

## Characteristics of the *Opuntia humifusa* (Cactaceae) locality in the Harmanli district, South Bulgaria

Alexander Tashev

Department of Dendrology, Faculty of Forestry, University of Forestry,  
10 Kliment Ohridski Blvd., Sofia 1756, Bulgaria, e-mail: atashev@mail.bg

Received: March 01, 2012 ▷ Accepted: March 29, 2012

**Abstract.** A botanical description of a habitat of *Opuntia humifusa* in the district of Harmanli is provided for first time in Bulgaria. The floristic diversity and phytocenological structure of the plant community, where the surveyed species exist, are discussed and a characteristic of its locality is also suggested. Eighty-nine species have been identified in the locality. Seven of these are endemic and four are entered in the *Red Data Book of PR Bulgaria* (1984), two of these four species are covered by the Biological Diversity Act (*Alkanna primuliflora* and *Crepis stojanovii*). Two species have never been reported so far for the floristic region of the Thracian Lowland (*Cionura erecta* and *Vitis bulgarica*).

**Key words:** alien species, floristic and phytocenological description, *Opuntia humifusa*, Thracian Lowland

### Introduction

Many representatives of genus *Opuntia* Mill. (Cactaceae), which comprises over 200 species and originates from North and South America, have been and still are transported across the world to countries with a warm and mild climate. They are used for decorative purposes and to combat erosion. Some species of the genus, resistant to low temperatures, are cultivated in the open in parks and gardens, mainly for decorative purposes. Almost everywhere under favourable conditions these cacti spread by means of vegetative and seed reproduction (Jordanov 1970). Thus they become part of the alien flora in the respective territory.

Five representatives of genus *Opuntia* have been introduced for decorative purposes in Bulgaria: *O. tortispina* Engelm., *O. ficus-indica* (L.) Mill., *O. vulgaris* Mill., *O. procumbens* Engelm., and *O. compressa* (Salisb.) J.F. Macbr. These species occur along the Black Sea Coast (Zmiyski Island – *O. tortispina*, *O. compressa*), in the Balchik Botanical Garden (*O. fi-*

*cus-indica*, *O. vulgaris*, *O. procumbens*), others could be seen in the parks in Krichim and Evksinograd (Jordanov 1970). According to Delipavlov (2003), *O. compressa* has grown wild and could be seen in some localities in the districts of Chirpan, Plovdiv, Harmanli, and Yambol, in dry and stony places and among rocks. Assyov & Petrova (2006) mentioned as naturalized for the flora of Bulgaria the adventive species of *O. tortispina* (South Black Sea Coast) and *O. vulgaris* (Black Sea Coast, Tundzha Hilly Country, Thracian Lowland, and Valley of River Struma (*Southern*)). The present author has not found any studies of the locality of representatives of genus *Opuntia* in the Bulgarian botanical literature.

There are differences in respect to taxonomic treatment of the studied species. According to some North American sources, *Opuntia humifusa* (Raf.) Raf. is the priority name of the species, and *Opuntia compressa* (Salisb.) J.F. Macbr. is a synonym (e.g. Pinkava 2003). Moore (1968) mentioned *O. vulgaris* Mill. as a priority name and *Opuntia humifusa* (Raf.) Raf. as a syno-

nym, while *O. compressa* was not mentioned at all. A study on the taxonomic history and nomenclature of the species gives priority to the name *Opuntia humifusa* (Leuenberger 1993). This name was accepted by the authors of the present study. The species is conservationally important and is covered by the CITES Appendix II (Hunt 1992).

*Opuntia humifusa* propagates naturally in the northeastern part of the Great Plains of North America and winters successfully in South Ontario (Canada). It has been naturalized across North America, South and Central Europe (Austria, Bulgaria, Croatia, Corsica, Greece, Italy and Serbia), Argentina, China, Ethiopia, Haiti, Mauritius, and South Africa (Errea & al. 2009). It is considered a dangerous invasive species in Australia and Tasmania (Kunte & Subik 2004). Its usual localities are rocky or sandy dry plains or valleys, or stretch along streams or dunes.

