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INVASIVE CULTIVAR *OPUNTIA LINDHEIMERI* ENGELM. GROWING IN SOUTH CRIMEA

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Introduction

Genus of *Opuntia* Mill. is one of the largest genera of cactaceous, including from 90 till 250 cultivars according to different authors [7, 9, 20, 39 – 41, 43, 44]. No less than 27 cultivars are characterized as invasive in different parts of the Earth [44]. The first cultivation of opuntia in the Crimea happened in the beginning of XIX century in Nikitsky Botanical Gardens. The first adaptation of the opuntia on the peninsula occurred in the middle of the same century. Taking into consideration that till the middle of last century wild cactuses were found only on areas of foreign army burials dated by the Crimean War period and on old German cemeteries, these facts are obviously connected not only with considerable introduction in the parks, but a real tradition of some European peoples to bed these evergreen attendance free plants on cemeteries. The first data about opuntia running wild in the Crimea are presented in works of the first half of XX century [1, 2, 15]. Afterwards opuntia naturalization was noted by other authors. The most part of publications deals with *O. humifusa* (Raf.) Raf (or *O. vulgaris*, *O. opuntia*) [1, 4, 15 – 17, 27, 28, 35, 37, 38 and etc.] and single works note spontaneous sprouting of some other cultivars [4, 5, 8 – 12, 14, 25, 26, 31, 38]. In 2012-2013 four cultivars of opuntia were marked out as alien plants in the Crimean flora [3, 23], in 2014 – eight taxons [6], in accordance with researches of 2014 within grant RFFI, we can say about naturalization from nine to ten genus representatives, but nomenclatural position of some taxons demands some clarification.

Research objective is to specify systematical location, assess population present state, character and spreading tendencies of one of the most dangerous invasive cultivars in South Crimea.- *Opuntia lindheimeri* Engelm

Objects and research methods

Research objects are cenopopulations and single specimens of *O. Lindheimeri*, spontaneously sprouting on South Coast of the Crimea within the following areas: Foros, Simeiz, Gaspra, Cape Martiyan, Gurzuf, Artek, Ayu-Dag piedmont, Cape Plaka, outskirts of Lazurnoye, Solnechnogorskoye. Some parameters and characteristics were taking into consideration in introduction populations in Simeiz, Livadiya, Nikitsky Botanical Gardens, Solnechnogorskoye, Malorechenskoye. Investigation of *O. Lindheimeri* population on areas of Artek, Cape Plaka was launched in late 1980 – 1990, further study of the cultivar naturalization in South Crimea was conducted in 2013-2014.

To find out places of opuntia populations method of route and reconnoitering studies was applied, literature and Internet sources and verbal communication of other specialists were in use as well. Morphological parameters of plants were researched applying traditional methods as in natural as under conditions of laboratory. Surveying was conducted by digital cameras Canon PowerShot SX130 IS, Sony DSC-H1, Sony DSC-HX200. Identification of opuntia was carried out due to standard reports, accepted for Cactaceae Juss. family [39 – 41], analysis of modern on-line sources [45]. Nomenclature corresponds to international database IPNI [47]. Native flora was defined using “Identification guide for Crimean higher plants” [32] and other sources. Their nomenclature corresponds to accepted nomenclature for

last checklist of the Crimean flora. [23]. Plant syntaxon names are presented according to international requirements [48].

Most of study localities of wild *O. Lindheimeri* are in the central part of South Coast of the Crimea; according to system of physical and geographical zoning this territory belongs to the western district of the Crimean South Coast of the Submediterranean [34]. The Local climate is Mediterranean, subtropical, dry, hot, with moderately warm winter. Average annual air temperature is 12-14°C. Temperature in the warmest month (July or August) makes 23-25°C, in the coldest months (February) is +2,5 – +4,5°C. Absolute minimum makes –15–17°C. Annual precipitation is 550mm, the most part falls in cold season [13]. Soils on weathering product of clay slate, limestone and igneous rocks are brown. Single localities were found out in the eastern part of South Crimea, belonged to the Eastern district of the Crimean South Coast of the Submediterranean, where winters are a little colder and annual precipitation is less. In accordance to floristic zoning this area belongs to Krymsko-Yuzhnoberezhny region of Yuzhnokrymsky district of Krymsko-Novorossiyskaya subprovince of Evksynskaya province of Sredizemnomorskij region [23]. According to geobotanical zoning Mountain Crimea belongs to Sredizemnomorskij region of sclerophyllous forests, maquis, sibljak, phryganas and tomillares [21]. Being in the system of high-altitude zonation South Coast of the Crimea is in the belt of maritime xerophytic juniper and oak forests and shrubs [34], or in the lower forest-steppe belt of hemixerophilous forests, xerophilous lighted forests and savannahs of southern macroslope of Crimean mountains [19].

Research results and discussion

While researching present situation of biological diversity in the Crimea, it was found out that invasive activity of some representatives of *Opuntia* genus has been increased in recent years. Till the middle of XX century there were notes about only one cultivar running wild - *O. humifusa* (Raf.) Raf. (syn. *O. rafinesquii* Engelm, *O. humifusa* Raf., *O. vulgaris* Haw. non Mill., *O. mesacantha* Raf., *O. opuntia* (L.) Karsten, *O. caespitosa* Raf., *O. compressa* McBride, *O. intermedia* Salm.-Dyck, *O. nana* Vis., *C. compressus* Salisb. *Cactus humifusus* Raf., *Cactus opuntia* L. with different varieties [9, 20, 24, 41, 43, 45 and etc.]). After scientific researches (1930-1960), conducted in Nikitsky Botanical Gardens, in cultivation and adoption of different winterhardly cultivars of opuntia in green building within parks of sanatoria and populated localities of South Coast of the Crimea, introduction populations of these plants occurred there. Further concerning some localities the cultivars of opuntia adopted and started their distribution outwards the cultivated places, invaded into natural biotopes as well. This fact refers opuntia to adventive or invasive plants on occasion.

