Review of the studies on aero-terrestrial cyanoprokaryotes and algae in Bulgaria with a Checklist of the recorded species. I.

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Dedicated to Assoc. Prof. Dr Stefan Draganov in honour of his 75th anniversary

Abstract. The present paper provides a review of the phycological studies on aero-terrestrial cyanoprokaryotes and algae in Bulgaria, following the different aero-terrestrial habitats, which have been examined in the country so far. In total, 81 publications with records of more than 500 taxa are analysed. The complete checklist is provided in the second part of the paper. Nonetheless, it could be said that the knowledge of aero-terrestrial phycoflora in Bulgaria is far away form being complete.

Key words: aero-terrestrial algae, Bulgaria, cave algae, cyanoprokaryotes, soil algae

Introduction

Aero-terrestrial cyanoprokaryotes (cyanobacteria) and algae are worldwide known as important organisms for the primary rock deterioration and have an exceptional role for soil fertility. Presently, the interest in autotrophic inhabitants of the walls has significantly increased and this is related mainly to the possibility of using them for thermal insulation. On the other hand, the algae change the colour of walls and buildings and this explains the need of creating effective methods for their elimination.

Although the above-mentioned ecological group is so significant and is represented by over 1000 species (Ettl & Gärtner 1995), it is relatively less investigated and certainly underrepresented in the context of aquatic studies (Johansen & Shubert 2001). The latter authors explained the reason for this as possibly related to the general necessity of obligatory cultivation of the materials in laboratory, with their full life history, including the flagellated and adult stages. The same is valid for the knowledge of aerophytes in Bulgaria, despite the fact that phycological studies in the country had started at the end of 19th century. Brief notes on this ecological group in Bulgaria, outlining the fragmentary character of the data, could be found in the general papers on cryptogamic biodiversity by Vodenicharov & al. (1993) and Temniskova & al. (2005). The aim of the present paper is to review the phycological studies on this interesting ecological group in Bulgaria, tracing out the different aero-terrestrial habitats, which have been examined in the country so far. The complete checklist is provided in the second part of the paper. The aero-terrestrial phy-

coflora and related terminology follows the Syllabus of Ettl & Gärtner (1995), but the photobionts in lichens remained out of the scope of this paper.

Aerophytic cyanoprokaryotes and algae on rocks

The first investigations of rock algae were carried out in the Rila Mts, on the wet rock slopes of Chadur-Tepe (Petkoff 1905). Other early floristic works were those of Petkoff (1907, 1908, 1908-1909, 1922, 1925, 1929a, b, 1933), in which the author examined samples from wet calcareous and archaic rocks, as well as from marl rocks above karst springs. The author studied different localities in the Balkan Range (above the Cherepishki and Sokolski monasteries; in the pot-holes between Karloukovo and Panega), Mt Vitosha (from river Boyanska below the waterfall), Pirin Mts (nearby river Bunderitsa), Rila Mts (in the Kostensko Gorge – above the baths and around the Kostenski waterfall), in the town of Lovech and in its vicinities (above the Ezero and Bash Bounar karst springs, and around the old water-mill's weir in the town), and in the nearby water fountains (above Konyovo village and above the Sveti Vrach baths, Sandanski region).

Over 20 years later interest in the aerophytes arose again. The cyanoprokaryotes and algae from the Rila Mts, which developed on the wet gneisses around the lakes in the Ourdin Cirque and along the banks of its outflowing streams, rivers Ourdina and Malka Ourdina, have been already studied (Wodeničaroff 1958; Wodenitscharoff 1962; Draganov 1964a). Vodeničarov (1962) reported cyanoprokaryotes and algae from the wet calcareous rocks around lake Blatnishko. In the comprehensive *Algal Flora of Bulgaria* (Vodenicharov & al. 1971) the distribution of rock algae was generalised for the following sites: Mt Ograzhden, the Balkan Range (with entries on Zlatna Panega and Zheravna), Rila, Pirin (with an entry on the region of Bansko), Vitosha, and Rhodopi Mts, the Black Sea Coast (and particularly the Devnya springs), the Valley of Strouma River, Madara, and the regions of the towns of Kyustendil, Sofia, Trun, Vidin, Lovech, Shoumen, Veliko Turnovo, Sozopol, and Plovdiv.

