

Research Article

***Opuntia macrorhiza* Engelm.: a new record of an invasive alien species in the flora of Turkey**Bilge Tunçkol^{1,*}, Hasan Yaşayacak² and Lucas C. Majure³¹Bartın University Ulus Vocational School Department of Forestry, 74100 Bartın, Turkey²Küre Mountains National Park Directorate, Bartın, 74100 Bartın, Turkey³University of Florida Herbarium (FLAS), Florida Museum of Natural History, Gainesville, Florida, United States

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Citation: Tunçkol B, Yaşayacak H, Majure LC (2022) *Opuntia macrorhiza* Engelm.: a new record of an invasive alien species in the flora of Turkey. *BioInvasions Records* 11(2): 245–350, <https://doi.org/10.3391/bir.2022.11.2.06>

Received: 11 July 2021**Accepted:** 25 January 2022**Published:** 11 April 2022**Handling editor:** Margarita Arianoutsou**Thematic editor:** Giuseppe Brundu**Copyright:** © Tunçkol et al.

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Abstract

Opuntia macrorhiza (Cactaceae) was first found in Turkey in 2020 during floristic surveys in the Boyabat district of the Sinop province and in the Cide district of the Kastamonu province. We provide an identification key to distinguish it from *Opuntia ficus-indica*, a morphological description, as well as some basic information on invaded habitat and potential threats. Considering the traits of this new alien plant, allowing for rapid reproduction, and spread, it is expected it might invade further land without adequate interventions.

Key words: biological invasions, cacti, Eudicots, western prickly pear**Introduction**

Cactaceae comprise ca. 150 genera and 1500–1800 species native to North, Central and South America, including the Caribbean region (Majure et al. 2012a). Many of them grow slowly, flower infrequently, and have a long-life span (Godínez-Álvarez et al. 2003; Novoa et al. 2015).

The genus *Opuntia* Mill. s.s. (Cactaceae) is composed entirely of perennial species, many of which can be spread easily through vegetative propagation (see Majure et al. 2017). There are between 150–200 species recognized species within *Opuntia* genus, which occur broadly in North America, Central America, South America, and many species have been introduced in other parts of the world for human consumption or ornamental purposes (e.g., Mahr 2001; Casas and Barbera 2002; Majure 2007; Erre et al. 2009) and are also known as some of the most highly invasive species in arid areas of their nonnative range (e.g., Chahdoura et al. 2015; Novoa et al. 2015).

The subclade *Humifusa* (sensu Majure et al. 2012a), which is native to North America and most abundant in eastern North America consists of around 10 recognized taxa, and several interclade hybrid species, such as *O. cymochila* Engelm. ex J.M. Bigelow, *O. ochrocentra* Small, and *O. tortispina* Engelm. & J.M. Bigelow (Majure et al. 2017).

The *Humifusa* subclade is distributed widely from the western U.S. and northern Mexico (represented by *O. macrorhiza* Engelm. s.l. and *O. pottsii* Salm-Dyck) and throughout the eastern U.S., including the upper Midwest (e.g., Michigan, Minnesota, Wisconsin) and southern Ontario (Benson 1982; Pinkava 2003), represented by *O. abjecta* Small, *O. austrina* Small, *O. cespitosa* Raf., *O. drummondii* Graham, *O. humifusa* (Raf.) Raf., *O. nemoralis* Griffiths, *O. macrorhiza* Engelm.s.l., *O. mesacantha* Raf. subsp. *lata* (Small) Majure, and *O. mesacantha* subsp. *mesacantha* (Majure et al. 2017).

Opuntia macrorhiza s.l. is often described as a species complex, and it is currently under investigation by Majure (*unpubl. data*). Taxa within the *O. macrorhiza* complex are both diploids and tetraploids (Majure et al. 2012b), with plants either spineless or more commonly with 1–3 spines per areole; the spineless entities within *O. macrorhiza* s.l. have sometimes been referred to as *O. grandiflora* Engelm. (Engelmann 1857).