At present one of the most popular opuntia species either cultivated or wild in the Crimea is *O. lindheimeri*. (Fig.1)



Fig.1 Explored places of introduced and spontaneously sprouted plants and cenopopulations of *Opuntia lindheimeri* in South Crimea

Brief morphological description of this species, cultivated in Batumi, was presented by Zamyatnin B.N. in Russian [24], but we suppose it's necessary to characterize peculiarities of some plants naturalized in the Crimea. Under conditions of South Coast of the Crimea *O. Lindheimeri* is a large succulent plant, height of 0,5 – 1m. Due to more intensive shoot growing horizontally, inherent for this species, in comparison with growth rate vertically, a specimen can make a clump of 1-2m across diameter (fig.2A). With time separate clumps are able to unite and create growth; populations occupy any available free of trees and shrubs territory. Shoot segments are rounded or inversely egg-shaped, large, (10) 17 – 30 (39) sm by length, (9) 15 – 20 (23) sm by width, 0,7 – 1,0 sm by depth, light green or dull green, occasionally with lighted dove-coloured shade in autumn and winter (after fall of temperature close to 0°C) often gain yellowish and reddish anthocyanin shade (Fig. 2F). Leaves, typically for all opuntia genus representatives, are pulpy, slightly pointed and round reaching 1 sm by length and 2 mm by depth; leaves develop in areolas at the beginning of vegetative and generative shoots regrowth, quite fugacious. Areolas are large, oval sized 5 – 6 x 3 – 4 mm, with brown stands of wool with spacing place of 3-4 sm from each other, one diagonal row has 4-5 areolas. Barbs are all over the whole segment excluding bottom areolas on the flat surface – (1) 2 – 3 on each areola, on the border there can be 3-5. Barbs are quite large (till 4,7 sm by length, 1 mm by depth), hard, sometimes have perpendicular disposition according to segment surface, but more often bent at an angle of (30) 45 – 60 ° towards it, often slightly arched, flattened at the bottom, quite often twisted round at an angle of 90 - 180°. Barb color at the bottom of segment is red and brown (“rusty-coloured”), barbs located higher are yellow and amber-coloured, that become lemon-coloured at the point; there are dark ring-shaped structures. Glochidia are not numerous, placed on crescent-shaped line at the top of areola, 1 – 2 (4) mm by length, green and brown with reddish (rusty) shade (Fig. 2. B,F; 3.C). Flower size is 5 – 7 sm by length (with ovary), 7 – 9 sm across diameter, perianth leaves (petals) number is 12 – 15, 15 – 18 mm by length, 15 – 21 mm by width. They are bright-, dark – or orange-yellow (Fig.2. E; 3.A), rarely orange-red, before wilting periods flower colour gets a bit darker. Blossoming period under conditions of South Coast of the Crimea is in the end of May – beginning of June. Fruits ripen in October – November, typically for this cultivar after getting ripened fruits fall off. Fruit size is (2,5) 4,5 – 5,5 (7,2) sm by length,

(2,3) 3 – 3,2 (3,8) sm across diameter. Form rate is from almost round till pear-shaped, but mostly they are oval or barrel-shaped with rounded bottom, that resembles percussion instrument timpani and conga (fig. 2. F; 3.B). One population can include plants with different by fruit form and size.



Fig. 2 Morphological characteristics of *Opuntia lindheimeri* under conditions of South Crimea:

A – common plant habitus; B – vegetative renewal; C – sprouts; D – juvenile specimen; E – flowers; F – fruits; G – cut along fruit and its seeds.

Fruit top has a slight basin sized from 4 – 7 mm. Fruit color is bordeaux or crimson and bordeaux, pulp is bordeaux and purple (bordeaux). Fruits are quite soft, juicy, slightly fibrous, sour-sweet, tasty. One segment can contain from 1 till 12 fruits, average number is 5-7. One plant divided into 30-40 segments yields about 150-200 fruits. Each fruit contains 90 – 265 seeds (usually 180 – 220). Seed color is yellow-light grey; its size is 3,2 – 4,3 mm across diameter, 1,5 – 2 mm by depth, form is irregular round and heart-shaped with wide yellowish border, flattened at the top and bottom (Fig.2. G). These plants are able to grow under conditions of South Coast Crimea (Fig. 2.C).

As systematics of Cactaceae family on the whole and *Opuntia* genus particularly is still conflicting, to determine properly systematic position of cultivated and running wild representatives of this genus in the Crimea is a difficult task. In Nikitsky Botanical Gardens study opuntia was cultivated as *O. engelmannii* Salm-Dyck [1, 2, 7, 45]. Wild opuntia on cape Plaka has the same name in publications [8 – 12, 38] and some internet sites [18, 33 and etc.]. Though according to modern concepts its morphological characteristic mostly corresponds to *O. engelmannii* subsp. *lindheimeri* (Engelm.) U. Guzmán et Mandujano, often taken as a separate cultivar *O. lindheimeri* Engelm. [45, 47], but not to *O. engelmannii* subsp. *engelmannii* (or *O. engelmannii* s. str.). It differs from typical opuntia *O. Engelmannii* by glochidia and barbs (yellow with red-brown bottom and well-emphasized rings, but not white with chalky shade and umber almost black bottom with non-expressed rings) color, fruit form and color, and some other distinguish features (Fig.3).

In the Crimea *O. Lindheimeri* is successfully cultivated in the coastal zone of South Coast (cape Sarych, Foros, Goluboj Zalyv, Simeiz, Alupka, Miskhor, Gaspra, Livadiya, Yalta, Nikita, Gurzuf, Partenit, Alushta, Solnechnogorskoye, Malorechenskoye, Morskoj and etc.), piedmont and steppe areas (in Sevastopol, Saki, Yevpatoriya). Last decades cases of this cultivar running wild and invasion into phytocenoses were registered. For the first time it was included into checklist of adventive plants by Bagrykova N.A. and Yena A.V. [3, 23]. In scientific literature there is detailed information about *O. Lindheimeri* population only (named by *O. Engelmannii*) on cape Plaka [8, 12, 38]. Although quite adapted populations, which have vegetative or seed renewal, were described during field researches in 2014 in Foros, Gaspra, on cape Martyan, Gurzuf, Atek and other places.

The largest and obviously oldest population of *O. Lindheimeri* grows 2 km to East from village Partenit on the territory of sanatorium “Utyos” on the seaside slope of Plaka cape. This cape is a rocky cliff by 50m height, composed by intrusive igneous magmatic geological materials – diabase porphyrites dated by Middle Jurassic period, the cape top is covered by clay slates dated by Triassic period and hornstoned rocks. Population of this cultivar is mostly located on steep slopes (angle slope rates from 15° till 60°) of the southern and southeast exposition at altitude range 10 - 45m, total area is 1,5 ha. Opuntia is found in biotopes of two types.

