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A new pubescent variety of Conophytum from the southern Richtersveld: Conophytum flavum subsp. novicium var. kosiesense.

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Photographs by the authors.

Summary: Here we introduce a new, distinctive variety of Conophytum: C. flavum subsp. novicium var. kosiesense, named for the Kosies mountain where it grows. This taxon is characterized by the prominent covering of the bodies by a dense layer of trichomes, resulting in a greyish-white appearance. This feature can be seen with the naked eye but is especially evident when the epidermis is viewed using scanning electron microscopy.


Introduction

The dwarf succulent genus Conophytum is the largest in the Aizoaceae displaying a remarkably high degree of speciation with 165 species and subspecies (together with a number of varieties) now recognised (Hammer & Young, 2017). Several morphologically distinct Sections have been defined in Conophytum of which the largest and arguably the most variable is Section Wettsteinia (Hammer, 1993, 2002; Hammer & Young, 2017). The genus displays a number of adaptations to its arid environment, including CAM-photosynthesis (Crassulacean Acid Metabolism) and miniaturisation of growth form. In some Conophytum the plants may possess a very distinct covering of trichomes (which is thought to assist with moisture capture), a prominent wax layer and, more rarely, sunken stomata.

Conophytum is strongly associated with the winter-rainfall region of South Africa and Namibia, and especially the Succulent Karoo biome. Niche-level environmental conditions, especially the availability of moisture (particularly non-rainfall events such as fog and dew) are a major factor in the distribution of dwarf succulents such as Conophytum (Matimati et al., 2012). Species richness and the occurrence of point endemics are highest in the vicinity of the small town of Steinkopf in the southern Richtersveld (Young & Desmet, 2016; Young & Rodgerson, 2016). Approximately one quarter of all Conophytum species and subspecies may be considered to be point endemics and their distribution is highly localised (e.g., to a single hill). By contrast, some other species are much more widely distributed (e.g., C. pageae and C. bilobum). Over the last 20 years or so several new Conophytum taxa have been discovered with all of them being found within the known distribution area of the genus, i.e., none have extended the range.

This paper describes a distinctive form of C. flavum subsp. novicium from an area of existing species richness in the southern Richtersveld.

Methods - Electron microscopy

Epidermal samples of newly emerged leaves of Conophytum were prepared for electron microscopy by adapting the method of Neinhuis and Edelmann (1996) which uses methanol as a rapid dehydration and fixative agent. Samples were cut from the uppermost sides of healthy turgid leaves (after Opel, 2002, 2004) and immediately immersed in methanol for 30min. Tissues were then transferred through a sequence of three solvent washes (30 min each step) consisting of ethanol, acetone and a final immersion in acetone. The use of acetone as the final step meant that subsequent critical point drying was more effective than with ethanol. Critical point drying with CO₂ was per-
Figure 1. Map of southwestern Africa showing the location of *C. flavum* subsp. *novicium* var. *kosiesense*.

Figure 2. *C. flavum* subsp. *novicium* var. *kosiesense* in habitat.
(A) a large cluster of bodies showing the paper-white sheath and idioblastic spots;
(B) a plant showing the distinctive covering of the epidermis by a dense layer of short trichomes and the purple colouration the leaves can achieve in habitat in the austral spring;
(C) a young plant clearly showing the dense layer of trichomes present on the leaf surface.
formed using the Emitech K850 critical point drier (Quorum Technologies Ltd., East Grinstead). This approach preserved both cell structure and the epidermal wax coating of the highly succulent tissues of Conophytum.

Freshly harvested seeds of Conophytum taxa were directly applied to aluminium stubs and coated in gold using an Emitech K550X sputter-coater (Quorum Technologies Ltd., East Grinstead). Epidermal and seed samples were viewed using a FEI Quanta 200 scanning electron microscope (Thermo Fischer Scientific).