The first studies of aerophytes on the granite and limestone monuments in Bulgaria with use of algal cultures in addition to direct microscoping were published by Gärtner & Stoyneva (2003). In their study the occurrence of a free-living *Trebouxia arboricola* Puym. was discussed and proved for Bulgaria, and the existence of *Apatococcus lobatus* (Chodat) J.B. Petersen, reported earlier for the country under the confusing name *Protococcus viridis* C. Agardh., was documented for first time. The same authors continued with studies of the aerophyton on the rocks in the Erma Gorge near the town of Trun and by means of direct microscoping, followed again by investigation of algal cultures, recorded a free-living *T. arboricola* was (Stoyneva & Gärtner in press).

Draganov (1964a) and Draganov & al. (1984) examined numerous samples from wet and shady andesite rocks on the capes Ekrene, Emine, Kaliakra, Kartaliyski, Kavaklar, Houmata, Kochan, Kolokita, Sivriboroun, Shabla, Cherni Nos, and Atanas. They also reported algae from the wet rocks around Tyulenovo, Yailata, Rousalka Resort, Kavarna, Ilandzhik, Galata, Balchik, the canal between lake Varnensko and the Black Sea, Varna and the vicinities (Traka, Zhournalist, etc.), Drouzhba Resort, Byala, Obzor and Vlas villages, nearby the peculiar haline lakes of Balchishka Touzla, Nanevska Touzla and Shablenska Touzla, etc. Further data on the distribution of cyanoprokaryotes and algae on the Black Sea coastal rocks were provided by Vodenicharov & al. (1971) and by Jordanov & Dimitrova (1959).

On the rocks of the Black Sea island St. Ivan, Petkoff (1919) found a new diatom taxon and named it *Taxorium undulatum* var. *ponticum* Petkoff.

In total, the recorded rock phycoflora contains 146 species, 10 varieties and two forms of six divisions. Most of the detected taxa belong to the group of cyanoprokaryotes (122 species and four varieties).

Aerophytic cyanoprokaryotes and algae on stones and sands

The phycoflora on stone surfaces was studied in samples from the wet stones of water fountains and wells in the towns of Svishtov and Velingrad, from stones around the springs of Panega and Devnya, from the wet sandstones in the Lovech region, from stones around the lakes in the Ourdin Cirque in the Rila Mts and Kremenski Cirque in the Pirin Mts (Petkoff 1908-1909, 1938; Wodeničaroff 1958; Wodenitscharoff 1962; Vodeničarov 1962; Vodenicharov & al. 1971; Rott & Pernegger 1994). The concrete walls of a water fountain near Dolno Linevo village were examined by Stoyneva (1991).

Protococcus viridis was found as widely distributed on stones in the Pirin Mts (Petkoff 1925). However, owing to lack of detailed descriptions and drawings of the findings of this complicated taxon, it is now difficult to say whether the examined material belongs to the more recently established species *Desmococcus olivaceus* (Pers. ex Ach.) J.R. Laundon, or to *Apatococcus lobatus*.

Vodenicharov & al. (1971) reported the cyanoprokaryotes *Gloeocapsopsis crepidinum* (Thur.) Geitler (Syn. *Gloeocapsa crepidinum* Thur.) and *Isactis plana* Thur. from the Black Sea coastal stones.

Draganov (1964a) and Kirjakov (1985) encountered cyanoprokaryotes and algae on the wet sands near the Varna beach, the wet shady sands along the right bank of river Vidbol near Sinagovtsi village (Yasovitsa locality), and in the surroundings of Sofia.

The epilithic phycoflora in Bulgaria is represented by 23 species and one variety of three divisions, and cyanoprokaryotes are the richest group (18 species). Only seven species from four divisions have been identified as related to sand substrates.

Aerophytic cyanoprokaryotes and algae on walls and roofs

The earliest reports of this attention-arresting group in Bulgaria featured the walls of the Sofia Botanical Garden and the wooden walls of different buildings in Sofia, as well as moist roofs tiles (Petkoff 1904, 1907). The algae from the wet stones and wooden walls of the troughs and water fountains in the towns of Lovech and Svishtov, along the Danube and below the Madarska Cave were reported by Petkoff (1908-1909, 1911b, 1933, 1939b). Petkoff (1908–1909) reported *Pleurococcus vulgaris* Menegh from pails and boards of wells in and around the town of Lovech.

