

First data on the taxonomic diversity of the *Portulaca oleracea* aggregate (Portulacaceae) in Iran

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Received: 23.11.2016 • Accepted/Published Online: 03.04.2017 • Final Version: 28.09.2017

Abstract: The review of specimens from Iran belonging to the *Portulaca oleracea* L. aggregate resulted in the recognition of six microspecies: *P. cypria* Danin, *P. granulatostellulata* (Poelln.) Ricceri & Arrigoni, *P. nitida* (Danin & H.G.Baker) Ricceri & Arrigoni, *P. rausii* Danin, *P. socotrana* Domina & Raimondo, and *P. trituberculata* Danin, Domina & Raimondo, all reported for the first time for the flora of Iran. The identification was based on the microscopic study of seeds. It is noted that *P. oleracea* is not confirmed for Iran. Distribution data and an identification key for *Portulaca* microspecies in Iran are presented.

Key words: Floristic investigation, Iran, micromorphology, purslane, Middle East

1. Introduction

Although the traditional delimitation of the family Portulacaceae Juss. includes about 15–30 genera and 500 species of therophytes and chamaephytes, recent molecular studies reduced this family to a single monophyletic group including only the genus *Portulaca* L. with about 100 species (Nyffeler and Egli, 2010).

Portulaca, English vernacular name purslane, is known as a weed throughout the world with moderate interest as a food plant, though it is of little economic importance. It is used for various purposes in different parts of the world. In the Mediterranean area, Central Europe, and some Asian countries it is used as food (Danin et al., 2016). It is reported to have diuretic, antipyretic, disinfecting, antispasmodic, and anthelmintic properties (Xiang et al., 2005). Moreover, it is considered a valuable pharmaceutical plant for the future due to its antioxidants and high nutritious value (Simopoulos et al., 2005).

The genus *Portulaca* is cosmopolitan; it mainly occurs in tropical and semitropical regions, and to a lesser extent in temperate Europe and Asia (Gilbert and Philips, 2000). It is found from sea level to high altitudes (Kim, 2012) and its species colonize habitats close to human settlements, preferring soils with higher nitrate contents (Domina and Raimondo, 2009).

The area of origin of *P. oleracea* L. is not known (Ocampo and Columbus, 2012). Ridely (1930) and Hagerup (1932)

considered it as a native of the North African deserts. Mitich (1997) cited West Asia and Europe as its area of origin. Recently, Ocampo and Columbus (2012) studied the molecular phylogenetics of *Portulaca*. They stated that *P. oleracea* represents a nonmonophyletic taxon, with *P. oleracea* subsp. *oleracea* of North American origin and a number of further subspecies and separate species of the *P. oleracea* complex most probably of African origin.

In previous basic floras and checklists of Europe and Asia, a low number of species was reported for *Portulaca* (Coode, 1966; Walters, 1993). In Pakistan (Ghafoor, 1973), representatives of this genus include *P. quadrifida* L., *P. oleracea* L., *P. tuberosa* Roxb., *P. grandiflora* Hook, and *P. pilosa* L. For Afghanistan (Podlech, 2012) and Iraq (Blakelock, 1957), *P. oleracea* and *P. grandiflora* have been reported.

In Iran, the oldest report of *Portulaca* dates back to Parsa (1950), who gave an account of *P. oleracea*, called “khorfe” in Persian, with populations from Lahijan, Tehran, and Sistan and Baluchestan. Mobayen (1985) reported *P. grandiflora* as a cultivated species. In *Flora Iranica* (Rechinger, 1976), *P. quadrifida*, *P. tuberosa*, *P. grandiflora*, *P. pilosa*, and *P. oleracea* were reported, with only the last one found on the territory of Iran itself. In addition, Rechinger (1976) stated that *P. oleracea* subsp. *sativa* (Haw.) Čelak. exists mostly in cultivated forms in Iran and is occasionally found as escaped from cultivation in the wild.

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The plants of this genus usually produce many small seeds of about 1 mm in diameter. The seed dispersal mechanism and the anatomical dynamics of seed dispersal have been investigated only recently (Kim, 2012; Danin et al., 2014, 2016).

Seed surface ornaments are used to distinguish the microspecies forming the *P. oleracea* aggregate (Danin and Reyes-Betancort, 2006; Domina et al., 2010; Danin and Raus, 2012; Kim, 2012).

