deeply rooted, woody base. *Branches* mostly erect, slender, striate, young shoots sparsely villose. *Leaves* subopposite, sometimes appearing opposite, distantly spaced throughout, sometimes deciduous below, sessile, linear to narrowly lanceolate,  $5\text{--}8 \times 1.5\text{--}2.0$  mm, almost semiterete, adaxially flattened, pale glaucous green, insertion on stem marked by a narrow brownish band, young leaves lightly pubescent with filiform, 1-seriate hairs on both surfaces, older leaves glabrescent, minutely granular from remnants of hair bases under a  $10 \times$  lens, each comprising a swollen basal cell and narrowly tubular distal cell directed towards apex, anatomy non-Kranz. *Inflorescence* resembling a terminal spike, up to 70 mm long, of up to 15 subopposite, axillary flower clusters. *Flowers* bisexual, 2 per axil (rarely with additional, aborted accessory flower), sessile, without bracteoles, protogynous; perianth campanulate, mostly 5-lobed, lobes  $\pm$  ovate,  $\pm 2.0\text{--}2.5 \times 1$  mm, connate for up to  $\pm 1$  mm, succulent, thinly villose, pale glaucous green, each with small, glabrous, dorsal tubercle below apex, margins membranous in distal third; stamens mostly 5, perigynous, shortly exerted, filaments slender,  $\pm$  sigmoid, anthers dorsifixed, spreading horizontally at anthesis, broadly oblong-sagittate,  $1.25 \times 1.25$  mm, apex  $\pm$  smooth, dehiscence latrorse, pale yellow, pollen yellow; ovary ovoid,  $\pm 0.5 \times 0.5$  mm, unilocular; ovule 1, basal; style short, stigmas 2, filiform,  $\pm 0.75$  mm long, entirely covered with papillae, reddish, well exerted prior to anthesis,  $\pm$  withering thereafter. *Fruiting perianth* accrescent, free from pericarp,  $\pm 4$  mm diam., depressed-spherical, lobes dark and  $\pm$  leathery, each ornamented distally with an enlarged, dorsal tubercle, tubercles succulent, rugose, 1.5 mm diam., pale brown and glistening, lobes below the tubercle shortly keeled, margins of lobes remaining narrowly membranous in distal third. *Fruit* an achene, with a membranous pericarp; mature seeds unknown. *Flowering period*: Feb. to Mar. Figure 1.

*Distribution and habitat*: *Chenolea convallis* is currently known from just one population near the foot of the west-facing slopes of the low hills on the eastern banks of the Greater Brandvlei Dam near Worcester, Western Cape (Figure 2). The plants, numbering no more than about 50 individuals, grow in stony loam, at approximately 212 m above sea level. The area lies on bedrock of the Witteberg Series, the youngest deposits of the Cape Supergroup and these are tilted towards the Breede River, which runs along the Worcester fault line. The soils of the hills are derived from shales and sandstones of the oldest formations of the Witteberg Series (Grasse & Theron 1992).

The surrounding vegetation, classified as Breede Shale Renosterveld (Rebello *et al.* 2006), includes succulent and asteraceous shrubs such as *Crassula tetragona* L. (Crassulaceae), *Elytropappus rhinocerotis* (L.f.) Less., *Eriocephalus africanus* L., *Helichrysum rutilans* (L.) D. Don, *Oedera genistifolia* (L.) Anderb. & K. Bremer, and *Pteronia ovalifolia* DC. (all Asteraceae). Some rare species found at the site are *Aspalathus muraltioides* Eckl. & Zeyh. (Fabaceae), *Phyllobolus caudatus* (L. Bolus) Gerbaulet (Aizoaceae) and two Iridaceae, *Moraea vuvuzela* Goldblatt & J.C. Manning and *Sparaxis maculosa* Goldblatt. An average rainfall of  $\pm 300$  mm per annum falls mainly between May and August. *Chenolea convallis* is one of the few species in the Greater Brandvlei Dam area that flowers during the late summer drought, between February and March.

*Conservation status*: the current water level of the Greater Brandvlei Dam was reached in 1985 after successive enlargements to the dam in 1950 and 1972 (Le Roux *et al.* 2010), resulting in the inundation of the renosterveld, which now barely fringes the dam to the north and east. In effect, the rising water levels may already have been destroyed other suitable local habitats of *Chenolea convallis*. New proposals by the Department of Water Affairs to raise the water level of the Brandvlei Dam once again are further cause for concern about the future survival of *C. convallis*, given its close proximity to the present water's edge. According to the South African Red List categories and criteria (Raimondo *et al.* 2009) we suggest that *C. convallis* should be classified as Critically Endangered. It is noteworthy that prior to the collections made by Mrs. A. le Roux, *C. convallis* was not known in any of the major herbaria of South Africa (BOL, NBG, PRE, SAM) (acronyms after Holmgren *et al.* 1990).

