A. Danin, G. Domina & F. M. Raimondo

Microspecies of the *Portulaca oleracea* aggregate found on major Mediterranean islands (Sicily, Cyprus, Crete, Rhodes)

Abstract

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The 178 samples belonging to the *Portulaca oleracea* aggregate, originating from Sicily, Cyprus, Crete, and Rhodes, seed size and seed coat micromorphology have been studied. The material was found to belong to 9 different microspecies, 5 of which are described as new to science. This raises the number of microspecies known in the aggregate to 15: 6 hexaploids (5 present in the area), 4 tetraploids (all present), 2 diploids and 3 uncounted (none present). A key for identification of all 15, based on seed coat characters, is presented and is illustrated by SEM micrographs for 14 of them.

Key words: *Portulaca*, Micromorphology, SEM.

Introduction

In a series of excursions to several large Mediterranean islands, planned as a follow-up to a study of *Portulaca oleracea* in the Canary Islands (Danin & Reyes-Betancort 2006), seeds were collected in Sicily, Cyprus, Crete, and Rhodes. The polyploid complex of *P. oleracea* L. is considered here as an aggregate of several microspecies, following the concept of Greuter & al. (1984: x). For taxon delimitation we keep using seed morphology characters, since the vegetative parts do not provide any stable diagnostic features (Danin & al. 1979). The previously known and newly discovered taxa are here presented, with their typical seed-surface morphology, seed size, and chromosome number.

The present study reports the identity of material of the *P. oleracea* aggregate from 53 populations sampled in Sicily, 52 in Cyprus, 43 in Crete, and 30 on Rhodes. Five microspecies new to science are described. Attempts are made to look at this polyploid complex from an evolutionary viewpoint, taking into account seed surface morphology, seed size, and ploidy level.

Material and methods

The micromorphological terms here used to define the taxa are as follows. The testa surface may be smooth (Fig. 7c), covered with wax (Fig. 11d), or with minute swellings sloping steeply (Fig. 13c) or gradually like the swellings from mosquito bites (Fig. 6d). Small projections emerging on the testa cells' surface are designated as papillae (Fig. 7b, 10b), large ones as tubercles (Fig. 6b, 6c). The cells in surface view have rays (lateral projections from the main body), and take the shape of either isodiametric stars with long rays (Fig. 6b, 9c), or they are elongated and with either long (Fig. 8b, d) or short rays (Fig. 13b).

The seeds were collected in the summers of 2004-2006. The collecting localities are listed in Appendix 1. Populations were determined under the light microscope at magnifications of 500-1000× and, in some instances, SEM, using seed size and seed-coat morphology as criteria. Seeds were compared with the SE micrographs in Danin & al. (1979) and Danin & Reyes-Betancort (2006). Additional SE micrographs were produced at the Geological Institute of Jerusalem , at the Dipartimento di Scienze botaniche of Palermo, and at the Unit for Nanoscopic Characterization of the Hebrew University of Jerusalem. Seeds were fixed onto metal stubs and coated with a 20 nm gold layer or onto aluminium stubs with carbon tapes and coated with a 5-10 nm carbon layer in auto-sputter-coaters. Scanning electron micrographs of 14 out of the 15 microspecies recognised by us (all except *Portulaca africana*) are here included (Figs. 1-14).

For several samples, chromosome counts were made on root tips germinated from seeds collected in the field. All specimens enumerated in Appendix 1 were studied by the first author. Seed size information (Table 1), is derived from published data (Danin & al. 1979), from unpublished SE micrographs and from seed measurments of several microspecies.

Seeds were raised under stable greenhouse conditions in both Jerusalem and Palermo for 3 successive generations, in order to assess possible changes in vegetative characters and seed morphology.

Synopsis of known microspecies

Following Ricceri & Arrigoni (2000) and Danin & Reyes-Betancort (2006), the presently known microspecies of the *Portulaca oleracea* aggregate are presented, arranged according to their ploidy level:

A. Hexaploids

Portulaca oleracea L., Sp. Pl.: 445 (1753). – Fig. 1.

Syn.: *P. stellata* (Danin & H. G. Baker) Ricceri & Arrigoni in Parlatorea 4: 93 (2000), *P. oleracea* subsp. *stellata* Danin & H. G. Baker in Israel J. Bot. 27: 198 (1979).

Jarvis in Linn. Pl. Name Typif. Project correctly states:" Geesink stated "T[ype]: LINN (photograph seen)" and as the only sheet he could have intended is 625.1 (LINN), and it is original material for the name, this choice is accepted here. Danin & al. (in *Israel J. Bot*. 27: 196. 1978), however, stated "The lectotype should be chosen from the Hortus Siccus Cliffortianus material in the British Museum (Natural History!)", and applied their infraspecific nomenclature accordingly. They identified (*l.c.*: 198) the LINN material (accept-

Table 1. Seed size of the studied populations of *Portulaca oleracea* aggregate.

Name	Locality	Seed length mm	Seed width mm	Source
P. oleracea	Rhodes, Calithea	1	0.9	avg of 31 seeds
P. trituberculata	Israel, Jerusalem	1	0.9	avg of 31 seeds
P. papillato-stellulata	Sicily, Castellammare del Golfo	0.9	0.8	avg of 31 seeds
P. sativa	Switzerland, Geneve	1.45	1.3	avg of 7 photos
P. rausii	Rhodes, Kritinia	0.95	0.8	avg of 31 seeds
P. cypria	Lefkosia, Cyprus	1	0.85	avg of 31 seeds
P.granulato-stellulata	Sicily, Palermo	0.8	0.6	avg of 31 seeds
P. nitida	Sicily, Termini Imerese	0.8	0.7	avg of 31 seeds
P. sicula	Sicily, Castel di Tusa	1.1	0.9	avg of 31 seeds
P. zaffranii	Portugal, Lisboa	0.7	0.6	avg of 31 seeds
P. nicaraguensis	Tenerife, Los Cristinos	0.7	0.6	avg of 31 seeds
P. africana	Timbuktu	0.7	0.6	Danin & al. 1979
P. impolita	Texas, Bailey Co.	1	0.9	Danin & al. 1979
P. canariensis	Lazarote	1.1	1	avg of 4 photos
P. tuberculata	Peru, Puerto Maldonado	0.65	0.55	avg of 31 seeds

ed here as the type) with subsp. *stellata* Danin & Baker. Most recent authors appear to accept Geesink's choice of type but have adopted a broad species concept. Therefore the name *P. oleracea* L. sould be applied to the taxon previously named *P. stellata*.
Chromosome number: 2*n* = 54 (Danin & al. 1979).

Portulaca trituberculata Danin, Domina & Raimondo **sp. nov.** – Fig. 2.
Chromosome number: 2*n* = 54 (Danin & al. 1979; Danin & Reyes-Betancort 2006).
This taxon was considered since our first article (Danin & al. 1979) as the type of *P. oleracea*. However, review of the typification of this species have led us to rename this taxon.
Seminibus longo diametro 0.85-1mm. Cellulis testae latitudine 2-3plo longioribus (2-) 3 tuberculatis.
Type: Sicily, Trapani, 18.9.2005, *Danin & Domina* (holo-PAL, iso-HUJ).

Portulaca papillato-stellulata (Danin & H. G. Baker) Danin in Lagascalia 26: 76 (2006). – Fig. 3.
Syn.: *P. oleracea* subsp. *papillato-stellulata* Danin & H.G. Baker in Israel J. Bot. 27: 200 (1979).
Chromosome number: 2*n* = 54 (Danin & al. 1979).

Portulaca sativa Haw., Misc. Nat.: 136 (1803). – Fig. 4.
Pending study of the seeds of original material, the name *P. sativa* is here provisionally used in the sense of the taxon represented by Chenevard's specimens from Switzerland (G). The morphology of the testa cells in this specimen and all other speciemns from Switzerland (G) resembles much that of *P. cypria.* However, the morphology of the testa cells of the seeds of *P. sativa* from Deftera, Cyprus resemble much the morphology of *P. rausii* or *P. zaffranii*.