Danin et al. (1978, 2008) used combined ploidy and seed surface characters for identifying the members of the *P. oleracea* aggregate, which includes mainly autogamous microspecies. Kim (2013) studied the pollen morphology in the broad-leaved and terete-leaved groups of the genus *Portulaca*. Although it has been verified that the morphological features of the seeds are a constant character in the progeny (Danin and Reyes-Betancort, 2006; Danin et al., 2008), recently Walter et al. (2015) asserted that no correlation seems to exist between karyology and seed micromorphology.

Danin and Raus (2012) distinguished and provided a determination key for the 19 microspecies within the *P. oleracea* aggregate.

Taking into account the importance of this group from the biogeographic point of view, and noting that only *P. oleracea* and *P. oleracea* subsp. *sativa* have been reported from Iran to date (Rechinger, 1976) and that in the Mediterranean area 15 microspecies are reported, 8 of them in adjacent Turkey (Uotila, 2011), the present study aimed at surveying the microspecies of the *P. oleracea* aggregate in Iran and revising the available samples using seed morphology as a key character.

2. Materials and methods

Twenty-eight specimens of the *Portulaca oleracea* aggregate available in the Herbarium of the Iranian Research Institute of Plant Protection (IRAN) and the Herbarium of the Research Institute of Forests and Rangelands (TARI) were studied. Seed morphological characters (dimension, shape, color, and ornamentation) of 10 seeds from each specimen were observed and measured using Olympus binoculars (SZH). The specimens were identified using the key provided by Danin and Raus (2012).

For the preparation of SEM images (Figures 1A–1F and 2A–2F), the seeds were covered with a layer of gold, mounted on metal stubs, and observed with a SU3500 scanning electron microscope. Selected images were edited in Adobe Photoshop CS5 version 12.0 × 32 for background subtraction and image level adjustments.

The terminology, definitions of seed ornaments, and classes of seeds diameter are according to Danin and Raus (2012).

Distribution maps (Figures 3 and 4) and a determination key are presented for the taxa identified.

3. Results

The study of the seed characters of 28 Iranian specimens of the *P. oleracea* aggregate revealed the presence of six microspecies altogether: *P. cypria* Danin, *P. granulostellulata* (Poelln.) Ricceri & Arrigoni, *P. nitida* (Danin & H.G.Baker) Ricceri & Arrigoni, *P. rausii* Danin, *P. socotrana* Domina & Raimondo, and *P. trituberculata* Danin, Domina & Raimondo. All microspecies were recorded for the first time from Iran and are fully commented on below, followed by a dichotomous identification key relating to the territory of Iran. Interestingly, *P. oleracea* L. and *P. sativa* Haw. were not observed and thus the presence of these taxa in Iran is not actually confirmed so far. Previous literature records of *P. oleracea* L. from Iran that are not substantiated by voucher material refer to the aggregate and hence cannot be used for detailed floristic mapping purposes.

3.1. *Portulaca cypria* Danin in Fl. Medit. 18: 92 (2008)

Seed subreniform, with glossy surface, black, diameter 0.9 mm to 0.94 mm. Individual cells isodiametric to elongated, star-shaped, with long rays. Anticlinal walls undulate, with T-, U-, and V-type patterns. Tuberculate, with 1–2 tubercles in the center (Figures 1A and 1B).

Mediterranean microspecies reported as casual alien in Switzerland and Belgium (Uotila, 2011). Three specimens in central and northern Iran were studied (Appendix).

3.2. *Portulaca granulostellulata* (Poelln.) Ricceri & Arrigoni in *Parlatorea* 4: 93 (2000)

Seed subreniform, with glossy surface, black, diameter 0.6 mm to 0.81 mm. Individual cells star-shaped and elongated. Anticlinal walls long, undulate, with U-type patterns. Periclinal walls convex, nearly flat to low-convex. Papillate, with papillae located at the end of the cell rays, papillae more inflated than the cells (Figures 1C and 1D). Microspecies reported from Europe, the Mediterranean basin, subtropical areas of America, and Asia (Matthews et al., 1993; Danin and Reyes-Betancort, 2006; Feráková et al., 2012). Nine specimens from the north and south coasts of Iran were studied (Appendix).

