The *Portulaca oleracea* complex in Belgium: an update

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Samenvatting. – ***Het* Portulaca oleracea*-complex in België: een update.*** *Sinds de publicatie van een voorlopig overzicht van de in België gevonden (micro-)soorten van het* P. oleracea*-complex, ondertussen tien jaar geleden, is de kennis met betrekking tot deze groep verder toegenomen. Nieuw onderzoek heeft aangetoond dat* P. granulatostellulata *en* P. nitida *(voordien onderscheiden op basis van zaaddiameter en verondersteld ploïdie-niveau) synoniemen zijn van respectievelijk* P. papillatostellulata *en* P. oleracea *s.str. Bovendien slopen in het eerdere overzicht fouten in de benoeming van de SEM-foto's (zo werden de zaden van* P. cypria *en* P. papillatostellulata *verwisseld). Tenslotte maakt een nieuwe, eenvoudige techniek het beoordelen van de versiering van de zaadhuid mogelijk, zonder dat SEM-fotografie nodig is. Omdat dit mogelijk tot een betere kennis met betrekking tot dit complex kan leiden, wordt een nieuwe determinatiesleutel met nieuwe foto's voorgesteld.*

Résumé. – ***Le complexe de* Portulaca oleracea *en Belgique : une mise à jour.*** *Depuis la publication, il y a dix ans, d'un aperçu préliminaire des (micro-) espèces du complexe* P. oleracea *trouvées en Belgique, les connaissances sur ce groupe ont augmenté. De nouvelles recherches ont montré que* P. granulatostellulata *et* P. nitida*, auparavant distingués uniquement sur la base du diamètre des graines et du niveau de ploïdie présumé, sont conspécifiques avec* P. papillatostellulata *et* P. oleracea *s.str., respectivement. De plus, dans l'aperçu précédent, certaines images MEB ont été mal étiquetées (par exemple, les graines de* P. cypria *et de* P. papillatostellulata *ont été confondues). Enfin, une nouvelle technique simplifiée permet d'évaluer l'ornementation de la surface tégumentaire des graines sans avoir recours à la photographie MEB. Afin d'améliorer la connaissance de ce complexe, une nouvelle clé de détermination avec de nouvelles photographies est proposée.*

Abstract. – *Since the publication, ten years ago, of a preliminary overview of the (micro-) species of the* P. oleracea *complex found in Belgium, knowledge about this group has increased. New research has shown that* P. granulatostellulata *and* P. nitida *(which were distinguished only by seed diameter and presumed ploidy level) are conspecific with* P. papillatostellulata *and* P. oleracea *s.str. respectively. Furthermore, in the previous overview some of the SEM images were mislabeled (e.g. the seeds of* P. cypria *and* P. papillatostellulata *were intermingled). Finally, a new, simple technique allows the assessment of the ornamentation of the seed coat, without the need for SEM photography. Because this could possibly lead to a better knowledge about this complex, a new identification key and new photos are presented.*

Illustrations:
Elena Bulakh and Aleksandr Terebilenko (Fig. 1, 2, 4), Hans Reichert (Fig. 3, 5) and Dominik Vogt (Fig. 6).

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Introduction

Portulaca oleracea L. is a troublesome weed in the temperate and tropical regions of the world. Supposedly as a result of a changing climate, it has considerably spread northwards in recent decades, to the extent that it is now considered naturalized in Belgium and neighboring areas (Verloove & Van Rossum 2024). Until recently it was an ephemeral alien that normally did not survive the average Belgian winters (Verloove 2002).

Almost 100 years ago already, it was pointed out that the species was composed of several autogamous taxa (morphotypes), which could be distinguished on the basis of the ornamentation of the seed surface (Poellnitz 1936a). Avinoam Danin & co (numerous references, for an overview see e.g. Danin & Raus 2012; Hassler *et al.* 2024) have studied the issue since the 1970s. As a result, eventually about 20 taxa were distinguished worldwide which, depending on the author, were considered separate spe-

cies ('micro-species'), subspecies or varieties. In addition to seed surface ornamentation, seed size was also taken into account to distinguish taxa, with tetraploid taxa being assumed to have small seeds (diameter < 0.85 mm) and hexaploid taxa large seeds (diameter > 0.85 mm). However, the correlation between ploidy level and seed diameter was never tested systematically.