Portulaca rausii Danin, **sp. nov.** – Fig. 5.
A *P. papillato-stellulata* differt seminibus granulatis (nec granulato-stellulatis).
Holotype: Sicily, Mazara del Vallo TP, road edge, 18.9.2005, *Danin & Domina* (PAL).
Chromosome number: 2*n* = 54 (voucher: the type specimen).

Portulaca cypria Danin, **sp. nov.** – Fig. 6.
A *P. trituberculata* differt cellulis testae isodiametricis, asteriformibus (nec latitudine 2-3plo longioribus), radiis latitudine 2-3plo longioribus (nec latitudine brevioribus).
Type: Cyprus, Fasouri forest nursery at Akrotiri Peninsula, 5 km west of Lemesos port, 1.8.2007, Hadjikiryakou 6976 (holo-: PAL, iso-: HUJ, B, herb. Hadjikyriakou)
Chromosome number: 2*n* = 54 (vouchers: the type specimen and Sc26, Sicily, Linguaglossa CT, 17.9.2005, *Danin & Domina,* (PAL).

B. TETRAPLOIDS
Portulaca granulato-stellulata (Poelln.) Ricceri & Arrigoni in Parlatorea 4: 93 (2000). – Fig. 7.
Syn.: *P. oleracea* var. *granulato-stellulata* Poelln. in Occas. Pap. Bernice Pauahi Bishop Mus. 12(9): 5 (1936), *P. oleracea* subsp. *granulato-stellulata* (Poelln.) Danin & H. G. Baker in Israel J. Bot. 27: 189 (1979).
Chromosome number: 2*n* = 36 (Danin & al. 1979, Danin & Reyes-Betancort 2006).

Portulaca nitida (Danin & H. G. Baker) Ricceri & Arrigoni in Parlatorea 4: 93 (2000) – Fig. 8.
Syn.: P. oleracea subsp. *nitida* Danin & H.G. Baker in Israel J. Bot. 27: 194 (1979).
Chromosome number: 2*n* = 36 (Danin & al. 1979, Danin & Reyes-Betancort 2006).

Portulaca sicula Danin, Domina & Raimondo, **sp. nov.** – Fig. 9.
A *P. africana* diametro seminum 0.85-1.1 mm (nec 0.6-0.75 mm), a *P. oleracea* cellulis testae planis elongatis et margine tuberculatis differt.
Type: Sicily, cult. in the Botanical Garden of Palermo (from seeds of Sc17 – Castel di Tusa, 14.9.2005, *Danin & Domina*), 31.08.2006, *Domina* (PAL).
Chromosome number: 2*n* = 36 (voucher: Sc17 – Sicily, Castel di Tusa, 14.9.2005, *Danin & Domina,* (PAL).

Portulaca zaffranii Danin, **sp. nov.** – Fig. 10.
A *P. granulato-stellulata* (Poelln.) Ricceri & Arrigoni differt seminibus minute tantum tuberculatis (nec alte tuberculatis et stellulatis).
Chromosome number: 2*n* = 36 (vouchers: Sc48 – Sicily, Marsala, 18.9.2005, *Danin & Domina;* Sc16 – Sicily, Siracusa, 14.9.2005, *Danin & Domina*).

C. DIPLOIDS
Portulaca nicaraguensis (Danin & H. G. Baker) Danin in Lagascalia 26: 73 (2006). – Fig. 11.
Syn.: P. oleracea subsp. *nicaraguensis* Danin & H. G. Baker in Israel J. Bot. 27: 186 (1979).

Portulaca africana (Danin & H. G. Baker) Danin in Lagascalia 26: 76 (2006).
Syn.: *P. oleracea* subsp. *africana* Danin & H. G. Baker in Israel J. Bot. 27: 187. 1979.

D. CHROMOSOMES NUMBER NOT KNOWN YET

Portulaca impolita (Danin & H. G. Baker) Danin in Lagascalia 26: 76 (2006). – Fig. 12.
Syn.: *P. oleracea* subsp. *impolita* Danin & H. G. Baker in Israel J. Bot. 27: 195 (1979).

Portulaca canariensis Danin & Reyes-Betancort in Lagascalia 26: 77 (2006). – Fig. 13.

Portulaca tuberculata (Danin & H. G. Baker) Danin in Lagascalia 26: 76 (2006) – Fig. 14.
Syn.: *P. oleracea* subsp. *tuberculata* Danin & H. G. Baker in Israel J. Bot. 27: 194 (1979).

Culture from seeds

Portulaca cypria, P. sicula, P. nitida, P. zaffrani, P. oleracea and *P. rausii* were grown from seeds under controlled conditions, in Jerusalem and in Palermo, for 3 generations. Throughout cultivation no sensible differences in vegetative characters (plant habit, color of the stem, dimension and shape of the leaves) where detected. This suggests that variations observed in the field are mainly due to environmental differences. The constancy of seed morphology was also confirmed, supporting the conclusion, in our previous studies (Danin & al. 1979, Danin & Reyes-Betancort 2006) that seeds caracters are reliable markers in discriminating taxa.

Seed morphology and size

A detailed description of seed morphology was presented in Danin & al. (1979). The main features here commented are: 1) seed diameter, with 0.85 mm being the threshold between the hexaploids (above it) and the tetraploids and diploids below it. One species, *P. sicula*, has a "hexaploid seed size" but is actually a tetraploid.

Key for the determination of taxa by their seed features

Danin & al. (1979) provided a first key to the microspecies of the *Portulaca oleracea* aggregate, covering the 9 species known at that time. Six taxa, including the four first described in the present paper, have since been added. For convenience, the following artificial key includes all 15 taxa that are presently known; those occurring in the Mediterranean area and on the Canary islands appear in **bold-face** type:

1. Seeds bluish, few or many of any one specimen covered with wax; testa cells radially elongated; rays short (Fig. 11a).....***P. nicaraguensis***
1. Seeds not covered with wax.....2
2. Major seed diameter > 0.85 mm 3
2. Major seed diameter < 0.85 mm.....11
3. Seed surface dull; surface with steeply sloping swellings that may appear as white dots, at a manification of 100 × to 1000 × (Fig. 13c).....4
3. Seed surface shiny; if covered with swellings, their edge sloping gradually.....5

4. Testa cells isodiametric, with long rays, their center convex, resembling a turtle shell (Fig. 12).....*P. impolita*
4. Testa cells elongated, with short rays (Fig. 13b).....***P. canariensis***
5. Seed surface covered with small papillae of almost equal size.....6
5. Testa cells with a large tubercle at the centre (Fig. 6b), or with papillae on the rays (Fig. 7b), or flat, devoid of emergences, star-shaped cells and (Fig. 8b).....7
6. Diameter of most seeds > 1.1 mm (Fig. 4).....***P. sativa***
6. All seeds 0.85-1 mm in diameter (Fig. 5).....***P. rausii***
7. Testa cells flat devoid of emergences, star-shaped (Fig. 1).....***P. oleracea***
7. Lateral testa cells with at least one kind of tubercles or papillae.....8
8. Testa cells star-shaped, rays long, many of them with papillae at the end (Fig. 3) ....***P. papillato-stellulalta***
8. Testa cells with a tubercle in their central part but not on the rays.....9
9. Most lateral testa cells elongated, with (2-)3 tubercles close to each other (Fig. 2) .....***P. trituberculata***
9. Some or all testa cells star-shaped, isodiametric, with long rays and single or paired tubercles at the centre 10
10. All but the peripheral lateral testa cells elongated, flat, resembling those of *P. oleracea* and *P. nitida* (Fig. 9).....***P. sicula***
10. All testa cells isodiametric, star-shaped, with long rays and single or paired tubercles at the centre (Fig. 6b).....***P. cypria***
11. Testa cells isodiametric, with long rays, star-shaped, flat, with neither tubercles nor papillae (Fig. 9).....***P. nitida***
11. Testa cells elongated, with short rays, often tuberculate or papillate.....12
12. Testa cells papillate.....13
12. Testa cells tuberculate, or with both tubercles and papillae.....14
13. Testa cells star-shaped, the papillae emerging from the rays (Fig. 7) .....***P. granulato-stellulata***
13. Seed surface evenly covered with small papillae of almost equal size; stellulate cell pattern hardly visible (Fig. 10).....***P. zaffranii***
14. Testa cells with tubercles in their central part and papillae on some of the rays.....*P. tuberculata*
14. Peripheral lateral testa cells tuberculate and with long rays, all the others elongated, flat, resembling those of *P. oleracea* and *P. nitida*. Tuberculate cells only at the periphery of the lateral face.....*P. africana*

Similarity of taxa with a different ploidy level

The following pairs or groups of species have a similar seed surface morphology but differ in seed size and ploidy level.
P. africana (2x) and *P. sicula* (4x);
P. nitida (4x) and *P. oleracea* (6x);
P. nicaraguensis (2x), *P. canariensis* (?), *P. granulato-stellulata* (4x) and *P. papillato-stellulata* (6x);

P. tuberculata (?) and *P. trituberculata* (6x);
P. zaffranii (4x) and *P. rausii* (6x) and *P. sativa* (in Cyprus).
P. cypria (6x) and *P. sativa* (6x; in Switzerland).

