

## Smut fungi of Ukraine, a checklist\*

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An overview of the smut fungi in Ukraine is presented based on several years of intensive collections, reexamination of materials from all major Ukrainian herbaria, and critical revision of literature data. All species recorded from the country are listed according to recent nomenclature changes. For each species, the list of host plants on which they were reported is included. Ukrainian smut mycobiota consists of 157 species. Among them, six species, i.e. *Anthracoidea buxbaumii*, *A. caryophylleae*, *A. echinospora*, *A. pilosae*, *A. pseudirregularis*, and *Entyloma gaillardianum* were recorded as new for the country and four species, viz. *Entyloma microsporum*, *Microbotryum tragapogonis-pratensis*, *Schizonella cocconii*, and *Vankya ornithogali* were found on new hosts. The main genera of smut fungi for Ukraine are *Entyloma* with 30 spp., *Urocystis* with 24 spp., *Microbotryum* with 20 spp., *Ustilago* with 19 spp., and *Anthracoidea* with 17 spp. Of 27 genera recorded from Ukraine, 14 genera contain one species each. Furthermore, we compared the composition of smut fungi in Ukraine with those of well-documented adjacent and remote countries using the Tripartite Similarity Index. The results revealed a strong similarity between the smut biota of Ukraine and Central Europe.

Keywords: *Anthracoidea*, biodiversity, Exobasidiomycetes, Microbotryales, Ustilaginomycetes.

Smut fungi are a group of plant parasites united in having similar life strategy and organisation. They infect species of angiosperms, gymnosperms, pteridophytes, and lycopodiophytes (Vánky 2011). This often leads to a sterility of affected plants, and therefore plays an important role in regulating ecosystem dynamics (Alexander *et al.* 1996, Wennström 1999, Wennström & Ericson 1990). As parasites of a number of economically important hosts, smuts have been of great interest in agriculture. However, considering their phylogenetic position, smut fungi do not comprise a natural taxon, rather they are a group of plant parasitic fungi with similar morphology, i.e. possessing thick-walled teliospores as propagules of dispersion and survival. According to modern taxonomy, they are distributed among classes Entorrhizomycetes, Exobasidiomycetes, Ustilaginomycetes, and Microbotryomy-

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\* This paper is dedicated to the memory of the first author's grandmother, Zinaida V. Morozova, whose overall support helped him to start a scientific career.

cetes, sharing them with some phytopathogenic (e.g., Exobasidiales, Microstromatales), humanopathogenic (*Malassezia* Baill.), or saprobic (*Rhodospiridium* Banno, *Rhodotorula* F.C. Harrison) fungi (Bauer *et al.* 1997, Begerow *et al.* 2006). Moreover, such ascomycetous genera as *Sacroterium* G. Winter and *Restilago* Vánky could also be considered as smuts (Vánky 2011).

The diversity of smut fungi is unevenly studied in different regions of the world. Europe, in fact, is the best explored region. In addition to a continental monograph (Vánky 1994), there are a number of country-level monographs, checklists, or catalogues (e.g., Austria: Zwetko & Blanz 2004; Bulgaria: Denchev 2001; Finland: Liro 1924, 1938; France: Viennot-Bourgin 1956; Germany: Scholz & Scholz 1988, 2000; Great Britain: Ainsworth & Sampson 1950, Mordue & Ainsworth 1984; Hungary: Moesz 1950, Vánky *et al.* 1982; Italy: Ciferri 1938; Lithuania: Ignatavičiute 2000; Norway: Jørstad 1963; Poland: Kochman 1936, Kochman & Majewski 1973, Piątek 2005 a; Romania: Săvulescu 1957; Russia: Karatygin & Azbukina 1989, Azbukina & Karatygin 1995; Slovenia: Lutz & Vánky 2009; Sweden: Lindeberg 1959; Switzerland: Zogg 1985). Nonetheless, the smut mycobiota of Ukraine, the largest European country after Russia, has remained largely unexplored.

*Uredo violacea* Pers. was the first species of smut fungi recorded in Ukraine. It was collected in late 1820 by J. Jundzill (Jundzill 1830) and undoubtedly belonged to the *Microbotryum violaceum* (Pers.) G. Deml & Oberw. species complex that is now split into a number of host-specialized taxa parasitizing Caryophyllaceae. Later, several new species were reported by Valtz & Rishavi (1871) from the territory corresponding to modern Kyiv and Cherkasy regions. Plant pathogenic fungi of southern Ukraine were studied by Sredinski (1872-1873), Isachenko (1896) and Tranzschel (1902, 1905). However, a systematic, focused investigation of the diversity of these plant parasites has not been undertaken in this country. Nevertheless, certain regions of Ukraine were given more attention during the 20<sup>th</sup> century. Thus, collections have been carried out in the west of the country (Krupa 1888, 1889; Bobiak 1907; Raciborski 1909; Rouppert & Wróblewski 1910; Namysłowski 1914; Wróblewski, 1912, 1913, 1914, 1915, 1916, 1922 a, b; Piątek 2005 b), on the territories around Kyiv (Bondarceva-Monteverde 1922, Zelle 1925, Grodzinska 1928, Gizhytska 1929, Lavitska 1949, 1976, 1978), in the Steppes (Geshele 1927, Morochkovskiyi 1956, 1957 a, b), and in Crimea (Garbowski 1924, Naumov & Dobrozrakova 1931). In light of a turbulent history of development, some regions of Ukraine were occupied by adjacent countries, thus the information of their smut fungi could be found in the relevant monographs of foreign scientists, e.g. western part of Ukraine (Kochman 1936), Transcarpathian (Moesz 1950), North Bukovina and South Bessarabia (Săvulescu 1957), Carpathian region (Vánky 1985), and Ukraine, as a part of the USSR (Gutner 1941, Uljanishchev 1968, Karatygin & Azbukina 1989). Volume 4 of the 'Identification guide of fungi of Ukraine', published 40 years ago (Zerova *et al.* 1971), has been the main resource on the smut species of Ukraine. However, the information in this identification guide is outdated and incomplete. In recent years, more intensive studies