Petkoff (1925) also examined the moist walls around the hot springs of Shafa-Banya (Blagoevgrad), Sveti Vrach (Sandanski) and Marikostenovo and found there a wide distribution of the green alga *Protococcus viridis* (?*Desmococcus olivaceus*). Semerdzhiev & al. (1980) reported coccal green and blue-green algae from the walls around the springs of Haskovo.

The development of *Prasiola crispa* (Ligthf.) Menegh. (originally as '*Schizogonium crispum* (Lightf.) Gay ad β (var. *prasioloides*) Chodat) was recorded on the nitrogen-enriched wooden outhouse walls in Choupetlovo village on Mt Vitosha, again by Petkoff (1922, 1934). Other representatives of the aerophyton were reported from the calcareous walls of Garvan-Kamuk (Petkoff 1907); from the walls in Berkovitsa town and its environments (Petkoff 1911a), from Devnyanski and Madarski springs (Petkoff 1938, 1939b), and from different walls in the regions of Sofia, Plovdiv, Zlatna Panega, and Mt Vitosha (Kiriakow 1970; Vodenicharov & al. 1971; Vodeničarov & al. 1991). From the stone walls of Plovdiv, Vodeničarov & Benderliev (1971) described the new species *Kentrosphaera gibberosa* Voden. & Benderl. They noted the aerophillic character of the alga, but mentioned also that it could develop on stone walls submerged in water.

The lack of a more detailed description of wall substrata makes impossible a more profound analysis of the data on algal distribution on different wall types. However, the calcareous walls from the Garvan-Kamuk locality and from Devnyanski and Madarski springs reported by Petkoff (1907, 1938, 1939b) apparently have to be excluded from the group of artificial walls in recent settlements.

In total, 44 species, five varieties and one form were detected as epilithes, which develop as aerophytes, or could live in a submerged state too. The epilithic algal flora of stone walls contains 43 species and four varieties. As it could be expected, is very similar to the epilithic flora in the field and to the tile phycoflora too. Only three species and one variety have been detected on wooden walls.

Aerophytic cyanoprokaryotes and algae on barks of trees and trunks

Studies on these algae in Bulgaria began with the report of Petkoff (1905) on the development of *Pleurococcus vulgaris* on the barks of *Picea abies* L. in Sitovo region. Petkoff (1907, 1908, 1908–1909, 1911a, 1922) examined tree barks and moist wooden old buildings in Sofia and in the region of Sofia, barks of trees in the Korou-Baglar locality, and near the river above Dragalevski Monastery (Mt Vitosha), in the Baram locality and around Panega springs (between Karloukovo and Panega), in the town of Berkovitsa and its environments. Petkoff (1911b, 1929a) and Wodenitscharoff (1962) recorded algae on tree trunks along the Danube River, in the town of Lovech and in the Ourdin Cirque (Rila Mts). Vodenicharov & al. (1971) added some species from the regions of Sofia,

Lovech, Zlatna Panega, from the Rila, Rhodopi and Vitosha Mts.

Petkoff (1925) wrote of the wide distribution of *Protococcus viridis (?Apatococcous lobatus*) on tree trunks in the Pirin Mts. Vodenicharov & al. (1971) reported *Klebsormidium pseudostichococcus* (Heering) Ettl & G. Gärtner (as *Hormidium pseudostichococcus* Heering) and *Prasiola crispa* as widely distributed in Bulgaria.

Petkoff (1908-1909) described the new green algal taxon, *Ulothrix aequalis* var. *variabilis* Petkoff, from boards and beams of a water-mill in the vicinity of Svishtov town.

In total, 16 species and one variety of three divisions have been recorded on barks and trunks. Chlorophytes were represented by 10 species and one variety, while of the cyanoprokaryotes only six species were recorded.