Morphological similarities between many taxa were discussed already by Danin & al. (1979). The scanning electron micrographs of the six additional taxa fit well into their hypothesis of phylogenetic links between the taxa. The above scheme accounts for 14 of the 15 known taxa (all except *Portulaca impolita*). Future studies will likely reveal additional taxa, so that further similarity links may be found. Cytogenetic and molecular systematic studies are recomended to underpin or disprove our assumption that morphological likeness and phylogenetic relationship are positively correlated in this group.

Speciation under self-pollination

Zohary (1999), to explain the high diversity of annual species of, in particular, *Gramineae*, *Papilionaceae*, and *Asteraceae* in the East Mediterranean, postulated that self-pollination is the mechanism by which sympatric speciation takes place. The minute changes in the environment imposed by human activity since the Neolithic agricultural revolution started 10,000 years ago opened new habitats. Self-pollination, Zohary suggested, enabled the preservation of mutants which fit the newly formed habitats. He wrote: "Chromosomal rearrangements, once spontaneously induced, have a good chance to quickly establish themselves as independent homozygous lines".

Zohary's assumption seems to be well suited for explaining the high diversity of microspecies in the *Portulaca oleracea* aggregate, where the situation is similar and, we believe even higher barriers to gene exchange exist. Sympatric microspecies often have a different ploidy level. In Tenerife (Danin & Reyes-Betancort 2006) a diploid grows together with various tetraploids, hexaploids, or both. The situation in the *Vicia sativa* complex (Zohary & Plitmann 1981) illustrating the role of human activity, is also relevant here. Primary populations of members of the *P. oleracea* aggregate are confined to sodic soils in tropical countries, coastal habitats on oceanic islands, river banks, and beaches of freshwater lakes, where natural disturbance of the substratum occurs regularly. Throughout the world, however, the common habitats of these plants are synanthropic. In these sites, water and light are freely available in the warm season.

Our studies, in the past, have met scepticism from many who feared an endless proliferation of microspecies and asked for a logical explanation of their sympatric growth. The fact is that the several hundreds of specimens we have studied turned out to belong to a finite number of clearly delimited taxa. Of the more than 55 relevant specimens in the Geneva herbarium (G), only 5 could not yet be named, 25 are *Portulaca granulato-stellulata*, 17 belong to *P. trituberculata,* and the rest represent some of the rarer species. In our own collections (HUJ, PAL) there were many mixed gatherings, pointing at sympatric growth of different species. In a single pot, in Palermo, two different species were found growing together. Material in other collections similarly indicates that several microspecies of this cosmopolitan aggregate use to grow sympatrically. They may repressent one, two, or three ploidy levels, and are believed to be selfers. We hope to further investigate pollination in this aggregate.

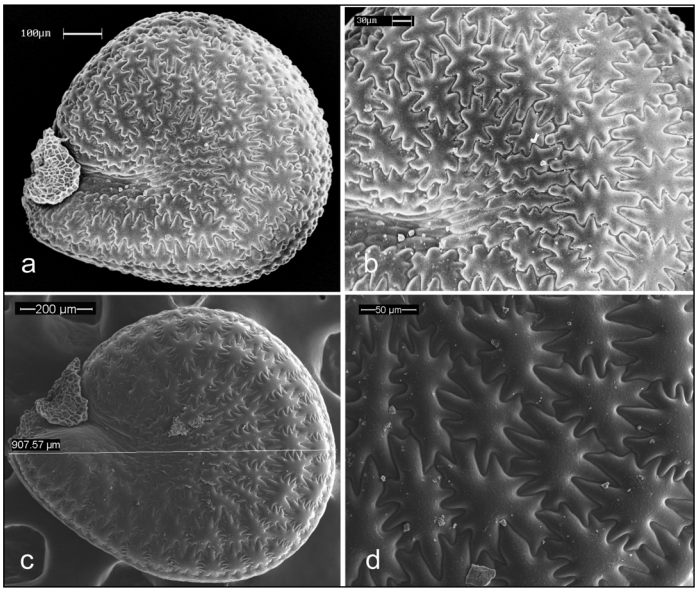

Fig. 1. *Portulaca oleracea*: **a, b,** Sicily, Valderice, 18.9.2005, *AD & Domina* (HUJ, PAL); **c, d,** Turkey, Kumburgaz, 1.7.2007, *Danin* (HUJ).

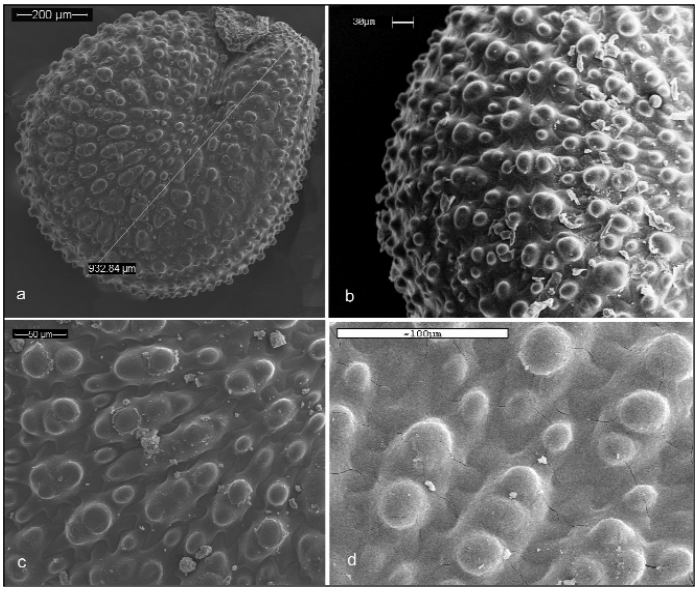

Fig. 2. *Portulaca trituberculata*: **a, b,** Crete, Rethymno, 8.10.2004, *Danin & Zaffran* (HUJ); **c, d,** Sicily, Trapani, 18.9.2005, *Danin & Domina* (HUJ, PAL).

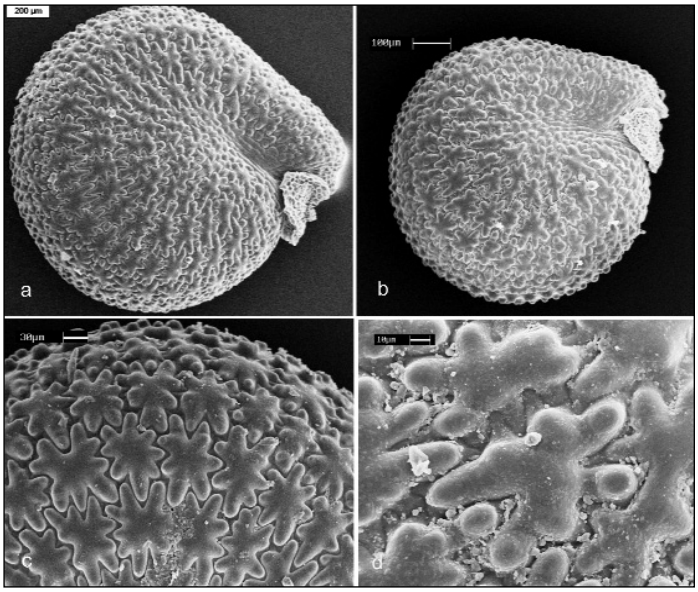

Fig. 3. *Portulaca papillato-stellulata*: **a, b, c, d,** Sicily, Castellammare del Golfo, 18.9.2005, *Danin & Domina* (HUJ, PAL).

