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PIONEER LICHEN COMMUNITIES OF THE TETERIV RIVER BASIN (UKRAINE)

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The results of phytosociological studies of pioneer lichen communities of siliceous outcrops carried out in 2014–2016 in Teteriv River basin (Ukraine) are provided. The dataset of 302 relevés was analysed, 6 associations and 1 subassociation from 3 classes were distinguished as a result of the phytosociological survey in the Teteriv River basin. Four associations, i.e.: *Aspicilietum contortae* Kaiser ex Klement 1955, *Cladonietum mitis* Krieger 1937, *Parmelietum conspersae* Hilitzer 1925, *Parmelietum somloensis* Wirth 1995 and the alliance *Aspicilion calcareae* Albertson ex Roux 1978 are new for Ukraine, and one new association *Aspicilio cinerei-Ramalinetum pollinariae* Kapets et Khomyak, ass. nova is described here.

Key words: *Aspicilietum cinereae, Aspicilio cinerei-Ramalinetum pollinariae, Aspicilietum contortae, Cladonietum mitis*, cryptogam communities, siliceous outcrops, syntaxonomy, *Parmelietum conspersae, Parmelietum somloensis*

INTRODUCTION

Lichens like the other cryptogams differ from vascular plants in many characteristics (poikilohydry, intensity of biochemical processes, rootless structure, etc.). Due to specific biological processes lichens can colonise extreme habitats that would be unsuitable for most vascular plants, thus forming a special type of vegetation. Cryptogamic communities can form special vegetation types and these can be classified as separate syntaxa. The study of lichen communities is one of the sources of additional information on habitats and monitoring changes therein (Bültman and Daniëls 2009, Paus 1997). It is extremely important to study habitats and biotopes with poor vascular plant vegetation (siliceous screes and rocky slopes, 8150 (Medio-European upland siliceous screes), 8220 (siliceous rocky slopes with chasmophytic vegetation), 8230 (siliceous rock with pioneer vegetation of the Sedo-Scleranthion Br.-Bl. et Richard 1950 or of the Sedo albi-Veronicion dilleni Korneck 1974) according to the Directive 1992/43/EEC, etc.). Some types of these habitats are located in the Teteriv River basin. It should be noted that lichen communities of these habitats, unlike vascular plant vegetation, has never been studied in Ukraine.

The low degree of recovery is one of the features inherent to extreme rock habitats, which increases importance of studying changes therein. Some more detailed study covering all components of these habitats can help improving protection at the study area.

Lichen communities of Ukraine have hitherto been researched poorly. Some information to this end was published first in the early 20th century. The data on three epilithic lichen communities from central and northern Ukraine was published in 1927 by Oxner (1927). The author used an original method to find out the percentage cover of each species. The studies of epilithic, epiphytic and epigeic lichen communities of central Ukraine using Braun-Blanquet method were carried out in the first half of the 20th century. These data are also included in 'Prodromus der mitteleuropäischen Flechtengesellschaften' (Klement 1955). Some peculiar vegetation studies on cryptogamic communities have been carried out in various parts of Ukraine (Crimea Peninsula, steppe zone and forest-steppe zone) at the beginning of the 21st century (Gapon 2013, Khodosovtsev 2015, Khodosovtsev *et al.* 2011, 2014, Redchenko 2004).

The objective of this research was to investigate the syntaxonomic structure of the pioneer lichen communities of siliceous outcrops in the Teteriv River basin (Ukraine). This information will not merely provide intimate knowledge covering syntaxonomy of the pioneer vegetation on the siliceous screes and rocky slopes, but it will also be interesting for further syntaxonomic research of the lichen communities of Ukraine. More detailed study covering this type of habitats will facilitate development of an efficient conservation system to be applied at this territory.

MATERIAL AND METHODS

Study area

Geographic position. The Teteriv River flows in the north of Ukraine and flows into the Dnieper River. The total length of the river is 365 km, the average velocity ranging from 0.3–0.5 m/s to 1.0–2.5 m/s at rock ledges. The Teteriv River basin is located in the northwestern part of the Ukrainian Crystal Shield, covering the area of 15,100 km^2. The Hnylopiat, Huyva, Irsha and Zdvyzh Rivers are the major tributaries of the Teteriv River. The rivers' banks in the basin are normally steep, 1–2 m high, often with outcrops forming riverside rocks. The major type of the area landscape is outwash plains resting on crystalline basement. The major types of soils are turf-podzolic, turf-podzol, black and forest soils. The outcrops form rock ledges, riverside rocks, and sometimes even canyons of 25 to 30 m wide (Fig. 1). The crystalline rocks are represented by granitoids of the Kirovohrad-Zhytomyr and the Korosten intru-

sive sheets. Most of the exposures are located at the upper and middle course of the Teteriv River basin. Therefore, these sections are the most suitable for studying epilithic lichen communities (Marinich 1963, Marinich *et al.* 1985).

Vegetation and climate. Some portions of the Teteriv River basin's upper course are located at the forest-steppe zone of Ukraine. The middle and lower course of the basin are located at the forest zone. More than half of the area is covered with forest vegetation, as represented by three major types: acidophilous beech and mixed fir-beech forests (ass. F*icario vernae-Ulmetum campestris* Knapp ex Medwecka-Kornaś, *Tilio cordatae-Carpinetum betuli* Traczyk 1962, *Poo nemoralis-Tilietum cordatae* Firbas et Sigmond 1928, *Potentillo albae-Quercetum* Libb. 1933); acidophilous oak and oak-birch forests on nutrient-poor soils (ass. *Trientalo europaeae-Quercetum roboris* Vorobyov 2014) and pine forests on nutrient-poor and hydromorphic soils (ass. *Dicrano-Pinetum* Preising et Knapp ex Oberd. 1957, *Molinio-Pinetum* Matuszkiewicz (1973) 1981, *Peucedano-Pinetum* Mat. (1962) 1973, *Vaccinio uliginosi-Pinetum* de Kleist 1929). Mesotrophic regularly flooded alder (ass. *Ribo nigri-Alnetum* Solińska-Górnicka 1975, *Sphagno squarrosi-Alnetum* Sol.-Gorn. (1975) 1987) and willow carrs (ass. *Salicetum pentandro-cinereae* Pass. 1961) are frequent in floodplains (Didukh *et al.* 2011, Orlov and Yakushenko 2005).