Aerophytic cyanoprokaryotes and algae among mosses

Investigations of these algae began with the report on the development of *Hormiscia flaccida* (Kütz.) Lagerh. on wet fossilized mosses from Hadzhi-Elesko (Petkoff 1907). Petkoff (1908, 1908-1909, 1922) described cyanorpokaryotes and green algae, which develop on the moss thalli on archaic rocks and trunks in Kostensko Gorge, near river Dragalevska, and on a calcareous terrain in the region of Vurshets. In samples from *Sphagnum* and *Hypnum* mosses below lake Bunderitsa in the Pirin Mts, Roubal (1947) found desmid algae. Wodenitscharoff (1962) also recorded desmid algae and diatoms in moist places in the Ourdin Cirque (Rila Mts). In the same year Vodeničarov (1962) reported *Hormotilla mucigena* Borzí, together with *Nostoc ellipsosporum* Rabenh. found among mosses on rocks in the valley of the rivulet Lebnitsa (Mt Ograzhden). Draganov (1964a) studied a dry blue-green crust among hepatic mosses on shady lime rocks of river Zlatna Panega and found there *Tolypothrix byssoidea* (Hassall) Kirchner. Kiriakow & Vodeničarov (1984) examined the algae between *Sphagnum* mosses in the Smolyan Lakes (Rhodopi Mts). However, according to the species composition reported by them, the studied mosses were probably submerged. Vodenicharov & al. (1971) reported *Symploca muscorum* (C. Agardh) Gomont as developing among the mosses in the Magourata Cave. The latter authors had also noted some species from the regions of Rhodopi, Rila, Ograzhden, Vitosha, Lyulin, Pirin, and Stara Planina Mts.

In total, 38 species, 12 varieties and four forms of four divisions have been found among the mosses in samples collected from different sites in Bulgaria. Most of the species belong to the group of streptophytes (19 species, 11 varieties and four forms), while cyanoprokaryotes were represented by 12 species only.

Soil cyanoprokaryotes and algae

The earliest investigation of algae from the soil surface in Bulgaria could be traced back to the end of the 19th century. The first alga recorded from this group was the hydro-terrestrial species *Botrydium granulatum* (Grev.) Vischer found on wet soils near river Iskur (Petkoff 1898-1899a). Most of the early surveys on soil algae were associated with different wet substrates. In the Rila Mts, Petkoff (1905) studied the soils in humid places around and below Bistrishki lakes, below the springs of the stream Beli Iskur and along its left bank. On Mt Vitosha, Petkoff (1922) explored the humid areas near the stagnant waters and sluggish streams below the villages Boyana, Dragalevtsi, Bistritsa, and in the Kourou-Baglar locality. More humid areas were investigated in the town of Sofia and its region (Petkoff 1907, 1922). Petkoff (1898-1899b, 1907, 1908, 1908-1909, 1938) reported algae from loesses near the town of Rouse, from soggy places above Obzor village (= Gyozike) and in the vicinity of the town of Lovech, from wet calcareous soils in the vicinity of the town of Veliko Turnovo, and in the region of the town of Troyan, from wet soils around some water fountains in the town of Svishtov and in its vicinities (Manastirska, Ribarska and Voivodska water fountains), from the peripheral parts of Achika locality of the Sindelsko swamp, on dried up parts of the Dragomansko swamp, and near to the springs of river Panega. Petkoff (in Georgieff 1906) reported *Bangia atropurpurea* (Roth.) C. Agardh, based on material collected by Prof. Stefan Georgieff from calcareous soil in the region of Lakatnik in the Balkan Range. Most probably, this finding was occasional considering the development of this red alga in the fresh waters near the studied site.

Over 20 years after the publications by Prof. Stefan Petkoff and sixty years after the first finding, *Botrydium*

granulatum was found for the second time near river Palakariya (Temniskova 1959). Subsequently, Vodenicharov (1960) and Vodeničarov (1972) investigated the genus *Botrydium* Wallr. from different sites along the Black Sea Coast, along the Danube River and from Bulgarian inlands and described the new species *B. corniforme* Voden.

Bulgaria is known for the great diversity of soil types and the territory of the country is a real museum of soils specific for the Southeastern Europe (Donov 1973). However, only a small part of this diversity has been investigated:

- alluvial soils in the Stariya Dub Reserve on the Danubian island Vardim (Stoyneva 1991; Draganov & al. 1992);
- alluvial-meadow soils in the Sofia Plain, near Obrochishte and Mikrevo villages, close to river Rezovska (Draganov & Genova 1966; Draganov & Dimova 1971; Draganov & al. 1992);
- brown forest soils on Mt Vitosha (below the last station of the chair lift, above the Bai Krustyo shelter and in the Mecha Polyana locality (Draganov & Genova 1966);
- chernozems (blacksoil) in the North Bulgarian forest-steppe zone (Draganov 1975);
- meadow chernozem in the cornfields and mangel-wurzel near Aidemir village and peat-boggy soils under reeds in the vicinity of Vidin town (Draganov 1981a);
- grey forest soils in the North Bulgarian forest-steppe zone (Draganov 1975);
- leached chernozem-smolnitsa soils from the experimental field of the Institute of Hydrology and Meteorology of Bulgarian Academy of Sciences (Decheva 1965);
- leached brown Mediterranean soils (maroon forest soils) from the experimental fields of the Institute of Plant-Growing of the Agricultural Academy in Vranya and the Institute of Hydromechanics and Melioration Works in Chelopechene (Decheva 1965); in the vicinity of Podgoumer village (Draganov & Lilova 1984);
- mountain-meadow soils below the peak Golyam Rezen on Mt Vitosha (Draganov & Genova 1966);
- light-grey forest soils in Dolen Bliznak (Draganov & Dimova 1971);
- humus carbonate soils (rendzina) in Emen and Komshtitsa (Draganov & Dimova 1971; Draganov 1977);
- poorly leached chernozem in Chestimensko (Draganov & Dimova 1971);
- leached smolnitsi soils in Bozhourishte (Draganov & Dimova 1971);
- leached brown forest soils below *Fagus orientalis* in the Lopoushna Reserve (Draganov & al. 1992);
- alluvial bog soils in the Kamchiya riparian forest (Draganov & Dimova 1971);
- carbonate chernozem in the test field near Trustenik (Draganov & Lilova 1984);
- leached brown Mediterranean soils (maroon forest soil) in the vicinities of Podgoumer village (Draganov & Lilova 1984).

The peculiar algae developing on Bulgarian haline soils of the solonchak type were studied for the first time by Aleksieva (1960). Her investigations were carried out in the Training and Experimental Farm of the Vasil Kolarov Higher Agriculture Institute (Plovdiv) and most of the reported taxa were cyanoprokaryotes (22 species and two forms) and green algae (18 species and two varieties).

Draganov (1964a, b, c) – a prominent name in the investigation of soil algae in Bulgaria – was the first to use algal cultures in soil studies, to describe soil algal coenoses from Bulgarian soils and to investigate the soils from the western part of the Sofia Plain (in the region of Bozhourishte and Prolesha villages), the rendzina soil near Emen village, and the alluvial soil near to river Batova and to Obrochishte village. From the two latter sites he described the new cyanoprokaryote *Cylindrospermum echinulatus* Draganov and afterwards changed its species name to *Cylindrospermum dobrudjense* Draganov (Draganov 1969). Draganov (1981a) also described the new cyanoprokaryote species *Calothrix hollerbachii* Draganov and *Aulosira valkanovii* Draganov from the chernozem soils. Draganov (1964b) found dependence between the floristic richness of studied soils and their pH characteristics. The same author proposed a technique for quantitative determination of the soil algae and by means of fluorescence microscopy proved the close relation of humidity, temperature and insulation with the amount of active (chlorophyll-containing) algae in the surface soil layer (Draganov 1981b).

Vodeničarov (1958), Wodeničaroff (1957/1958) and Draganov (1960, 1965) reported different soil algae from the regions of Godech, Sofia (Hadzhi Dimitur and Ovcha Koupel residential districts, and Dolno Boyansko Blato), Kourilo, Kostinbrod, Samokov, Zabel,

Varna, Sozopol, Primorsko, from the mouth of river Kamchiya, the Lyulin, Rila (Ourdin Cirque), Rhodopi (the vicinities of Smolyan and Chervenata Stena Reserve), Balkan Range (Berkovitsa Divide), Vlahina, and Rouy (peak Boboshevski Rouen) Mts. Draganov & Witschewa (1966) investigated the soils from different plant pots in the greenhouse of the University Botanical Garden in Sofia. The cyanoprokaryotes of zonal and intrazonal soils in the North Bulgarian forest-steppe zone, nearby the Third Metallourgical Centre – Bourgas, and in Mt Strandzha were investigated in detail (Draganov & Mešinev 1971; Draganov 1979; Dahn 1986). The cyanoprokaryote crusts on wet soils along the left bank of river Yablanitsa (Filipovtsi-Trun) were examined by Draganov & Dimova (1971). Vodenicharov & al. (1971) in their comprehensive work generalized data on the Bulgarian soil phycoflora. Besides the above-mentioned investigations of alluvial soils, Stoyneva (1991) studied the edaphophyton from the Danubian islands (Bogdan, Kozlodoui, Svraka, Bezimen, Vardim, Mishka, and Leskovets) and the moist sites along the Danube in the vicinities of Ostrov, Slivata and Orsoya villages, below the towns of Lom and Ryahovo, above the town of Toutrakan, and the sand strip of the Lyuta island. Stoyneva (1995) discussed the amphibian development of the symbiotic nitrogen-fixing system *Azolla filliculoides* Lam. – *Trichormus azollae* (Strasb.) Komárek et Anagn. in the vicinities of Sreburna wetland along the Danube. Most recently, the soil from the Borisova Garden in Sofia was studied and some interesting yellow-green algae have been recorded (Stoyneva & Gärtner in press).