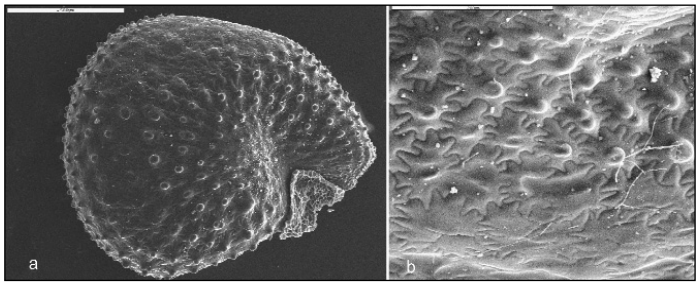

Fig. 4. *Portulaca sativa*: **a, b,** Switzerland, 8.1899, *Chenevard* (G!).

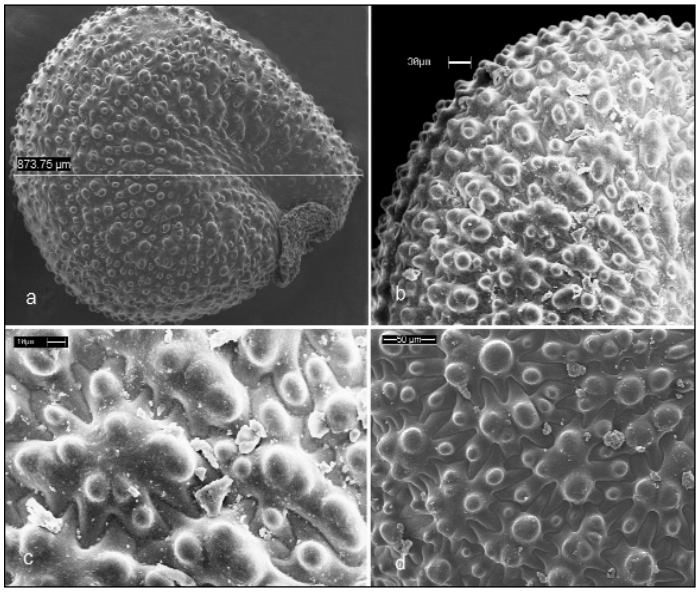

Fig. 5. *Portulaca rausii*: **a, c,** Rhodos, Arhipoli, 28.9.2005, *Danin* (HUJ); **b, d,** Sicily, Marsala, 18.9.2005, *Danin & Domina* (HUJ, PAL).

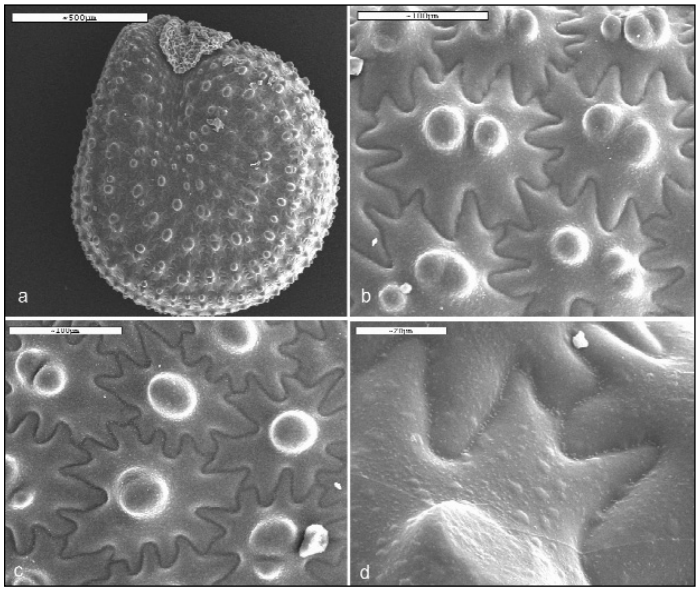

Fig. 6. *Portulaca cypria*: **a, b, c, d,** Cyprus, Xylofagou - Ormideia, 21.9.2004, *Danin & Hadjikiryakou* (HUJ).

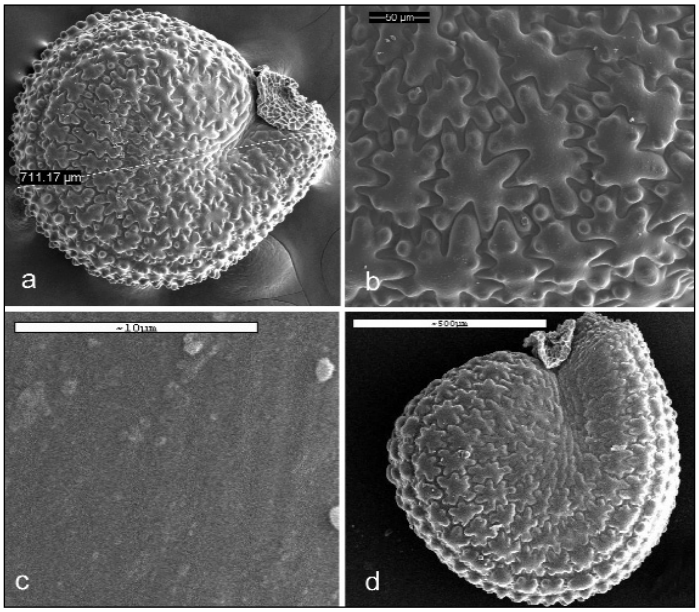

Fig. 7. *Portulaca granulato-stellulata*: **a, b, c,** Israel, Afula, 7.11.2005, *Danin* (HUJ); **d,** Sicily, Terrasini, 18.9.2005, *Danin & Domina* (HUJ, PAL).

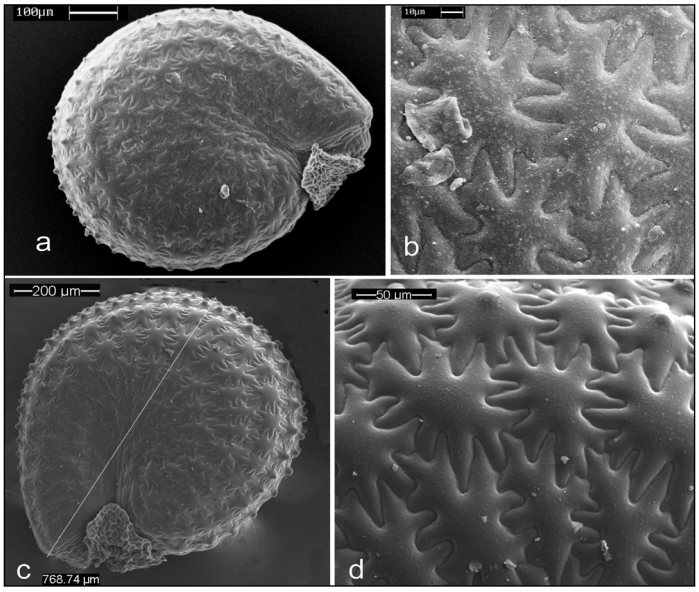

Fig. 8. *Portulaca nitida*: **a, b,** Sicily, Termini Imerese c.da Sacchitello, 14.9.2005, *Danin* & *Domina* (HUJ, PAL); **c, d,** Israel, Gan Yavne, 29.7.2005, *Danin* (HUJ).