3.3. *Portulaca nitida* (Danin & H.G.Baker) Ricceri & Arrigoni in *Parlatorea* 4: 93 (2000)

Seed subreniform, with glossy surface, black, diameter 0.76 mm to 0.78 mm. Individual cells star-shaped or elongated, isodiametric, uninflated, with long rays. Anticlinal walls undulate, with U- and V-type patterns. Periclinal walls convex, nearly flat to slightly convex, without papillae and tubercle (Figures 1E and 1F).

Microspecies reported from Europe, the Mediterranean basin, and North America (Danin and Reyes-Betancort, 2006). One specimen from the north coast of Iran was studied (Appendix).

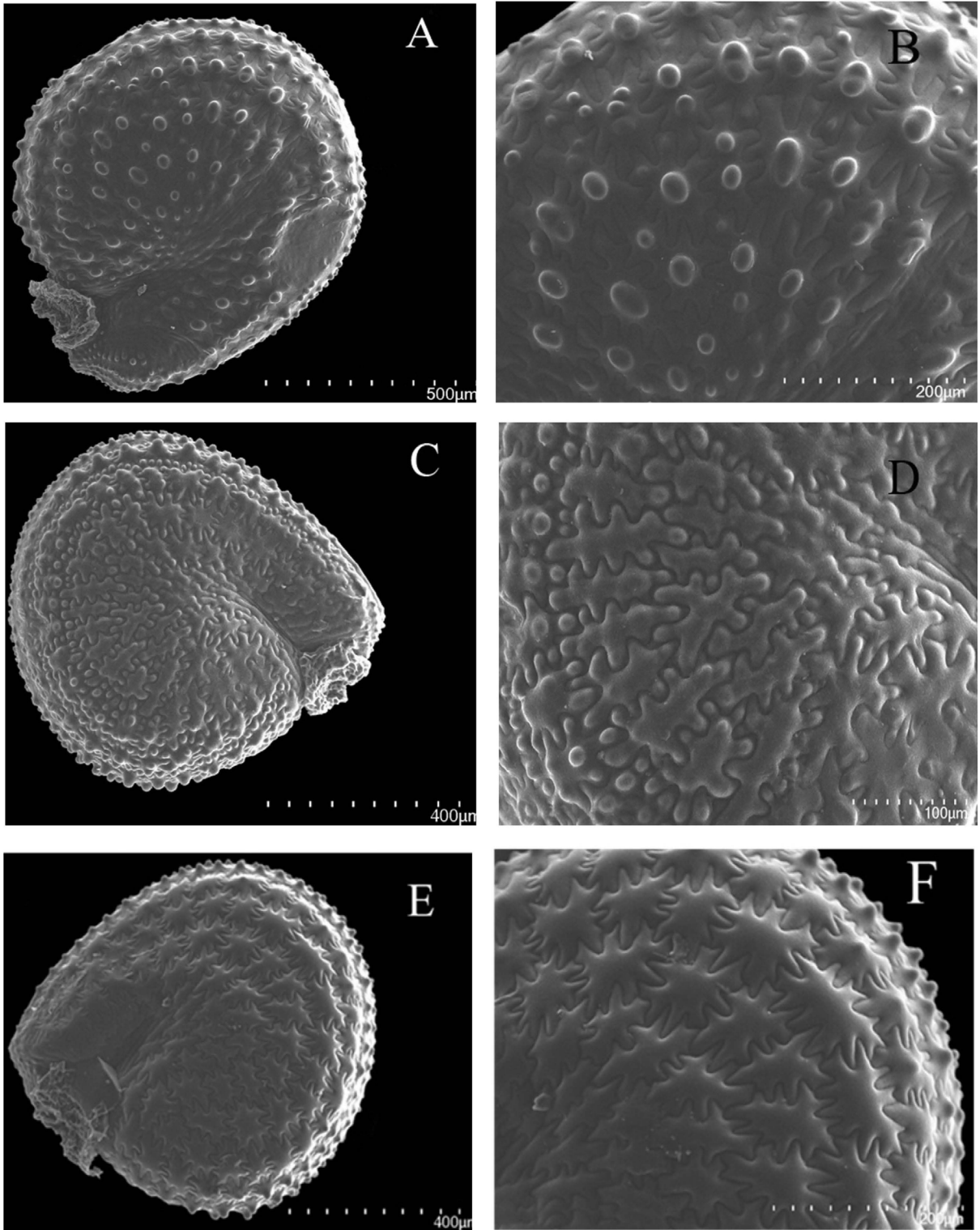


Figure 1. Seed micromorphology of *Portulaca cypria* (A and B), *P. granulatostellulata* (C and D), and *P. nitida* (E and F).

