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Verrucario viridulae-Staurotheletum hymenogoniae, a new calcicolous lichen community as a component of petrophytic grassland habitats in the Northern Black Sea region

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Abstract. The new lichen association, *Verrucario viridulae-Staurotheletum hymenogoniae* (*Aspicilion contortae* Roux 2009, *Aspicilietalia calcareae* Roux 2009, *Verrucarietea nigrescentis* Wirth 1980) is described here. It is formed on marl limestone pebbles in arid landscapes in the Northern Black Sea lowland. Forty-six species of lichens and ten lichenicolous fungi were observed and *Staurothele hymenogonia*, *Verrucaria muralis* s. lat., *V. viridula* are diagnostic for the association. The new association is a component of the Nord-Pontic calcicline pale fescue grasslands habitats (EUNIS). It occurs in protected areas "Yelanetsky Steppe" (Mykolayiv region), "Troitska balka" (Zaporizha region), the National Nature Park "Kam`yanska Sich" and the Regional Landscape Park "Gavrylovsky" (Kherson region).
Keywords: Ukraine, *Aspicilion contortae*; EUNIS; Phytocenology; Syntaxonomy.

Verrucario viridulae-Staurotheletum hymenogoniae, una nueva comunidad de liquenes calcícolas de los hábitats de pastizales petrofíticos en la región norte del Mar Negro

Resumen. Se describe la nueva asociación liquénica *Verrucario viridulae-Staurotheletum hymenogoniae* (*Aspicilion contortae* Roux 2009, *Aspicilietalia calcareae* Roux 2009, *Verrucarietea nigrescentis* Wirth 1980) que crece sobre guijarros de piedra caliza en zonas áridas del norte del Mar Negro. 56 especies de líquenes y 10 de hongos liquenícolas fueron observados; *Staurothele hymenogonia*, *Verrucaria muralis* s.l. y *V. viridula* son las especies diagnósticas de la asociación. La nueva asociación es un componente del hábitat de pastizales Nord-Pónticos de *Festuca pallens* (EUNIS); aparece en áreas protegidas como "Estepa Yelanetsky" (región de Mykolayiv), "Troitska balka" (región de Zaporizha), el Parque Nacional "Kam`yanska Sich" y el Parque Regional "Gavrylovsky" (región de Kherson).
Palabras clave: Ucrania, *Aspicilion contortae*; EUNIS; Fitocoenología; Sintaxonomía.

Introduction

The syntaxa are used for indication of the environment, assessment of landscape biodiversity conservation and formation of the protected areas in the national and regional ecological networks. The syntaxonomic classification of vegetation is a background for habitat ranking which has recently become important in nature conservation NATURA 2000. Although the basis for habitat classification is vegetation of vascular plants, communities of bryophytes, lichens and algae are particularly important in habitats where vascular plants are sparse or almost absent. The syntaxonomy of these communities is currently developed (Khodosovtsev & *al*., 2011; Bültmann & *al*., 2015; Mucina & *al*., 2016). Most lichen communities are ignored by phytocenological classifications produced by botanists, but epilithic calcicolous lichen communities are involved in classifications of steppe habitats. When we classified habitats on carbonate outcrops within the Northern Black Sea lowland, we realized that existing geobotanical studies only insufficiently characterize the lichen communities present in the Northern Black Sea lowland and we provide more comprehensive descriptions here. Moreover, we found a petrophytic community within *Aspicilion contortae* Roux 2009 that has specific species composition and that is described here as a new association.

Surveyed territory

The study area covers the Black Sea lowland formed by Neogene sediments. Light Sarmatian Miocene with the Pontic Neogene limestones and yellow-brown clays are outcropp in the study region. Usually, Quaternary loess sediments covered these rocks (Marynych & Shyshchenko, 2005). The geomorphological structure of the lowland is characterized by slightly wavy landscapes, which are dissected by river valleys and dry gullies up to 50 m deep. The altitude range in the territory is 0 to 179 m. Annual precipitation is low, 400-500 mm per

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year; 250-300 mm falls during the summer period. The average annual temperature is 9-10˚C, the average June temperature is 23-24˚C and average January temperature -3 – -4˚C (Babichenko & *al*., 1984; Marynych & *al*., 1985). Arid conditions of the territory are intensified by fast desiccation of prevailing porous, well-aerated carbonate substrates. Predominant vegetation types in the territory are grass-womwood steppes and meadows of the Dnipro-Azov geobotanical district, grass steppes, meadows and vegetation of limestone outcrops of the Bug-Ingul district (Didukh & Shelyag-Sosonko, 2003).

Among habitat diversity in the Black Sea region, we studied petrophytic steppes where limestone sediments protruded on the dry gullies slopes and rivers banks. These outcrops have been destroyed with age and anthropogenic activity (weathering, erosion, grazing). These habitats have very thin soils that are extremely rich in coarse fragments of bedrock (leptosols according to the IUSS Working Group WRB, 2015). Generally, these habitats appear as white spots or lines along dry gullies slopes of various steepness (5-35˚) and exposure.