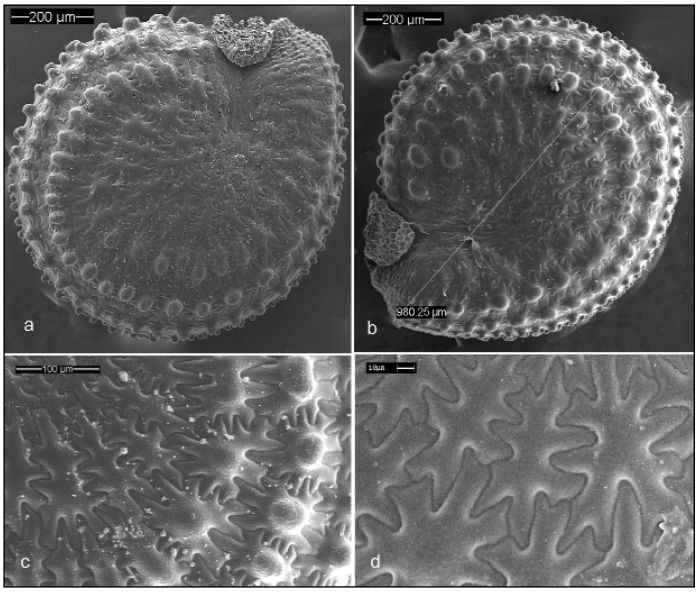

Fig. 9. *Portulaca sicula*: **a, b, c, d,** Sicily: Castel di Tusa, 17.9.2005, *Danin & Domina* (HUJ, PAL).

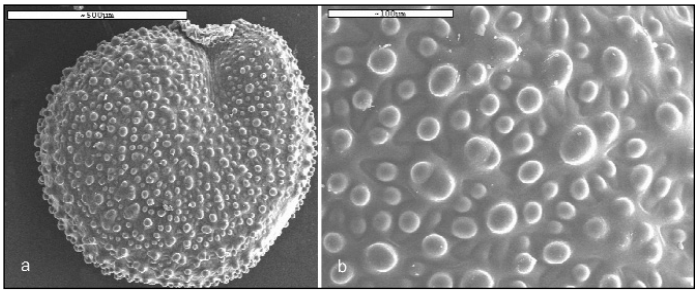

Fig. 10. *Portulaca zaffranii*: **a, b,** Crete, Souda, 8.10.2004, *Danin & Zaffran* (HUJ).

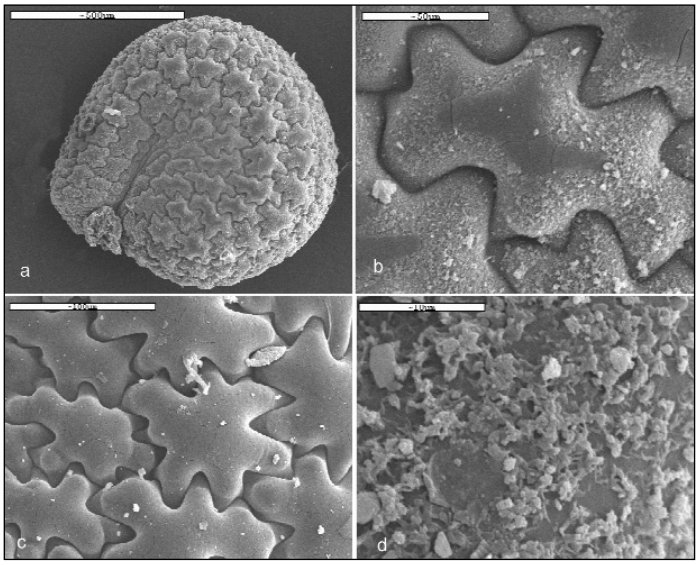

Fig. 11. *Portulaca nicaraguensis*: **a, b,** Canary Islands, Tenerife, Los Cristianos, near the port, gardens, 13.10.2003, *Danin* (HUJ); **c, d,** Canary Islands, Tenerife, Playa de la Arena, gardens, 3.10.2003, *Danin* (HUJ).[from Danin & Reyes-Betancort (2006), reproduced with permission from *Lagascalia*].

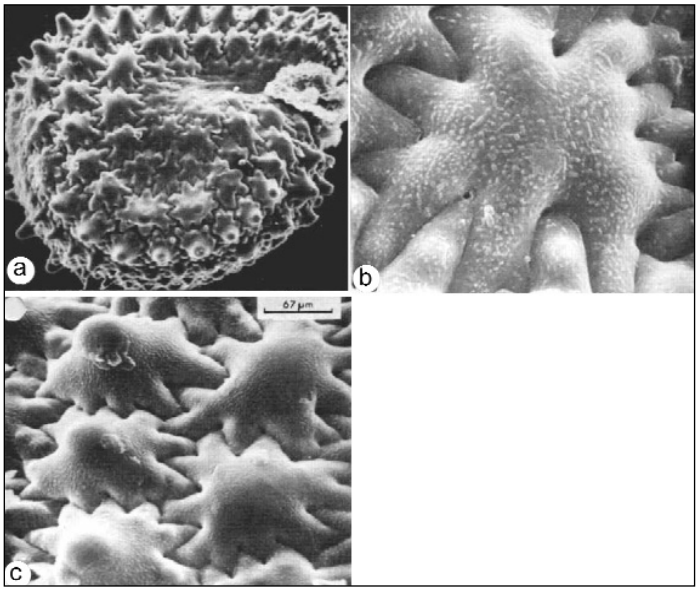

Fig. 12. *Portulaca impolita*: **a, b, c,** California, San Bernadino Co., 14.9.1955, *Burns* (UC). [from Danin & al. (1979), reproduced with permission from the *Israel J. Bot.*].

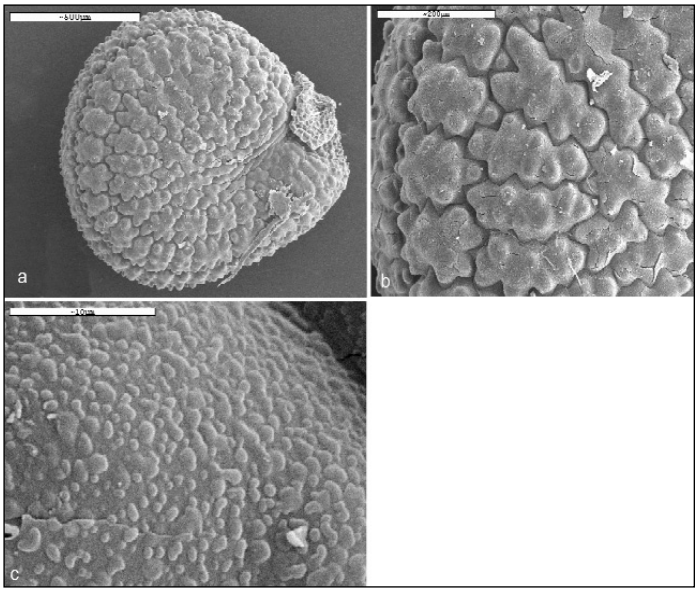

Fig. 13. *Portulaca canariensis*: **a, b, c,** Canary Islands, Lanzarote, Timanfaya, Halcones, 29.2.2002*, Cruz Trujillo* (TFC), [from Danin & Reyes-Betancort (2006), reproduced with permission from *Lagascalia*].