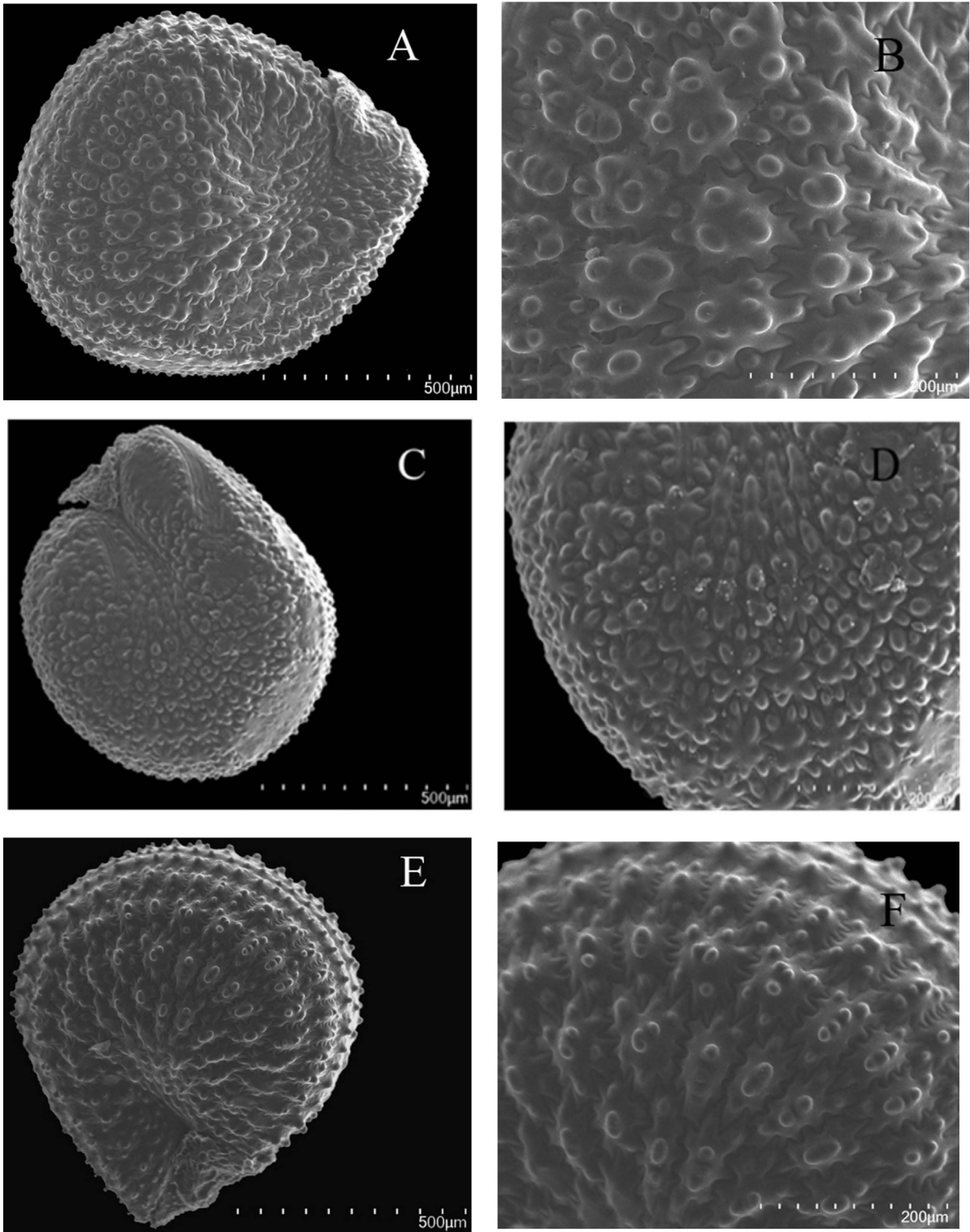


Figure 2. Seed micromorphology of *Portulaca rausii* (A and B), *P. socotrana* (C and D), and *P. trituberculata* (E and F).