In Turkey, only one species belonging to *Opuntia*, *O. ficus-indica* (L.) Mill., has been recorded (Matthews 1972; as *O. ficus-barbarica* A. Berger) until our recent discovery of a new taxon for the country. Through this current study, a second *Opuntia* species, *O. macrorhiza* s.l., was recorded as a new alien taxon for Turkey.

Materials and methods

Plant samples belonging to the genus *Opuntia* were collected during floristic surveys (May and August 2020) in the Boyabat district of the Sinop province and in the Cide district of the Kastamonu province in Turkey. It was not possible to identify the species neither in the field nor according to the Flora of Turkey and its supplements and to “A Checklist of the Flora of Turkey” (Matthews 1972; Güner et al. 2012; Uludağ et al. 2017). Only after additional investigations, and based on field experience by Majure, the samples were identified as *Opuntia macrorhiza* s.l. (Mahr 2001; Rebman and Pinkava 2001; Casas and Barbera 2002; Reyes-Agüero et al. 2006; Majure and Ervin 2008; Majure et al. 2017). The identified specimens were deposited at the Herbarium of Duzce University, Faculty of Forestry (DUOF) and at the Bartın University Ulus Vocational School Plant Samples Laboratory.

The morphological description of the species presented in this paper is based on field observations and herbarium samples from Turkey. A distribution map of the studied taxon was created according to the grid system adopted by Flora of Turkey.

Results and discussion

Opuntia macrorhiza Engelm.

Boston J. Nat. Hist. 6: 206 (1850).

The two alien *Opuntia* species recorded so far in Turkey can be distinguished according to the following identification key:

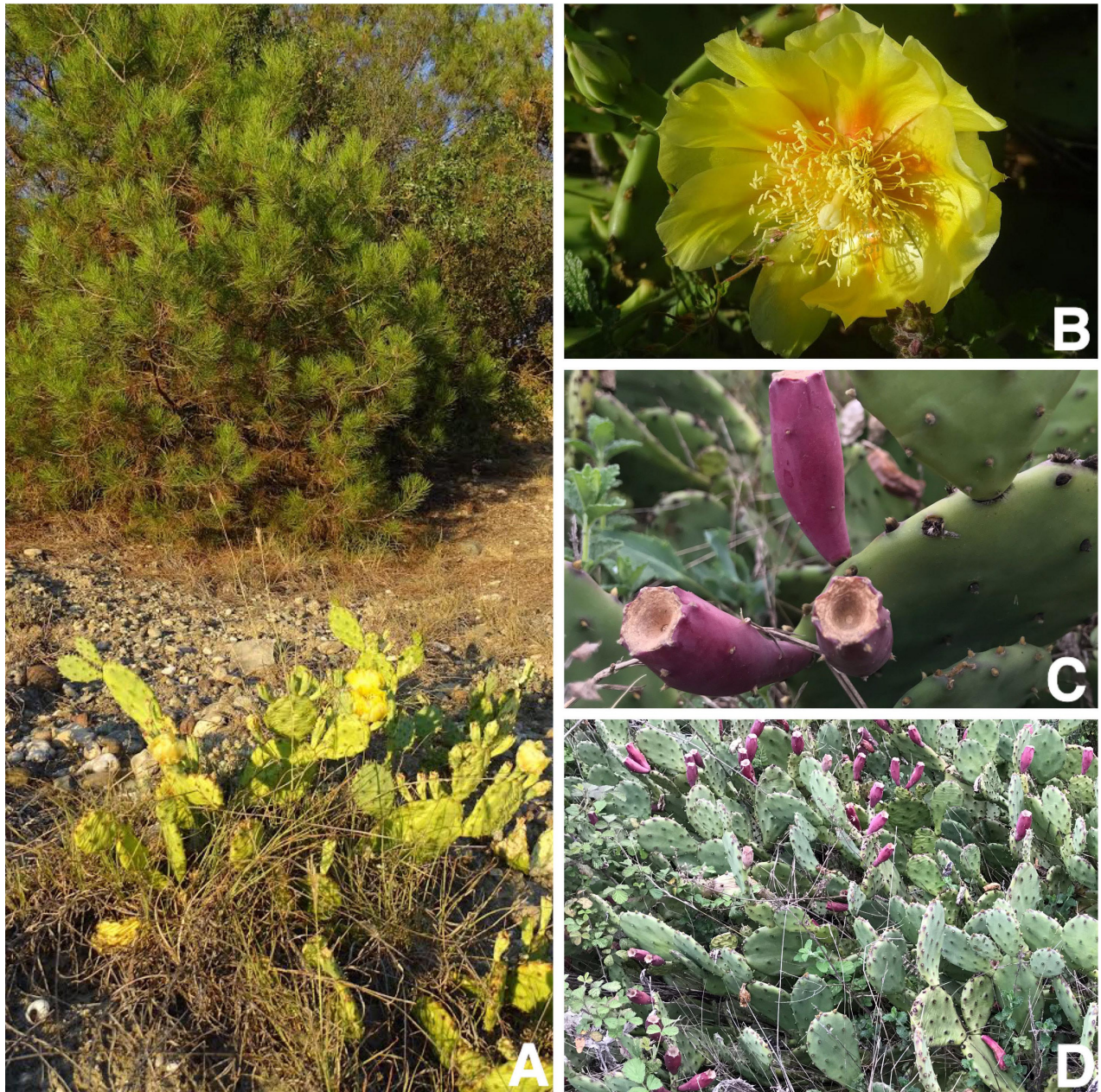


Figure 1. *Opuntia macrorhiza* Engelm. in Turkey. A. Plant in the invaded habitat. B. Flower. C. Fruit. D. Cladodes with fruit. Photographs by B. Tunçkol.

1. Plant height more than 1 m, usually tree like, often with trunk, glochids inconspicuous..... *O. ficus-indica*
- . Plant height less than 1 m, shrub like, procumbent or ascending, glochids conspicuous..... *O. macrorhiza*

Taxon description

Opuntia macrorhiza (Figure 1) is a low, sprawling shrub up to 25–30 cm tall. Plants often have tuber like swollen rootstocks to 2.2 cm thick. Stem segments not easily detached, dark dull green, often cross wrinkled when stressed, flattened, obovate to circular, 4–10 × 3–6 cm, fleshy, tuberculate, glaucous; areoles 5–6(–8) per diagonal row across midstem segment, ovate