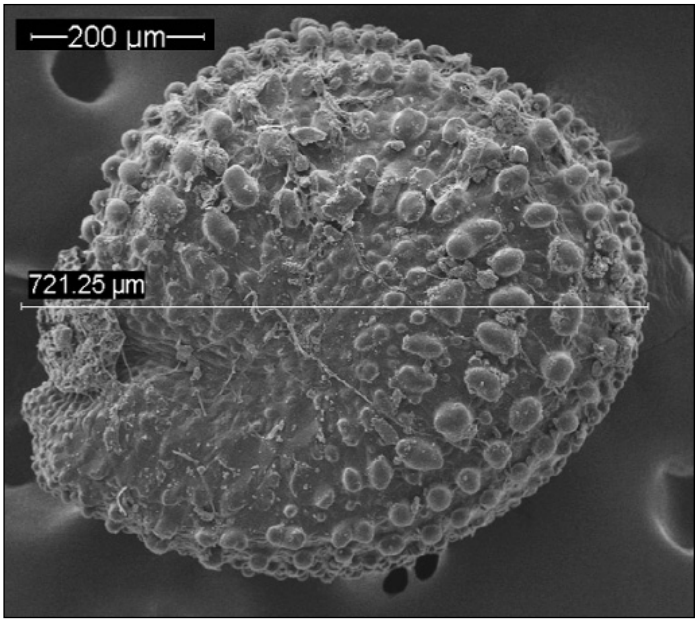

Fig. 14. *Portulaca tuberculata*: S. America, Perù, Puerto Maldonado, riverside, 13.2.2007, *Danin* (HUJ).

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Appendix 1. A list of seed samples of the *Portulaca oleracea* aggr. Arranged in taxonomic and countries order. Collector abbreviations: A. Danin = AD, Gianniantonio Domina = GD, Georgios Hadjikiryakou = GH, Jacques Zaffran = JZ.

Portulaca oleracea L.

Sicily: Gela, 14.9.2005, *AD & GD* (HUJ, PAL); Castel di Tusa, 17.9.2005, *AD & GD* (HUJ, PAL); Solicchiata, 17.9.2005, *AD & GD* (HUJ, PAL); Acireale, 17.9.2005, *AD & GD* (HUJ, PAL); Milazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Campofelice di Roccella, 17.9.2005, *AD & GD* (HUJ, PAL); Terrasini, 18.9.2005, *AD & GD* (HUJ, PAL); Castellammare del Golfo, 18.9.2005, *AD & GD* (HUJ, PAL); Valderice, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Sciacca, 18.9.2005, *AD & GD* (HUJ, PAL).

Cyprus: Athalassa, Lefkosia 22.9.2004, *AD & GH* (HUJ);
Rhodes: Simy, 27.9.05, *AD* (HUJ); Kalithea, 28.9.2005, *AD* (HUJ); Eleoussa, 28.9.2005, *AD* (HUJ).

Portulaca trituberculata Danin, Domina & Raimondo

Sicily: Caltanissetta, 14.9.2005, *AD & GD* (HUJ, PAL); Gela, 14.9.2005, *AD & GD* (HUJ, PAL); Comiso, 14.9.2005, *AD & GD* (HUJ, PAL); Ragusa, 14.9.2005, *AD & GD* (HUJ, PAL); Modica, 14.9.2005, *AD & GD* (HUJ, PAL); Rosolini, 14.9.2005, *AD & GD* (HUJ, PAL); Siracusa, 14.9.2005, *AD & GD* (HUJ, PAL); Caltanissetta, 14.9.2005, *AD & GD* (HUJ, PAL); Linguaglossa, 17.9.2005, *AD & GD* (HUJ, PAL); Taromina, 17.9.2005, *AD & GD* (HUJ, PAL); Valderice, 18.9.2005, *AD & GD* (HUJ, PAL); Trapani, 18.9.2005, *AD & GD* (HUJ, PAL); Marsala, 18.9.2005, *AD & GD* (HUJ, PAL); Sciacca, 18.9.2005, *AD & GD* (HUJ, PAL); Porto Empedocie, 18.9.2005, *AD & GD* (HUJ, PAL); Vicari, 18.9.2005, *AD & GD* (HUJ, PAL); Palermo, 18.9.2005, *AD & GD* (HUJ, PAL);

Cyprus: North of Agia Napa, 21.9.2004, *AD & GH* (HUJ); Kavo Gkreko – Protaras, 21.9.2004, *AD & GH* (HUJ); Kappari NE of Paralimni, 21.9.2004, *AD & GH* (HUJ); Paralimni, 21.9.2004, *AD & GH* (HUJ); Sotira Ammochostou , 21.9.2004, *AD & GH* (HUJ); Liopetri, 21.9.2004, *AD & GH* (HUJ); Xylofagou - Ormideia, 21.9.2004, *AD & GH* (HUJ); Xylofagou, 21.9.2004, *AD & GH* (HUJ); Ormideia beach, 21.9.2004, *AD & GH* (HUJ); Agios Theodoros Larnakas, 21.9.2004, *AD & GH* (HUJ); Athalassa, Aromatics plantation, Lefkosia, 22.9.2004, *AD & GH* (HUJ); Lefkosia Forestry Department, 22.9.2004, *AD & GH* (HUJ); Anthoupoli, 22.9.2004, *AD & GH* (HUJ); Deftera, 22.9.2004, *AD & GH* (HUJ); Akaki, 22.9.2004, *AD & GH* (HUJ); , 22.9.2004, *AD & GH* (HUJ); Peristerona , 22.9.2004, *AD & GH* (HUJ); Evrychou 400 m alt. , 22.9.2004, *AD & GH* (HUJ); Galata 600 m alt., 22.9.2004, *AD & GH* (HUJ); Episkopi Lemesou , 22.9.2004, *AD & GH* (HUJ); Trachoni Lemesou, 22.9.2004, *AD & GH* (HUJ); Lemesos near Miramare Hotel, 22.9.2004, *AD & GH* (HUJ); Kolossi, 22.9.2004, *AD & GH* (HUJ); Chapotami, 23.9.2004, *AD & GH* (HUJ); Kouklia, 23.9.2004, *AD & GH* (HUJ); Nikokleia, 23.9.2004, *AD & GH* (HUJ); Mouth of Asprokremmos dam, 23.9.2004, *AD & GH* (HUJ); Pafos – Geroskipou, 23.9.2004, *AD & GH* (HUJ); Pafos port, 23.9.2004, *AD & GH* (HUJ); Chloraka, 23.9.2004, *AD & GH* (HUJ); Pegeia, 23.9.2004, *AD & GH* (HUJ); Agios Georgios Pegeias, 23.9.2004, *AD & GH* (HUJ); Lakki, 23.9.2004, *AD & GH* (HUJ); Polis, 23.9.2004, *AD & GH* (HUJ); Argaka, 23.9.2004, *AD & GH* (HUJ); Skoulli, 23.9.2004, *AD & GH* (HUJ); Stroumpi, 23.9.2004, *AD & GH* (HUJ); Pafos near the general hospital, 23.9.2004, *AD & GH* (HUJ);

Crete: Orthodox Academy, 7.10.2004, *AD & JZ* (HUJ); GeorgioPolis, 7.10.2004, *AD & JZ* (HUJ); 15 km E of GeorgioPolis, 7.10.2004, *AD & JZ* (HUJ); Gournes, 7.10.2004, *AD & JZ* (HUJ); Agios Nicolaos, 7.10.2004, *AD & JZ* (HUJ); Iereptera, 7.10.2004, *AD & JZ* (HUJ); Mirtos, 8.10.2004, *AD & JZ* (HUJ); Ano Vianos, 8.10.2004, *AD & JZ* (HUJ); Pefko, 8.10.2004, *AD & JZ* (HUJ); Pangia, 8.10.2004, *AD & JZ* (HUJ); Arakchori, 8.10.2004, *AD & JZ* (HUJ); Garipa, 8.10.2004, *AD & JZ* (HUJ); Kas Mesahori, 8.10.2004, *AD & JZ* (HUJ); Pretori, 8.10.2004, *AD & JZ* (HUJ); Gangales-Cangales, 8.10.2004, *AD & JZ* (HUJ); Kapariana, 8.10.2004, *AD & JZ* (HUJ); Timbaki, 8.10.2004, *AD & JZ* (HUJ); Kok Pirgos, 8.10.2004, *AD & JZ* (HUJ); Spili, 8.10.2004, *AD & JZ* (HUJ); Armeni, 8.10.2004, *AD & JZ* (HUJ); Rethymno, 8.10.2004, *AD & JZ* (HUJ); Chania, 8.10.2004, *AD & JZ* (HUJ); Pollimarhi, 8.10.2004, *AD & JZ* (HUJ); Kandanos, 9.10.2004, *AD & JZ* (HUJ); Pleochora, 9.10.2004, *AD & JZ* (HUJ); Koundoura, 9.10.2004, *AD & JZ* (HUJ); Hirisos Kalimisa, 9.10.2004, *AD & JZ* (HUJ); Plokiana, 9.10.2004, *AD & JZ* (HUJ); Kefali, 9.10.2004, *AD & JZ* (HUJ); Kambos, 9.10.2004, *AD & JZ* (HUJ); Sfinari, 9.10.2004, *AD & JZ* (HUJ); Platanos, 9.10.2004, *AD & JZ* (HUJ); Kissamos, 9.10.2004, *AD & JZ* (HUJ).