Materials and methods

The field research was performed in May and June 2017 in the Kherson region (Novovorontsovsky, Bilozersky, Beryslavsky districts) and the Mykolayiv region (Beryznigovatsky district) in Ukraine. We also used relevés made in 2008 in the Zaporizha region (Melitopolsky district) (Figure 1). Descriptions of communities of vascular plants and terricolous and saxicolous lichen communities were carried out in 5 x 5 m test plots. Lichens on pebbles (stone fragments of 1-10 cm diameter) were collected in different parts of plots (5-10 different pebbles). The percentage of the coverage for saxicolous lichens was determined from the total area of pebbles in the plot. The percentage of the coverage for terricolous lichens, bryophytes and vascular plants was established from the total area of soil in the plots. Identifications of lichens and lichenicolous fungi were done using microscopes MBS-1 and MICROMED-2. 15 relevés of terricolous, 15 relevés of saxicolous lichen communities and 15 relevés of vascular plant communities were used for the analysis. The numbering of relevés and their description are presented on Figure 1 and Table 1. The Braun-Blanquet scale of abundance was used in the descriptions: r, the species is very rare, the coverage is negligible; +, the species is rare, has a small coverage up to 1%; 1, coverage 1-5%; 2, coverage 6-20%; 3, coverage 20-50%; 4, coverage 50-75%; 5, coverage more than 75%. Constant classes: I, less than 20%, II, 21-40%, III, 41-60%, IV, 61-80%, V, 81-100%. Constant species were pointed out as species with a frequency above 60% (grade IV and V). Characteristic species are those of lower frequency (II and III classes). Dominant species are those with a coverage above 20% (Khodosovtsev & *al*., 2011). The new lichen association was described in accordance with the phytosociological recommendations (Weber & *al*., 2000). The comparison of the similar syntaxa with new association was carried out in the STATISTICA 6.0 StatSoft Inc. 2014 (Ward's method and Euclidean distances). For the construction of the graph, information on the constancy of species from 3 associations and 3 sub-associations was used. The species lists of these associations taken from relevés and synoptic tables in O. Klement (1955) and C. Roux (1978). In the working table, data of constant class (from I to V) were transformed in numerical designations from 1 to 5 and 0 if the species is absent (Khodosovtsev & *al*., 2017). Names of lichens and lichenicolous fungi follow Index Fungorum (Index Fungorum, 2017). The specimens collected in the type locality of the new lichen association are deposited in the Herbarium of the Kherson State University (KHER). The nomenclature of vascular plants follows Mosyakin & Fedoronchuk (1999). The following abbreviations are adopted in the Tables 1 and 2: ass., association, C, constancy.

The difficult group of lichens in *Circinaria* (*Aspicilia*) *calcarea* group, *Xanthocarpia* (*Caloplaca*) *crenulatella* group and *Verrucaria* were identified following Roux & *al*., (2016), Vondrák & *al.* (2011) and Breuss (2007). For the maximum comparison of relevés (Klement, 1955; Roux, 1978), we used the following taxonomic generalizations in Table 2:

Calogaya pusilla (A. Massal.) Arup, Frödén & Søchting (= *Placodium saxicola* sensu Klement 1955: 73; *Caloplaca murorum* (Ach.) Th. Fr.).

Diplotomma hedinii (H. Magn.) P. Clerc & Cl. Roux (= *Buellia epipolia* sensu Cl. Roux 1978: 132, 143).

Flavoplaca oasis (A. Massal.) Arup, Søchting & Frödén (= *Caloplaca tenuatula* sensu Cl. Roux 1978: 132, 146; *C. lithophila* sensu Cl. Roux 1978: 133, 138; 147; incl. *Caloplaca tenuatula* f. *athallina* Clauzade & Cl. Roux).

Flavoplaca flavocitrina (Nyl.) Arup, Frödén & Søchting (= *Caloplaca citrina* sensu Cl. Roux 1978: 132).

Lecania rabenhorstii (Hepp) Arnold (= *Lecania erysibe* sensu Cl. Roux 1978: 133, 143).

Myriolecis dispersa (Pers.) Śliwa, Zhao Xin & Lumbsch s.lat. (incl. *M. invadens* (H. Magn.) Śliwa, Zhao Xin & Lumbsch, *M. hagenii* Śliwa, Zhao Xin & Lumbsch.

Pyrenodesmia variabilis s. lat. (incl. *Caloplaca alpestris* (Ach.) Ozenda & Clauzade).

Verrucaria muralis Ach. s. lat. (incl. *Verrucaria schindleri* Servit sensu Khodosovtsevmust & Darmostuk, 2018).

Verrucaria tectorum (A. Massal.) Körb. (= *Verrucaria nigrescens* (forme isidiée) sensu Cl. Roux 1978: 143).

Verrucaria nigrescens Pers. (= *Verrucaria fusca* sensu Cl. Roux 1978: 147).

Xanthocarpia crenulatella (Nyl.) Frödén, Arup & Søchting s.lat. (= *Caloplaca pyracea* sensu Klement 1955: 73).

Other synonyms in paper of Cl. Roux (1978) presented in Table 2 follow Roux & *coll*., (2017).

Table 1. Selected relevés of *Verrucario viridulae-Staurotheletum hymenogoniae* ass. nova (*Aspicilion contortae*, *Aspicilietalia calcareae*, *Verrucarietea nigrescentis*)

