BIOLOGY

Coprophilous microfungi of the genus *Sporormiella* Ellis & Everh. from Ukraine

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Abstract. Data on morphological and ecological features, and distribution of 10 species of *Sporormiella* (Pleosporales, Dothideomycetes) of Ukraine are presented. Three species of *Sporormiella* (*S. australis* (Speg.) S.I. Ahmed & Cain, *S. minima* (Auersw.) S.I. Ahmed & Cain, *S. vexans* (Auersw.) S.I. Ahmed & Cain) were not previously described for the Steppe zone of Ukraine. The detailed description of all the species, synonyms, substrates, and localities in Ukraine and world distribution are also provided as well as the identification key.

Keywords: *coprophilous microfungi, Dothideomycetes, Sporormiella, species diversity, ecological features*

Introduction. Microscopic fungi that develop on the animal excrement belong to the ecological group of coprophilous species. Recently, a number of articles describing new species of coprophilous fungi were published [8, 14, 16, 17]. We also have described a new species of the genus *Sporormiella* Ellis & Everh., *S. tomilinii* [5]. Currently, many members of the coprophilous loculoascomycetes of the genus *Sporormiella* are insufficiently investigated in Ukraine and require careful study.

Overview of the publications. Genus *Sporormiella* was described in 1892 by J.B. Ellis and B.M. Everhart based on a single new species found in cow dung, *Sporormiella nigropurpurea* [6]. The main feature by which the authors distinguish *Sporormiella* Ellis & Everh. from *Sporormia* De Not. was the presence of stromata on the surface of the substrate, but in the subsequent investigations of a representative sample of *S. nigropurpurea* it was not confirmed. This fact has called into question the validity of the description of the genus *Sporormiella*, and stimulated a systematic review of certain species belonging to the genera *Sporormia* and *Sporormiella*.

A. Breton in 1964 proposed to divide the genus into two genera, *Sporormia* and *Sporormiopsis* [12]. The distinguishing characteristic of the genus *Sporormia* is the presence of cylindrical ascospores that are united by a common gelatinous sheath in a cylindrical formation in the center of the asc. All other species of the former genus *Sporormia* with cylindrical or clavate ascospores, each of which has an individual gelatinous sheath were assigned to the new genus *Sporormiopsis* [12]. Using as the types species for the new genus *Sporormiopsis* Bret. et Faur. the fomer spesies *Sporormia minima* Auersw. was renamed as *Sporormiopsis minima* (Auersw.) Breton & Faurel in their revision of the genera *Sporormia* and *Sporormiella* reverted to the earlier published name *Sporormiella*, and *Sporormiopsis* was listed as a synonym [6].

In modern taxonomy genus *Sporormiella* is assigned to the family *Sporormiaceae*, order *Pleosporales*, subclass *Pleosporomycetidae*, class *Dothideomycetes*, division *Ascomycota* [22]. All of the currently known 60 *Sporormiella* species are found on all the continents [10-13, 19, 21]. In Ukraine, species of the genus were described from the territory of Polissia, Forest-steppe, and Mountaeous Crimea [1-4]. Most of our research provides information on the least explored area of the Steppe zone where only 2 species were previously described, *Sporormiella intermedia* (Auersw.) S.I. Ahmed & Cain ex Kobayasi and *S. lageniformis* (Fuckel) S.I. Ahmed & Cain, found in Lugansk Nature Reserve [3].

Purpose. The purpose of the research was study the species diversity of *Sporormiella* (Dothideomycetes, Ascomycota) from Ukraine, to identify the morphological and ecological characteristics, and distribution of the studied mycobiota.

Materials and methods. Samples of dung were collected during 2000-2014 years in expeditions to the Steppe zone of Ukraine as well as were from the National Herbarium of Ukraine at the M.G. Kholodny Institute of Botany (KW). Mycological samples were collected according to the conventional methods [9]. Fruiting bodies of micromycetes were isolated from the substrate by a wet chamber method. Identification of species was done using light microscopy, taxonomic descriptions, and handbooks [6, 10, 11]. Taxonomic names of fungi strictly follow the international database «Index Fungorum» [22]. Herbarium specimens of the fungi were deposited to the National Herbarium of Ukraine at the M.G. Kholodny Institute of Botany (KW) and at the herbarium of I.I. Mechnikov Odessa National University (MSUD).