The first biotopes concerns expositions of porphyrite rocky monolith, divided by horizontal and vertical cracks into separate layers and blocks; it occupies southeast and southwest parts of the cape and down slope area in its central (southern) part. *O. lindheimeri* specimens inhabit in rock cracks and being the largest and strongest among local vegetation, become dominants of khazmophyte groups of the following classes: *Asplenietea trichomanis* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberdorfer 1977 and *Koelerio-Corynephoretea* Klika in Klika et Novák 1941.



**Fig.3 Comparative characteristics of some morphological parameters of *Opuntia lindheimeri* (A,B,C) and *O. Engelmannii* (D,E,F,G).
A,D – flowers; B,E – fruits; C, F – barbs and glochidia**

Common vegetative projective cover of this biotope makes from 10 till 90%. *Opuntia* projective cover ranges from 3 till 90%, besides it creates single-species growth at the bottom of the southern slope (Fig.4), but it hasn't been found on edge western and edge eastern areas yet. Here is a list of other cultivars typical for rocky cenoses of Plaka cape: *Parietaria judaica* L., *Sedum hispanicum* L., *S. pallidum* M. Bieb., *Allium saxatile* M. Bieb. s. l., *Ceterach officinarum* DC., *Galium mollugo* L., *Veronica cymbalaria* Bodard, *Avena barbata* Pott ex Link subsp. *barbata*, *Misopates orontium* (L.) Raf., *Cheiranthus cheiri* L. (two last cultivars are adventive).

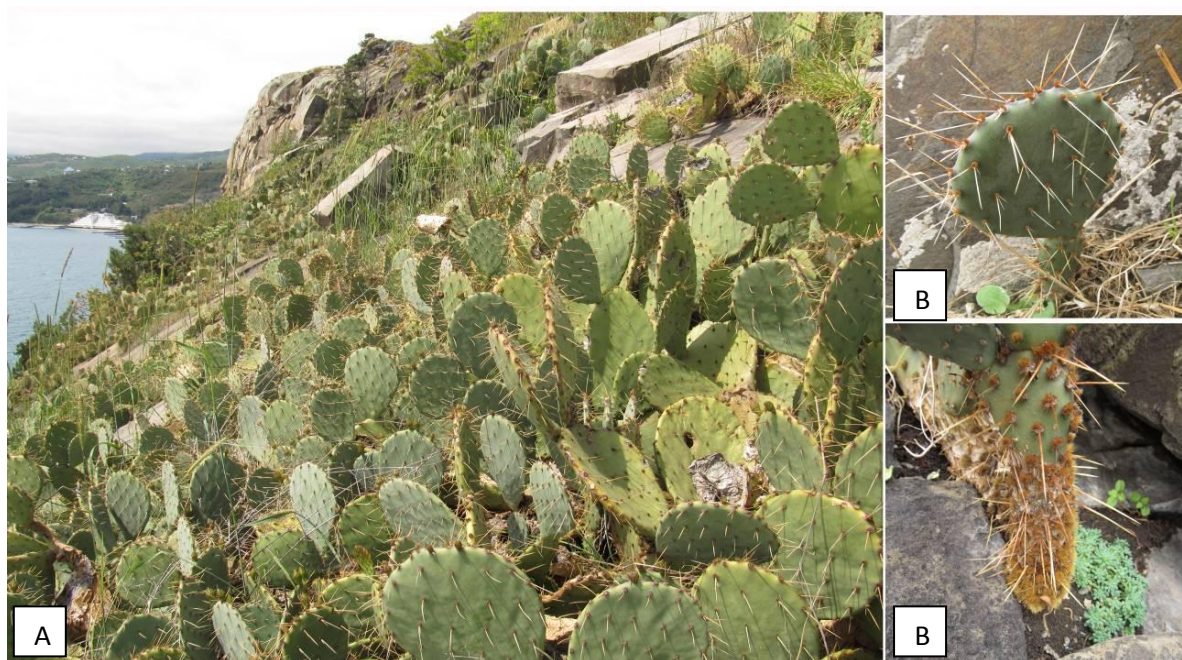


Fig. 4 Cenopopulation of *O. Lindheimeri* on Cape Plaka:
A – general view of opuntia growth; B,C – seedlings

The second biotope is rubbly and clay screes and slide slopes in the middle of the cape area. A large number of ceramic fragments and other artifacts are found here. It proves historical information about anthropogenic development of the territory opened up many years ago. Along with exogenous geological processes, man economical activity became dangerous for natural vegetative cover, degradation process was launched. Nowadays vegetative of this biotope consists of three layers. The first layer includes small cenoses of short trees (1,5 – 4 m) *Pistacia mutica* Fisch. et C.A. Mey., *Juniperus excelsa* M. Bieb., *Cupressus sempervirens* L., they create lighted forests with closing of leaf canopy from 0,1 till 0,5 (av. 0,2) in the middle and upper parts of the slope, young specimens of *Ailanthus altissima* (Mill.) Swingle are presented on this area as well. Shrub layer was created by *Jasminum fruticans* L. with projective cover from 0 – 30% (on average 5 – 10%). In the herb layer, which is presented by groups of Mediterranean class *Thero-Brachypodietea* Br.-Bl. ex O. de Bolós y Vayreda 1950, dominant plant are *Asphodeline lutea* (L.) Rchb., *Ephedra distachya* L., *Teucrium chamaedrys* L., *Taraxacum hybernum* Steven, *Convolvulus cantabrica* L., *Hordeum bulbosum* L., *Aegilops biuncialis* Vis. and etc. A considerable role of agrestal species was marked out: *Rapistrum rugosum* (L.) All., *Tribulus terrestris* L., *Portulaca oleracea* L. The common projective cover ranges from 45 till 90%, while *O. Lindheimeri* cover makes 10 – 90% of the total area. Among *O. lindheimeri* growth in this locality there are single specimens of another opuntia cultivar naturalized on South Coast of the Crimea, beforehand referred to *O. tunoidea* Gibbes (it is registered in catalogues of Nikitskiy Botanical Gardens as *O. pseudotuna* Salm-Dyck). Phytocenosis of cape Plaka contains a number of plants, being protected in the Red Data Book of Russian Federation (RDBRF) [30], the Red Data Book of Ukraine (RBU) [36] or candidates for the Red Data Book of the Crimea (RDBC). They are *Juniperus excelsa*, *Pistacia mutica* (included into RDBRF, RDBU, candidates for RDBC), *Asphodeline lutea* (included into RDBU, candidate for RDBC), *Avena barbata*, *Hedypnois rhagadioloides* (L.) F.W. Schmidt, *Dianthus marschallii* Schischk. (included into the checklist of plants being in need of protection on the territory of Autonomous Republic of the Crimea, 2013, they are candidates for RDBC as well), *Avena sterilis* L. subsp. *ludoviciana* (Durieu) Nyman (included into checklist of plants,

being in need of special protection in the Crimea). A highly invasive activity of *O. Lindheimeri* becomes a considerable danger for plant populations of rare cultivars on area of the Cape Plaka.