Altitude (m asl)	41	16	29	44	22	21	28	25	42	25	16	41	50	39	
Inclination (˚)	30	10	25	20	30	20	30	30	15	20	10	30	10	25	
Exposure	SW	E	E	NE	S	E	N	S	SE	S	E	S	W	N	
Cover pebbles with lichens (%)	20	15	30	25	40	50	35	40	20	40	40	40	40	50	
Ref. N.	210	211	214	240	242	480	269	476	479	249	483	245	246	247	C
N. species	7	24	18	23	14	16	19	21	12	24	12	12	26	16	
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Diagnostics of *Verrucario viridulae-Staurotheletum hymenogoniae*															
Verrucaria viridula (Schrad.) Ach.	2	2	2	+	2	2	3	1	+	+	2	1	2	1	V^{r-3}
Verrucaria muralis Ach. s.l.	1	1	+	.	+	1	2	+	.	+	+	+	+	1	V^{+-2}
Staurothele hymenogonia (Nyl.) Th. Fr.	1	.	.	.	.	+	2	2	r	.	+	.	+	1	III^{+-2}
Diagnostics of *Caloplacetum lactea-marmoratae*															
Xanthocarpia marmorata (Bagl.) Frödén, Arup & Søchting	.	2	1	+	+	+	2	+	+	+	+	.	+	+	IV^{+-2}
Diagnostics of *Aspicilion contortae*															
Circinaria contorta (Hoffm.) A. Nordin, Savić & Tibell s.str.	.	2	+	2	.	+	2	+	.	2	+	2	2	2	V^{+-2}
Rinodina bischoffii (Hepp) A. Massal.	.	2	+	+	+	1	2	+	+	2	+		2	2	V^{+-2}
Sarcogyne regularis Körb.	+	2	1	+	1	+	1	+	+	1	1	+	1	1	V^{+-2}
Clauzadea metzleri (Körb.) Clauzade & Cl. Roux ex D. Hawksw.	.	+	1	.	.	.	.	.	.	.	+	.	.	.	II^{+-1}
Diagnostics of *Aspicilion calcareae*															
Placopyrenium fuscellum (Turner) Gueidan & Cl. Roux	.	+	.	1	1	.	+	.	+	+	.	.	1	1	III^{+-1}
Lobothallia radiosa (Hoffm.) Hafellner	.	+	.	+	.	.	.	.	.	.	.	.	.	.	I^{+-1}
Diagnostics of *Caloplacion decipiens*															
Calogaya pusilla (A. Massal.) Arup, Frödén & Søchting	.	.	.	+	.	.	.	.	.	.	.	.	r	.	I^{r-+}
Calogaya decipiens (Arnold) Arup, Frödén & Søchting	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I^{+}
Diagnostics of *Acarosporion cervinae*															
Verruculopsis lecideoides (A. Massal.) Gueidan & Cl. Roux	+	1	.	.	.	+	2	+	.	.	+	.	.	.	II^{+-2}
Diagnostics of *Caloplacion arnoldii* Roux 2009															
Myriolecis crenulata (Ach.) Śliwa, Zhao Xin & Lumbsch	.	+	+	.	+	.	.	.	.	2	.	+	+	+	III^{+-2}
Diagnostics of *Aspicilietalia calcareae*															
Circinaria calcarea (L.) A. Nordin, Savić & Tibell	.	2	+	1	2	2	2	+	+	2	.	2	.	2	IV^{+-2}
Bagliettoa calciseda (DC.) Gueidan & Cl. Roux	.	+	.	+	1	.	2	+	+	3	.	1	2	.	IV^{+-3}
Diplotomma hedinii (H. Magn.) P. Clerc & Cl. Roux	.	.	.	.	.	.	.	.	.	.	.	.	r	.	I^{r}
Diagnostics of *Verrucarietea nigrescentis*															
Verrucaria nigrescens Pers.	+	4	4	2	2	2	2	2		2	3	2	2	2	V^{+-4}
Pyrenodesmia variabilis (Pers.) A. Massal.	.	1	2	2	2	+	.	.	+	+	.	+	2	.	IV^{+-2}
Candelariella aurella (Hoffm.) Zahlbr.	.	1	+	2	+	.	.	+	+	1	.	1	1	.	IV^{+-1}

Xanthocarpia crenulatella (Nyl.) Frödén, Arup & Søchting s. lat.	.	2	+	2	.	1	2	+	+	2	2	1	2	2	V^{+-2}
Flavoplaca oasis (A. Massal.) Arup, Frödén & Søchting	.	.	+	2	.	.	+	+	.	1	.	1	.	.	III^{+-2}
Myriolecis semipallida (H. Magn.) Śliwa, Zhao Xin & Lumbsch	.	.	.	1	+	.	.	.	.	+	.	.	+	+	II^{+-1}
Myriolecis dispersa (Pers.) Śliwa, Zhao Xin & Lumbsch	.	+	.	.	.	.	+	.	.	1	.	.	.	.	II^{+-1}
Lecania turicensis (Hepp) Müll. Arg.	.	+	.	+	.	+	.	.	.	.	.	.	+	.	II^{+}
Rinodina calcarea (Hepp ex Arnold) Arnold	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I^{+}
Verrucaria macrostoma Dufour ex DC.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	I^{1}
Diagnostics of *Clauzadeetea immersae*															
Aspicilia coronata (A. Massal.) B. de Lesd.	.	1	.	.	.	.	.	.	.	1	+	.	.	.	I^{1}
Baglietto a parmigera (J. Steiner) Gams	.	.	.	+	.	.	.	.	.	+	.	.	.	.	I^{+}
Clauzadea immersa (Hoffm.) Hafellner & Bellem.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I^{+}
Protoblastenia rupestris (Scop.) J. Steiner	.	.	.	.	.	1	.	.	.	.	.	.	.	r	I^{r}
Rinodina immersa (Körb.) J. Steiner	.	.	.	.	.	.	.	.	.	2	.	.	.	.	I^{2}
Other species															
Pyrenodesmia concreticola (Vondrák & Khodos.) Søchting, Arup & Frödén	.	+	.	.	.	.	+	+	.	.	.	.	.	.	I^{+}
Aspicilia calcarea (L.) Mudd morpho. xerophile	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}
Caloplaca microstepposa Frolov, Nadyeina, Khodos. & Vondrák	.	.	.	.	+	.	.	.	.	2	.	.	.	.	I^{+-2}
Flavoplaca coronata (Kremp. ex Körb.) Arup, Frödén & Søchting	.	.	.	2	.	.	.	.	.		.	.	.	.	I^{2}
Variospora glomerata (Arup) Arup	.	.	.	.	.	.	.	.	.	+	.	.	r	.	I^{r-+}
Arthonia calcicola Nyl.	.	.	.	.	.	+	.	.	.	2	.	.	.	.	I^{2}
Verrucaria tectorum (A. Massal.) Körb.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	I^{+-1}
Candelariella rosulans (Müll. Arg.) Zahlbr.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	I^{1}
Verrucaria cf. *transiliens* (Arnold) Lettau	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I^{+}
Scytinium plicatile (Ach.) Otálora, P.M. Jørg. & Wedin	.	.	.	.	.	.	.	.	.	.	.	.	.	+	I^{+}
Psorotichia montinii (A. Massal.) Forssell	.	.	2	.	.	.	.	2	.	.	.	.	.	.	I^{2}
Verrucaria papillosa Ach.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	I^{1}
Lichenicolous fungi															
Acaroconium punctiformis Kocourk. & D. Hawksw.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	I^{r}
Adelococcus interlatens (Arnold) Matzer et Hafellner	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Arthonia apotheciorum (A. Massal.) Almq.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}
Intralichen christiansenii (D. Hawksw.) D. Hawksw.	+	.	+	+	.	.	+	+	+	+	.	.	+	+	IV^{+}
Lichenochora wasseri S.Y. Kondr. s.lat.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I^{+}
Muellerella lichenicola (Sommerf.) D. Hawksw.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	I^{+}
Stigmidium clauzadei Cl. Roux & Nav.-Ros.	.	.	+												I^{+}