Discovery and Habitat

C. flavum subsp. novicium is abundant and widespread amongst the quartz hills that lie to the northwest of the small Northern Cape town of Steinkopf in the southern Richtersveld (Figure 1). In this area Kosiesberg is a prominent quartz mountain, well known amongst conophiles as being the type locality for C. tantillum subsp. heleniae. The lands to the north and west of this mountain are however, to the best of our knowledge, relatively unexplored, especially when compared to the quartz-rich Wyepoort valley (‘Umdaus’) to the east. In August 2015 the authors (together with Alice and Alan Vanden Bon, Ivor Crook and Mike Thewles) visited the area, with the intention of climbing a remote quartz hill. The landscape around Kosies is used for low-level livestock farming and crisscrossed by little used tracks (4x4 required). As we drove away from Kosies the quartz became less extensive and patchy, often appearing as small, isolated, ridges or outcrops. We stopped to explore some of these patches and found that most had a Conophytum flora typical of the area: the diurnal flowering C. bilobum subsp. bilobum and C. flavum subsp. novicium dominating together with scattered plants of the nocturnal flowering C. stevens-jonesianum.

Further away from Kosies we explored the south-facing slope of a small quartz hill where we saw what, at first glance, simply looked like some clusters of C. flavum subsp. novicium. Only on closer inspection did these plants reveal their intriguing pubescent epidermis. A more substantial stand of these plants was later found on the flat top of the hill (Figures 2 & 3). Plants were found both in full sun and in partial shade. In August
there were no signs of flower buds or flower remnants so we revisited the site the following April (when the vast majority of Conophytum species flower) to specifically compare these plants with a nearby stand of C. flavum subsp. novicium (see below and Figure 3).

Other succulents plentiful on the hill included Adromischus alstonii, Sarcostemma viminalle, Anacamperos baeseckei, Crassula namaquensis subsp. namaquensis, Pelargonium crithmfolium and Monsonia crassicaule (Figure 3). Both C. bilobum subsp. bilobum and C. flavum subsp. novicium grew in the general vicinity but were not sympatric with the pubescent plants that are being described here as var. kosiesense.

Distracted as we were by the find of this Conophytum we ran out of time and never reached our intended target, the remote quartz peak, in 2015. We rectified this on our return in 2016, finding a disjunct population of C. tantillum subsp. heleniae and small numbers of C. flavum subsp. novicium var. kosiesense. To date, var. kosiesense has only been observed in the Kosiesberg Succulent Shrubland vegetation unit in the Succulent Karoo biome, Richtersveld bioregion.

Discussion

In his original book on the genus Conophytum, Hammer (1993) combined several taxa into C. flavum subsp. novicium, namely: C. luteolum, C. luteolum var. macrostigma, C. ellipticum and C. rubristylodium. In this new combination Hammer stated that the epidermis was “glabrous, rarely finally papillate”. This, in part, reflects his own observations taken from the herbarium sheets deposited at the Bolus Herbarium (University of Cape Town). Specifically, it contrasts with the formal descriptions for these taxa which specifically describe the epidermis as glabrous and make no mention of the presence of papillae or trichomes. The distinguishing feature of var. kosiesense is the presence of a prominent covering of trichomes, rendering the appearance of the plant bodies uniformly greyish. This can be readily seen with the naked eye (Figures 2 & 4) but is most clearly seen in scanning electron microscope images (Figure 5). These trichomes bear a close resemblance to the epidermis of two other members of Section Wettsteinia, namely C. bolusiae subsp. bolusiae and C. ernstii subsp. ernstii. Both of these taxa occur in conditions which experience localised fogs.

Figure 4. A comparison of the flowers of (A) C. flavum subsp. novicium var. kosiesense and (B) C. flavum subsp. novicium var. novicium (pictures taken in habitat, April 2016).
and it is thought that the dense layer of epidermal trichomes helps with moisture capture. We do not know whether such fogs occur in the vicinity where var. kosiesense was found but its morphology suggests such an adaptation.