According to data of previous researches in 1990th opuntia population growing on the cape Plaka consisted of 40 groups (clumps) after the fire in 1998, its size ranged from 0,5m till 3,0m across diameter [8]. By present number of groups has increased till 500. Generative specimens occupy about 90% of the whole population. Percentage of juvenile specimens is approximately 8%. Senile specimens and several old dead plants were revealed. Propagation of *O. Lindheimeri* is mainly vegetative; it occurs due to anthropogenic factor (segments are cutting off), hurricanes, raging along the cape during winter, or falling down rock debris. All these factors stimulate opuntia further movement down the steep slope being under gravity action and rootage. From 5 till 10% of the population are specimens with seed origin. The most popular areas for seed sprouting are cracks in a rock monolith, places not favorable for segment rootage; owing to moisture high level, storage of humus and more stable substrate. In narrow cracks, bent vertically mainly specimens of seed origin survive.

O. lindheimeri displays an obvious invasive activity in another habitat - 1 km to west of Ayu-Dag mountain on the coastal slope between camp complexes of "Morskoj" and "Pribrezhny" of the International Children's Centre "Artek" (fig. 5, 2B – F, 3A). These conditions are similar to the cape Plaka conditions – rocky expositions of clay slate of Triassic period in an altitude range of 5 – 15 m above the sea level. Populations occupy slopes of southeast, south and southwest expositions with slope angle from 5 - 10° in the near watershed zone it reaches 30 - 40° on steep lands. Natural vegetation of the territory is a composition of shrub growth of Mediterranean class (class *Cisto-Micromerietea julianae* Oberdorfer 1954) with a few short arboreal breeds, fragments of bluegrass, nodular and wheatgrass petrophyte and steppe cenoses (*Festuco-Brometea* Br.-Bl. et R. Tx. ex Br.-Bl. 1949) and calciphobous ephemerum (Koelerio-Corynepherea). In floristical composition the principle role belongs to *Paliurus spina-christi* Mill., *Pyrus elaeagrifolia* Pall., *Cistus tauricus* J. Presl et C. Presl, *Jasminum fruticans* L., *Bothriochloa ischaemum* (L.) Keng, *Elytrigia caespitosa* (K. Koch) Nevski subsp. *nodosa* (Nevski) Tzvelev, *Convolvulus cantabrica* L., *Clinopodium nepeta* (L.) Kuntze, *Eryngium campestre* L., *Taraxacum hybernum*, *Prospero autumnale* (L.) Speta, *Anisantha tectorum* (L.) Nevski, *Aegilops biuncialis* Vis., *Vulpia ciliata* Dumort., *Alyssum umbellatum* Desv., *Helianthemum salicifolium* (L.) Mill., *Sedum caespitosum* (Cav.) DC. and etc. There were revealed some synanthropic (*Echium italicum* L. subsp. *biebersteinii* (Lacaita) Greuter et Burdet, *Tribulus terrestris* L.) and adventive (*Rhamnus alaternus* L., *Olea europaea* L., *Bupleurum fruticosum* L., *Foeniculum vulgare* Mill.) plants.

In accordance with data of Volokitina Yu.S. (oral report) and our observations in 1970-1980th on area described above only 1-3 specimens of this opuntia cultivar grew there, obviously carried in from the neighbor territories of camps "Morskoj" and "Pribrezhny"; on the camp territory it was planted in late 60th and early 70th of last century with the purpose of area reconstruction and landscaping. Nowadays population consists of no less than 70 large specimens, being mainly on generative stage. Most plants propagate by vegetative way, but there are specimens with seed origin. There were fixed approximately twenty seedlings of last and current year. Area size of a population makes about 1000 m². Percentage of *O. Lindheimeri* makes 10 – 40% relative to the common vegetative projective cover (70-90%). On the border of populations single specimens prevail, as a rule centers are occupied by clumps of some plants, their size reaches 1,5 – 3m across diameter. In this locality *O. Lindheimeri* grows close to another naturalized opuntia cultivar *O. macrorhiza* Engelmann. Mostly opuntia colonizes exposed stony, rubbly or clay areas on slate slopes with vegetative deficit or occupied by efemerum cenoses. Though their adaptive capacity is striking; these plants take root successfully under crown of small xerophytic especially therophyllous trees, even among

rockrose growth, supplanting it gradually. Therefore opuntia colonization of this area is a direct threat for three rare and protected plant cultivars - *Cistus tauricus* (included into RDBU, candidate for RDBC), *Vitex agnus-castus* L., *Sedum rubens* L. (included into checklist of plant cultivars, being in need of special protection on the territory of AR Crimea, 2013, candidates for RDBC) and a number of Crimean, Crimean and Caucasian endemics as well.



Fig.5 General view of *O. Lindheimeri* cenopopulation in Artek.