Zwackhiomyces lithoiceae (B. de Lesd.) Hafellner & V. John	.	.	.	.	.	.	+	.	.	.	.	.	.	.	I^{+}
Zwackhiomyces lecanorae (Stein) Nik. Hoffman & Hafellner	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I^{+}
Zwackhiomyces sp. 1	.	+	.	.	.	.	.	+	.	.	.	.	.	.	I^{+}

Localities: 1: Mykolayiv region, Yelanets district, village Uralske, "Yelanetsky Step" Nature Reserve, 47°33'43.3"N 32°01'29.5"E, 25.05.2017, A. Khodosovtsev, V. Darmostuk, Ya. Didukh; 2: Nova Odessa district, village Mykhaylovka, "Yelanetsky Step" Nature Reserve, department "Mykhaylyvsky step", 47°23'56.2"N 31°37'23.5"E, 26.05.17, A. Khodosovtsev, V. Darmostuk, Ya. Didukh; 3: same locality, 47°24'37.1"N 31°37'20.1"E; 44: Bereznigovate district, village Pryshyb, 47°12'48.6"N 32°50'14.9"E, 31.05.2017, A. Khodosovtsev, V. Darmostuk, Ya. Didukh; 5: village Zapovit, 47°05'50.3"N 32°58'28.8"E, 31.05.2017, A. Khodosovtsev, V. Darmostuk, Ya. Didukh; 6: village Novogrygorovka, 47°14'38.6"N 33°09'13.9"E, 06.05.2018, A. Khodosovtsev, V. Darmostuk; 7: Kherson region, Bilozerka district, village Zeleny Gay, 47°09'12.0"N 32°57'38.3"E, 06.05.2018, A. Khodosovtsev, V. Darmostuk; 8: Vysokopillya district, village Natalino, 47°28'40.9"N, 33°20'41.4"E, 5.05.2018, A. Khodosovtsev, V. Darmostuk, *holotypus ass.*; 9: village Rozovka, 47°32'49.7"N 33°11'32.9"E, 05.05.2018, A. Khodosovtsev, V. Darmostuk; 10: Beryslav district, village Dudchany, 47°06'27.2"N 33°41'01.8"E, 04.06.2017, A. Khodosovtsev, V. Darmostuk, Ya. Didukh; 11: Novovorontsovka district, village Gavrylovka, 47°12'01.3"N 33°49'59.8"E, 30.07.2017, A. Khodosovtsev, V. Darmostuk, I. Pylypenko; 12-14: village Osokorivka, Osokorivska balka, 47°27'31.3"N 33°51'27.8"E, 03.06.2017, A. Khodosovtsev, V. Darmostuk, Ya. Didukh, I. Pylypenko; 47°27'24.4"N 33°50'59.3"E; 47°27'47.5"N 33°52'03.6"E, A. Khodosovtsev, V. Darmostuk, Ya. Didukh, I. Pylypenko.