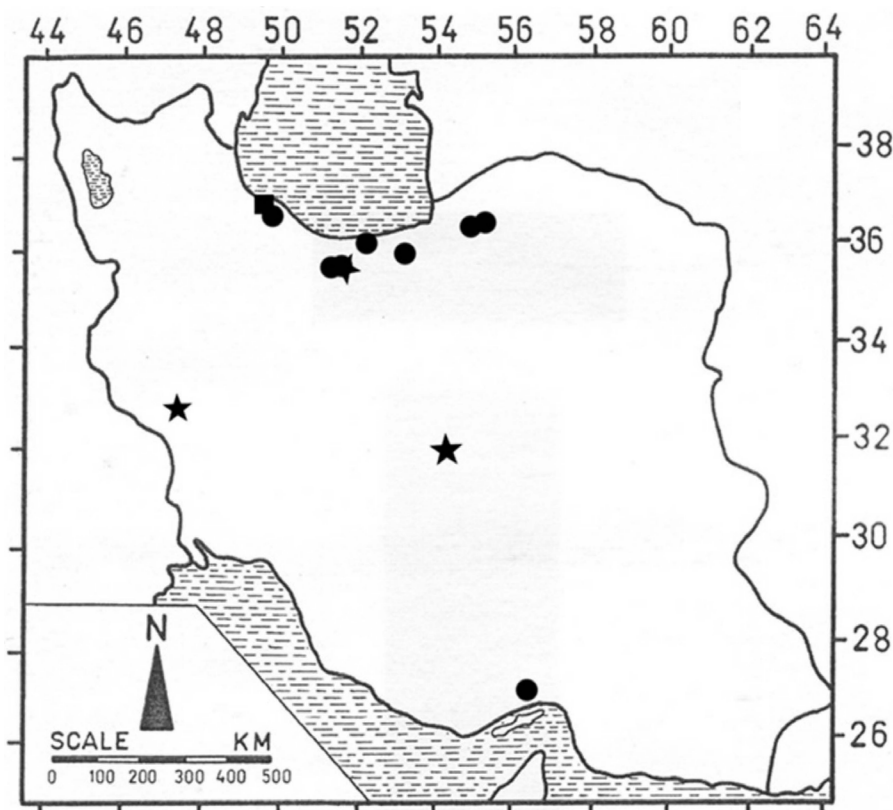


Figure 3. Distribution map of *Portulaca cypria* (star), *P. granulostellulata* (circle), and *P. nitida* (square).

3.4. *Portulaca rausii* Danin in Fl. Medit. 18: 92 (2008)

Seed subreniform, with glossy surface, black, diameter 0.875 mm to 0.94 mm. Individual cells elongated. Anticlinal walls undulate, with T-, U-, and V-type patterns. Periclinal walls convex, domed. Papillate, with 4–9 scattered papillae (Figures 2A and 2B).

Microspecies native to the southern Mediterranean basin (Uotila, 2011), reported as casual alien in warmer areas of Europe (Feráková et al., 2012). Eight specimens from northern and southern Iran were studied (Appendix).

3.5. *Portulaca socotrana* Domina & Raimondo in Webbia 64(1): 10 (2009)

Seed subreniform, with glossy surface, black, diameter 0.76 mm to 0.78 mm. Individual cells star-shaped, elongated. Anticlinal walls undulate, with U- and V-type patterns. Periclinal walls convex. Papillate, with papillae located at the end of the cell rays, papillae more inflated than the cells (Figures 2B and 2C).

Microspecies previously known only from the Island of Socotra, Yemen (Domina and Raimondo, 2009). One specimen from northern Iran was studied (Appendix).

3.6. *Portulaca trituberculata* Danin, Domina & Raimondo in Fl. Medit. 18: 91 (2008)

Seed subreniform, with glossy surface, black, diameter 0.875 mm to 0.94 mm. Individual cells elongated. Anticlinal walls undulate, with T-, U-, and V-type patterns, rarely bifurcating. Periclinal walls par-convex, par-domed. Tuberculate, with 3–6 tubercles, often located in the center of the cells (Figures 2D and 2E).

Microspecies reported from Europe, the Mediterranean basin, Asia, and America (Feráková et al., 2012). Six specimens from western and eastern Iran were studied (Appendix).