Next locality of *O. Lindheimeri* is situated 3 km to west in southeast part of Gurzuf village. Simultaneously with other sorts of opuntia (according to preliminary data: *O. tunoidea* and *O. laevis* J.M. Coulter) *O. Lindheimeri* grows on rocky limestone slopes between Geologov and Krymskaya streets above musical school. This area includes southern spurs of Bolgatur cliff, composed of Massandra formation limestone, that is a tongue of ancient Pliocene landslide. Opuntia plants are spread along watershed ridge, precipitous slopes of southeast and southwest expositions on an altitude of 60 – 70 m above the sea level. Residential zone has taken place here for many centuries, but in spite of it on stony slopes difficult to access there are well-reserved natural complexes, typical for limestone expositions of South Coast. Though in late 1900-th – early 2000-th anthropogenic effect on reserved natural landscapes increased a lot as a result of a new cottage development in the upper part of the slope. First spontaneously sprouting plants of opuntia on this area are dated to the same period. Their first sprouting place was refuse dump, where separate segments occurred after pruning of plants used in landscaping of house territory. Later opuntia spread down the watershed ridge probably because of accidental mechanical damage caused by man. At present populations consists of no less 5 large (height – 40-50 sm) specimens, propagated by segment establishment. Three of them have got the stage of active blossoming and bearing fruits, but another two specimens are on pregenital stage. There is also a young plant with seed origin, inhabited in the line of a limestone rock. Rest of specimens grows either on rocky outcrops of limestone or clay-rubbly and scree slopes, either on open up places or in the shadowed, partly under the crown of not high deciduous trees. Area of *O. Lindheimeri* growing in this locality makes approximately 100 m². The total projective vegetative cover is 60%, but study opuntia cultivar occupies no more than 3 % of the area, but on the upper part

of the slope this value gets 15%. Natural vegetative cover of the area is composed of fragments of pistachio lighted forests with cenoses of limestone rocks, stony floral chaos and elements of petrophyte variants of Mediterranean steppes (classes of *Quercetea pubescenti-petraeae* (Oberdorfer 1948) Jakucs 1960, *Asplenietea trichomanis* и *Thero-Brachypodietea*). A dominant is *Pistacia mutica*, *Celtis glabrata* Steven ex Planch., *Rhus coriaria* L., *Jasminum fruticans*, *Clinopodium nepeta*, *Taraxacum hybernum*. An important role belongs to adventive plants (*Prunus cerasifera* Ehrh., *P. dulcis* (Mill.) D.A. Webb, *Lonicera etrusca* Santi) and a weed component (*Ballota nigra* L., *Carduus pycnocephalus* L. subsp. *albidus* (M. Bieb.) Kazmi, *Galium aparine* L.). Considerable increasing of anthropogenic effect on this area last decades, including pollution by construction waste and household rubbish, trampling down, more frequent fire cases, destroying of natural vegetation as well as possible sources of plants in close proximity favor spreading of alien plants, such dangerous potential species-transformers as opuntia.

One more locality of adapted *O. Lindheimeri* population is a territory of nature reserve “Mys Martiyan” [4,29], bordered to buildings of a former military unit, situated 200 – 250 m to East from the village of Nikitsky Botanical Gardens, on 180-190 m altitude above the sea level (Fig.6).

Source of invasion is vegetation planted on the military unit area in 1950 – 1970. At present opuntia renews by vegetative and seed ways as in residential zone as in natural phytocenoses of the reserve. This habitat is characterized by outcrops of limestone on the daylight surface, as a result the soil cover consists of carbonate varieties of brown soils in dry forests and brushes. Growth and single specimens of opuntia on the reserve territory belong to highly juniper and bushy oak cenoses (class *Quercetea pubescenti-petraeae*), total projective cover makes 50 – 70%, *O. lindheimeri* occupies till 15 – 30%. Woody shrub layer presents *uniperus excelsa* (till 25 – 30%), *Quercus pubescens* Willd., *Pistacia mutica*, *Juniperus deltoides* R.P. Adams, *Carpinus orientalis* Mill. и *Fraxinus angustifolia* L. (till 10 – 15%), *Jasminum fruticans* (от 5 до 30%), *Cistus tauricus* (от 10 до 30%), *Clematis vitalba* L. (до 25 – 30%), *Ruscus aculeatus* L. (до 45%), *Hedera helix* L. (до 10%), single instance *Cornus mas* L. Dominants in the herb layer are *Dactylis glomerata*, *Elytrigia repens* (L.) Nevski, *Taraxacum erythrospermum* Besser, *T. hybernum*, *Geranium robertianum* L., *Teucrium chamaedrys*, highly stable but not having a high projective cover: *Aegonychon purpureocaeruleum* (L.) Holub, *Prospero autumnale*, *Fibigia clypeata* (L.) Medik., *Melandrium album* (Mill.) Garcke., *Achnatherum bromoides* (L.) P. Beauv., *Crepis pulchra* L., *Stachys velata* Klokov, *Melilotus neapolitanus* Ten. And etc. Synanthropic species: *Diploaxis tenuifolia* (L.) DC., *Galium aparine*, *Chenopodium album* L., *Marrubium peregrinum* L.