Results and Discussion. Analysis of the collected material and of all the deposited herbarium specimens have shown that the diversity of genus *Sporormiella* in Ukraine is represented by 10 species. Three species of *Sporormiella* were not previously described for the Steppe zone of Ukraine. Below, the description of all the species is given in the alphabetical order. The source, synonyms, substrates, and localities in Ukraine and the world distribution are also provided.

Sporormiella australis (Speg.) S.I. Ahmed & Cain, Can. J. Bot. 50(3): 434 (1972).

Ascomata scattered, immersed or partially immersed in the substrate, globose, with short papilliform neck and rounded hole, 240-270 μm, smooth, bare, dark brown. Asci 130-135 × 19-22 μm, cylindrical, 8-spore, spores arranged in two rows. Pseudoparaphyses numerous, filiform, unbranched, septate. Ascospores cylindrical-fusiform, 38-44 (-46) × 7-8 μm, sometimes slightly curved, dark brown, transversely 3-septate, easy to break down into individual cells in places all septa, terminal cells tapered, germ slits located diagonally, zigzag, gelatinous sheath colourless, narrow.

Mykolaiv region, Yelanetskyi district, Nature Reserve «Yelanetskyi Step», steppe plot, on dung of roe deer (*Capreolus capreolus L.*, 1758), 8.07.2012.

General distribution: Europe, North America, South America, Africa, Australia, New Zealand.

Note. This species is described for the first time for the Steppe zone of Ukraine. Previously, it was known only from National Park «Desniansko-Starohutskyi» [1, 3].

Sporormiella corynespora (Niessl) S.I. Ahmed & Cain, Can. J. Bot. 50(3): 435 (1972).

Ascomata scattered or loosely aggregated, immersed when young, becoming nearly superficial when old, subglobose, with papilliform neck and wide hole, 320-400 μm, smooth, bare, black. Asci 150-200 × 20-23 μm, cylindrical-clavate with a short stipe, 8-spored. Pseudoparaphyses a few, filiform, septate. Ascospores clavate, 50-59 × 10-11.5 μm, straight and curved, dark brown, transversely 7-septate, third cell is much larger than the other, spores do not break up into separate segments, terminal cells are large, the first cell is conical, the last cell round-conical, germ slits located diagonally, zigzag, no drops of oil, gelatinous sheath colourless, narrow.

General distribution: Europe, North America, Australia. In Ukraine it was known from National Park «Sviati Gory» [3]. On dung of rabbit (*Oryctolagus cuniculus* L., 1758), cervids (Cervidae).

Sporormiella cymatomera S.I. Ahmed & Cain, Can. J. Bot. 50(3): 438 (1972).

Ascomata scattered, immersed or partially immersed, at maturity almost superficial, pear-shaped, with short papilliform neck and rounded hole, 270-318 × 200-220 μm, soft, dark brown. Asci 135-143 × 15.5-17.5 (-19.0) μm, cylindrical, rounded at the apex, extended downwards, with a short stipe, 8-spored, spores arranged in two or three rows. Pseudoparaphyses numerous, unbranched, septate. Ascospores fusiform, 40-44.5 (-49.0) × 7-9 μm, straight or curved, dark brown, transversely 3-septate, spores are break down (separated) mainly in place central septum, terminal cells tapered, the first cell ascospores conical, slightly narrowed at the apex, the last cell rounded, germ slits located diagonally, direct, gelatinous sheath colourless, broad.

General distribution: Europe (Denmark, Spain, Netherlands, Ukraine, Sweden), North America (Canada, USA), South America (Argentina), Africa (Kenya), Australia, New Zealand. On dung of horse (*Equus ferus* Boddaert, 1785, *E. ferus caballus*).

Note. *Sporormiella cymatomera* is morphologically close to *Sporormiella lageniformis*. *S. cymatomera* differs from the latter by transverse septae and parallel germ slits of the spores. Spores of *S. lageniformis* are characterized by oblique septae and diagonal germ slits. Described for the first time for Ukraine in 2010 [2].

Sporormiella intermedia (Auersw.) S.I. Ahmed & Cain ex Kobayasi, Bull. natn. Sci. Mus., Tokyo 12: 339 (1969).