## DISCUSSION

### Leaf anatomy

Leaves of Chenopodiaceae often exhibit specialized anatomy apparently related to the xeric and saline habitats favoured by the family (Metcalf & Chalk 1965; Kühn *et al.* 1993; Kadereit *et al.* 2003). Those of *Chenolea convallis* are typical of many xeromorphic leaves (Figure 3), being thick and leathery, covered with a thick cuticle and apparently by wax layers. Slightly sunken stomata are scattered on both surfaces and are transversally oriented to the median vein as in all Chenopodiaceae (Figure 4). Internally, the mesophyll is isobilateral, with chloroplasts confined to three or four layers of palisade-like parenchyma on each side of the leaf. The middle of the leaf has about six layers of large, chloroplast-free, water-storage cells and a centrally situated vascular network, comprising one central bundle and five lateral bundles in the same median plane. In addition, two groups of smaller bundles join the outermost laterals on the abaxial leaf side. Only the central bundle is strengthened by a sclerenchyma cap abaxially. The small lateral veins are all oriented with the xylem facing out towards the chlorenchyma. This non-Kranz anatomy is a good match with the *Neokochioid* leaf type, illustrated by Carolin *et al.* (1975) and Chu & Sanderson (2008). It may also fit the leaf type briefly described for



FIGURE 1.—*Chenolea convallis*, Snijman & le Roux 2368 (NBG). A, part of plant showing resprouting habit; B, detail of striate stem showing subopposite leaves; C, part of inflorescence showing protogynous flowers: female phase; D, solitary flower at female phase; E, flowers: male phase; F, solitary stamen and gynoecium showing attachment, plus details of stamen showing dorsifixed anther; G, gynoecium (plus longitudinal section at lower magnification showing solitary, basal ovule); H, persistent fruiting perianth and achene, side view and from above. Scale bar: A, 10 mm; B–E, H, 1.5 mm; F, G, 0.5 mm. Artist: John Manning.

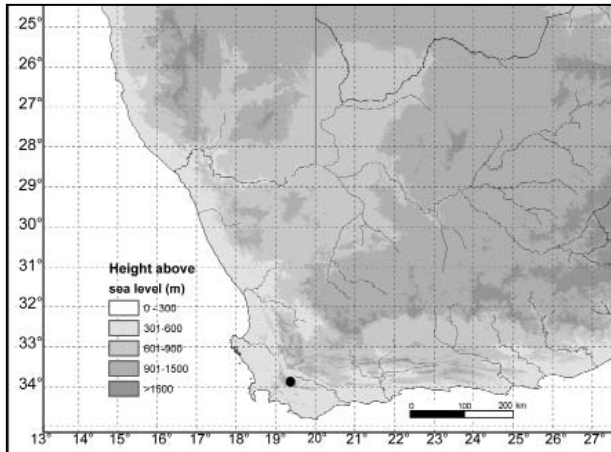


FIGURE 2.—Distribution of *Chenolea convallis*, ●.

*Eokochia* Freitag & G.Kadereit, but not yet illustrated (Kadereit & Freitag 2011). Both genera fall within the *Chenolea* group *sensu* Kadereit & Freitag (2011) of Camphorosmeae.

#### Leaf trichomes

Young leaves of *Chenolea convallis* are sparsely pubescent with appressed, three-celled, uniseriate, filiform hairs. The terminal cell of each hair is shed in the older, more succulent leaves, leaving only the swollen, thick-cuticled basal cell and narrow, tubular intermediate cell (Figure 4). Under a  $10\times$  lens, these appear as small granules on the leaf surface. Similar trichomes have been described for many species of Camphorosmeae (Carolin 1983) and illustrated for *Neokochia americana* (S.Watson) G.L.Chu & S.C.Sand. (Chu & Sanderson 2008, Figure 2B) from North America and *Bassia muricata* (L.) Asch., distributed from Morocco to southern Iran (Metcalfé & Chalk 1965, Figure 262A). *Chenolea diffusa*, in contrast, has more specialized, T-shaped hairs with a pluricellular stalk (Carolin 1983).

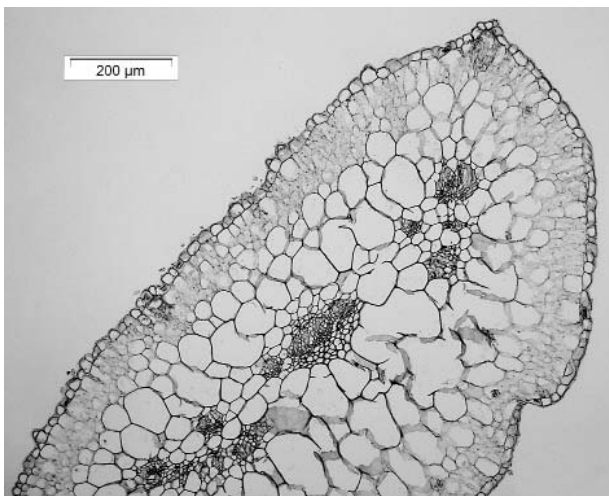


FIGURE 3.—*Chenolea convallis*, Snijman & le Roux 2368 (NBG). Transverse section of isobilateral leaf showing scattered, persistent, swollen, basal cells of partially shed trichomes on abaxial surface and vascular bundles arranged in the same median plane within water storing tissue in the middle of the leaf. Scale bar = 200  $\mu$ m.