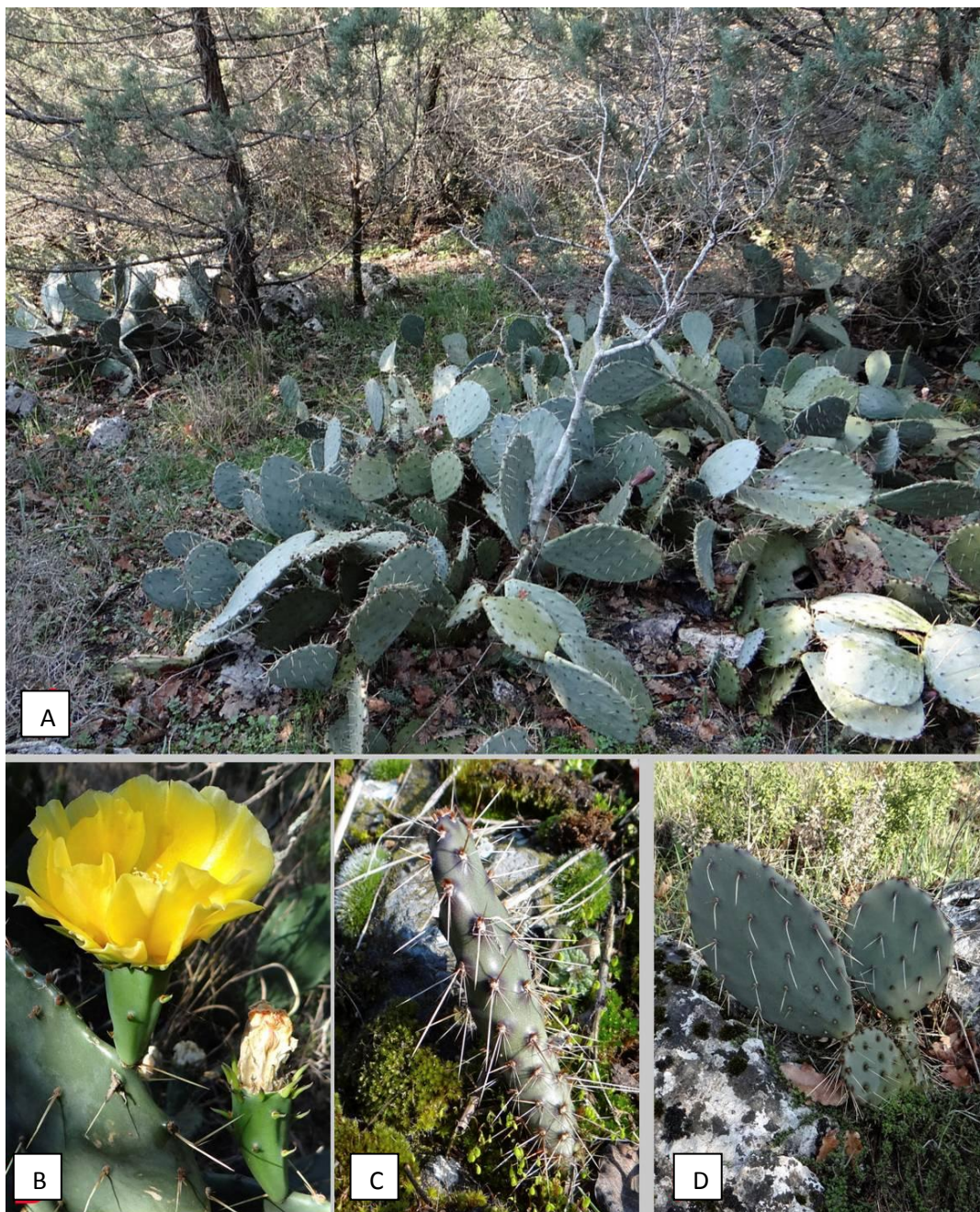


Fig. 6 Population of *O. Lindheimeri* in the natural reserve “Mys Martiyan”:
A – general cenosis view with opuntia; B – a flower; C – a juvenile plant; D – an immature specimen with seed origin

Naturalized population occupies territory more than 150 m². It has some groups sized from 2 till 4,5m (each group has 8-12 plants), besides along the perimeter of growth there are specimens of generative, virginal and juvenille plants. Total number of plants makes more thn 80. Percentage of generative specimens is more than 80% plants, in opuntia growth it was found more than twenty seedlings of last and current years. Most of plants fructify abudantly, segments have 1-10 fruits, an average number is 5-6. Segments are big 25-30sm by length, fruit form is oblong, characteried by quite big size (till 7 sm by length and 3,3 sm across diameter). In most cases opuntia plants grow on gaps between trees, where has an abundant bearing fruit. Basically virginal speciemens are noted under tree crowns.

Several running wild cactuses including opuntia, were found on area of village Gaspra, on the seaside slopes of western spur of Cape Aj-Todor (Mayachny) within area of sanatorium "Dnepr" (former estate "Kharaks"). Five groups and separate specimens of *O. Lindheimeri* (total number is 75 – 85 specimens) are spread on the plot of 550-600 m on precipitous seaside slopes (slope angle ranges from 15 till 60°) of southern and southeast expositions with altitude range of 20 – 45 m above the sea (fig.7A), as well as on the park clumps (fig.7C). Natural vegetative cover combined of bush growth of *Cisto-Micromerietea julianae* class and fragments of petrophyte and steppe vegetation of *Festuco-Brometea* class, is extremely damaged, as in 1970-th a considerable part of slopes was covered by antilandslide layer made of armature and concrete (fig.7A). At present such ground has its dominants: naturalized introduced cultivars (*Petrosedum reflexum* (L.) Grulich, *Bupleurum fruticosum* L., *Centranthus ruber* (L.) DC., *Jacobaea maritima* aggr. (= *Senecio cineraria* DC.), *Antirrhinum majus* L., *Cheiranthus cheiri* L.), where occurrence of opuntias was fixed. The total projective cover of these synantropic cenoses makes 5-20%. Majority of *O. Lindheimeri* plants on slopes, most probably were planted in 1970 – 1980-th. [22], young specimens on terraces at flights of stairs might have been planted recently (last years) together with other representatives of *Opuntia* genus from Cactaceae family.

Self-renewed separately growing specimens of opuntia or their groups, consisting of 3-14 adult specimens, are found in the lower and middle parts of slopes, or on the rocky outcrops of limestone or rubbly and clay slopes in a composition of half-natured cenoses among single growing trees of *Quercus pubescens*, *Pinus brutia* Ten., *Jiniperus excels* (fig. 7B). Bushy and herb layers contain *Paliurus spina-christi*, *Cistus tauricus*, *Jasminum fruticans*, *Elytrigia caespitosa* subsp. *nodosa*, *Taraxacum hybernum*, *Prospero autumnale*, *Alyssum obtusifolium* Steven ex DC. and etc. Besides them among adventive cultivars there were revealed mentioned-above introduced plants, and *Rhamnus alaternus*, *Ailanthus altissima* as well. The total projective cover makes 30-40%, *O. Lindheimeri* occupies 5-10%. Inspection of present population state was carried out in late autumn period – November 2014, that didn't allow reveal the floristic composition completely. Diameter of adult opuntias or their groups makes 1,2 – 4,5m, height of plants is 60-90sm. Mostly populations include generative plants, which had abundant bearing fruits, number of fruits on segments is 2-10, average number is 7-8. Fruits have diverse form and size. Sometimes (single cases) juveniles with seed origin and immature specimens with vegetative origin were found on park clumps and slopes (fig. 4C). In western part of the park on damaged by man slope separate specimens or clumps of *O. tunoidea* were marked next to *O. Lindheimeri* plants. Cultivated and naturalized plants of the second type of opuntia occur more often on clumps and seaside slopes in the central and east parts of sanatorium "Dnepr".