Under natural conditions the species reproduces mainly by seeds, although vegetative reproduction dominates in some cases. In the temperate climate zone, the individuals of *O. humifusa* flower from May to July. The fruits ripen two to three months after the flowering and may remain attached to the stem until the next spring. The individuals of this species are referred to obligate heliophytes and owing to this in shade are ousted by other species (Benson 1982) <http://www.fs.fed.us/database/feis/plants/cactus/opuhum/references.html> – 9. In the warmer regions (under the climatic conditions of Florida) the individuals may flower round the year (Wunderlin 1998) <http://www.fs.fed.us/database/feis/plants/cactus/opuhum/references.html> – 87.

Under extreme conditions, the individuals of *O. humifusa* survive by offshoots at the base of the stem and by root-striking of parts of the stem at contact with soil. After fires the cacti may colonize the terrains by external seed sources (in animal excrements) or internal sources – seeds that has survived the fire (<http://www.fs.fed.us/database/feis/plants/cactus/opuhum/references.html> – 10; Bunting & al. 1980; Thomas 1991).

The purpose of the present study is to give a floristic and phytocenological characteristic of one of the largest in area localities of *Opuntia humifusa* in Bulgaria, in the vicinities of Harmanli town. Our earlier study has shown the excellent capacities of the species for vegetative and seed reproduction under glasshouse and natural conditions (Tashev & Kabatliyska 2008).

## Material and methods

The study was carried out in the period 2002–2010. An inventory of the flora in the locality was made and phytocenotic structure of the investigated plant community was determined. The biological range of the species was analysed, as well as their phytogeographical affiliation, according to Walter's classification adapted for the Bulgarian flora (Assyov & Petrova 2006). The inventory was made during different vegetation periods of the species. GPS coordinates and altitude of the points outlining the boundaries of the locality were taken. A list of species in the locality was drawn during the visits there and herbarium samples were taken for determination. Taxonomy of the native species follows Delipavlov & Cheshmedzhiev (2003).

## Results and discussion

The investigated locality of *O. humifusa* is situated in the vicinities of Harmanli town, close to the right-hand bank of river Harmanliyska. The territory around the river is declared a protected site – 'Ustieto na Reka Harmanliyska' [= Mouth of River Harmanliyska]. In close proximity to it there is a hotel complex with a Prikazkite Restaurant and during the flowering season of the cacti at the end of May and the beginning of June they become an attraction for visitors.

The locality is triangular in outline and covers an area of about 6 ha. It lies on a steep southern slope. Its highest point is at 175 m a.s.l., with coordinates 41°55'08.8"N and 25°53'28.0"E. The lower eastern part of the locality borders on a gully and lies at 122 m a.s.l., with coordinates 41°55'01.4"N and 25°53'16.9"E. The lower western part of the locality borders on the same gully and lies only several metres off the parking site of the hotel complex. It is at 94 m a.s.l., with coordinates 41°55'01.0"N and 25°53'08.5"E. Denivelation between the uppermost and lowermost parts of the locality is about 80 m, which explains the steepness of the terrain.

The soil in the locality is Luvisoil, often strongly eroded. It is sandy-clayey, medium to strongly stony, poor, shallow and dry. Base rock consists of granites and gneisses, with occasional outcrops, which determines the rocky character of most of the territory and, respectively, the floristic richness.

Climatically, the region of the locality falls into the Continental-Mediterranean Climate Zone, South Bulgarian Subzone, the climatic region of the East Rhodopean River Valleys (Sabev & Stanev 1963; Velev 2002). According to the forest-and-plant regionalisation, it falls into the Thracian Forest Plant Zone, in the lower plain-and-hilly and hilly-foremountain belt of the oak forests and sub-belt of the plain-and-hilly oak forests. According to the floristic regionalisation of Bulgaria, it lies in the floristic region of the Thracian Lowland.

