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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.

**Zusammenfassung:** Wir stellen hier eine neue, unverwechselbare *Conophytum*-Varietät vor: *C. flavum* subsp. *novicium* var. *kosiesense*, benannt nach den Kosies-Bergen, auf denen sie wächst. Dieses Taxon ist durch die auffällige Bedeckung der Körper mit einer dichten Schicht von Trichomen gekennzeichnet, die sie gräulich weiß erscheinen lassen. Dieses Merkmal ist auch mit dem nackten Auge sichtbar, es wird aber besonders deutlich, wenn die Epidermis mit dem Rasterelektronenmikroskop betrachtet wird.

### 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 CO<sub>2</sub> was per-



**Figure 1.** Map of southwestern Africa showing the location of *C. flavum* subsp. *novicium* var. *kosiesense*.



**A**



**B**



**C**

**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.



**Figure 3.** The general landscape where *C. flavum* subsp. *novicium* var. *kosiesense* was found. Other succulents present in this habitat include *Adromischus alstonii*, *Crassula namaquensis* subsp. *namaquensis*, *Sarcostemma viminale*, *Pelargonium crithmifolium* and *Monsonia crassicaule*.

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



**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).

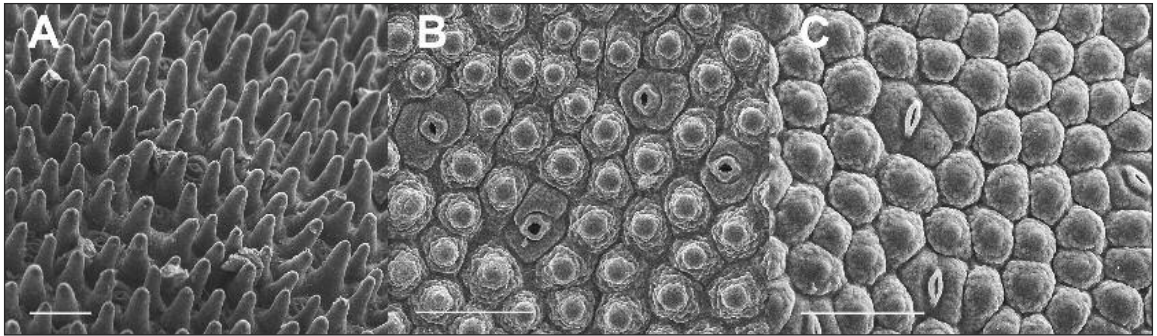
there were no signs of flower buds or flower remnants so we revisited the site the following April (when the vast majority of *Conophytum* species flower) to specifically compare these plants with a nearby stand of *C. flavum* subsp. *novicium* (see below and Figure 3).

Other succulents plentiful on the hill included *Adromischus alstonii*, *Sarcostemma viminalis*, *Anacampseros baeseckei*, *Crassula namaquensis* subsp. *namaquensis*, *Pelargonium crithmifolium* 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*.

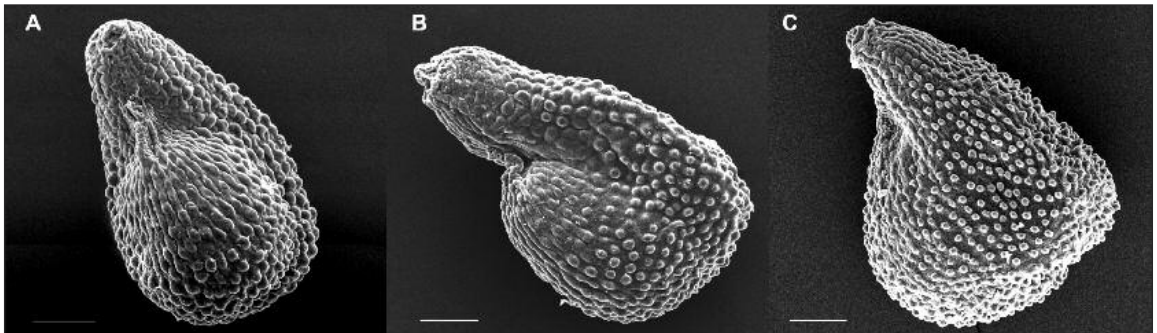
Distracted as we were by the find of this *Conophytum* we ran out of time and never reached our intended target, the remote quartz peak, in 2015. We rectified this on our return in 2016, finding a disjunct population of *C. tantillum* subsp. *heleniae* and small numbers of *C. flavum* subsp. *novicium* 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. rubristylosum*. 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 5.** Scanning electron microscope images of the epidermis of (A) *C. flavum* subsp. *novicium* var. *kosiesense*; (B) *C. flavum* subsp. *novicium* var. *novicium*; (c) *C. flavum* subsp. *flavum* (*tetracarpum*). The scale bar is 100 $\mu$ m.



**Figure 6.** Scanning electron microscope images of seeds of (A) *C. flavum* subsp. *novicium* var. *kosiesense*; (B) *C. flavum* subsp. *novicium* var. *novicium*; (c) *C. flavum* subsp. *flavum* (*ornatum*). The scale bar is 100 $\mu$ m.

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 70 $\mu$ m 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  $\times$  9  $\mu$ m) 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*



**Figure 7.** An extremely large (but not atypical) cluster of *C. flavum* subsp. *novicium* var. *novicium* growing in deep shade a few kilometres to the east in Umदाus. By contrast, var. *kosiesense* has not been observed to grow in such low light conditions or reach this size of plant.

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.Rodgers 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. *novicium* var. *kosiesense* is readily distinguished from *C. flavum* subsp. *novicium* var. *novicium* by its dense covering of trichomes.

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