Ascomata scattered or aggregated in small groups, embedded when young, becoming more or less superficial when old, subglobose to pyriform, with short papilliform neck, 150-250 μm, smooth, bare, dark brown to black. Asci 145-175 × 24-28 μm, cylindrical-oval, slightly broader below the middle, 8-spored. Pseudoparaphyses filiform, septate, longer than the asci. Ascospores cylindrical, 47-59 × 9-11(-12) μm, broadly rounded at the ends, straight or curved, dark brown at maturity, transversely 3-septate, segments easily separable, terminal cells widely rounded, germ slit located diagonally, zigzag, gelatinous sheath colourless, broad.

Mykolaiv region, Yelanetskyi district, Nature Reserve «Yelanetskyi Step», steppe plot, on dung of roe deer, 8.07.2012; Kherson region, Chaplynskyi district, Askania-Nova Biosphere Reserve, steppe plot, on dung of hare, 26.05.2013.

General distribution: Europe, Asia, North America, South America, Africa, New Zealand, Arctic. On dung of hare (*Lepus europaeus* Pallas, 1778), roe deer (*C. capreolus)*, cow (*Bos taurus* L., 1758; *Bos taurus taurus*, domestic), rabbit (*Oryctolagus cuniculus* L., 1758), cervids (Cervidae).

Note. This species is morphologically similar to *Sporormiella teretispora* S.I. Ahmed & Cain, but differs with respect to the width of asci and ascospores (60-66 × 10-13 μm) [6, 11]. Some authors characterise this species along with *S. minima* as endophytic [20].

Sporormiella lageniformis (Fuckel) S.I. Ahmed & Cain, Can. J. Bot. 50(3): 446 (1972).

Ascomata scattered, immersed or partially semiimmersed in the substrate, subglobose, with elongated papilliform neck, 400-500 × 450-580 μm, black. Asci 120-145 (158) × 18-20 (25) μm, cylindrical, 8-spore, spores arranged in two of three rows. Pseudoparaphyses numerous, filiform, unbranched, septate. Ascospores elongate-clavate, 35-49 × 7-8.5 μm, straight or sometimes slightly curved, brown, 3-septate, to break down into individual cells in places all septa, septa are oblique, terminal cells conical, slightly narrowed at the apex, germ slits located diagonally, zigzag, gelatinous sheath colourless, broad.

General distribution: Europe (Ukraine, Latvia), Asia (Far East), North America. In Ukraine it was known from Luhanskyi Nature Reserve [3]. On dung of horses, deers, roes, boars.

Sporormiella megalospora (Auersw.) S.I. Ahmed & Cain, Can. J. Bot. 50(3): 449 (1972).

Ascomata immersed in the substrate, globose, 250-300 × 200-300 μm, with a wide hole at maturity, black. Asci 180-200 × 25-32 μm, cylindrical, with a short stipe. Pseudoparaphyses numerous, filiform, unbranched, septate. Ascospores cylindrical-clavate, 52.5-78,5 × 11.5-13 μm, straight or slightly curved, from greenish-brown to dark brown, transversely 3-septate, spores are break down mainly in place central septum, terminal cells conical, germ slits located diagonally, zigzag, gelatinous sheath colourless, narrow.

General distribution: Europe (Denmark, Lithuania), North America (Canada). In Ukraine it was known from National Park «Sviati Gory» [3]. On dung of cervids (Cervidae).

Sporormiella minima (Auersw.) S.I. Ahmed & Cain, J. scient. ind. Res. 12(3): 241 (1970).

Ascomata scattered or loosely aggregated, immersed when young, becoming nearly superficial when old, subglobose to nearly pyriform, 90-130 μm, smooth, bare, with short papilliform neck, dark brown to nearly black. Asci (80-) 90-100 × 13-18 μm, cylindrically oval with a short stipe, 8-spored, with spores obliquely arranged in two or three rows. Pseudoparaphyses a few, filiform, septate. Ascospores cylindrical, 28-33 (-36) × 5-6 μm, broadly rounded at the ends, straight or curved, ranging from colourless when young through yellowish brown to dark brown, transversely 3-septate, break up into segments prim arily on the central septum, cells nearly equal in size, terminal cells widely rounded, germ slit arranged in parallel, zigzag, gelatinous sheath colourless, narrow.