The habitat of *O. humifusa* occupies places with degraded mixed oak forests of *Quercus cerris*, *Q. frainetto* and *Q. pubescens*, in which secondary xerothermic grassy communities formed, with prevalence of *Chrysopogon gryllus*, *Dichanthium ischaemum*, *Poa bulbosa*, as well as some ephemeral species (Bondev 1991).

The plant community with participation of *O. humifusa* is secondary in character and has a heterogeneous vertical and horizontal structure. Various “microhabitats” have formed in different parts of the locality as a result of the long years of anthropogenic impact. Part of the investigated territory, chiefly at the higher level of the locality, is covered by about 40-year old canopied plantation of *Pinus nigra*, with single groups or individual trees surviving elsewhere on the slope. The other part of the slope is covered with thinned shrubs, while the strongest eroded and most rocky places have only a grassy cover, dominated by *Graminaeae* species. *Opuntia humifusa* occurs singly, or more frequently in small groups, represented either by several individuals, or by approximately large patches with an area of 10–15 m<sup>2</sup>. The patches are scattered randomly close to each other, or are distanced at tens or hundreds of metres. The cacti grow usually in open places but some groups were found even under the canopy of the Black Pine, which obviously does not impede their normal development, considering the fact that they had flowered and yielded fruit.

Vertically, the structure could be divided into two horizons: a layer of trees and shrubs and another grassy one. The arboreal horizon is covered mainly by *Pinus nigra*, with single specimens of *Quercus cerris*, *Q. pubescens*, *Acer monspessulanum*, *Robinia pseudoacacia*, *Pyrus pyraeaster*, *Fraxinus ornus* and other tree species. In the shrub layer, most characteristic are *Carpinus orientalis*, *Paliurus spina-christi*, *Pistacia terebinthus*, *Syringa vulgaris*, *Rubus sanguineus*, etc. *Clematis vitalba*, *Vitis bulgarica* and *Cionura erecta* climb up and

coil themselves around the trees and shrubs. The herbaceous layer is dominated by the gramineous species, with the highest coverage of *Chrysopogon gryllus*, *Dichanthium ischaemum*, *Poa bulbosa*, *Brachypodium pinnatum*, etc. Many ruderal and weedy plants occur in the locality, with prevalence of *Alyssum alyssoides*, *Arabidopsis thaliana*, *Buglossoides arvensis*, *Calepina irregularis*, *Capsella bursa-pastoris*, *Chondrilla juncea*, *Erodium cicutarium*, *Fumaria officinalis*, *Geranium columbinum*, *Neslia paniculata*, *Senecio vulgaris*, *Trifolium arvense*, *Tribulus terrestris*, *Viola kitaibeliana*, etc. Their presence confirms the strong and lengthy anthropogenic impact exercised on that community. The presence of *Opuntia humifusa* in the investigated phytocoenosis has been known for many decades and this is confirmed by the elder local inhabitants. This proves that the ecological conditions in the locality are favourable for the seed reproduction of the cacti, which results in expansion of their territories.

The full floristic composition and phytocoenotic structure of the community with participation of *Opuntia humifusa* are presented in Table 1. It shows that 89 higher plants have been identified in the locality, of which 13 belonged to trees and shrubs, 10 to gramineous species, three to leguminous and the rest to herbage. The biological range of the species is very typical: 26 species (29.2%) are phanerophytes and 31 species each (34.8%) are hemicryptophytes and therophytes. Only one cryptophyte was identified (1.2%), and no chamaephytes whatsoever. Such correlation of life forms is characteristic of the Mediterranean plant communities, which permanently lack moisture.