The geomorphological features of this area facilitated forming special types of vegetation. The chasmophytic vegetation of crevices, rocky ledges and faces of rocky cliffs (ass. *Hypno-Polypodietum* Jurko et Peciar 1963, *Asplenio-Cystopteridetum fragilis* Oberd. (1936) 1949, etc.) and pioneer vegetation on shallow soils on rocky siliceous rocks (ass. *Melico transsylvanicae-Sedetum ruprechtii* Kontar 1998, *Thymo pulegioidis-Sedetum sexangularis* Didukh et Kontar 1998 (Didukh *et al.* 2011) are some of them.

The climate of the Teteriv River basin is temperate continental, with increasing continentality from the northwest to the southeast. The average annual temperature is +6 °C to +7 °C. The average temperature is +19.4 °C in July, and –5.7 °C in January. The average annual amount of precipitation reaches about 562 mm.

Research methods

A total of 302 phytosociological relevés had been collected in 2014–2016. The vast majority of relevés were done on lichen-rich outcrops, and a few relevés on sandy areas near the outcrops. The phytosociological relevé sampling procedure followed the Braun-Blanquet approach (Braun-Blanquet 1964, Mirkin and Rozenberg 1983). Some guidelines on selecting relevés plots of epilithic lichen communities, as proposed by Klement (1955), were also considered. The relevés include lichens, bryophytes and some epilithic fungi of the genus

Lichenothelia D. Hawksw. The lichens and bryophytes were identified according to the standard techniques and using light microscopy (Kondratyuk and Martynenko 2006). The analysis of some ecological characteristics (pH of the substratum, light, xerophytism) was completed relying on scales proposed by Nimis and Martellos (2008), and by Wirth (2010).

The relevés were stored in the Turboveg 2.0 database (Hennekens 2009). The analysis of lichen communities was completed with the Juice 7.0 software package (Tichý 2002) using Two-way indicator species analysis (Twinspan) (Hill 1979) with the following default parameters: 3 pseudospecies cut levels: 0%, 5%, 25%; minimum group size – 5; maximum level of division – 6. The phi fidelity index was used to identify diagnostic species (Chytrý *et al.* 2002). We considered diagnostic species with phi > 25%, constant species with frequencies > 25%, dominant species with a mean cover of more than 10% and minimum frequency 10%. The names of syntaxa were specified according to the third edition of the International Code of Phytosociological Nomenclature (Weber *et al.* 2000). The names of the high level syntaxa were disclosed according to the modern European hierarchical system of classification of vascular plants, bryophytes, lichens and algae (Mucina *et al.* 2016). Species names are given according to the 'Index Fungorum' for lichens (CABI 2018), and according to Boiko (2008, 2014) for bryophytes.

RESULTS

The pioneer communities of the study area are represented by six associations, one subassociation of three alliances and three classes. As a result of the syntaxonomic interpretation of phytosociological data, the following chart of the pioneer lichen communities of the Teteriv River basin was created.

Cl. Rhizocarpetea geographici Wirth 1972
- Ord. Rhizocarpetalia Klement 1949
  - All. Parmelion conspersae Hadac in Klika et Hadac 1944
    - *Aspicilietum cinereae* Frey 1922
    - *Parmelietum conspersae* Hilitzer 1925
    - *Parmelietum somloensis* Wirth 1995
    - *Aspicilio cinerei-Ramalinetum pollinariae* Kapets et Khomyak in Kapets *et al.* 2018 (this paper)

Cl. Verrucarietea nigrescentis Wirth 1980
- Ord. Verrucarietalia nigrescentis Klement 1950
  - All. Aspicilion calcareae Albertson ex Roux 1978
    - *Aspicilietum contortae* Kaiser ex Klement 1955

Cl. Ceratodonto purpurei-Polytrichetea piliferi Mohan 1978
- Ord. Peltigeretalia Klement 1949
  - All. Cladonion arbusculae Klement 1949
    - *Cladonietum mitis* Krieger 1937

Characteristics of the associations

Ass. ***Aspicilio cinerei-Ramalinetum pollinariae*** Kapets et Khomyak, *ass. nova, hoc loco*

Holotypus hoc loco: Table 1, relevé № 6 (Zhytomyr Oblast, Korostyshiv Rayon, the northeast outskirts of Horodske village, the right bank of the Teteriv River, outcrops, 50° 22′ 26.5″ N, 29° 10′ 53.3″ E, alt. 175 m a.s.l.; Sampled by N. Kapets on 8 August 2016).

Diagnostic species: *Aspicilia cinerea, Ramalina pollinaria*.

Constant species: *Ramalina pollinaria, Candelariella vitellina*.

Dominant species: *Ramalina pollinaria, Aspicilia cinerea, Protoparmeliopsis muralis, Physcia dubia, Rhizocarpon eupetraeum*.