Mykolaiv region, Yelanetskyi district, Nature Reserve «Yelanetskyi Step», steppe plot, on dung of cow (*B. taurus taurus*, domestic), 8.05.2009 p.; Zaporizhzhya region, Kamiansko-Dniprovskyi district, the vicinity of the village Velyka Znamianka, on dung of cow, 16.08.2013.

General distribution: Europe, Asia, North America, South America, Africa, Australia, New Zealand, Arctic. On dung of cow (*B. taurus taurus*, domestic).

Note. This species is common in Ukraine [2], but for the Steppe zone of Ukraine is described for the first time. According to the literature it can be isolated from soil samples [4, 18].

Sporormiella minimoides S.I. Ahmed & Cain, Can. J. Bot. 50(3): 450 (1972).

Ascomata scattered or loosely aggregated, semi-immersed, becoming nearly superficial when old, subglobose to nearly pyriform, 160-220 μm, smooth, bare, with short papilliform neck, dark brown to nearly black. Asci 90-100 × 16-17 μm, cylindrically oval with a short stipe, 8-spored, with spores obliquely arranged in two or three rows. Pseudoparaphyses filiform, septate. Ascospores cylindrical, 28-35 × 6-7 μm, broadly rounded at the ends, straight or curved, from olivaceous brown to dark brown, transversely 3-septate, break up into separate segments in places all septa, terminal cells widely rounded, germ slits located diagonally, direct, gelatinous sheath colourless, narrow.

General distribution: Europe (Bulgaria, Lithuania, Ukraine), Asia (China), Africa (South Africa), North America (Canada, Mexico). On dung of roe deer (*C. capreolus)*.

Note. *Sporormiella minimoides* by morphological features in similar to the common for Ukraine *S. minima* and differs from the latter by the width of the spores and by the separation pattern and orientation of germ slit [6]. In *S. minimoides* spores are wider and separate into individual cells at the site of all the septae, whereas in *S. minima* – mostly at the central septum. Germ slits of *S. minimoides* are diagonal and straight, but in *S. minima* are parallel to the longitudinal axis of the cell and zigzag bent. Previously, *S. minimoides* was known from National Park «Desniansko-Starohutskyi» [1].

Sporormiella tomilinii O.V. Korol., Mikol. Fitopatol. 34(5): 11 (2000).

Ascomata scattered, immersed or partly immersed in the substratum, pear-conical, with a wide hole at the apex, 250-300 μm, glabrous, black. Asci cylindrical-clavate, 160-200 × 20-23 μm, 8-spore. Pseudoparaphyses numerous, elongated, unbranched. Ascospores fusiform, straight and slightly curved, with 7 partitions (third cell of spores wider than the other), with a deep constriction, dark brown, with small drops of oil, 55-70 × 13-15 μm. Mature spores easily break down into individual cells. Young spores colored, with drops, banners less expressive. surrounded by thick mucosa.

Kherson region, Holoprystanskyi district, the vicinity of the village Vynohradove, plot the sandy steppe, on dung of rabbit, 5.09.1998.

General distribution: Ukraine; holotype was deposited to the herbarium of the National Herbarium of Ukraine at the M.G. Kholodny Institute of Botany (KW).

Note. This species is morphologically similar to *Sporormiella corynespora* Niessl with respect to the structure and size of ascomata, the size and shape of asci, the eight cell composition of spores, both species have straight and curved spores, the third cell of the spores is significantly larger than other cells [5]. However, *S. corynespora* has distinctive features, mainly in the spore morphology. *S. corynespora* spores are smaller (50-59 × 10.0-11.5 μm [10]), the terminal cells are significantly larger, pear-shaped, as in the species described, septae less pronounced, spores do not separate into segments, there are no oil dropled inclusions, significantly thinner gelatinous spore sheaths, and generally are clavate shaped spores, not fusirorm.

Sporormiella vexans (Auersw.) S.I. Ahmed & Cain, Can. J. Bot. 50(3): 374 (1972).