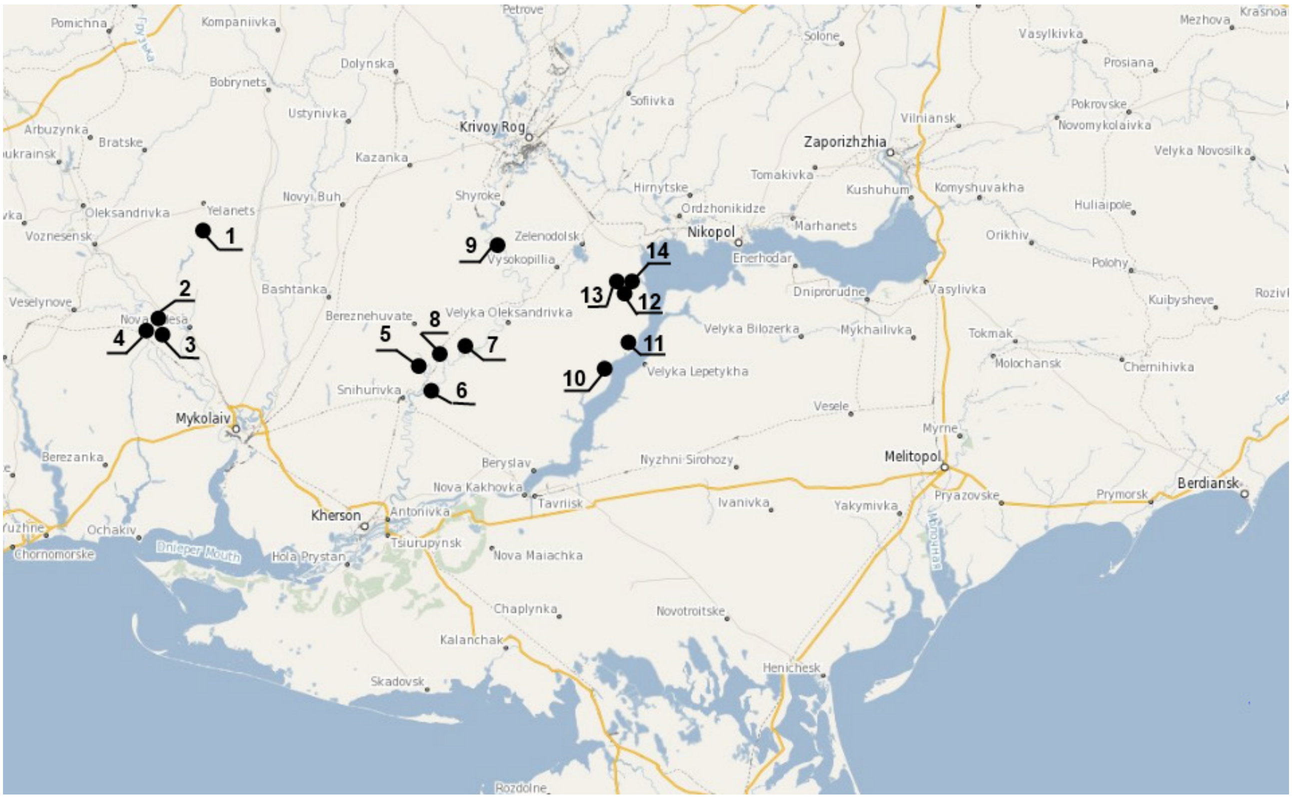

Figure 1. Localities and relevés of the association *Verrucario viridulae-Staurotheletum hymenogoniae* (numbering of the localities follows table 1).

Results and discussion

Verrucario viridulae-Staurotheletum hymenogoniae Khodosovtsev, Darmostuk & Didukh *ass. nova hoc loco*
Holotypus: Table 1, rel. 8, Figure 2.

Diagnostic species: *Staurothele hymenogonia, Verrucaria muralis*, *V. viridula.*

Constant species: *Bagliettoa calciseda, Candelariella aurella, Circinaria calcarea, C. contorta, Pyrenodesmia variabilis, Rinodina bischoffii, Sarcogyne regularis, Verrucaria nigrescens, V. muralis* s.l., *V. viridula, Xanthocarpia crenulatella, X. marmorata.*

Dominant species: *Bagliettoa calciseda, Verrucaria nigrescens, V. viridula.*

Symphysiognomy. More than 40% of species are endolithic lichens (e.g. *Arthonia calcicola, Aspicilia coronat*a, *Bagliettoa calciseda, B. parmigera, Clauzadea monticola, C. immersa, Rinodina immersa, Sarcogyne regularis, Staurothele hymenogonia, Verrucaria papillosa*) on limestone pebbles. Some species are areolated (e.g. *Circinaria contorta*, *Placopyrenium fuscellum*, *Pyrenodesmia variabilis*, *Verrucaria nigrescens*, *Verruculopsis lecideoides*) and few species have a placodioid life form (*Calogaya pusilla, C. decipiens*, *Lobothallia radiosa*) and one gelatinouse *Scytinium plicatile*. There are mainly fertile taxa with apothecia and perithecia, and only *Pyrenodesmia concreticola* and *Verrucaria tectorum* formed soredia.

Synfloristic. Forty-five species of crustose lichens, gelatinous *Scytinium plicatile* and ten lichenicolous fungi were included in Table 1. Most of them are diagnostic for *Verrucarietea nigrescentis* Wirth 1980. However, there are also elements characteristic of *Clauzadeetea immersae* Roux 2009. Within a single relevé, seven to twenty-six species of lichens and lichenicolous fungi were observed. The studied lichen communities contain recently described species *Caloplaca microstepposa* (Frolov & *al.*, 2016) and *Pyrenodesmia concreticola* (Vondrák & *al.*, 2008) that are rare for Europe. The lichenicolous fungus *Adelococcus interlatens* was reported for the first time from Ukraine. *Clauzadea immersa* and *Rinodina immersa* are new to the plain part of Ukraine. *Protoblastenia rupestris* is new to the steppe zone of Ukraine.

Synecology. Heliophilous, xerophilous, basiphilous, heminitrophilous crustose lichen communities on the marl limestones in arid landscapes. Communities are formed on small pebbles (1-10 cm wide) that are washed out of the soil, mainly in the middle and upper parts of dry slopes of gullies (inclination 10˚–30˚).

Syndynamic. Pioneer communities on marl limestones in petrophytic steppes along the slopes of dry gullies.

Synchorology. Known from the Black Sea lowland (South-Eastern Europe). Probably, similar communities can form on porous marl limestone in southern and southwestern Europe (e.g. 28 relevé in Roux, 2017), but it needs further research.

Syntaxonomy. The association *Verrucario viridulae-Staurotheletum hymenogoniae* is described here within the alliance *Aspicilion contortae* Roux 2009 (*Aspicilietalia calcareae* Roux 2009 and class *Verrucarietea nigrescentis* Wirth 1980), because it is forms on small pebbles containing lime and consists of alliance-diagnostic species *Clauzadea metzleri, Rinodina bischoffii* and *Sarcogyne regularis*.

Figure 2. The Nord-Pontic calcicline pale fescue grasslands habitats with the association *Verrucario viridulae-Staurotheletum hymenogoniae* on pebbles: A, dry gully slope in the "Kam`yanska Sich" protected National Nature Park (Kherson region, Beryslavsky district); B-D, Osokorivska balka (dry gully) slope in the "Gavrylovsky" protected Regional landscape Park (Kherson region, Novovorontsovsky district); E, dry slope near village Novogrygorovka (Mykolaiv region, Bereznegovate district); F, holotype of association (Table 1, rel. 8).