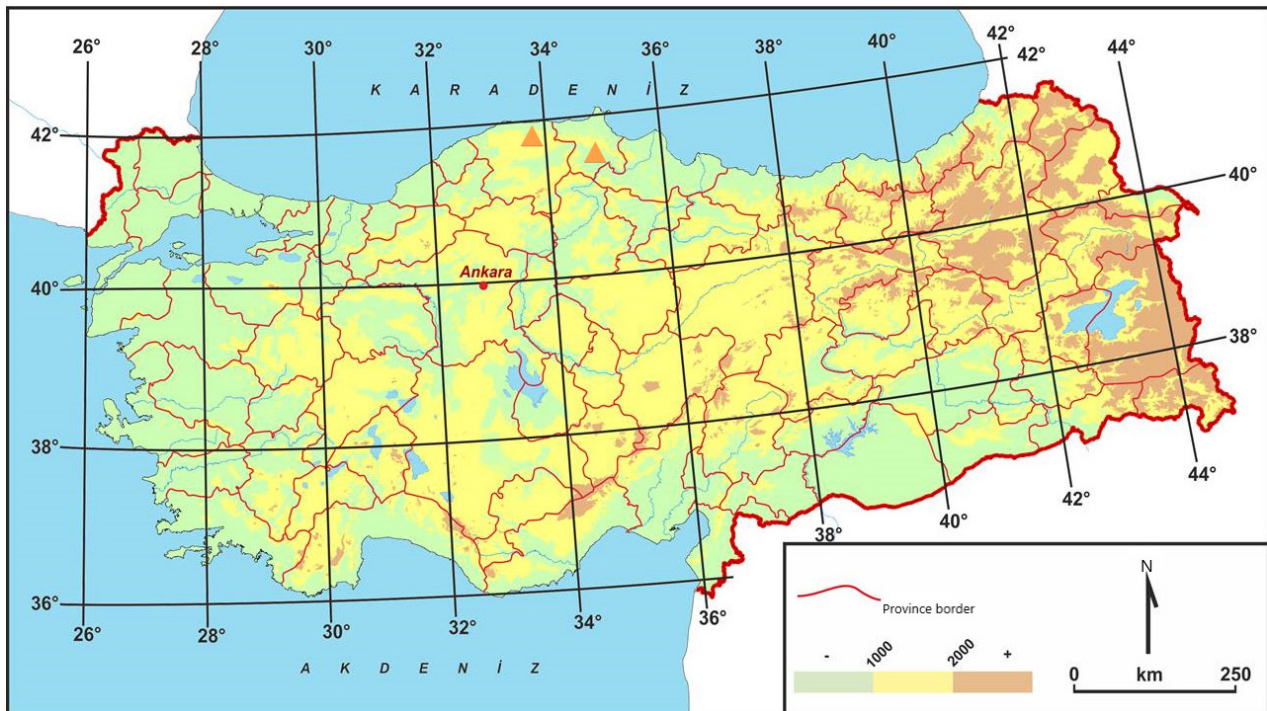


Figure 2. Distribution map of *Opuntia macrorhiza* occurrences in Turkey.

to subcircular, 2–4 mm diam.; wool tan. Cladodes are wrinkled after the first winter, 4–9 cm long and 7–10 cm wide, ellipsoid. Cladodes are spineless (in populations found so far in Turkey). Glochids are usually obvious and may be profuse. Flowers are yellow with orange or red in centers. Stigmas are cream-colored as is the style. Flowers size 5 cm long and 9 cm in diameter. Filaments are cream-colored distally and greenish basally. Anthers are yellow. The pericarpel is slender and about 2.7 cm long. Fruits are red berries with a sour taste, obovoid, 5 cm long and 1.5 cm in diameter with few and small areoles. Very few areoles on fruit. Seeds are irregularly shaped, 3 mm diameter, 1.5 mm thick, notched at the hilum, and with a narrow margin to 0.4 mm. Spineless material of *O. macrorhiza* s.l. can be confused with *O. humifusa* s.s. However, *O. humifusa* has entirely yellow inner tepals, whereas *O. macrorhiza* has yellow inner tepals that are basally tinged red or reddish-brown (see Majure et al. 2017 for further details).

Invaded habitat and distribution in Turkey

Turkey (Western Black Sea Region; Figure 2): A5-Sinop, Boyabat district (41.481944°N; 34.757222°E), at an elevation of 250 (–350) m, at grassy woodlands and *Pinus brutia* clearing, 29.05.2020, B. Tunçkol 5999, DUOF and A4-Kastamonu, Cide district (41.909167°N; 32.985278°E), at an elevation of 0–15m, in sandy to loamy soils, sand dunes, 20.06.2020, B. Tunçkol 6345. Flowering time late spring (May–June).

Besides *O. macrorhiza*, the following taxa were recorded in the invaded habitat: *Cakile maritima* Scop., *Centaurea kilaea* Boiss., *Cionura erecta* (L.) Griseb., *Crambe maritima* L., *Crithmum maritimum* L., *Digitalis lamarckii*

Ivanina, *Eryngium maritimum* L., *Glaucium flavum* Crantz, *Pancreatium maritimum* L., and *Pinus brutia* Ten.