Fig.7 Opuntia on the territory of sanatorium “Dnepr”:

A – two cultivars of opuntia in anthropogenically converted biotopes on the seaside slopes; B – virginal specimen of *O. lindheimeri* in a half-natured cenosis; C – juvenile, immature and generative *O. lindheimeri* plants on a park clump

Other localities of South Coast of the Crimea contain single spontaneously growing *O. lindheimeri* plants. One of them was found in 2014, within outskirts of Alushta – 1 km to west from village Lazurnoye on the steep seaside slope of Khalikin-Tepesi mountain, composed of clay slates of Triassic period so-called “Granilnya Golovkinskogo”. *Opuntia* (bearing fruit specimen) grows on the altitude of about 10m above the sea, on the slope of east exposition with the slope angle of 20° on site of landslip, zone of short-sized oak and

pistachio light forests (class *Quercetea pubescenti-petraeae*), among growth of *Ruscus aculeatus* and *Cotinus coggygria* Scop. As in the nearest locality there is no any seed sources, perhaps *O. Lindheimeri* specimen has an ornithogenic origin, otherwise seeds were brought by birds presumably from cape Plaka, 3 km to the east.

A small *O. Lindheimeri* population, to our opinion, of 2-3 years, was revealed by Belych T.V (oral report) on the watershed range, adjoined from North to Ayu-Dag mountain, district of the cottage village "Novaya derevnya". This locality is situated at altitude about 225 m above the sea, it's the highest point out of all localities containing this cultivar plants on South Coast of the Crimea. Opuntia grows two meters from macadamized road on a glaciis of the northwest exposition of clay slates in herbaceous cenoses which include *Bothriochloa ischaemum*, *Hordeum bulbosum* L., *Poa bulbosa* L., *Clinopodium nepeta*, *Prospero autumnale*, *Taraxacum hybernum*, *Plantago lanceolata* L., small annual plants as well (a vegetable variant with anthropogenically damaged cycle of *Koelerio-Corynephoretea* class). The population occupies about 1m², includes three vegetative fruitless specimens of 20sm height; it consists of 2 – 10 segments and one separate established cladode. All specimens have vegetative origin. Plants are in the depauperated condition, probably caused by unfavorable hydrothermal regime (excess humidity and too low air temperature in winter) and anthropogenic effect. The population origin is a sequence of plant rubbish dump being next to its emergence. Cultivated opuntia specimens were found on territories of neighboring housing estates.

The eastern point of cultivated and naturalized opuntia *O. lindheimeri* (data of 2014) is situated to east of village Solnechnogorskoye (Fig.8). The total area where opuntia was found in this locality makes 1,5 ha; it was revealed more than 50 specimens, what makes less 3% of the given territory, dominants are introduced plants on purpose. Cultural plantations of opuntia were found on terraces, adjoined to housing estates (Fig. 8, C, D) down the highway Alushta-Sudak and up the area of geological monument of nature "A part of the seaside territory between Solnechnogorskoye vil. and Malorechenskoye". Most part of vegetation are generative, but there were found immature specimens with vegetative origin as well. Besides opuntia there are other cultivars on terraces (*Juniperus excelsa*, *Cedrus deodara* (Roxb.) G. Don, *Pinus brutia*). Opuntia plants have been cultivated in half-natured cenoses that cover seaside slopes. Natural vegetative cover of this area is probably composed fragments and derivatives of blue grass and knotty coach grass, wormwood petrophyte steppe assemblages of *Festuco-Brometea* class, pistachio light forests and efemeretum of *Koelerio-Corynephoretea* and *Thero-Brachypodietea* classes. *Orijective cover of steppe cenoses makes 30-50 %*. In floristical composition the principle role goes to *Bothriochloa ischaemum*, *Elytrigia caespitosa* subsp. *nodosa*, *Artemisia lerchiana* Stechm., *Alyssum umbellatum*, *Convolvulus cantabrica*, *Eryngium campestre*, *Taraxacum hybernum*, *Poterium polygamum* Waldst et Kit and etc., in arboreal and bush layer: *Pistacia mutica*, *Jasminum fruticans* are emphasized. Some synatrobe plants were revealed (*Echium italicum* L. subsp. *biebersteinii*, *Tribulus terrestris*, *Malva erecta* J. Presl. et C. Presl.). Opuntia plants are mainly represented by virginal specimens consisting of 2 – 8 segments.



Fig.8 Cenopopulation of *Opuntia lindheimeri* growing on area between villages Solnechnogorskoye and Malorechenskoye: A,B – single plants of opuntia on the seaside cliff; C,D – general view of the slope with plantations, opuntia specimen is on the house territory.

Cultivated young specimens and spontaneously sprouting single plants with vegetative origin were found on the edge and stony positions of the cape, composed of quartzitic sandstone (Fig. 8 A,B), deeply cracked and spotted with small and round hollows. At the bottom of the cape there is a disorderly bulk of boulders; rocks rise above the sea in a seaside zone. Cenoses located on the seaside and steep slopes (slope angle from 20-30 till 60-70°) of southeast expositions with the common projective cover of herbage 10-40% the followings have been frequently found: *Ephedra distachya* L., *Artemisia lerchiana*, *Kochia prostrata* (L.) Schrad., *Galatella linosyris* (L.) Rchb.f., *Teucrium polium* L. *Elytrigia caespitosa* subsp. *nodosa*, *Capparis herbacea* Willd.

Generally the percentage of spontaneously sprouted opuntia plants for counted specimens what is no more than 10%; they grow in the middle part and bottom of the steep seaside slopes at altitude 10-15 m above the sea level among bulks of boulders and stones. It is possible to presume that further opuntia can spread the cape territory and its adjacent zone.

Lately wild *O. Lindheimeri* was found in the western part of South Coast of the Crimea, settlements Foros and Simeiz. Foros park contains 5 localities with 19 sprouted opuntia specimens. 8 specimens having vegetative origin consist of 10-20 cladodes, six specimens have 1-7 segments and 5 specimens with seed origin (3 of them are juvenile plants) have from 2 till 4 segments. All plants weren't in a bearing fruit period at the moment of inspection (23-24.11.2014). Opuntia is mainly spread out on the seaside limestone slopes of the southern and southeast expositions at altitude 10-15m above the sea level, slope angle is 10-35°. Vegetation cover is damaged significantly in most localities, common projective cover makes 20-40%, *O. Lindheimeri* occupies no more than 5%. Large specimens of *Pistacia mutica* are found rarely; dominant species are *Rhus coriaria*, *Jasminum fruticans*, *Hordeum bulbosum*, *Dactylis glomerata*, *Taraxacum hybernu*. Plant cultivars which mostly grow in synathrope localities are found here as well: *Carduus pycnocephalus* subsp. *albidus*,

Rhagadiolus edulis Gaertn., *Chondrilla juncea* L., *Lepidium draba* L., *Galium aparine*. Adventive plants are also revealed there: *Ailanthus altissima*, *Sonchus oleraceus* L., *Jacobaea maritima* aggr., *Cheiranthus cheiri*. Some juvenile and immature *O. Lindheimeri* specimens grow on artificial stone hill (Fig.9 B) 3,5 m height with more than 25 m² of total area. Dominants of this cenosis is *Opuntia humifusa*; while *Sedum pallidum*, *Anizantha sterilis* (L.) Nevski, *Geranium robertianum*, *Galium aparine*, *Lathyrus* sp. are found frequently; and adventive plants - *Setaria viridis* (L.) P. Beauv., *Ailanthus altissima*, *Cheiranthus cheiri*. Separate juvenile and virginal specimens are found on the park clumps (Fig. 9C).