The association of epilithic lichens is found in the Ukrainian Crystal Shield's outcrops (Fig. 2). This community occurs on inclined, almost vertical and perched surfaces mainly of the northern and northwest exposures. The average number of species per relevé is 7.7. The community characterised by a high total cryptogam layer cover consisted of 40–60%, with a significant proportion of the substrate surface remaining bare. The cover of lichens ranged from 40 to 90%. The bryophytes are not always present and their cover usually does not exceed 20%. The minimum range of the association is 30 cm^2. Rather acidophytic, mesophytic moderately photophytic, usually occurred in sun-exposed sites without extreme solar irradiation. The characteristic feature of communities of this association is presence of fruticose lichen *Ramalina pollinaria* in the species composition (cover up to 20–75%). This association was described on mesophilous damp and shaded vertical or perched surfaces of outcrops.

Ass. *Aspicilietum cinereae* Frey 1922

Syn.: *Aspicilia gibbosa-Ges*. Mattick 1937, *Lecanoretum sordidae* Hilitzer 1936, *Candelarilletum vitellinae* Motyka 1925, *Lecanora polytropa*-Ges. Mattick 1937, *Aspicilia cinerea*-Ass. Hilitzer 1927.

Diagnostic species: *Aspicilia cinerea, Circinaria caesiocinerea, Circinaria gibbosa, Lecanora rupicola*.

Constant species: *Acarospora fuscata, Aspicilia cinerea, Candelariella vitellina, Lecidea fuscoatra, Polysporina simplex, Protoparmeliopsis muralis*.

Dominant species: *Acarospora fuscata, Aspicilia cinerea, Candelariella vitellina, Lecidea fuscoatra, Polysporina simplex, Protoparmeliopsis muralis*.

The boreal-Mediterranean, high-altitude association of epilithic lichens on well-illuminated, nutrient-rich, igneous rocks (Fig. 3). The average number of species per relevé is 9.3. The community characterised by a high total cryptogam layer cover consisted of 80–98% (Table 2). The cover of lichens ranged from 70 to 99%. The bryophytes occurred rarely and had an insignificant cov-

Table 1
Relevé table of *Aspicilio cinerei-Ramalinetum pollinariae* Kapets et Khomyak 2018, ass. nova

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	C
№ of relevé in the field	120	4	2	114	5	119	3	1	112	111	194	
Altitude a.s.l. (m)	149	149	149	149	149	149	149	149	149	158	149	
Cover of lichens (%)	40	80	70	60	75	50	65	90	89	44	80	
Cover of mosses (%)	–	–	5	–	20	–	–	5	1	1	–	
Cover of open stone (%)	60	20	25	40	5	50	35	5	10	60	20	
Exposition	SE	N	NW	NE	N	SE	NW	N	W	W	NW	
Inclination (°)	90	90	4	30	90	90	90	10	30	30	90	
Number of species	5	5	9	10	10	9	7	6	11	8	5	
D.s. Ass. *Aspicilio cinerei-Ramalinetum pollinariae*												
Ramalina pollinaria	5	5	4	4	3	3	2	2	2	2	2	$V^{2–5}$
Aspicilia cinerea			2	r	3	r	4	4				$III^{r–4}$
D.s. Ass. *Parmelietum conspersae*												
Xanthoparmelia conspersa						r						I^{r}
D.s. All. Parmelion conspersae												
Xanthoparmelia pulla		r	r								+	$II^{r–+}$
Xanthoparmelia stenophylla			r				r					I^{r}
D.s. Ord. Rhizocarpetalia												
Rhizocarpon distinctum			r		r	r						I^{r}
Buellia badia									2			I^{2}

Table 1 (continued)

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	C
D.s. Cl. Rhizocarpetea geographici												
Acarospora fuscata					r		r	+				II^{r-+}
Diploschistes scruposus									3			I^{3}
Lecanora alpigena							r					I^{r}
Other species												
Candelariella vitellina		r		r	r	2	r		r	r		IV^{r-2}
Polysporina simplex	2			2		2			+	2		III^{+-2}
Protoparmeliopsis muralis			r	2		2			3	2		III^{r-3}
Lichenothelia tenuissima	2			1								I$^{1-2}$
Pertusaria coccodes	2											I^{2}
Acarospora veronensis	+			2		+			+	+		III^{+-2}
Physcia dubia				2						3	3	III$^{2-3}$
Rhizocarpon eupetraeum						2			2			I^{2}
Hypocenomyce scalaris											2	I^{2}
Grimmia pulvinata		2								r		I^{r-2}
Pertusaria sp.		r		r				+				II^{r-+}
Grimmia muehlenbeckii			r		r				r			II^{r}
Hypnum cupressiforme			r		r		r	r				II^{r}
Scoliciosporum umbrinum					2			+				I^{+-2}

Sporadic taxa: *Cladonia* sp. (6: r; 9–10: +), *Lichenothelia convexa* (6: +), *Lepraria incana* (11: +), *Lepraria membranacea* (5: r), *Rhymbocarpus neglectus* (5: +), *Xanthoparmelia* sp. (4: +; 9: +).

List of localities: 1–10 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Horodske village, outcrops on the right bank of the Teteriv River; 11 = Zhytomyr Oblast, Zhytomyr Rayon, outskirts of the Denyshi village, outcrops on the right bank of the Bobrivka River (near resort Denyshi), 12.06.2015.

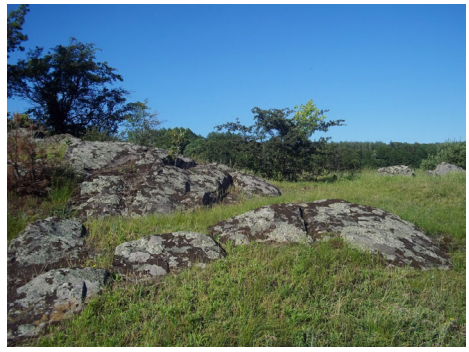

Fig. 1. Granite outcrops in the Teteriv River valley

Fig. 2. The association *Aspicilio cinerei-Ramalinetum pollinariae* Kapets et Khomyak 2018

er. Rather subneutrophytic to subacidic, mesophytic, moderately photophytic, usually occurred in sun-exposed sites without extreme solar irradiation. The characteristic feature of communities of this association is predominance of crustose lichens, such as *Acarospora fuscata, Aspicilia cinerea, Candelariella vitellina* and *Lecidea fuscoatra*. The cover of foliose lichens on most of studied sites was very low, under 30%. It is distributed on surfaces of different steepness and exposition. The association is fairly homogeneous, subassociations are not known.