Conclusions

The total number of records of invasive alien plants is continuously increasing in Turkey and well documented by several recent studies (Coşkunçelebi et al. 2007; Eminağaoğlu et al. 2012; Tunçkol et al. 2017; Yıldırım et al. 2019a; Yıldırım et al. 2019b; Yüzbaşıoğlu 2014).

Opuntia macrorhiza was first observed over an area of ca. 1 ha, and after 3 years, it has been recorded in two different sites, over an area of ca. 2 ha (Figure 2). There are important stopover sites for migratory birds in the invaded area. Therefore, although the introduction pathway is unknown, an accidental introduction and possible spread due to birds may be expected. In the invaded sites, on sandy soils and grassy woodlands, *O. macrorhiza* represents a threat to important endemic and rare species such as *Centaurea kilaea*, *Digitalis lamarckii*, and *Pancreatium maritimum*. Therefore, *O. macrorhiza* can be considered as a potential threat for natural biodiversity in the Kastamonu and Sinop provinces in Turkey. Considering the traits of this alien plant, allowing for fast reproduction and vegetative spread, it is expected it might invade further land in the lack of adequate interventions.

Acknowledgements

We gratefully acknowledge the two anonymous reviewers and the thematic editor Dr. Giuseppe Brundu for excellent editorial suggestions.

References

- Benson L (1982) The Cacti of the United States and Canada. Stanford University Press, Stanford, 1044 pp
- Casas A, Barbera G (2002) Mesoamerican domestication and diffusion. In: Nobel P (ed), Cacti: Biology and Uses. Berkeley & Los Angeles: University of California Press, pp 143–162, <https://doi.org/10.1525/california/9780520231573.003.0009>
- Chahdoura H, Barreira JC, Barros L, Santos-Buelga C, Ferreira I C, Achour L (2015) Seeds of *Opuntia* spp. as a novel high potential by-product: Phytochemical characterization and antioxidant activity. *Industrial Crops and Products* 65: 383–389, <https://doi.org/10.1016/j.indcrop.2014.11.011>
- Coşkunçelebi K, Terzioğlu S, Vladimirov V (2007) A New Alien Species for the Flora of Turkey: *Bidens frondosa* L. (Asteraceae). *Turkish Journal of Botany* 31: 477–479
- Eminağaoğlu Ö, Özcan M, Kültür Ş (2012) Contributions to the leaf and stem anatomy of *Tradescantia fluminensis*: an alien species new to the flora of Turkey. *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi* 13(2): 270–277
- Engelmann G (1856) [1857] Synopsis of the Cactaceae of the territory of the United States and adjacent regions. *Proceedings of the American Academy* 3: 259–346, <https://doi.org/10.5962/bhl.title.46890>
- Erre P, Chessa I, Nieddu G, Jones PG (2009) Diversity and spatial distribution of *Opuntia* spp. in the Mediterranean Basin. *Journal of Arid Environments* 73: 1058–1066, <https://doi.org/10.1016/j.jaridenv.2009.05.010>
- Güner A, Aslan S, Ekim T, Vural M, Babaç MT (eds) (2012) Türkiye Bitkileri Listesi (Damarlı Bitkiler) [List of Turkey Plants]. Nezahat Gökyiğit Botanic Garden and Flora Research Society Publishing, Istanbul, 1290 pp
- Godínez-Álvarez H, Valverde T, Ortega-Baes P (2003) Demographic trends in the Cactaceae. *The Botanical Review* 69: 173–203, [https://doi.org/10.1663/0006-8101\(2003\)069\[0173:DTITC\]2.0.CO;2](https://doi.org/10.1663/0006-8101(2003)069[0173:DTITC]2.0.CO;2)