3.7. Identification key for the microspecies of the *Portulaca oleracea* aggregate found in Iran

1. Major seed diameter > 0.85 mm 2
- Major seed diameter < 0.85 mm 4
2. The reliefs are papillae-like and distributed at the cell center and on the rays *P. rausii*
- Testa cells with 1–3 tubercles at the center 3
3. Testa cells isodiametric, star-shaped, with one or two tubercles at the center *P. cypria*

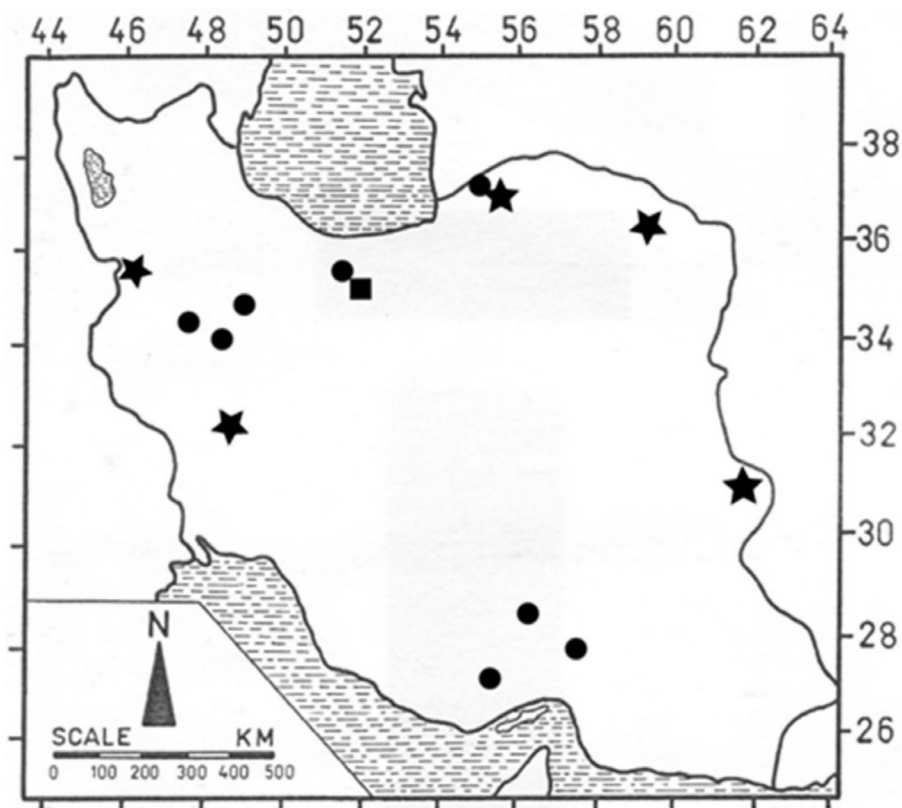


Figure 4. Distribution map of *Portulaca rausii* (circle), *P. socotrana* (square), and *P. trituberculata* (star).

- Testa cells elongated, with (2–)3 tubercles close to each other at the center *P. trituberculata*
- 4. Testa cells isodiametric, star-shaped, without relief (tubercle and papillae) *P. nitida*
- Testa cells elongated, with tubercle or papillae 5
- 5. Rays elongated (1.5–2 times as long as wide); papillae situated on the tips of the rays *P. granulostellulata*
- Rays about as long as wide; papillae situated at the base of the rays *P. socotrana*

4. Discussion

The present survey shows the taxonomic diversity within the *P. oleracea* aggregate, which had not previously been reported from Iran. The microspecies identified from a greater number of samples from different localities were *P. granulostellulata*, *P. rausii*, *P. cypria*, and *P. trituberculata*. *P. nitida* and *P. socotrana* were found only at one locality (Figure 3). These results give new information on the general distribution of these taxa. In particular, *P. socotrana*, previously considered endemic to the island of Socotra in the Indian Ocean (Domina and

Raimondo, 2009), is presented more than 2500 km from its locus classicus. *P. cypria* and *P. rausii* were known from the Mediterranean basin and Europe (Uotila, 2011; Feráková et al., 2012); thus, their distribution range is expanded eastwards. *P. granulostellulata*, *P. nitida*, and *P. trituberculata* are known from Europe, the Mediterranean basin, Asia, and America (Feráková et al., 2012). We added further localities inside their distribution area. These results indicate that, although the taxonomy and the distribution of this group are fairly well known in Europe and the Mediterranean basin, outside of this area the information is still too scattered and further investigations are needed to achieve a clearer picture. Further herbarium and extensive field surveys will help in clarifying the consistency and distribution of the microspecies of the *P. oleracea* aggregate in the country, as well as the abundance of single microspecies in different regions.