Ass. *Parmelietum conspersae* Hilitzer 1925

Diagnostic species: *Xanthoparmelia conspersa*.

Constant species: *Xanthoparmelia conspera, Xanthoparmelia pulla*.

Dominant species: *Xanthoparmelia conspera, Lecidea fuscoatra, Protoparmeliopsis muralis, Rhizocarpon distinctum*.

Fig. 3. The association *Aspicilietum cinereae* Frey 1922

Fig. 4. The association *Parmelietum somloensis* Wirth 1995

The boreal-Mediterranean, subcontinental association of epilithic lichens on well-illuminated, nutrient-rich, igneous rocks. The average number of species per relevé is 7.4. The association characterised by a high total cryptogam layer cover consisted of 70–98% (Table 3). The lichens cover ranged up 70 to 98%. The cover of bryophytes does not exceed 2–30%. The minimal area of the community is 30 cm^2. Rather acidophytic, mesophytic, usually occurred in sun-exposed sites without extreme solar irradiation. It is distributed on surfaces of different steepness and exposition.

Ass. *Parmelietum somloensis* V. Wirth 1995

Syn.: *Parmelietum molliusculae* Gams 1927, *Parmelietum stenophyllae* Gams ex Klem. 1955, *Parmelietum taracticae* Klem. 1955.

Diagnostic species: *Xanthoparmelia stenophylla*.

Constant species: *Xanthoparmelia stenophylla, Xanthoparmelia conspersa, Protoparmeliopsis muralis*.

Dominant species: *Sarcogyne simplex, Xanthoparmelia stenophylla*.

The boreal-Mediterranean, subcontinental association of epilithic lichens on well-illuminated, nutrient-rich, igneous rocks (Fig. 4). The average number of species per relevé is 7.5. The total cryptogamic layer cover was high and consisted of 70–98% (Table 4). The lichen cover constituted 80–95%, the cover of bryophytes does not exceed 10%. Subacidophytic to subneutrophytic, mostly mesophytic, usually occurred in sun-exposed sites without extreme solar irradiation. The community was common on partially shaded outcrops. The association is quite variable. Our research resulted in identifying subassociation *Parmelietum somloensis* var. *Xanthoparmelia pulla*. The subassociation is different due to availability of the foliose lichen *Xanthoparmelia pulla*. Communities of the association are distributed on surfaces of different steepness and exposition.

Ass. *Aspicilietum contortae* Kaiser ex Klement 1955

Diagnostic species: *Aspicilia contorta*.

Constant species: *Aspicilia contorta, Candelariella vitellina, Protoparmeliopsis muralis, Sarcogyne simplex*.

Dominant species: *Aspicilia contorta, Bellemerea cupreoatra, Caloplaca atroflava, Candelariella vitellina, Endocarpon trachyticum, Protoparmeliopsis muralis, Sarcogyne simplex, Acarospora* sp., *Verrucaria nigrescens*.

The subboreal, European-Mediterranean association of epilithic lichens on calcareous rocks. The average number of species per relevé is 8.2. The association characterised by a high total cryptogamic layer cover ranged from 65 to 90% (Table 5). Bryophytes are not always present, only three species hav-

Table 2
Relevé table of *Aspicilietum cinereae* Frey 1922

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
№ of relevé in the field	135	136	59	150	40	52	54	134	145	61	62	53	57	75	98	
Altitude a.s.l. (m)	149	158	158	149	159	158	158	149	149	158	158	158	158	158	158	
Cover of lichens (%)	90	90	97	99	95	95	90	89	97	80	90	97	90	90	90	
Cover of mosses (%)	–	–	–	1	–	–	–	1	1	–	–	–	–	–	–	
Cover of open stone (%)	10	10	3	–	5	5	10	10	2	20	10	3	10	10	10	
Exposition	SE	SE	E	SE	–	S	S	SE	NW	N	NE	S	E	E	SE	
Inclination (°)	50	50	70	10	–	45	45	50	45	10	30	70	40	30	30	
Number of species	3	6	8	11	10	14	14	9	10	9	8	12	10	10	8	
D.s. Ass. *Aspicilietum cinereae*																
Aspicilia cinerea	5	5	4	4	3	3	3	3	3	2	2	2	2	2	2	V^{+-5}
D.s. All. Parmelion conspersae																
Xanthoparmelia pulla	2	r		2	2	r		2	r	r				r		III^{r-2}
Xanthoparmelia stenophylla				2	+	r			2	r	r				r	III^{r-2}
D.s. Ord. Rhizocarpetalia																
Xanthoparmelia conspersa	2	2		+		2	+	1	2			2	+	r		III^{r-3}
Lecidea fuscoatra		r	+		r	+	2	2		+	2	2	2	+	2	IV^{r-3}
Rhizocarpon distinctum						+	+	2				3	+			III^{+-3}
Buellia badia						+			r							I^{r-+}
D.s. Cl. Rhizocarpetea geographici																
Acarospora fuscata			r			+	+			+	2	+	+	+	2	IV^{r-3}
Lecanora alpigena			+		r	+	+					+		r		III^{r-2}

Table 2 (continued)