Aspicilion contortae has two another associations. The type association is *Aspicilietum contortae* Kaisser 1926 em. Klement 1955, characterized by 12 species of lichens (Klement, 1955; Table 2). This association has a high constancy of alliance-diagnostic species *Circinaria contorta* $V^{3\text{-}5}$, order-diagnostic *Bagliettoa calciseda* $IV^{+\text{-}2}$, and class-diagnostic *Verrucaria nigrescens* $V^{+\text{-}2}$. Other characteristic species of *Aspicilion contortae* are also present, but with a low constancy (*Rinodina bischoffii* $I^{+\text{-}2}$, *Sarcogyne regularis* $II^{+\text{-}1}$). Roux & *al*. (2009) noted that the lectotype of *Aspicilietum contortae* cannot be selected from the tables presented by E. Kaiser (1926) and O. Klement (1955), therefore, the association needs to be neotypified.

Caloplacetum lactea-marmoratae Roux 2009 was described in *Aspicilion contortae* in Roux & *al.* (2009) on the basis of their own relevés published before (Roux, 1978) (type relevé No. 9 and all other relevés except No. 4). As the authors pointed out, the characteristic species of this association are *Xanthocarpia marmorata* (= *Caloplaca marmorata*) and *X. lactea* (= *Caloplaca lactea*), as well as lichenicolous fungus *Verrucula lactearia* on *X. lactea*. The association is distributed on limestone pebbles and blocks in Mediterranean regions (France and Spain). It contains 51 species of lichens and 6 species of lichenicolous fungi.

Table 2. Synoptic table of the *Aspicilion contortae* Roux 2009. 1. *Aspicilietum contortae*, 2. *Caloplacetum lactea-marmoratae*, 3. *Verrucario viridulae-Staurotheletum hymenogoniae*. (*, characteristics in Roux & *al*., 2009)

	1	2	3
Diagnostics of *Verrucario viridulae-Staurotheletum hymenogoniae*	.	.	.
Verrucaria viridula (Schrad.) Ach.	.	.	V
Verrucaria muralis Ach. s.l.	.	I	V
Staurothele hymenogonia (Nyl.) Th. Fr.	.	.	III
Diagnostics of *Caloplacetum lactea-marmoratae*			
Xanthocarpia lactea (A. Massal.) A. Massal. s. str.	.	IV	.
Verrucula lactearia Nav.-Ros. & Cl. Roux	.	*?	.
Xanthocarpia marmorata (Bagl.) Frödén, Arup & Søchting	.	*III	IV
Caloplaca lacteoides Nav.-Ros. & Hladún	.	*II	.
Diagnostics of *Aspicilietum contortae* and *Aspicilion contortae*			
Circinaria contorta (Hoffm.) A. Nordin, Savić & Tibell s. str.	V	V	V
Rinodina bischoffii (Hepp) A. Massal.	I	V	V
Sarcogyne regularis Körb.	II	II	V
Clauzadea metzleri (Körb.) Clauzade & Cl. Roux ex D. Hawksw.	.	II	II
Diagnostics of *Aspicilion calcareae*	.	.	.
Lobothallia radiosa (Hoffm.) Hafellner	.	I	I
Placopyrenium fuscellum (Turner) Gueidan & Cl. Roux	.	.	III
Diagnostics of *Caloplacion decipientis*			
Calogaya pusilla (A. Massal.) Arup, Frödén & Søchting	II	.	I
Flavoplaca flavocitrina (Hoffm.) Arup, Frödén & Søchting s.l.	.	II	.
Calogaya decipiens (Arnold) Arup, Frödén & Søchting	.	.	I
Diagnostics of *Acarosporion cervinae*			
Verruculopsis lecideoides (A. Massal.) Gueidan & Cl. Roux	.	I	II
Diagnostics of *Caloplacion arnoldii*			
Myriolecis crenulata (Ach.) Śliwa, Zhao Xin & Lumbsch	.	I	IV
Diagnostics of *Aspicilietalia calcareae*			
Bagliettoa calciseda (DC.) Gueidan & Cl. Roux	IV	V	IV
Diplotomma hedinii (H. Magn.) P. Clerc & Cl. Roux	III	II	I
Circinaria calcarea (L.) A. Nordin, Savić & Tibell	.	V	IV
Diagnostics of *Verrucarietea nigrescentis*			
Verrucaria nigrescens Pers.	V	V	V
Circinaria hoffmanniana (S. Ekman et Froberg) A. Nordin	.	V	.
Lecania turicensis (Hepp) Müll.	.	.	II
Flavoplaca oasis (A. Massal.) Arup, Frödén & Søchting	.	III	III
Pyrenodesmia variabilis (Pers.) A. Massal. s. lat.	.	IV	IV
Myriolecis dispersa (Pers.) Śliwa, Zhao Xin & Lumbsch	III	.	II
Xanthocarpia crenulatella (Nyl.) Frödén, Arup & Søchting s.l.	III	.	V
Lecania rabenhorstii (Hepp) Arnold	.	IV	.
Pyrenodesmia chalybaea (Fr.) A. Massal.	.	II	.
Caloplaca inconnexa (Nyl.) Zahlbr.	.	II	.
Candelariella aurella (Hoffm.) Zahlbr.	.	.	IV
Myriolecis semipallida (H. Magn.) Śliwa, Zhao Xin & Lumbsch	.	.	III
Flavoplaca coronata (Kremp. ex Körb.) Arup, Frödén & Søchting	.	.	I
Candelariella rosulans (Müll. Arg.) Zahlbr.	.	.	I
Rinodina calcarea (Hepp ex Arnold) Arnold	.	.	I
Verrucaria macrostoma Dufour ex DC.	.	.	I
Diagnostics of *Clauzadeetea immersae*			
Protoblastenia rupestris (Scop.) J. Steiner	V	.	I
Rinodina immersa (Körb.) J. Steiner	I	III	I
Bagliettoa parmigera (J. Steiner) Gams	.	II	I
Thelidium decipiens (Hepp) Kremp.	II	I	.
Bagliettoa marmorea (Scop.) Gueidan & Cl. Roux	.	II	.