As far as Belgium is concerned, a preliminary overview was published ten years ago by Danin & Verloove (2015). Seven taxa were distinguished and these were accepted at species level: *Portulaca cypria* Danin, *P. granulatostellulata* (Poelln.) Ricceri & Arrigoni, *P. nitida* (Danin & H.G.Baker) Ricceri & Arrigoni, *P. oleracea* s.str., *P. papillatostellulata* (Danin & H.G.Baker) Danin, *P. sativa* Haw. and *P. trituberculata* Danin, Domina & Raimondo. The sample was based on about sixty, historical as well as recent collections, and thus relatively limited; nevertheless, it turned out that *P. granulatostellulata* was by far the most frequently collected species.

Since the publication of this paper, knowledge about the complex has improved considerably. Although the rank that should be given to these taxa is still under discussion, a number of other problems have been solved. Very shortly after the publication of Danin & Verloove (2015), a cytogenetic study by Walter *et al*. (2015) was published. This showed that there is no correlation at all between seed coat ornamentation and seed diameter and therefore that putative tetra- and hexaploid taxa cannot be distinguished on the basis of seed size. This means that taxa with similar ornamentation of the seed coat that differ only in seed size belong to one and the same taxon. As a result, several taxa were reduced to synonymy of others. Also, Walter *et al*. (2015) were not able to confirm any tetraploid counts in Europe and around the Mediterranean, even in populations which were assumed to be tetraploid previously, and in seeds of supposedly tetraploid taxa supplied by Danin. Therefore, all European populations must be considered homogeneously hexaploid.

Another interesting novelty is that Reichert (2023) proposed a technique that can, in many cases, render the use of SEM photography — a tool inaccessible to most botanists — unnecessary. By making nail varnish impressions of the seeds, a detailed imprint of the seed surface can be obtained. The technique is explained in detail in the aforementioned article, the link to which is provided in the literature reference. Nevertheless, it should be noted that certain minute structural details can only be observed with SEM photographs.

On the other hand, it needs to be emphasized that a genetic study demonstrates that *P. oleracea* should be considered a polymorphic species, indivisible into micro-species on the basis of seed ornamentation and size (El-Bakatoushi *et al*. 2013). Therefore, and also because local knowledge of micro-species has not increased despite and since the publication of Danin & Verloove (2015), no attention has been paid to these taxa in the most recent edition of the Belgian Flora (Verloove & Van Rossum 2024). Also, in the most recent editions of the Dutch and British floras, micro-species were left unmentioned (Stace 2019; Duistermaat 2020). However, in other recent floras of neighboring countries the micro-species are treated in detail (e.g. in France and Germany; Tison & de Foucault 2014; Hassler *et al*. 2024) and new national or regional studies dealing with the micro-species are still regularly being published, recently e.g. for Poland and the Balkans (Bulakh *et al*. 2022; Peregrym & Dragićević 2024). As mentioned previously, it remains disputed at which taxonomic rank these apomictic taxa should be treated. However, they can be clearly and reliably separated by analysis of their seed coat pattern.

Because the aforementioned new research sheds new light on Danin & Verloove (2015), it seemed useful to propose a short update for Belgium

Portulaca oleracea and its micro-species in Belgium: an update

Portulaca sativa

Reichert (2023) found out that in Germany commercial seed samples of cultivated purslane mostly belonged to *P. edulis* Danin & Bagella, a micro-species from the eastern Mediterranean area and Africa (Cyprus, Lebanon, Sudan and Turkey), not to *P. sativa*. *P. edulis* has 10-15 papillae on each epidermal cell, whereas *P. sativa* only has 1 or 2 bigger tubercles on each cell, resulting in a quite regular pattern on the seed surface (as depicted by Danin & Bagella 2012).

It can be assumed that both taxa are also confused in Belgium and that this issue needs to be investigated. Also, it needs to be tested whether *P. edulis* is really a valid species or simply belongs to the variation of *P. sativa*.