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
Other species																
Candelariella vitellina			+		3	3	2	r	r	2	2	2	+	2	2	V^{r-3}
Polysporina simplex					2	2	2	+	+	2	+	2	r	2	+	V^{r-2}
Protoparmeliopsis muralis			+		2	2	3	1		2	3	+	3	2	3	IV^{+-3}
Lichenothelia tenuissima				+	r	2	+		+			+	r			III^{r-2}
Acarospora sp.					+	+	+			+	r	+		2	r	III^{r-3}
Fuscidea lygaea			+				+					r	+			II^{r-+}
Rhizocarpon eupetraeum				r												I^{r-3}
Scoliciosporum umbrinum				+												I^{+-2}
Parmelia sulcata				2												I^{r-2}
Hypogymnia physodes				r												I^{r}
Grimmia muehlenbeckii				1				1	1							I^{1}
Lepraria incana				2					r							I^{r-2}

Sporadic taxa: *Caloplaca atroflava* (2: r), *Lepraria membranacea* (8: r), *Myriolecis dispersa* (2: r), *Rhymbocarpus neglectus* (8: r), *Xanthoparmelia* sp. (4: +).

List of localities: 3, 5–7, 10–13 = Zhytomyr Oblast, Korostyshiv town, outcrops on the right bank of the Teteriv River, near the 'Maria' cliff, 50° 08′ 51″ N, 29° 04′ 29″ E, 25.07.2014; 1–2, 4, 8–9 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Horodske village, outcrops on the right bank of the Teteriv River, 50° 22′ 23″ N, 29° 11′ 01″ E, 5.06.2015; 14, 15 = Zhytomyr Oblast, outskirts of the Zhytomyr city, outcrops on the right bank of the Teteriv River, near the 'Holova Chatskoho' cliff, 30.10.2014.

Table 3
Relevé table of *Parmelietum conspersae* Hilitzer 1925

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
№ of relevé in the field	88	191	190	192	115	109	107	116	90	118	56	87	195	83	133	
Altitude a.s.l. (m)	158	212	212	212	149	149	158	149	158	149	158	158	149	158	149	
Cover of lichens (%)	98	80	95	85	85	95	88	90	95	55	70	95	98	80	89	
Cover of mosses (%)	–	–	–	–	–	–	2	–	–	15	–	–	–	–	1	
Cover of open stone (%)	2	20	5	15	15	5	10	10	5	30	30	5	2	20	20	
Exposition	–	SE	SE	SE	NW	NE	NE	E	E	SE	E	SE	SW	E	SE	
Inclination (°)	–	45	85	30	20	30	48	35	90	85	35	90	40	20	10	
Number of species	3	6	4	6	10	10	8	10	5	11	9	5	7	8	11	
D.s. Ass. Parmelietum conspersae																
Xanthoparmelia conspera	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	V^{2-4}
D.s. All. Parmelion conspersae																
Xanthoparmelia pulla		2	+	+	+	+	2	2	r	r			+	r	r	IV^{r-2}
Xanthoparmelia stenophylla		+						+	2				+	2	r	II^{r-2}
D.s. Ord. Rhizocarpetalia																
Rhizocarpon distinctum					1	+	2			1	+		2		4	II^{+-4}
Lecidea fuscoatra						3	3	2			+				2	II^{+-3}
Aspicilia cinerea						+					+			1	r	II^{r-1}
Buellia badia						+										I^{+}

Table 3 (continued)

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
D.s. Cl. Rhizocarpetea geographici																
Acarospora fuscata				2							+				2	I^{+-2}
Diploschistes scruposus					+			2								I^{r-2}
Other species																
Protoparmeliopsis muralis					3	2	2	3		2	3	+	+	+	r	IV^{+-3}
Polysporina simplex					2	3	2	+	+	+	2			+		III^{+-3}
Candelariella vitellina					r	r			r		+	r				II^{r-+}
Lichenothelia tenuissima					+						+		+	+	+	II^{+-2}
Parmelia sulcata		2	+	+						r						II^{+-1}
Lichenothelia convexa		+		+				+		1						I^{+}
Acarospora veronensis					+	+	+	+								II^{+-4}
Rhymbocarpus neglectus	+											3		2		I^{r-3}

Sporadic taxa: *Cladonia chlorophaea* (1: 2; 12: 2; 13: r), *C. pyxidata* (10: +), *Didymodon rigidulus* (7: +), *Grimmia muehlenbeckii* (15: r), *Hypogymnia physodes* (10: 2), *Lepraria incana* (2: +), *Pertusaria coccodes* (10: 1), *Ramalina pollinaria* (5: r; 10: r), *Rinodina teichophila* (15: r), *Scoliciosporum umbrinum* (3: 2; 4: 2).

List of localities: 1, 12–14 = Zhytomyr Oblast, Korostyshiv town, outcrops on the right bank of the Teteriv River, near the 'Maria' cliff, 50° 18′ 51″ N, 29° 04′ 29″ E, 25.07.2014; 2–4, 15 = Zhytomyr Oblast, Zhytomyr Rayon, outskirts of the Denyshi village, outcrops on the right bank of the Bobrivka River (near resort Denyshi), 12.06.2015; 5–6, 8, 10–11 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Horodske village, outcrops on the right bank of the Teteriv River, 50° 22′ 23″ N, 29° 11′ 01″ E, 5.06.2015; 7, 9 = Zhytomyr Oblast, outskirts of the Korostyshiv town, outcrops on the right bank of the Teteriv River, 50° 20′ 16.82″ N, 29° 04′ 29.49″ E, 30.10.2015.