	1	2	3
Pyrenodesmia agardhiana (Flot.) A. Massal.	.	II	.
Pyrenodesmia alociza (A. Massal.) Arnold	.	II	.
Staurothele immersa (A. Massal.) Dalla Torre & Sarnth.	.	II	.
Thelidium incavatum Nyl. ex Mudd.	.	II	.
Verrucaria hochstetteri Fr.	.	II	.
Bagliettoa baldensis (A. Massal.) Vězda	.	I	.
Bagliettoa limborioides A. Massal. (= *Bagliettoa sphinctrina* auct.)	.	I	.
Hymenelia prevostii (Duby) Kremp.	.	I	.
Toninia athallina (Hepp) Timdal (= *Catillaria athallina* (Hepp) Hellb).	.	I	.
Verrucaria pinguicula A. Massal.	.	I	.
Aspicilia coronata (A. Massal.) B. de Lesd.	.	.	I
Clauzadea immersa (Hoffm.) Hafellner & Bellem.	.	.	I
Other species			
Verrucaria cf. *transiliens* (Arnold) Lettau	.	I	I
Verrucaria tectorum (A. Massal.) Körb.	.	I	I
Verrucaria ochrostoma Borrer	.	II	.
Variospora dolomiticola (Hue) Arup, Søchting & Frödén	.	II	.
Verrucaria polysticta Borrer	.	II	.
Acarospora dolophana (Nyl.) H. Magn	.	I	.
Candelariella vitellina (Hoffm.) Müll. Arg.	.	I	.
Staurothele orbicularis (A. Massal.) Th. Fr.	.	I	.
Petractis clausa (Hoffm.) Kremp.	.	I	.
Sagiolechia protuberans (Ach.) A. Massal.	.	I	.
Caloplaca lecideina (Müll. Arg.) Clauzade & Rondon	.	I	.
Verruculopsis minuta (Hepp) Krzew	.	I	.
Verrucaria adelminienii Zschacke	.	I	.
Verrucaria ruderum DC.	.	I	.
Pyrenodesmia concreticola (Vondrák & Khodos.) Søchting, Arup & Frödén	.	.	II
Aspicilia calcarea (L.) Mudd morpho. xerophile	.	.	I
Caloplaca microsteppposa Frolov, Nadyeina, Khodos. & Vondrák	.	.	I
Variospora glomerata (Arup) Arup	.	.	I
Arthonia calcicola Nyl.	.	.	I
Verrucaria bernaicensis Malbr.	.	.	I
Scytinium plicatile (Ach.) Otálora, P.M. Jørg. & Wedin	.	.	I
Psorotichia montinii (A. Massal.) Forssell	.	.	I
Verrucaria papillosa Ach.	.	.	I
Lichenicolous fungi			
Intralichen christiansenii (D. Hawksw.) D. Hawksw.	.	V	IV
Muellerella lichenicola (Sommerf.) D. Hawksw. (sub *Discothecium gemmiferum* in Roux 1978, sub *Tichothecium pygmeum* on *Xanthocarpia lactea* in Roux 1978)	.	II	I
Opegrapha rupestris Pers.	.	II	.
Lichenothelia renobalesiana D. Hawksworth et V. Atienza (=*Microthelia marmorata* auct. notamment Roux 1978)	.	II	.
Arthonia lapidicola (Taylor) Branth et Rostr. (=*Arthonia* cf. *epimela* (Almq.) I.M. Lamb dans Roux 1978)	.	II	.
Zwackhiomyces calcisedus Cl. Roux (sub *Pharcidia dispersa* in Roux 1978, sub *Didymella sphinctrinoides* in Roux 1978)	.	II	.
Adelococcus interlatens (Arnold) Matzer et Hafellner	.	.	I
Acaroconium punctiformis Kocourk. & D. Hawksw.	.	.	I
Arthonia apotheciorum (A. Massal.) Almq.	.	.	I
Lichenochora wasserii S. Kondr. s.l.	.	.	I
Stigmidium clauzadei Cl. Roux & Nav.-Ros.	.	.	I
Zwackhiomyces lithoiceae (B. de Lesd.) Hafellner & V. John	.	.	I
Zwakhiomyces sp. 1	.	.	I
Zwackhiomyces lecanorae (Stein) Nik. Hoffm. & Hafellner	.	.	I

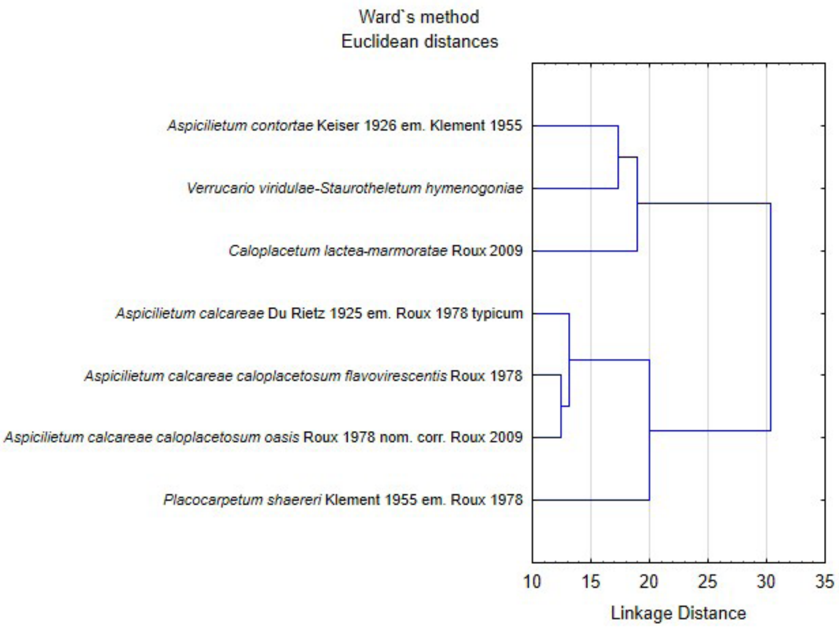

Figure 3. The similarity and distinction between associations and subassociations according to the species composition and constauntant class