The latter is confirmed by the analysis of the floristic elements in that community. Species with a Mediterranean component prevailed (*Med*, *subMed*, *Pont-Med*, *Eur-Med*, etc.) – 41 (46.6%). Next ranked are floristic elements with an European component (*Eur*, *Eur-As*, *Eur-Sib*, etc.) – 36 (40.9%). The remaining floristic elements showed insignificant participation. Among them of interest were the endemic species as part of the autochthonous flora of the territory. There are four Balkan endemic species – *Achillea pseudopectinata*, *Hypericum thasium*, *Alkanna primuliflora*, and *Myosotis macedonica* (in the opinion of some authors this species is conspecific with *M. incrassata* Guss., see Petrova & Vladimirov 2010), and two Bulgarian endemics – *Muscari vandasii* and *Vitis bulgarica*. *Crepis stojanovii* and *Thymus moeasiacus* are Balkan near endemics.

Table 1. Floristic composition and phytocoenotic structure of the community with participation of *Opuntia humifusa*.

№	Plant species	Life form acc. to Raunkiaer (1934)	Projection cover, %	Grouping acc. to Braun-Blanquet, points	Frequency, points	Floristic elements
1	2	3	4	5	6	7
<b>TREES</b>						
1	<i>Acer monspessulanum</i> L.	Ph	+	-	-	subMed
2	<i>Ailanthus altissima</i> (Mill.) Swingle	Ph	+	-	-	Adv
3	<i>Fraxinus ornus</i> L.	Ph	1	-	-	subMed
4	<i>Malus praecox</i> (Pall.) Borkh.	Ph	+	-	-	Pont-CAs
5	<i>Pinus nigra</i> Arnold	Ph	10	-	-	subMed
6	<i>Prunus mahaleb</i> L.	Ph	+	-	-	Eur-Med
7	<i>Pyrus amygdaliformis</i> Vill.	Ph	+	-	-	Med
8	<i>Pyrus pyrastrer</i> Burgsd.	Ph	+	-	-	subMed
9	<i>Quercus cerris</i> L.	Ph	1	-	-	Eur-subMed
10	<i>Quercus pubescens</i> Willd.	Ph	2	-	-	Eur-subMed
11	<i>Robinia pseudoacacia</i> L.	Ph	1	-	-	NAM
12	<i>Tilia tomentosa</i> Moench	Ph	+	-	-	Eur-Med
13	<i>Ulmus minor</i> Mill.	Ph	+	-	-	Eur-Med
<b>SHRUBS</b>						
14	<i>Amorpha fruticosa</i> L.	Ph	+	2	I	NAM
15	<i>Carpinus orientalis</i> Mill.	Ph	1	1	II	subMed
16	<i>Cionura erecta</i> (L.) Griseb.	Ph	+	2	I	Med
17	<i>Crataegus monogyna</i> Jacq.	Ph	+	1	II	subBoreal
18	<i>Ligustrum vulgare</i> L.	Ph	+	1	II	subMed
19	<i>Paliurus spina-christi</i> Mill.	Ph	+~1	1	III	Eur-As
20	<i>Pistacia terebinthus</i> L.	Ph	+~1	1	II	Pont-Med
21	<i>Prunus spinosa</i> L.	Ph	+	1-2	II	SPont
22	<i>Rosa canina</i> L.	Ph	+	1	II	subMed
23	<i>Rubus caesius</i> L.	Ph	+	1-2	II	Eur-As
24	<i>Rubus sanguineus</i> Friv.	Ph	+	2	II	Pont-Med
25	<i>Syringa vulgaris</i> L.	Ph	+	1-2	I	Carp-Bal
26	<i>Thymus moesiacus</i> Velen.	Ch	+	1-2	I	Bal-Anat
27	<i>Vitis bulgarica</i> Kov.	Ph	+	2	I	Bul
<b>GRAMINEOUS</b>						
28	<i>Brachypodium pinnatum</i> (L.) P. Beauv.	H	1	2	II	SSib
28	<i>Bromus tectorum</i> L.	Th	+	2	I	Boreal
29	<i>Calamagrostis epigeios</i> (L.) Roth.	H	+	2	II	Eur-As
30	<i>Chrysopogon gryllus</i> (L.) Trin.	H	7	2-3	III	Pont-Med
31	<i>Cynosurus echinatus</i> L.	H	+	1-2	II	subMed

Table 1. Continuation.