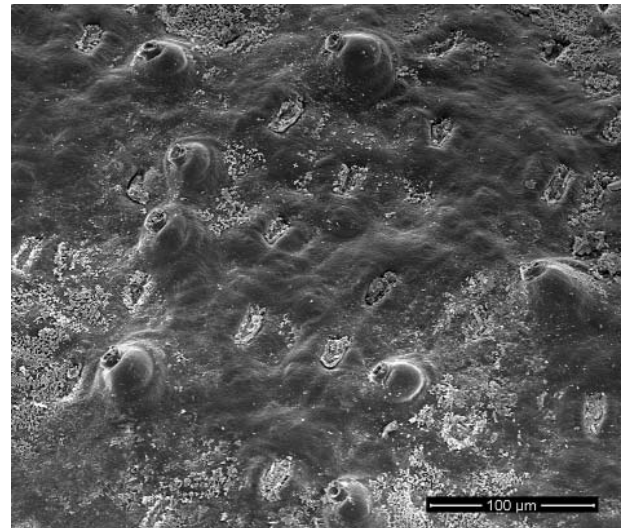


FIGURE 4.—*Chenolea convallis*, Snijman & le Roux 2368 (NBG). Detail of abaxial leaf surface showing sunken stomata and persistent swollen bases of uniseriate trichomes. Scale bar = 100  $\mu$ m.

#### Fruiting perianth

*Chenolea convallis* is distinguished from other African species of Camphorosmeae by the unusual fruiting perianth, which develops prominent, wart-like, dorsal outgrowths below the apex of each lobe. Contrasting with the mostly dark-coloured, somewhat leathery fruiting lobes, the dorsal outgrowths are pale brown, glistening and irregularly sculptured. This morphology is also unique amongst taxa of the *Chenolea* group *sensu* Kadereit & Freitag (2011). *Chenolea diffusa* has smooth, fleshy, somewhat cowl-shaped fruiting perianth lobes, *Spirobassia* Freitag & G.Kadereit has three, obtuse perianth appendages, *Neokochia* (Ulbrich) G.L.Chu & S.C.Sand. has five, free, wing-like appendages from the base of the lobe and *Eokochia* has a five-winged perianth.

Harvester termites, *Microhodotermes viator*, have been seen gathering and carrying fallen twigs and leaves of *C. convallis* into holes at the base of several plants and it may be that the fruits are dispersed in this way, although probably not exclusively so.

#### Classification

This new species is easily identified by opposite to subopposite leaves and the distinctive fruiting perianth, which develops a large wart-like, dorsal outgrowth below the apex of each lobe. Based on the non-Kranz leaf morphology it shows a strong alliance with taxa in the *Chenolea* group (*sensu* Kadereit & Freitag 2011), in which only *Neokochia* is not monotypic. According to the classification proposed by Kadereit & Freitag (2011) and which is based heavily on molecular data and leaf anatomy, this new taxon may eventually warrant recognition as a new genus in the *Chenolea* group, but this requires further molecular investigation throughout the tribe. Since some of the relationships among the monotypic genera in this group are still unclear and because intercontinental disjunctions have been invoked to support their separation, our interim decision is to place this

new species in the southern African genus *Chenolea*, a name which takes precedence over all others in this group.

The addition of *C. convallis* to the previously monotypic *Chenolea* requires expansion of the generic description only to the extent of adding the subshrubby habit to the otherwise low, decumbent, straggling, near perennial habit of the plants, increasing the number of flowers per axil from one to two, extending the fruiting perianth morphology to include the presence of warty dorsal outgrowths on the lobes and adding the presence of simple, uniseriate hairs to the trichome types. In other genera of the tribe, such as *Bassia* (*sensu* Kadereit & Freitag 2011), characters such as growth form and perianth appendages also vary among species.

Apart from major leaf anatomical differences between *Chenolea sensu lato* and *Bassia* (non-Kranz vs. Kranz), *Chenolea* can be distinguished from the native species of *Bassia* in southern Africa by subtle differences in leaf arrangement, subopposite, sometimes distant leaves in *Chenolea* and alternate, often tightly clustered leaves in *Bassia*.

#### Additional specimens examined

WESTERN CAPE.—3319 (Worcester): Worcester, Greater Brandvlei Dam, 217 m, (–CB), 21 February 2011, A. le Roux 910 (NBG), 2 June 2011, A. le Roux 910a (NBG).

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