Rhodes: 5 km S of Rhodes, 26.9.2005, *AD* (HUJ); Afantou, 26.9.2005, *AD* (HUJ); 5 km WSW of Lindos Rhodes, 26.9.2005, *AD* (HUJ); Polakia, 26.9.2005, *AD* (HUJ); Monolithos,

26.9.2005, *AD* (HUJ); Siana, 26.9.2005, *AD* (HUJ); Kritina, 26.9.2005, *AD* (HUJ); Kamiro Skala, 26.9.2005, *AD* (HUJ); Kakiro, 26.9.2005, *AD* (HUJ); Fanes, 26.9.2005, *AD* (HUJ); 2 km NE of Soroni, 26.9.2005, *AD* (HUJ); Rhodes, near the Acropolis, 27.9.2005, *AD* (HUJ); Rhodes, 2 km S of the Old City, 27.9.2005, *AD* (HUJ); Pastida, 27.9.2005, *AD* (HUJ); Faliraki, 28.9.2005, *AD* (HUJ); Kalythies, 28.9.2005, *AD* (HUJ); Psinthos, 28.9.2005, *AD* (HUJ); 5 km N of Arhipoli, 28.9.2005, *AD* (HUJ); Eleoussa, 28.9.2005, *AD* (HUJ); 5 km E of Eleoussa to Profitio, 28.9.2005, *AD* (HUJ); Salakos, 28.9.2005, *AD* (HUJ); 5 km S of Salakos, 28.9.2005, *AD* (HUJ); Rhodes, near the Synagogue, 28.9.2005, *AD* (HUJ).

Portulaca papillato-stellulata (Danin & H. G. Baker) Danin

Sicily: Gela, 14.9.2005, *AD & GD* (HUJ, PAL); Vittoria, 14.9.2005, *AD & GD* (HUJ, PAL); San Fratello, 17.9.2005, *AD & GD* (HUJ, PAL); Cesaro, 17.9.2005, *AD & GD* (HUJ, PAL); Randazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Solicchiata, 17.9.2005, *AD & GD* (HUJ, PAL); Acireale, 17.9.2005, *AD & GD* (HUJ, PAL); Taormina, 17.9.2005, *AD & GD* (HUJ, PAL); Messina, 17.9.2005, *AD & GD* (HUJ, PAL); Milazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Campofelice di Roccella, 17.9.2005, *AD & GD* (HUJ, PAL); Castellammare del Golfo, 18.9.2005, *AD & GD* (HUJ, PAL); Trapani, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Castelvetrano, 18.9.2005, *AD & GD* (HUJ, PAL);
Rhodes: Simy, 27.9.05, *AD* (HUJ).

P. sativa Haw. in Misc. Nat.: 136 (1803).
Switzerland: 8.1899, *Chenevard* (G!);
Cyprus: Deftera, 22.9.2004, *AD & GH* (HUJ).

Portulaca rausii Danin

Sicily: Caltanissetta, 14.9.2005, *AD & GD* (HUJ, PAL); Termini Imerese c.da Sacchitello, 14.9.2005, *AD & GD* (HUJ, PAL); Gela, 14.9.2005, *AD & GD* (HUJ, PAL); Vittoria, 14.9.2005, *AD & GD* (HUJ, PAL); Comiso, 14.9.2005, *AD & GD* (HUJ, PAL); Terrasini, 18.9.2005, *AD & GD* (HUJ, PAL); Valderice, 18.9.2005, *AD & GD* (HUJ, PAL); Trapani, 18.9.2005, *AD & GD* (HUJ, PAL); Marsala, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Sciacca, 18.9.2005, *AD & GD* (HUJ, PAL); Palermo, 18.9.2005, *AD & GD* (HUJ, PAL); Linosa, 9.8.2007, GD (HUJ, PAL);
Cyprus: Ormideia beach, 22.9.2004, *AD & GH* (HUJ); Athalassa, Lefkosia, 22.9.2004, *AD & GH* (HUJ);
Rhodes: 2 km S of Rhodes Old City, 27.9.2005, *AD* (HUJ); Simy, 27.9.05, *AD* (HUJ); Arhipoli, 28.9.05, *AD* (HUJ).

Portulaca cypria Danin

Sicily: Linguaglossa, 17.9.2005, *AD & GD* (HUJ, PAL); Taormina, 17.9.2005, *AD & GD* (HUJ, PAL).
Cyprus: North of Agia Napa, 21.9.2004, *AD & GH* (HUJ); Kavo Gkreko – Protaras, 21.9.2004, *AD & GH* (HUJ); Sotira – Liopetri, 21.9.2004, *AD & GH* (HUJ); Liopetri, 21.9.2004, *AD & GH* (HUJ); Xylofagou - Ormideia, 21.9.2004, *AD & GH* (HUJ); Ormideia beach, 21.9.2004, *AD & GH* (HUJ); Agios Theodoros Larnakas, 21.9.2004, *AD & GH* (HUJ); 2 km S of Agios Theodoros Larnakas, 21.9.2004, *AD & GH* (HUJ); Agios Theodoros Larnakas, near the coast, 21.9.2004, *AD & GH* (HUJ); Agios Theodoros Larnakas - Zygi, near Maroni junction, 21.9.2004, *AD & GH* (HUJ); Vasilikos river east of Mari, 21.9.2004, *AD & GH* (HUJ); Athalassa, Lefkosia, 22.9.2004, *AD & GH* (HUJ); Lefkosia, Kykkos area, 22.9.2004, *AD & GH* (HUJ); Akaki, 22.9.2004, *AD & GH* (HUJ).

Rhodes: Agios Agathi, 26.9.2005, *AD* (HUJ); Polakia, 26.9.2005, *AD* (HUJ); Monolithos, 26.9.2005, *AD* (HUJ); 2 km S of Rhodes Old City, 27.9.2005, *AD* (HUJ); Psinthos , 28.9.2005, *AD* (HUJ);

Portulaca granulato-stellulata (Poelln.) Ricceri & Arrigoni

Sicily: Palermo, 14.9.2005, *AD & GD* (HUJ, PAL); Caltanissetta, 14.9.2005, *AD & GD* (HUJ, PAL); Rosolini, 14.9.2005, *AD & GD* (HUJ, PAL);Santo Stefano di Camastra, 17.9.2005, *AD & GD* (HUJ, PAL); Sant'Agata di Militello, 17.9.2005, *AD & GD* (HUJ, PAL); San Fratello, 17.9.2005, *AD & GD* (HUJ, PAL); Cesaro, 17.9.2005, *AD & GD* (HUJ, PAL); Randazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Acireale, 17.9.2005, *AD & GD* (HUJ, PAL); Messina, 17.9.2005, *AD & GD* (HUJ, PAL); Milazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Campofelice di Roccella, 17.9.2005, *AD & GD* (HUJ, PAL); Terrasini, 18.9.2005, *AD & GD* (HUJ, PAL); Valderice, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Castelvetrano, 18.9.2005, *AD & GD* (HUJ, PAL); Sciacca, 18.9.2005, *AD & GD* (HUJ, PAL); Cammarata, 18.9.2005, *AD & GD* (HUJ, PAL); Lampedusa, 07.8.2008, *GD* (PAL)..