Acknowledgment

We thank the anonymous reviewers for having enhanced the quality and clarity of the submitted text.

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Appendix. Specimens examined.*Portulaca cypria* Danin

Khuzestan province: 20 km from Andimeshk to Ahvaz, margin of ditch, 150 m, 14.11.1985, *Mozaffarian* (58452-TARI). Yazd province: Yazd, 01.06.1995, collector unknown (70387-IRAN). Tehran province: Tehran, 15.06.1965, *Behboudi* (33913-IRAN).

Portulaca granulatostellulata (Poelln.) Ricceri & Arrigoni

Golestan: Gorgan, Araghi Mahalleh Research Station, 12.07.2000, *Termeh & Karavar* (70383-IRAN); Gorgan, Fazel Abad, 100 m, 06.07.1997, *Aghabeigi, Termeh & Karavar* (70382-IRAN). Mazandaran province: Sari, Bayea Kola Research Station, 11.10.1999, *Termeh, Aghabeigi & Tehrani* (70384-IRAN); ca. 2 km Sisangan to Nour, sea shore, -9 m, 06.09.2015, *Amini Rad & Bahramishad* (70068-IRAN). Gilan province: Roudsar, Shalman, 28.10.1967, *Mir-Kamali* (33914-IRAN). Hormozgan province: Bandar Abbas, Isin, ca. 50 m, 24.04.1985, *Mozaffarian* (49636-TARI). Tehran province: 22 km from Tehran to Karaj, 1320 m, 02.10.1981, *Banihashemi* (36303-TARI); Tehran, Chitgar, 1320 m, 26.09.1972, *Riazi* (7881-TARI); Tehran, Niyavaran Park, 06.08.1989, collector unknown (33912-IRAN).

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

Gilan province: Lahijan, 15.09.1963, *Mazaheri* (70386-IRAN).

Portulaca rausii Danin

Golestan province: Gonbad, Incheh Broun, Army sample fields, 12.07.2000, *Termeh & Karavar* (70385-

IRAN). Hamadan province: Hamadan to Tuyserkan (via Alvand), 3 km Tuyserkan, 1730 m, 03.08.1992, *Termeh, Moussavi & Tehrani* (58056-IRAN). Lorestan province: 25 km NE Alashtar, Darreh Tang, 1700–2000 m, 16.06.2001, *Sonboli, Shirzadian & Eskandari* (58058-IRAN). Kermanshah province: 15 km N of Bisetun, Bornage village, 1300 m, 19.08.1987, *Hamzehee & Mirabdali* (1638-TARI). Hormozgan province: Bandar Abbas, ca. 25 km from Kahrestan to Bastak, 200 m, 25.04.1985, *Mozaffarian* (49688-TARI). Kerman province: 22 km S of Kahnuj, Jiroft, 450 m, 22.04.1972, *Babakhanlou* (23054-TARI). Hormozgan province: Bandar Abbas, Hajiabad, in the field margin of field, 950 m, 30.04.1985, *Mozaffarian* (52112-TARI). Tehran province: Tehran, Velenjak, Iranian Research Institute of Plant Protection garden, 01.08.2010, *Amini Rad* (53982-IRAN).

Portulaca socotrana Domina & Raimondo

Tehran province: 18 km SE Varamin, Khaveh, 08.08.1989, *Moussavi* (70388-IRAN).

Portulaca trituberculata Danin, Domina & Raimondo

Golestan province: Gorgan, Kalaleh, 15.07.1967, *Hashemi* (33911-IRAN). Kordestan province: Marivan, Gardaneh-Taghah, 1800–1900 m, 03.08.1987, *Fattahi* (1556-TARI). Khuzestan province: Dezful, Seh Konaroun, 01.07.1967, *Jazayeri* (70389-IRAN). Sistan & Baluchestan province: Zabol to Jazynak, 500 m, 13.08.1985, *Valizadeh & Maassoumi* (20-TARI); Sistan, 01.07.1965, *Ayazi* (58467-IRAN; 5614; E00388950). Khorasan province: Mashhad, Abkuh, 11.07.1970, *Aghel* (58057-IRAN).