Portulaca granulatostellulata and ***P. papillatostellulata***

Portulaca granulatostellulata was described based on plant material from the Hawaiian Islands (Poellnitz 1936b). According to Danin *et al.* (1979) it is a tetraploid. However, European and Mediterranean specimens of this species, named as such by Danin, turned out to be hexaploid (Walter *et al*. 2015). It seems that the name of this subtropical species (by far the most common in western Europe!) has been wrongly applied to our plants. In the key for the species found in Belgium (Danin & Verloove 2015), this species differed from *P. papillatostellulata* only in seed diameter; it is now assumed that all these plants belong to a single species for which the name *P. papillatostellulata* (Danin & H.G.Baker) Danin [= *P. granulatostellulata* auct. non (Poelln.) Ricceri & Arrigoni] should be used. Plants from the Belgian-German border area, named *P. granulatostellulata* by Bomble (2013), also belong here.

Portulaca nitida and ***P. oleracea* s.str.** (= *P. stellata*)

This case is similar to the previous one. Plants with seeds similar in ornamentation to those of *P. oleracea* s.str. but with smaller seeds and supposedly tetraploid, were separated by Danin & Baker (Danin *et al*. 1979) as *P. nitida*. However, Walter *et al.* (2015) showed that these plants are hexaploid and thus essentially indistinguishable from *P. oleracea* s.str. Minor reported differences in seed coat patterns between both taxa are negligible and can be attributed to drying conditions and freshness of the seeds. Plants from the Belgian-German border area, named *P. nitida* by Bomble (2013), also belong to *P. oleracea* s.str.

This species was frequently treated as "*P. stellata* Danin & H.G.Baker". However, a recent analysis of SEM photographs of seeds of the lectotype of *P. oleracea* L. in the LINN Herbarium confirmed the assumption of Danin *et al.* (2008) that the seeds of the lectotype are identical with the seeds of the species once called *P. stellata*, which renders this name superfluous and reduces it to a synonym of *P. oleracea* (see Uotila *et al*. 2012 and Hassler *et al*. 2024 for details).

Illustrations in Danin & Verloove (2015)

The SEM photographs shown in the overview of the *Portulaca oleracea* complex in Belgium were provided by the first author and did not depict Belgian plant material. Unfortunately, two photos

apparently got interchanged: photo 6, labeled *P. papillatostellulata*, shows the typical seed of *P. cypria*, with one or two tubercles but no papillae. Photo 1, labeled *P. cypria*, shows a seed surface with papillae but without tubercles, typical of *P. papillatostellulata*. Also, some of the other photos showed at least abnormal seeds or were possibly also incorrect.

To avoid any doubt, new SEM photographs are here presented for the four taxa occurring spontaneously in Belgium. For *P. sativa,* which is only cultivated or occasionally escapes and differs mainly by its larger seeds, no new SEM photographs are provided. In addition, for some taxa, seed surface features are illustrated by nail-varnish impressions.

A schematic drawing is also included (Fig. 6), showing a detail of a testa cell with clearly indicated papillae and tubercles, to help clarify the morphological terminology and visual distinction between these structures.

Revised identification key

Based on the above, the key of Danin & Verloove (2015) can be simplified as follows:

1 Seed diameter 1.1-1.3 mm . . . . . ***Portulaca sativa*** / P. edulis
Seed diameter 0.65-1.1 mm **2**

2 Seeds shiny, smooth (without papillae nor tubercles), testa cells star-shaped (Fig. 1) . . . . . ***P. oleracea*** s.str. (= *P. stellata, P. nitida)*
At least some testa cells with papillae and/or tubercles **3**

3 Testa cells star-shaped, largely covered with papillae at the end of the arms, without tubercles (Fig. 2) . . . . . ***P. papillatostellulata*** (= *P. granulatostellulata* auct.)
Testa cells with at least one tubercle **4**

4 Testa cells star-shaped, about as long as wide, in the middle of each cell with 1(-2) tubercles (Fig. 3) . . . . . ***P. cypria***
Testa cells not star-shaped, clearly longer than wide, each cell with 2-3 tubercles (Fig. 4, 5) . . . . . ***P. trituberculata***