1	2	3	4	5	6	7
32	<i>Dactylis glomerata</i> L.	H	+	2	II	Eur-As
33	<i>Dichanthium ischaemum</i> (L.) Roberty	H	1	2	II	subMed-As
34	<i>Phleum pratense</i> L.	H	1	2	II	Eur-subMed
35	<i>Poa bulbosa</i> L.	H	3	2	III	Eur-As
36	<i>Poa pratensis</i> L.	H	1	2	II	Kos
<b>LEGUMINOUS</b>						
37	<i>Trifolium arvense</i> L.	Th	2	2-3	III	Eur-Sib
38	<i>Trifolium setiferum</i> Boiss.	Th	5	2-3	III	Med
39	<i>Vicia grandiflora</i> Scop.	Th	+	2	II	subMed
<b>HERBAGE</b>						
40	<i>Achillea pseudopectinata</i> Janka	H	1	1-2	III	Bal
41	<i>Alkanna primuliflora</i> Griseb.	H	+	1	I	Bal
42	<i>Alyssum alyssoides</i> (L.) L.	Th	+	1-2	II	Eur-Med
43	<i>Anthemis cotula</i> L.	Th	+	1	I	Eur-Sib
44	<i>Arabidopsis thaliana</i> (L.) Heynh.	Th	+	2	II	subBoreal
45	<i>Buglossoides arvensis</i> (L.) I.M. Johnst.	Th	+	1-2	II	Eur-As
46	<i>Calepina irregularis</i> (Asso) Thell.	Th	+	1-2	I	Med
47	<i>Capsella bursa-pastoris</i> (L.) Medik.	Th	+	1-2	II	Kos
48	<i>Centaurea stoebe</i> L.	H	+	1	I	subMed
49	<i>Chondrilla juncea</i> L.	Th	+	1	II	Eur-Sib
50	<i>Cichorium inthybus</i> L.	H	+	1	II	Eur-Sib
51	<i>Clinopodium vulgare</i> L.	H	+	1	II	subBoreal
52	<i>Crepis stojanovii</i> T. Georg.	Th	+	1-2	II	Bal-Anat
53	<i>Echinops sphaerocephalus</i> L.	H	+	1	II	Eur-Med
54	<i>Erodium cicutarium</i> (L.) L'H�r.	Th	+	1-2	I	subBoreal
55	<i>Erodium hoefftianum</i> C.A. Mey. ssp. <i>hoefftianum</i>	Th	+	1-2	I	Pont-CAs
56	<i>Eryngium campestre</i> L.	H	+	1	II	Pont-Med
57	<i>Euphorbia cyparissias</i> L.	H	+	2	II	Eur
58	<i>Filago vulgaris</i> Lam.	Th	+	1	I	Eur-As
59	<i>Fumaria officinalis</i> L.	Th	+	2	I	Eur-Sib
60	<i>Galium aparine</i> L.	Th	+	2	II	Eur-As
61	<i>Geranium columbinum</i> L.	Th	+	1	I	subMed
62	<i>Herniaria glabra</i> L.	Th	+	1	I	Eur-As
63	<i>Hypericum thasium</i> Griseb.	H	+	2	II	Bal
64	<i>Linaria vulgaris</i> Mill.	H	+	1-2	I	Eur-Sib
65	<i>Marrubium vulgare</i> L.	H	+	2	II	Eur-As
66	<i>Muscari vandasii</i> Velen.	Cr	+	2	I	Bul
67	<i>Myosotis macedonica</i> Velen. & Charrel	Th	+	2	I	Bal
68	<i>Neslia paniculata</i> (L.) Desv.	Th	+	2	II	As
69	<i>Opuntia humifusa</i> (Raf.) Raf.	H	2	2-3	IV	NAM
70	<i>Petrorhagia prolifera</i> (L.) P.W. Ball & Heywood	Th	+	1	I	Pont-Med
71	<i>Potentilla pilosa</i> Willd.	H	+	1-2	I	Eur
72	<i>Ranunculus illyricus</i> L.	H	+	1	I	Eur-subMed
73	<i>Rumex acetosella</i> L.	H	+	2	I	Eur-subMed
74	<i>Sanguisorba minor</i> Scop.	H	+	1	II	Boreal
75	<i>Scandix australis</i> L.	Th	+	1-2	I	Eur-Med

Table 1. Continuation.