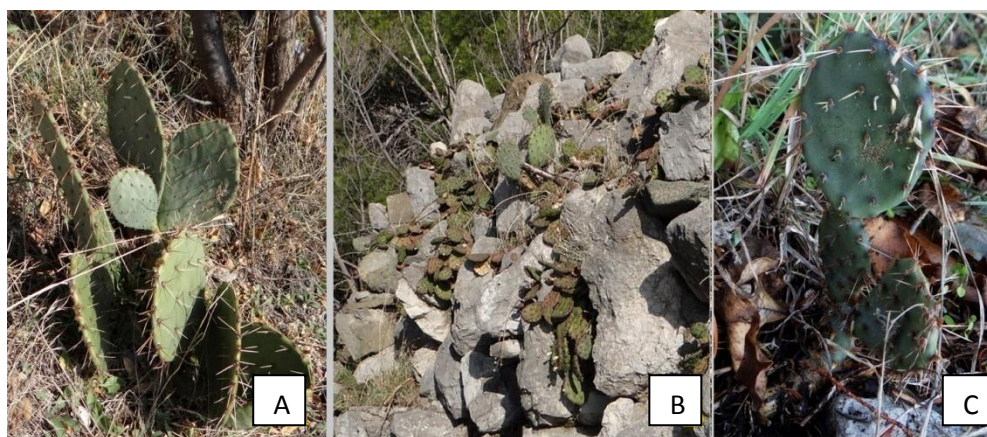


Fig.9 *Opuntia lindheimeri* in Foros park:

A – pregenerative specimen with vegetative origin on the seaside slope; B,C – juvenile specimens on the stone hill and park clumps

In Simeiz, Krasnomayachnaya street, at altitude of 75 m above the sea level on the steep rubbly scree limestone slope of the southern exposition it was found a fruit bearing specimen of *O. lindheimeri* with vegetative origin. This slope is covered by natural plant cenosis – light forest of *Quercus pubescens* and *Juniperus excels* with *Prunus dulcis* and *Rhus coriaria*. Dominant in the herb layer is *Euphorbia rigida* M. Bieb. Vegetation is an ecotone derivate cenosis of *Quercetea pubescentis-petraea* and *Thero-Brachypodietea* classes. The most popular anthropogenic effect on this area is constructional waste and household rubbish. Obviously opuntia segments occurred here with rubbish some years ago. According to still unproved oral reports, single specimens of opuntia grow on the area of natural monument “Cat Mountain”. Favorable biotopes and opuntia cultivation stimulate further invasion of this cultivar in Simeiz and its outskirts.

Morphological peculiarities of plant, growing in all revealed localities correspond to *O. lindheimeri*. description mentioned above. Wild plants of *O. engelmannii* s. str., cultivated in Nikitsky Botanical Gardens and some other parks of South Coast of the Crimea, haven't been registered.

Conclusions

According to the research, wild plants of large opuntia growing in South Crimea belong to *O. lindheimeri* (*O. engelmannii* subsp. *lindheimeri*), but not to close taxon *O. engelmannii* (*O. engelmannii* subsp. *engelmannii*) as it was supposed before.

In period 2013 – 2014 it was investigated known before and new-found localities of naturalized *O. Lindheimeri* population in South Crimea. At present following points of this opuntia cultivar spontaneous sprouting have been revealed and studied: Foros, Simeiz, Gaspra, Cape Martiyan, Guruf, Artek, piedmont of Ayu-Dag mountain, Cape Plaka, outskirts of Lazurnoye, Solnechnogorskoye. For the first time nine localities have been described.

Population of *O. Lindheimeri* has been found in lower zone of South Coast of the Crimea at altitude 5-225 m above the sea level (characterized by subtropical climat of mediterannian type) on diverse skeletal brown soils, on glacis and steep slope of different expositions of various rocks (limestone of Massandra formation, clay slates of Triassic period, intrusive igneous rocks), on rocks, landslide and scree rubbly and clay slopes among high juniper, pistachio and pubescent oak light forests, bush growth and herb cenoses, composed of petrophyte dwarf subshrubs, perrenial and small efemers in anthropogenically effected and more natural biotopes.

Almost all localities have plants chracterized by high vital parametres with plentiful blossoming and bearing fruits often with seed propagation, besides population at the northern piedmont of Ayu-Dag mountain. Considerable increasing of some populations size and occupying territory has been noted for last 20-30 years. New localities of this cultivar naturalization and intensive invasion into anthropogenically effected and natural cenoses have been found as well. These facts certify a high-level invasive activity of *O. Lindheimeri* in South Crimea, its further spreading, that`s why monitoring of the cultivar tends is essential for this region.

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Bagrikova N.A., Ryff L.E. Invasive cultivar of *Opuntia lindheimeri* Engelm. growing in South Crimea // Works of the State Nikit. Botan. Gard. – 2014. – V. 139 – P. 43 – 62.

The article concerns assessment of the current state of *Opuntia lindheimeri* Engelm. cenopopulations, one of the most dangerous invasive plants of the region, and distribution of this cultivar across South Crimea. Systematic position of the taxon previously identified as *O. engelmannii* was clarified. Morphological description of the form running wild in the Crimea was provided. Ten localities of spontaneous growth of opuntia cultivar were revealed and characterized. Its further spread trends are discussed as well.

Key words: *invasive cultivars, morphological description, Opuntia lindheimeri, Opuntia engelmannii, the Crimea, Nature Reserve “Cape Martyan”*.