- Mahr DL (2001) *Cactoblastis cactorum* (Lepidoptera: Pyralidae) in North America: A workshop of assessment and planning. *Florida Entomologist* 84: 465–473, <https://doi.org/10.2307/3496373>
- Majure LC (2007) The ecology and morphological variation of *Opuntia* (Cactaceae) species in the Mid-South, United States. Thesis, Mississippi, 101 pp
- Majure LC, Ervin GN (2008) The opuntias of Mississippi. *Haseltonia* 14: 111–126, <https://doi.org/10.2985/1070-0048-14.1.111>
- Majure LC, Puente R, Griffith MP, Judd WS, Soltis PS, Soltis DE (2012a) Phylogeny of *Opuntia* s.s. (Cactaceae): clade delineation, geographic origins, and reticulate evolution. *American Journal of Botany* 99: 847–864, <https://doi.org/10.3732/ajb.1100375>
- Majure LC, Judd WS, Soltis PS, Soltis DE (2012b) Cytogeography of the *Humifusa* clade of *Opuntia* s.s. Mill. 1754 (Cactaceae: Opuntioideae): Correlations with geographic distributions and morphological differentiation of a polyploid complex. *Comparative Cytogenetics* 6: 53–77, <https://doi.org/10.3897/compcytogen.v6i1.2523>
- Majure LC, Judd WS, Soltis PS, Soltis DE (2017) A taxonomic revision of the *Opuntia humifusa* complex (*Opuntia* s.s.: Cactaceae). *Phytotaxa* 290: 1–65, <https://doi.org/10.11646/phytotaxa.290.1.1>
- Matthews VA (1972) Cactaceae. In: Davis PH (ed), Flora of Turkey and East Aegean Islands vol. 4, Edinburgh University Press, Edinburgh, 209 pp
- Novoa A, Kaplan H, Kumschick S, Wilson JR, Richardson DM (2015) Soft touch or heavy hand? Legislative approaches for preventing invasions: Insights from Cactaceae in South Africa. *Invasive Plant Science and Management* 8: 307–316, <https://doi.org/10.1614/IPSM-D-14-00073.1>
- Rebman JP, Pinkava DJ (2001) *Opuntia* cacti of North America: An overview. *Florida Entomologist* 84: 474–483, <https://doi.org/10.2307/3496374>
- Pinkava DJ (2003) *Opuntia*. In: Flora of North America Editorial Committee (eds) 1993+ Flora of North America North of Mexico. 12+ vols., New York and Oxford, pp 123–148
- Reyes-Agüero JA, Aguirre JR, Valiente-Banuet A (2006) Reproductive biology of *Opuntia*: a review. *Journal of Arid Environments* 64: 549–585, <https://doi.org/10.1016/j.jaridenv.2005.06.018>
- Tunçkol B, Aksoy N, Yaşayacak H (2017) A new record for alien flora of Turkey: *Symphotrichum pilosum* (Willd.) G.L. Nesom var. *pilosum*. *Modern Phytomorphology* 11: 105–109, <https://doi.org/10.5281/zenodo.1041920>
- Uludağ A, Aksoy N, Yazlık A, Arslan ZF, Yazmış E, Üremiş I, Cossu TA, Groom Q, Pergl J, Pyšek P, Brundu G (2017) Alien flora of Turkey: checklist, taxonomic composition and ecological attributes. *NeoBiota* 35: 61–85, <https://doi.org/10.3897/neobiota.35.12460>
- Yıldırım H, Özdöl T, Yaşayacak H (2019a) A new invasive plant species record for Turkey: *Malvastrum coromandelianum* (L.) Gracke (Malvaceae). *Bağbahçe Bilim Dergisi* 6: 40–44, <https://doi.org/10.35163/bagbahce.559580>
- Yıldırım H, Özdöl T, Yaşayacak H (2019b) An alien species of *Bidens* (Asteraceae): *Bidens pilosa* L., new to the Turkish flora. *Acta Biologica Turcica* 32(1): 61–64
- Yüzbaşıoğlu İS (2014) *Oenothera parodiana* (Onagraceae): a new alien species record for the flora of Turkey. *Biological Diversity and Conservation* 7(2): 122–126