1	2	3	4	5	6	7
76	<i>Scleranthus perennis</i> L.	H	+	1	I	Eur-Med
77	<i>Scolymus hispanicus</i> L.	H	+	1	II	Med
78	<i>Scorzonera mollis</i> M. Bieb.	H	+	1	I	Med
79	<i>Sedum caespitosum</i> (Cav.) DC.	Th	+	2	II	Med
80	<i>Senecio vulgaris</i> L.	Th	+	1	II	Eur-As
81	<i>Thlaspi perfoliatum</i> L.	Th	+	1-2	II	Eur-Med
82	<i>Tribulus terrestris</i> L.	Th	+	1	I	Eur-As
83	<i>Valerianella locusta</i> (L.) Laterr.	Th	+	1-2	II	Eur-Med
84	<i>Veronica austriaca</i> L.	H	+	1	II	Eur-Med
85	<i>Veronica chamaedrys</i> L.	H	+	1	II	Eur-As
86	<i>Veronica hederifolia</i> L.	Th	+	2	II	Eur-Med
87	<i>Veronica verna</i> L.	Th	+	2	II	Eur-Sib
88	<i>Viola arvensis</i> Murr.	Th	+	1-2	II	Eur
89	<i>Viola kitaibeliana</i> Shult.	Th	+	1-2	II	Eur-Med

**Floristic elements:** **Adv** – adventive (alien); **Anat** – Anatolian; **As** – Asiatic; **Bal** – Balkan; **Boreal** – Boreal; **Bul** – Bulgarian; **Carp** – Carpathian; **Eur** – European; **Kos** – Cosmopolitan; **Med** – Mediterranean; **NAm** – North American; **Pont** – Pontic; **Sib** – Siberian; **prefixes:** **S-** – South; **sub-** – sub-; **W-** – West; **C-** – Central.

Four species occurring in the locality are conservationally important: they are entered in the *Red Data Book of PR Bulgaria* (Velchev 1984): *Alkanna primuliflora*, *Erodium hoefftianum*, *Scandix australis* and *Crepis stojanovii* are referred to as 'Rare' species. *Alkanna primuliflora* and *Crepis stojanovii* are protected under the Biological Diversity Act (2002), and the latter species is entered in the *List of Rare, Threatened and Endemic Plants in Europe* (Lucas 1983) in the category of 'Vulnerable'. In the new edition of the *Red Data Book of R Bulgaria*, vol. 1, Plants and Fungi (Peev & al. in press) *Crepis stojanovii* is already given as Critically Endangered (CR), while *Scandix australis* is entered in the *Red List of Bulgarian Vascular Plants* (Petrova & Vladimirov 2009) in the category 'Near Threatened' (NT). The discovery of *Cionura erecta* on the territory of Thracian Lowland is also interesting, as it has not been reported so far from there, while *Vitis bulgarica* was also reported only for the region of Malko Tarnovo town in Mt Strandzha (Tashev 2008).

Participation of a great number of Mediterranean species in the locality determined by the Continental-Mediterranean climate in the region comes to explain the progressive development of the population of *O. humifusa* at that uncharacteristic geographic latitude for this species. The population is in a good state and generative individuals flower from the end of May until June. The area under the cacti tufts is expanding. Both juvenile and generative plants have been observed.

The above finds in the study prompt the conclusion that *O. humifusa* is a completely naturalised species under the Bulgarian climatic conditions and could be referred to as part of the alien flora of the country. It breeds both by seeds and vegetatively and gradually expands to new areas, irrespective of several fires which have passed through its locality. Some conservationally important species have been identified in that locality, to which the cactus certainly is a threat.

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