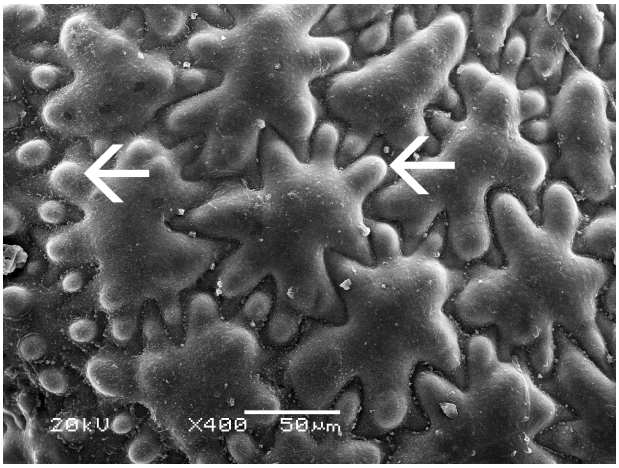

Figure 2. SEM photo of a seed of *Portulaca papillatostellulata*. Papillae are indicated by arrows.

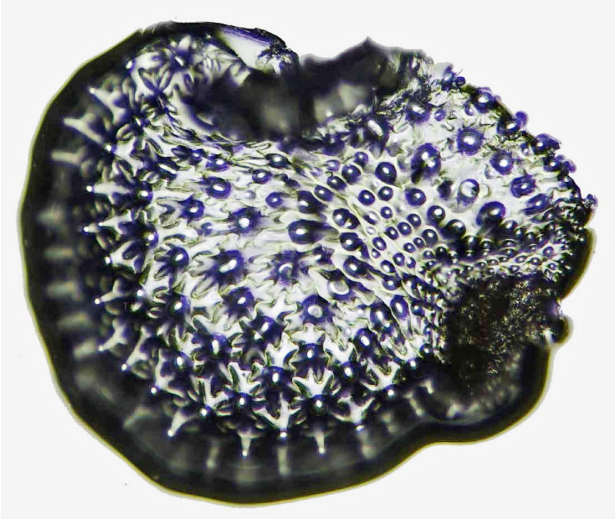

Figure 3. Nail-varnish impression of a seed of *Portulaca cypria*.

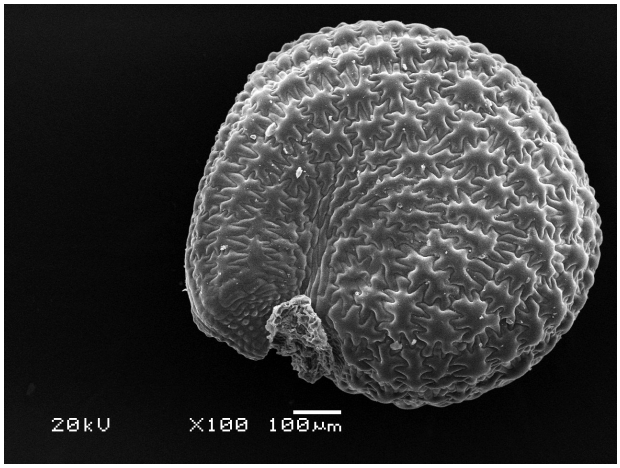

Figure 1. SEM photo of a seed of *Portulaca oleracea*.

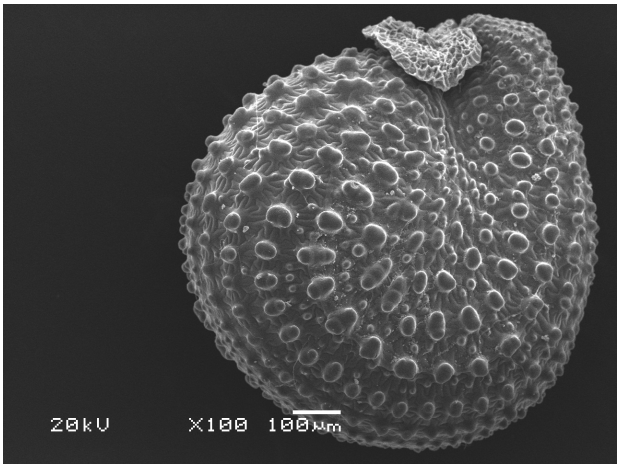

Figure 4. SEM photo of a seed of *Portulaca trituberculata*.