Ascomata scattered, immersed or partly immersed in the substratum, pear-shaped, with a wide hole, 250-320 μm, bare, dark brown. Asci 135-180 × 17.5-22 μm, cylindrical-clavate, 8-spored. Pseudoparaphyses numerous, filiform, unbranched, septate. Ascospores fusiform, 35-45 × 7,5-9 μm, straight and curved, dark brown, transversely 7-septate, mature spores split into individual cells, terminal cells rounded-conical, not equal sides, germ slits located diagonally, zigzag, gelatinous sheath colourless, narrow.

Zaporizhzhya region, Zaporizhzhya, island Khortytsia, National Park «Khortytsia», steppe, on dung of roe deer (*C. capreolus)*, 14.05.2008; Mykolaiv region, Yelanetskyi district, Nature Reserve «Yelanetskyi Step», steppe, on dung of roe deer, 13.04.2012.

General distribution: Europe, Asia, North America New Zealand. On dung of roe deer (*C. capreolus).*

Note. This species is described for the first time for the Steppe zone of Ukraine. Previously, it was known only for Polissia [1, 3]. The size of asci and spores of the investigated samples insignificantly differ from holotype [6], which is common for the genus *Sporormiella* [7].

A detailed analysis of our results, the herbarium specimens, and literature allows us to propose the following key for the identification of the studied species of *Sporormiella*:

1 – Ascospores transversely 3-septate……. (2)
– Ascospores transversely 7-septate……. (8)
2 – Ascospores less than 36 μm long …….. (3)
– Ascospores over 36 μm …… (4)
3 – Ascospores 6 μm or less in width - 28-33 (36) × 5-6 μm ……..... *S. minima*
– Ascospores 6 μm or more in width, 28-35×6-7 μm ……..... *S. minimoides*
4 – ascospores less than 46 μm in length …… (5)
– Ascospores more than 46 μm in length ……. (7)
5 – Ascospores septa oblique, ascospores 35-40 × 7-8 μm ……..... *S. lageniformis*
– Ascospores septa transverse and straight …….. (6)
6 – Germ slits parallel, 40-45 × 7-9 μm ……...… *S. cymatomera*
– Germ slits diagonal, ascospores 38-44 (46) × 7-8 (9) μm ……..….. *S. australis*
7 – Ascospores less than 60 μm in length - 46-59 × 9-11 (12) μm ……..... *S. intermedia*
– Ascospores larger, 71-87x17-18 μm ……. *S. megalospora*
8 – Ascospores less than 45 μm in length, 35-45 × 7.5-9 μm ……...… *S. vexans*
– Ascospores more than 45 μm in length ……. (9)
9 – Ascospores less than 60 μm in length, 45 (50) -59 (60) × 10-12 μm ……. *S. corynespora*
– Ascospores less than 60 μm in length, 60-70 × 13-15 μm ……... *S. tomilinii*

Some researchers have recorded a trend toward specialization of coprotrophs to the excrements of certain taxonomic groups of animals, however overall the fungi of this ecological group demonstrate a broad tolerance with the respect to the substrate [6, 19]. The substrates for the development of *Sporormiella* are the excrements of animals with different types of the digestive system, soil, plant debris [4, 10, 11]. The greatest number of species we found in the litter of *C. capreolus*.

We compared the species composition of the genus *Sporormiella* of Ukraine with other countries using Jaquard's Index. It was found that species composition of *Sporormiella* of Ukraine is close to the composition of that of Italy, Lithuania, and the United Kingdom correspondinly to the highest level of similarity (Kj from 0.60 to 0.75). The level of similarity is high due to the large number cosmopolitan species. The low degree of similarity was found in the species composition of *Sporormiella* of Ukraine of and New Zealand, China, Russia, and the Arctic areas (Kj from 0.14 to 0.26).

Conclusions. Species diversity of genus *Sporormiella* in Ukraine is presented by 10 species that have dark-colored multicellular cylindrical or club-shaped ascospores with individual gelatinous sheath. The main diagnostic features of species are dimensions of the ascospores, the number of cells in the ascospore, the direction of septa and germ slits.

The substrate for fungi of the genus *Sporormiella* is not only animal excrements of certain taxonomic groups, but also the soil, and plant debris. New locations of these loculoascomycetes in Ukraine can be predicted, taking into account the widespread trophic specialization of these species.

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