In total, 280 species, 22 varieties and 11 forms of six divisions of cyanoprokaryotes and algae are known from the Bulgarian edaphophyton. Among them, cyanoprokaryotes prevailed (181 species, seven varieties and 10 forms), followed by the green algae (57 species and 10 varieties).

Aerophytic cyanoprokaryotes and algae in caves

The first methodological directions for cave studies combined with notes on the Bulgarian cave flora were given by Petkoff (1939a). The first investigated cave in terms of algae in Bulgaria is Madarska Cave (Petkoff 1939b, 1943). Subsequently, the algal flora of Bulgarian caves attracted the attention of Draganov & Dimitrova (1968) and Draganov & Dimitrova-Burin (1977, 1980), who studied the speleophyton in the following caves: Temnata Doupka (near Lakatnik), Anduka and Bacho Kiro, Vodnata, Temnata Doupka (near Berende Izvor village), Tumni Pech and Peina Doupka, Chiflika, Ledenika, Magourata, Vodopada (near Kroushouna), Bezimenna 22, and Ovnarkata (near Karloukovo village). Data obtained by Draganov & Dimitrova (1968) revealed that all samples, without exception, taken from the inner and dark zones (distanced up to 520 m from the entrance) of the investigated caves, possess active, chlorophyll-containing algal cells. Vodenicharov & al. (1971) generalized the data on cyanoprokaryotes and algae from some caves in the Sofia region. Data published from the Ledenika Cave directed attention to the dangerous algal growth on the illuminated structures in the so-called "urbanized" caves (Stoyneva & al. 2002). Most recently studied is the aerophyton of the peculiar open Prokhodna Cave near Karloukovo (Stoyneva & Gärtner in press).

The Bulgarian aerophytic speleophyton contains 64 species, one variety and two forms of four divisions, with prevalence of cyanoprokaryotes (59 species).

Aerophytic cyanoprokaryotes and algae on snow

Aerophytic algae from the snow surfaces were studied by Petkoff (1929b) and Kol (1956) in the Pirin and Rila Mts, in the regions of peaks Vihren and Mousala (Stalin), respectively. Wodenitscharoff (1962) reported some algae from the snowdrifts in the Ourdin Cirque (Rila Mts) and subsequently Vodenicharov & al. (1971) added some species from the region of Sofia and Mt Lyulin. All reported nival algae from Bulgaria (11 species, two varieties and one form) belong to the groups of cyanoprokaryotes and of green algae.

Conclusions

In total, 480 species, 50 varieties and 19 forms of seven divisions of cyanoprokaryotes and algae have been found during the different phycological studies in Bulgaria. Most of the investigated aerophytic and soil inhabitants in Bulgaria belong to the group of cyanoprokaryotes (304 species, nine varieties and 10 forms), followed by representatives of the chlorophytes, streptophytes, ochrophytes (diatoms and yellow-green algae), euglenophytes, pyrrhophytes and the red algae.

The highest number of cyanoprokaryotes is easily explainable by their wide distribution on different substrates, but the special attention paid to them in most of the studies should be credited too. However, it should be emphasized that chlorophytes and streptophytes are the richest groups on wooden substrates (walls and troughs), barks, tree trunks, and among mosses. In spite of the 81 publications on the topic and over 500 recorded taxa, with eight taxa described, it could be pointed out that the knowledge of aero-terrestrial phycoflora in Bulgaria is far away form being complete.

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