Table 4
Relevé table of *Parmelietum somloensis* V. Wirth 1995

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
№ of relevé in the field	89	38	192	204	210	193	138	137	202	140	95	96	130	32	205	
Altitude a.s.l. (m)	158	159	212	159	159	212	149	149	154	149	158	158	149	181	154	
Cover of lichens (%)	99	95	85	80	85	80	90	70	80	90	95	35	70	98	80	
Cover of mosses (%)	–	–	2	10	5	5	–	–	5	–	–	15	–	–	10	
Cover of open stone (%)	1	5	13	10	10	15	10	30	15	10	5	50	30	2	10	
Exposition	SE	–	SE	S	SW	SE	SW	SW	SE	SW	S	E	SW	S	SE	
Inclination (°)	90	–	87	90	90	35	30	30	35	45	80	20	30	4	25	
Number of species	4	9	8	9	7	7	6	6	12	9	7	10	11	7	9	
D.s. Ass. Parmelietum somloensis																
Xanthoparmelia stenophylla	4	4	3	2	2	4	4	3	3	2	2	2	2	2	1	V^{1-4}
D.s. X. s. var. Xanthoparmelia pulla																
Xanthoparmelia pulla						2	2	+	r	4	2	2	1	+	+	IV^{r-4}
D.s. Ass. Parmelietum conspersae																
Xanthoparmelia conspersa	2	+		+	+											II^{+-2}
D.s. Ord. Rhizocarpetalia																
Aspicilia cinerea		r	+		2	+			+						r	II^{r-2}
Lecidea fuscoatra		r					+	2	+	+			1		+	II^{r-2}
Buellia badia				+					+	+				+		II^{+}
Rhizocarpon distinctum										2		3	2			I^{2-3}

Table 4 (continued)

№ of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C
D.s. Cl. Rhizocarpetea geographici																
Acarospora fuscata					2				2	2					2	II^{+-3}
Diploschistes scruposus										1			r			I^{r-1}
Lecanora alpigena		2									+	+				I^{+-2}
Other species																
Polysporina simplex	2	2					+	+			+		r			III^{r-2}
Protoparmeliopsis muralis		2	+	r	+				2		+	2	r		3	IV^{r-3}
Candelariella vitellina		2				+	+		2	+	r	+		+	1	III^{r-2}
Hypogymnia physodes				+		+	+	r	r	r		r				III^{r-+}
Rhizocarpon eupetraeum									+						r	I^{r-2}
Rhymbocarpus neglectus	2										2	2				I^{+-2}
Lichenothelia tenuissima		2											+			I^{+-2}
Scoliciosporum umbrinum			2			3			+							I^{+-3}

Sporadic taxa: *Acarospora* sp. (3: 2; 5: 1), *A. veronensis* (14: 3), *Bellemerea cupreoatra* (12: 3), *Caloplaca atroflava* (8: +; 15: +), *Cladonia chlorophaea* (13: r), *C. pyxidata* (4: r), *Didymodon rigidulus* (4: r; 9: 1;), *Grimmia pulvinat*a (13: 1), *Hypnum cupressiforme* (3: +; 5: 1), *Lecidea fuscoatra* var. *fuscoatra* (15: 2), *Lichenothelia convexa* (14: r), *Parmelia sulcata* (4: 2), *Pertusaria coccodes* (14: 1), *Physcia dubia* (3: 2; 6: +), *Trapelia involuta* (4: +; 16: +), *Verrucaria nigrescens* (15: 2), *Xanthoparmelia verruculifera* (3: 2).

List of localities: 1–2 = Zhytomyr Oblast, Korostyshiv town, outcrops on the right bank of the Teteriv River, near the 'Maria' cliff, 50° 18′ 51″ N, 29° 04′ 29″ E, 25.07.2014; 5 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Vysokyi Kamin village, outcrops on the right bank of the Teteriv River, 50° 21′ 47″ N, 29° 08′ 36″ E, 10.09.2016; 3, 6 = Zhytomyr Oblast, Zhytomyr Rayon, outskirts of the Denyshi village, outcrops on the right bank of the Bobrivka River (near resort Denyshi), 12.06.2015; 4, 9, 14–15 = Zhytomyr Oblast, outskirts of the Zhytomyr city, outcrops on the left bank of the Teteriv River, slopes of the Yu. Haharin Park, 50° 14′ 37.92″ N, 28° 39′ 45.71″ E, 30.10.2014; 7–8, 10 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Horodske village, outcrops on the right bank of the Teteriv River, 50° 22′ 24″ N, 29° 11′ 01″ E, 2015–2016; 11–13 = Zhytomyr Oblast, outskirts of the Zhytomyr city, outcrops on the right bank of the Teteriv River, near the 'Holova Chatskoho' cliff, 30.10.2014.

Table 5
Relevé table of *Aspicilietum contortae* Kaiser ex Klement 1955

№ of relevé	1	2	3	4	5	6	7	8	9	C
№ of relevé in the field	241	242	13	12	11	14	15	243	244	
Altitude a.s.l. (m)	180	180	181	181	181	181	181	181	181	
Cover of lichens (%)	85	90	75	70	70	70	90	65	85	
Cover of mosses (%)	5	2	–	–	–	–	–	–	–	
Cover of open stone (%)	10	5	25	30	30	30	10	35	15	
Exposition	SE	S	S	SW	SW	SW	SW	S	S	
Inclination (°)	35	5	20	30	30	40	45	3	5	
Number of species	9	9	8	11	10	9	10	6	3	
D.s. Ass. Aspicilietum contortae										
Circinaria contorta	3	3	3	2	2	2	2	2	2	V^{3-2}
D.s. All. Aspicilion calcareae										
Circinaria calcarea	2							+		II^{+-2}
D.s. Cl. Verrucarietea nigrescentis										
Verrucaria nigrescens	3	2		+	+					III^{+-3}
Myriolecis dispersa				+	+	+	+	2		III^{+-2}
Other species										
Candelariella vitellina	r	r	2	2	2	2	2	r	3	V^{r-3}
Protoparmeliopsis muralis	r	2	2	3	3	2	2		3	IV^{r-3}
Acarospora sp.			2	2	1		2			III^{1-2}
Physcia caesia		2	2	+	2			2		III^{+-2}
Bellemerea cupreoatra			1	2	2	+	2			III^{+-2}

Table 5 (continued)

№ of relevé	1	2	3	4	5	6	7	8	9	C
Other species										
Caloplaca atroflava			+	2		3	3			III^{+-3}
Lichenothelia convexa			+	+	r	+	+			III^{+-r}
Sarcogyne simplex	r	r		+	+	1	+			IV^{+-1}
Endocarpon trachyticum		3				2	+	3		III^{+-3}

Sporadic taxa: *Ceratodon purpureus* (1: 2), *Cladonia* sp. (1–2: r), *Hypnum cupressiforme* (1: r), *Syntrichia ruralis* (2: 1).