Cyprus: Athalassa, Lefkosia, 22.9.2004, *AD & GH* (HUJ);

Crete: Agios Nikolaos, 7.10.2004, *AD & JZ* (HUJ); Spili, 8.10.2004, *AD & JZ* (HUJ); Chania, 8.10.2004, *AD & JZ* (HUJ); Voukolis, 9.10.2004, *AD & JZ* (HUJ); Kandanos, 9.10.2004, *AD & JZ* (HUJ); Plokiana, 9.10.2004, *AD & JZ* (HUJ); Koundoura, 9.10.2004, *AD & JZ* (HUJ);

Rhodes: Agios Agathi, 26.9.2005, *AD* (HUJ); Lindos, 26.9.2005, *AD* (HUJ); Kalithea, 27.9.2005, *AD* (HUJ); 5 km N of Arhipoli, 27.9.2005, *AD* (HUJ); Kakiro, 26.9.2005, *AD* (HUJ); 2 km S of Rhodes Old City, 27.9.2005, *AD* (HUJ); Simy, 27.9.2005, *AD* (HUJ); Salakos, 27.9.2005, *AD* (HUJ).

Portulaca nitida (Danin & H. G. Baker) Ricceri & Arrigoni

Sicily: Caltanissetta, 14.9.2005, *AD & GD* (HUJ, PAL); Termini Imerese c.da Sacchitello, 14.9.2005, *AD & GD* (HUJ, PAL); Gela, 14.9.2005, *AD & GD* (HUJ, PAL); Vittoria, 14.9.2005, *AD & GD* (HUJ, PAL); Modica, 14.9.2005, *AD & GD* (HUJ, PAL); Rosolini, 14.9.2005, *AD & GD* (HUJ, PAL); Castel di Tusa, 17.9.2005, *AD & GD* (HUJ, PAL); Sant'Agata di Militello, 17.9.2005, *AD & GD* (HUJ, PAL); Solicchiata, 17.9.2005, *AD & GD* (HUJ, PAL); Linguaglossa, 17.9.2005, *AD & GD* (HUJ, PAL); Acireale, 17.9.2005, *AD & GD* (HUJ, PAL); Taormina, 17.9.2005, *AD & GD* (HUJ, PAL); Milazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Campofelice di Roccela, 18.9.2005, *AD & GD* (HUJ, PAL); Terrasini, 18.9.2005, *AD & GD* (HUJ, PAL); Castellammare di Golfo, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Castelvetrano, 18.9.2005, *AD & GD* (HUJ, PAL); Palermo, 18.9.2005, *AD & GD* (HUJ, PAL).

Cyprus: 2 km S of Agios Theodoros Larnakas, 21.9.2004, *AD & GH* (HUJ); Agios Theodoros Larnakas - Zygi, near Maroni junction, 21.9.2004, *AD & GH* (HUJ); Vasilikos river east of Mari, 21.9.2004, *AD & GH* (HUJ); Athalassa, Lefkosia, 22.9.2004, *AD & GH* (HUJ); Peristerona, 22.9.2004, *AD & GH* (HUJ); Erichou, 22.9.2004, *AD & GH* (HUJ); Lemesos near Miramare Hotel, 22.9.2004, *AD & GH* (HUJ); Kolossi, 22.9.2004, *AD & GH* (HUJ).

Crete: Orthodox Academy, 7.10.2004, *AD & JZ* (HUJ); GeorgioPolis, 7.10.2004, *AD & JZ* (HUJ); Mirtos, 8.10.2004, *AD & JZ* (HUJ); Ano Vianos, 8.10.2004, *AD & JZ* (HUJ); Pefko, 8.10.2004, *AD & JZ* (HUJ); Pangia, 8.10.2004, *AD & JZ* (HUJ); Kas Mesahori, 8.10.2004, *AD & JZ* (HUJ); Kok Pirgos, 8.10.2004, *AD & JZ* (HUJ); Chania, 8.10.2004, *AD & JZ* (HUJ); Sfinari, 9.10.2004, *AD & JZ* (HUJ); Nea Roumata, 10.10.2004, *AD & JZ* (HUJ); Skines, 10.10.2004, *AD & JZ* (HUJ); Platanias, 10.10.2004, *AD & JZ* (HUJ).

Rhodes: Lindos, 26.9.2005, *AD* (HUJ); Kiotari, 26.9.2005, *AD* (HUJ); Genadi, 26.9.2005, *AD* (HUJ); 5 km N of Kattavia, 26.9.2005, *AD* (HUJ); Kakiro, 26.9.2005, *AD* (HUJ); 2 km S of Rhodes Old City, 27.9.2005, *AD* (HUJ); Simy, 27.9.2005, *AD* (HUJ); Salakos, 27.9.2005, *AD* (HUJ).

Portulaca sicula Danin, Domina & Raimondo

Sicily: Termini Imerese c.da Sacchitello, 14.9.2005, *AD & GD* (HUJ, PAL); Castel di Tusa, 17.9.2005, *AD & GD* (HUJ, PAL); Santo Stefano di Camastra, 17.9.2005, *AD & GD* (HUJ, PAL); Sant'Agata di Militello, 17.9.2005, *AD & GD* (HUJ, PAL); Taormina, 17.9.2005, *AD & GD* (HUJ, PAL); Messina, 17.9.2005, *AD & GD* (HUJ, PAL); Sciacca, 18.9.2005, *AD & GD* (HUJ, PAL); Palermo, 18.9.2005, *AD & GD* (HUJ, PAL).

Portulaca zaffranii Danin

Sicily: Termini Imerese c.da Sacchitello, 14.9.2005, *AD & GD* (HUJ, PAL); Rosolini, 14.9.2005, *AD & GD* (HUJ, PAL); Siracusa, 14.9.2005, *AD & GD* (HUJ, PAL); Santo Stefano di Camastra, 17.9.2005, *AD & GD* (HUJ, PAL); Randazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Solicchiata, 17.9.2005, *AD & GD* (HUJ, PAL); Taormina, 17.9.2005, *AD & GD* (HUJ, PAL); Messina, 17.9.2005, *AD & GD* (HUJ, PAL); Milazzo, 17.9.2005, *AD & GD* (HUJ, PAL); Terrasini, 18.9.2005, *AD & GD* (HUJ, PAL); Marsala, 18.9.2005, *AD & GD* (HUJ, PAL); Mazara, 18.9.2005, *AD & GD* (HUJ, PAL); Cammarata, 18.9.2005, *AD & GD* (HUJ, PAL); Vicari, 18.9.2005, *AD & GD* (HUJ, PAL);

Crete: GeorgioPolis, 7.10.2004, *AD & JZ* (HUJ); Agios Nicolaos, 7.10.2004, *AD & JZ* (HUJ); Mirtos, 8.10.2004, *AD & JZ* (HUJ); Souda, 8.10.2004, *AD & JZ* (HUJ);

Rhodes: Simy, 27.9.2005, *AD* (HUJ);

Portulaca nicaraguensis (Danin & H. G. Baker) Danin

Canary Islands: Tenerife, Puerto Cruz, gardens, 7.10.2003, *AD* (HUJ); Tenerife, Las Galletas, 20.4.2002, *Serna Ramos* 43.630 (TFC); Tenerife, Los Cristianos, near the port, gardens, 13.10.2003, *AD* (HUJ); c, d) Canary Islands, Tenerife, Playa de la Arena, gardens, 3.10.2003, *AD* (HUJ).

Portulaca africana (Danin & H. G. Baker) Danin

Africa: Sudan Francais (Mali), Timbuktu, dry sand, 14.7.1927, *Hagerup* 262 (K).

Portulaca impolita (Danin & H. G. Baker) Danin

N America: California, San Bernadino Co., 14.9.1955, *Burns* (UC).

Portulaca canariensis Danin & Reyes-Betancort

Canary Islands: Tenerife, Fasnia, La Hondura, 30.3.1996, Cruz Trujillo 39.452 (TFC); Lanzarote, Timanfaya, Halcones, 29.2.2002*, Cruz Trujillo* (TFC).

Portulaca tuberculata (Danin & H. G. Baker) Danin

S America: Perù, Puerto Maldonado, riverside, 13.2.2007 *AD* (HUJ).