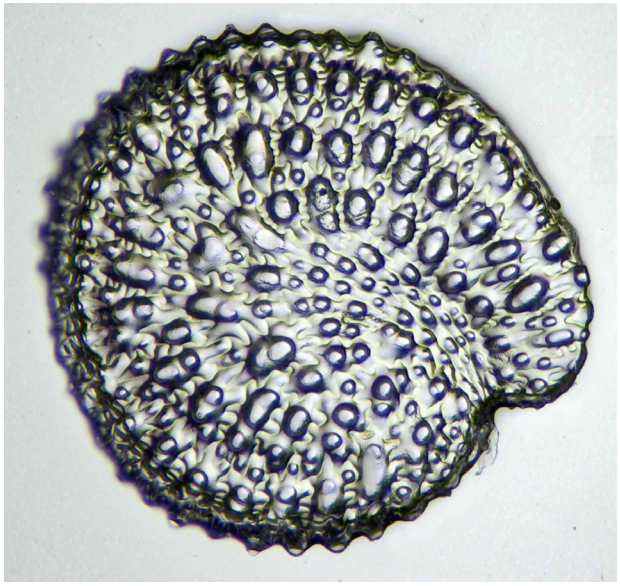

Figure 5. Nail-varnish impression of a seed of *Portulaca trituberculata*.

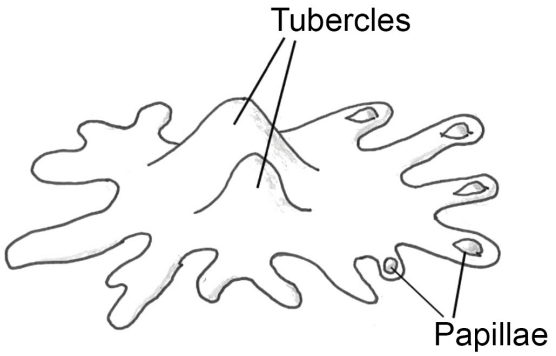

Figure 6. Schematic drawing of the seed coat of a seed of *Portulaca*, showing a detail of a testa cell with clearly indicated papillae and tubercles.

Frequency and distribution in Belgium

The frequency with which the micro-species are observed in Belgium is roughly the same as in Germany (Hassler *et al.* 2024). *Portulaca papillatostellulata* is by far the most common species (probably in the range of 90% of all occurrences), and it is prevalent in anthropogenic habitats such as nurseries, gardens, roadsides, etc. *P. oleracea* is the second most common species, but accounts for only 5-10% of all cases. *P. trituberculata* remains very rare and *P. cypria* is only found exceptionally.

Conclusion

This update clarifies several issues in the treatment of the *Portulaca oleracea* complex in Belgium. The distinction of putative tetraploid and hexaploid taxa based on seed size is no longer tenable, which leads to the synonymization of *P. granulatostellulata* with *P. papillatostellulata* and of *P. nitida* with *P. oleracea* s.str. The lectotypification of *P. oleracea* further renders the name *P. stellata* superfluous. Confusion between *P. sativa* and *P. edulis* remains unresolved and requires further study.

The corrected SEM photographs and additional nail-varnish impressions presented here provide reliable documentation of the Belgian taxa and allow for a simplified and more accurate identification key. Although nail-varnish impressions are a useful and accessible technique, SEM photography remains indispensable for detecting minute structural details.

In Belgium, *P. papillatostellulata* is by far the most widespread taxon, while *P. oleracea* s.str. is much less frequent, and *P. trituberculata* and *P. cypria* are rare to exceptional. This overview may serve as a practical reference for future floristic and taxonomic work on *Portulaca* in the region.

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