List of localities: 1–2, 8–9 = Zhytomyr Oblast, Korostyshiv Rayon, Kam'ianyi Brid village, outcrops on the left bank of the Bystrivka River, 50° 28′ 40″ N, 28° 57′ 01″ E, 08.09.2016; 50° 28′ 44″ N, 28° 57′ 20″ E, 08.09.2016; 3–7 = Zhytomyr Oblast, outskirts of the Zhytomyr city, outcrops on the left bank of the Teteriv River, slopes of the Yu. Haharin Park, 50° 14′ 37.92″ N, 28° 39′ 45.71″ E, 29–30.10.2015.

ing low coverage (not exceeding 5%) were identified. The total cryptogamic cover constituted 65–90%. The association includes mainly crustose lichens with grey, grey-black, black and brown slate. Rather subacidophytic to subneutrophytic, mesophytic to xerophytic avoiding extremely arid stands, occurred in sun-exposed sites without extreme solar radiation. Association was found on labradorite and granite outcrops and distributed on surfaces of different steepness and exposition.

Ass. *Cladonietum mitis* Krieger 1937

Diagnostic species: *Cladonia mitis, C. portentosa*.

Constant species: *Cladonia chlorophaea, C. furcata, C. portentosa, Peltigera malacea, Polytrichum piliferum*.

Dominant species: *Cladonia portentosa, C. furcata, Peltigera malacea, Polytrichum piliferum*.

The boreal-Mediterranean, subcontinental, photophilous, acidophilous, mesophytic association of epigeic

Fig. 5. The association *Cladonietum mitis* Krieger 1937

Table 6
Relevé table of *Cladonietum mitis* Krieger 1937

№ of relevé	1	2	3	4	5	6	7	8	C
№ of relevé in the field	256	257	253	258	255	254	259	260	
Area of relevé (m²)	1	1	1.5	1.5	1	1.5	0.5	0.5	
Altitude a.s.l. (m)	148	147	149	147	147	149	150	150	
Cover of lichens (%)	50	50	50	35	50	60	50	50	
Cover of mosses (%)	20	20	40	35	35	25	25	30	
Cover of vascular plants (%)	25	25	5	25	10	5	20	15	
Cover of open soil (%)	5	5	5	5	5	10	5	5	
Exposition	SW	–	–	–	–	–	–	SW	
Inclination (°)	22	–	–	–	–	–	–	19	
Number of species	10	9	10	12	7	7	9	7	
D.s. Ass. Cladonietum mitis									
Cladonia portentosa	4	4	3	3	3	2	2	2	V^{3-4}
Cladonia mitis	+						1	+	II^{+-1}
D.s. All. Cladonion arbusculae									
Cladonia furcata	2	2	3	2	2		2	+	V^{+-3}
D.s. Ord. Peltigeretalia									
Peltigera malacea			2	2		+	4	4	IV^{+-4}
D.s. Cl. Ceratodonto purpurei-Polytrichetea piliferi									
Polytrichum piliferum	2	r	2			2	2	2	IV^{r-2}

Table 6 (continued)

№ of relevé	1	2	3	4	5	6	7	8	C
Other species									
Cladonia chlorophaea	+	+	+	2	+	4	r		V$^{r–4}$
Cladonia subulata	+	r		+		+			III$^{r–+}$
Placynthiella dasaea		+	+	+	+				III^{+}
Abietinella abietina		2	+				+		II$^{+–2}$
Brachythecium albicans		+		+					II^{+}
Brachythecium salebrosum			2				+	+	II$^{+–2}$
Ceratodon purpureus				+			2	+	II$^{+–2}$
Hedwigia ciliata	2				2	2			II^{2}
Grimmia reflexidens	+				+	+			II^{+}
Cladonia fimbriata	+				+				II^{+}

Sporadic taxa: *Bryum argenteum* (3: +), *Cladonia cornuta* (1: +), *Dicranum scoparium* (4: 2), *Hedwigia ciliata* (4: 2), *Hypnum cupressiforme* (4: 2), *H. pallescens* (4: +), *Pleurozium schreberi* (2: +); *Syntrichia ruralis* (3: +).

List of localities: 1–8 = Zhytomyr Oblast, Korostyshiv Rayon, outskirts of the Horodske village, right bank of the Teteriv River, 50° 22′ 02″ N, 29° 11′ 03″ E, 10.09.2016.