During a visit to the Bolus Herbarium in May 2016 the sheets for *C. flavum* sensu lato were examined by AJY. On one of these (H. Hall 2768, NBG247/64) containing a number of specimens, a single piece of material collected from the ‘vicinity of Anenous Pass’ (which lies west of Steinkopf and close to Kosiesberg) showed the presence of trichomes covering the epidermis. By contrast, no other specimens from the same collection or indeed from any other collections of *C. flavum* and its relatives (*C. ornatum*, *C. novicium*) present in the Bolus displayed this particular feature – i.e., with the exception of this one piece all the material was uniformly glabrous. The lectotype for *C. novicium* (Brown, 1934) describes the plant as “smooth, glabrous, somewhat grass-green”. Clearly this does not match the morphology of var. kosiesense described here.

Scanning electron micrographs of the epidermis of *C. flavum* subsp. novicium var. kosiesense, subsp. novicium var. novicium and subsp. flavum are shown in Figure 5. The epidermal structure of both subsp. novicium var. novicium and subsp. flavum are similar in possessing short papillae and typical of Section Wettsteinia (Opel, 2002, 2004). Opel (2002) highlights the fact that epidermal structure in *C. flavum* is variable “low papillae are common but a few populations of *C. flavum* subsp. novicium have much more substantial protuberances, reminiscent of stubby version of the conical trichomes of some bilobes”. Low papillae are present in *C. flavum* subsp. flavum and in subsp. novicium var. novicium (Figure 5). By contrast var. kosiesense possesses a dense layer of long trichomes (approximately 70µm in length). In common with other species in section Wettsteinia, bladder cells are absent and epidermal cells are polygonal. Stomata possess two subsidiary cells, are superficial, and preliminary observations suggest that they may be significantly larger (28 × 9 µm) and may occur at a lower density on the epidermis than seen in other forms of *C. flavum*.

*C. flavum* subsp. novicium var. novicium is also characterised by the presence of sometimes very prominent idioblastic spots. By contrast, such spots are usually absent from *C. flavum*.
subsp. flavum. A notable exception to this is the old tetracarpum form which inhabits the western extent of Bushmanland. In this new taxon, idioblastic spots occur frequently across the epidermis and are quite prominent, despite the presence of a dense layer of trichomes over the body (Figures 2A–C).

The diurnal flower of var. kosiesense has a similar structure and petal colour to that of var. novicium but possesses fewer and more substantial anthers (Figure 4). The light brown, fragile capsule of var. kosiesense is identical to that of var. novicium, possessing 4–5 locules. The seeds (Figure 6) are covered in parabola-shaped papillae and are a typical shape (resembling the continent of Africa) for Conophytum. It is interesting to note that the papillae observed in seeds of plants that match the previously recognised ornatum form of C. flavum subsp. flavum (Figure 6C) differ from that of both var. kosiesense and subsp. novicium (Figures 6A & B).

It is also worth noting that in habitat, the plants of var. kosiesense typically possess up to 20 (occasionally up to 50) bodies but has not been seen to cluster to the size (sometimes 100’s of bodies; Figure 7) that var. novicium can achieve, especially in deeply shaded conditions (a particular habitat where we have not seen var. kosiesense growing, generally preferring full sun or partial shade).

Description
Conophytum flavum N.E.Br. subsp. novicium (N.E.Br.) S.A.Hammer var. kosiesense A.J.Young & C.Rodgerson var. nov. subg. Derenbergia, Section Wettsteinia.
Type: ADH5580 (Compton Herbarium, Kirstenbosch National Botanical Garden, Cape Town 19-4-2017 Holotype)
Caespitose, typically forming a cluster of up to 50 bodies; Leaves to 10mm in diameter, up to 20mm tall, apex convex, grey to whitish appear-
ance, densely papillate covered in layer of short (ca. 70µm tall) trichomes, spotted, flanks flushed reddish; Fissure slightly recessed, finely papillate, ca. 2–4mm long; Sheath white, fragile; Flowers diurnal appearing in early Autumn, small, c. 15mm diameter, petals ca. 30 slightly recurved, yellow; Fruits 4–5-locular; Seeds brown, 0.4–0.6mm. Ecology on quartz outcrops; Distribution Southern Richtersveld, Northern Cape, S. Africa, 2917BA.

Diagnosis

The proposed new variety C. flavum subsp. novicum var. kosiesense is readily distinguished from C. flavum subsp. novicium var. novicium by its dense covering of trichomes.

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References