A comparison of all the associations is presented in the synoptic table (Table 2) including the 93 species of the alliance. Thirty-three species (1/3 of all the species in the alliance) known in *Caloplacetum lactea-marmoratae* were not recorded in relevés of the new association from the Black Sea lowlands. Roux`s association does not contain *Staurothele hymenogonia* and *V. viridula* as diagnostic species of *Verrucario viridulae-Staurotheletum hymenogoniae*. In addition, 32 species of lichens and lichenicolous fungi (1/3 of all species in alliance) recorded in the new association are not known from *Caloplacetum lactea-marmoratae*. Comparison of species composition and species constancy in *Verrucario viridulae-Staurotheletum hymenogoniae* with *Aspicilion contortae* communities, *Placocarpetum schaereri* Klement 1955 em. Roux 1978 (*Acarosporion cervinae* Roux 2009) association and three *Aspicilietum calcareae* Du Rietz 1925 em. Roux 1978 (*Aspicilion calcareae* Alberton 1946 ex Roux 1978) subassociations indicated that new syntaxon has a sufficient Euclidean distance in association level (Figure 3). In our opinion, the association *Verrucario viridulae-Staurotheletum hymenogoniae* is ecological vicariant of the *Aspicilion contortae* communities on porous marl limestone.

Two other associations observed in the studied petrophytic grassland habitats

1. ***Enchylietum tenacis*** Khodosovtsev 2014 (*Toninion coeruleonigricantis* Hadač 1948, *Toninietalia coerule-onigricantis* Hadač in Klika ex Hadač 1962, *Psoretea decipientis* Mattik 1951).

Terricolous lichen community formed in calcareous petrophytic steppes in Northern Black Sea region around limestone pebbles. It is a common community in the Black Sea lowlands, in steppe areas, as xerophilous, basiphilous, heliophilous pioneer lichen community on carbonaceous soil (Khodosovtsev & *al.*, 2014). The diagnostic species of this association are *Enchylium tenax* and *Placidium squamulosum*. These species never form large coverage (usually up to 5%), but with high constancies. The association occurs on abandoned grazed pastures or on dry slopes of gullies (usually on the middle parts of slopes). It surrounds limestone gravels and pebbles on non-profiled soils (leptosols, calcisols, fluvisols, etc.).

2. ***Lino tenuifolii-Jurineetum brachycephalae*** Krasova & Smetana 1999 (*Potentillo arenariae-Linion czernjajevii* Krasova et Smetana 1999, *Stipo pulcherrimae-Festucetalia pallentis* Pop 1968, *Festuco-Brometea* Br.-Bl. et Tx ex Soó 1947).

This calciphilous community occurs in small spots of several to a few hundred square meters, usually in places where limestone slabs and crushed stones are outcrop. Under such conditions, open grassland communities do not grow, but shrubs with plagiotropic shoots and a coverage from 10 to 80% dominate. These are analogues of the Mediterranean “tomillo” vegetation. The dominant species are *Jurinea brachycephala*, *Thymus dimorphus*, *Genista scythica*, *Pimpinella lithophila*, *Teucrium polium*, *Centaurea marschalliana*, *Poterium polygamum* and grasses *Festuca valesiaca* and *Bromopsis riparia*. Here were found *Alyssum tortuosum* s.l., *Bromopsis riparia*, *Centaurea marschalliana*, *Cephalaria uralensis*, *Genista scythica*, *Jurinea brachycephala*, *Linum flavum* (incl. *L. szernjajevii*), *Potentilla arenaria*, *Poterium polygamum*, *Salvia nutans*, *Teucrium polium*, *Thymus* *dimorphus*, etc. *Chamaecytisus ratisbonensis* is new to the Kherson region. Particular attention should be paid to the presence of the dominant xerophilous grass *Poa sterilis*, which is common in the Crimean Mountains and is closely related to *P. versicolor*. The latter species grows on rocky substrata of limestone walls in the Dniester valley.

Petrophytic grassland habitats and its conservation in the northern Black Sea region

For the classification of EUNIS (Davias & *al.*, 2004), there are no analogues of the above-mentioned habitats with the complex of the three associations. Therefore we propose to ranking it as follows:

E1.2 Perennian calcareous grasslands and basic steppes.

E1.29 *Festuca pallens* grasslands (*Stipo pulcherrimae-Festucetalia pallentis*).

E1.292 Calcicline pale fescue grasslands.

E1.2923 Nord-Pontic calcicline pale fescue grasslands.

Several years ago, these habitats in the Black Sea lowland were partially protected in the Natural Reserve “Yelanetsky Step” (Mykolayiv region, Yelanetsky district). Recently, these habitats are protected in the newly established reserve “Mykhaylovsky Step” (Mykolayiv region, Novoodesky district; Figure 2.E, 2F), in the Botanical Reserve “Troitska balka” (Zaporizha region, Melitopolsky district) and in the National Nature Park “Kam`yanska Sich” (Kherson region, Beryslavsky district). Petrophytic habitats are widespread in the northern part of the Black Sea lowlands (e.g. Osokorivka Balka in Kherson region, Novovorontsovsky district) where the Regional Landscape Park “Gavrylovsky” is intended to be created.

Conclusion

The new lichen association, *Verrucario viridulae-Staurotheletum hymenogoniae* (*Aspicilion contortae* Roux 2009, *Aspicilietalia calcareae* Roux 2009, *Verrucarietea nigrescentis* Wirth 1980), is described here. The new association is a component of the Nord-Pontic calcicline pale fescue grasslands habitats and occupy porous marl limestone. It occurs in protected areas “Yelanetsky Step”·(Mykolayiv region), “Troitska balka” (Zaporizha region), the National Nature Park “Kam`yanska Sich” and the Regional Landscape Park “Gavrylovsky” (Kherson region).

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