Table 7
Shortened synoptic table with frequency (%) for the distinguished associations*

Lichen community	1	3	2	4	5	6
Number of relevés	24	22	21	11	9	8
Mean % cover	90.8	88.5	86	70	78.6	78
Mean number of species per relevés	10	7.4	7.9	7.7	8.3	8.9
Total number of species	32	30	36	30	17	23
D.s. All. Parmelion conspersae						
Xanthoparmelia pulla	63	64	76	27		
Xanthoparmelia stenophylla	42	32	100	18		
D.s. Ord. Rhizocarpetalia						
Aspicilia cinerea	100	23	29	55		
Lecidea fuscoatra	67	45	43			
Xanthoparmelia conspersa	54	100	19	9		
Rhizocarpon distinctum	29	36	29	27		
Buellia badia	13	5	29	9		
D.s. Cl. Rhizocarpetea geographici						
Acarospora fuscata	71	32	33	27		
Lecanora alpigena	46		14	9		
Diploschistes scruposus		14	19	9		
D.s. All. Aspicilion calcareae						
Circinaria calcarea					22	
D.s. Ord. Verrucarietalia nigrescentis						
D.s. Cl. Verrucarietea nigrescentis						
Myriolecis dispersa	4				56	

Table 7 (continued)

Lichen community	1	3	2	4	5	6
Verrucaria nigrescens	4		5		44	
D.s. All. Cladonion arbusculae						
Cladonia furcata						88
D.s. Ord. Peltigeretalia						
Peltigera malacea						63
D.s. Cl. Ceratodonto purpurei-Polytrichetea piliferi						
Polytrichum piliferum						75
Other species						
Candelariella vitellina	83	41	52	64	100	
Protoparmeliopsis muralis	67	55	67	45	89	
Polysporina simplex	83	59	48	45	67	
Acarospora sp.	54		10	45	44	
Lichenothelia tenuissima	50	32	14	18		
Circinaria contorta			5		100	
Lichenothelia convexa		23		9	56	
Bellemerea cupreoatra			5		56	
Physcia caesia					56	
Cladonia portentosa						100
Cladonia chlorophaea		14				88
Cladonia subulata						50
Placynthiella dasaea						50

Lichen community: 1 = *Aspicilietum cinereae* (Table 2), 2 = *Parmelietum conspersae* (Table 3), 3 = *Parmelietum somloensis* (Table 4), 4 = *Aspicilio cinerei-Ramalinetum pollinariae* (Table 5), 5 = *Aspicilietum contortae* (Table 6), 6 = *Cladonietum mitis* (Table 7). * = only species with constancy 50% and more at least in one column, are shown

lichens on nutrient-poor soils (Fig. 5). The average number of species per relevé is 8.8. The association characterised by a high total cryptogamic layer cover consisted of 70–90% (Table 6). The lichen cover is up to 35–60%, the cover of bryophytes varied from 20 to 40%. The vascular plant layer was rare and sparse (up to 25%). The minimal area of its communities is 0.5 m^2. The species composition of the association has a well-defined biological component. Rather subacidophytic to subneutrophytic, mesophytic, occurred in sun-exposed sites without extreme solar radiation. The association is quite variable, the cover of lichens and bryophytes varies depending on natural conditions. It is usually found on even or occasionally on slightly sloping surfaces of different exposures. In the study area, it is often found on almost horizontal sections of granite outflows underlying thin layer of accumulated soil.

DISCUSSION

The epilithic lichen communities of the Teteriv River basin are common on siliceous outcrops of the Ukrainian Crystalline Shield located in the forest zone of Ukraine. Only one epigeic association *Cladonietum mitis* was described on siliceous screes near outcrops along the river bank. The distinctive features of all studied associations are poor species composition including 3–14 of lichen and moss species per relevés (the mean species per relevé is 8.4) and high total cryptogamic cover (up to 98%). We believe that it is mainly determined by the natural conditions of the territory, particularly, by humidity level and the chemical composition of substrate (in most cases, the species composition of lichens on siliceous substrate is poorer than on carbonates). The mean environmental values of all associations are fairly homogeneous and indicate that the studied communities rather acidophytic to neutrophytic, photophytic, mesophytic to slightly xerophytic. More detailed analysis of ecological characteristics of lichen communities requires the development of ecological indicator values adapted for Ukraine.

Crustose lichens prevail in floristical compositions of the epilithic lichen associations from the classes Rhizocarpetea geographici and Verrucarietea nigrescentis, with higher coverage; where the foliose and fruticose species are much less distributed and their coverage is less, as well. Lichens with leprose crustose thallus are very rare and usually occur in some more shaded and wet sites. The fruticose lichen *Ramalina pollinaria* occurs sporadically in the epilithic communities from class Rhizocarpetea geographici and this species is diagnostic to the new association *Aspicilio cinerei–Ramalinetum pollinariae*. Species with *Cladonia*-type thallus are rare in all epilithic associations and dominate in the epigeic association *Cladonietum mitis*.

Lichens, such as *Acarospora fuscata, Candelariella vitellina, Lecidea fuscoatra, Polysporina simplex, Protoparmeliopsis muralis* are the most frequent species for

all epilithic associations. Some of them are diagnostic to syntaxa of different rank (Table 7). *Candelariella vitellina, Polysporina simplex* and *Protoparmeliopsis muralis* occur in more than 60% of all relevés. According to our observations, the foliose and fruticose species are almost completely absent and some crustose species (*Candelariella vitellina, Lecidea fuscoatra, Polysporina simplex, Protoparmeliopsis muralis*) have very high coverage on the rock surfaces actively exposed to anthropogenic influences (trampling, breeding of honeycombs, etc.).

CONCLUSIONS

This study is the first attempt to explore the lichen communities of the Teteriv River basin. Five epilithic lichen associations, one subassociation of two alliances and two orders of the classes Rhizocarpetea geographici and Verrucarietea nigrescentis, and one epigeic lichen association, one alliance and one order of the class Ceratodonto purpurei-Polytrichetea piliferi have been described. The associations *Aspicilietum contortae, Cladonietum mitis, Parmelietum conspersae, Parmelietum somloensis* and the alliance Aspicilion calcareae were found to be new for Ukraine, as well as the new association *Aspicilio cinerei-Ramalinetum pollinariae* is described in this paper.

The results of our study covering lichen communities of Teteriv River basin is merely a small contribution to developing syntaxonomy of Ukraine's cryptogamic vegetation. We hope that this field will be developed rapidly in Ukraine, and much more information will appear soon covering this subject.

*

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