have been carried out in Ukraine. Some data were published in papers on the general fungal diversity in certain territories of the country (Dzhagan *et al.* 2008, Golubtsova 2008). In addition, as a result of our investigations, several new smut species from Ukraine were reported (Heluta *et al.* 2004, Savchenko & Heluta 2010 a, b, c, 2011; Savchenko *et al.* 2010 a, b, 2011). The catalogue presented here aims to provide an updated list of smut fungi found thus far in Ukraine. Six species, *Anthracoidea buxbaumii* Kukkonen, *A. caryophylleae* Kukkonen, *A. echinospora* (Lehtola) Kukkonen, *A. pilosae* Vánky, *A. pseudirregularis* U. Braun, and *Entyloma gaillardianum* Vánky are reported as new for Ukraine, and *Tragopogon ucrainicus* Artemczuk is a new host for *Microbotryum tragopogonis-pratensis* (Pers.) R. Bauer & Oberw., *Ranunculus lanuginosus* L. for *Entyloma microsporum* (Unger) J. Schröt., *Carex melanostachya* Willd. for *Schizonella cocconii* (Morini) Liro, and *Gagea maeotica* Artemczuk for *Vankya ornithogali* (J.C. Schmidt & Kunze) Ershad.

### Materials and methods

The study is based on critical analyses of data from different sources, i.e. (1) our own collections, (2) herbarium materials from the National Herbarium of Ukraine of the M.G. Kholodny Institute of Botany (KW), Herbarium of the O.V. Fomin Botanical Garden (KWHU), Herbarium of the Chernovtsy National University (CHER), Herbarium of the Lviv National University (LW), Herbarium of the Department of Botany of the Taras Shevchenko Kyiv National University, and the Herbarium of the Podilski Tovtry National Park, (3) specimens collected by other people and given to us for identification, (4) data from literature sources. The checklist is arranged alphabetically by genus and species within genera. For each species the list of host plants on which it was recorded in Ukraine is included. The abbreviations of the authors of fungal names follows the second edition of Authors of Fungal Names ([www.indexfungorum.org](http://www.indexfungorum.org)). Plant names are given according to the International Plant Name Index ([www.ipni.org](http://www.ipni.org)) and a nomenclatural checklist by Mosyakin & Fedoronchuk (1999). Six species marked with an asterisk (\*) are new for Ukraine, and descriptions of these species are included following the checklist.

For comparison of Ukrainian smut mycobiota with those of European, Central Asian, Caucasian, and Middle Eastern countries we employed a Tripartite Similarity Index (T) (Tullos 1997, Tullos & Tullos 2004), which takes account of the number of entries common between two lists and also the number of entries in one list that are not present in the other list. T employs cost functions into its three elements U, S, and R which are calculated as the following:

$$U = \frac{\log \left( 1 + \frac{\min(b,c) + a}{\max(b,c) + a} \right)}{\log 2} \qquad S = \sqrt{\frac{\log 2}{\log \left( 2 + \frac{\min(b,c)}{a + 1} \right)}}$$

$$R = \frac{\log\left(1 + \frac{a}{a+b}\right) \cdot \log\left(1 + \frac{a}{a+b}\right)}{(\log 2)^2}$$

where  $a$  is the number of entries common to both lists,  $b$  is the number of entries in the first list that are not in the second, and  $c$  is the number of entries in the second list that are not in the first.  $U$  corrects for the difference in the size of the two lists being compared.  $S$  provides a penalty for the difference between size of  $a$  and the smaller of the two lists being compared.  $R$  takes into account whether  $a$  covers a fraction of one list that is different from that of the other list (Tullos 1997). The  $T$  is calculated by multiplying the three cost functions:

$$T = U \times S \times R$$

The value of  $T$  ranges from 0 to 1, where 0 indicates no elements in common while 1 indicates a complete identity. Lists of species from several monographs and papers were used for this analysis (Denchev 2001; Piątek 2005 a; Savchenko et al. 2010 c, 2011; Schwarzman 1960; Vánky *et al.* 1982, 1985, 1988; Vasyagina 1977, 1979; Uljanishchev 1952, 1959 a, b; Zwetko & Blanz 2004; *Checklist of nonvascular and vascular plants of Slovakia* <http://ibot.sav.sk/checklist/>). In the case of obsolete lists they were evaluated using current nomenclature.

Sorus and spore characteristics were studied using dried herbarium material. Sorus structure was studied under a Carl Zeiss Stemi Dv4 stereo microscope. For light microscopy (LM), spores were mounted in lactic acid, gently heated to the boiling point and cooled, and then examined under a Carl Zeiss Axiostar light microscope at 1000 × magnification. At least 50 spores were measured from each collection, and the variation is presented as a range, with extreme values given in parentheses. In the descriptions, mean (av.) and standard deviations (SD) were calculated from spore measurements and are given after the spore size ranges. For scanning electron microscopy (SEM), spores were attached to metal stubs by double-sided adhesive tape and coated with gold. The surface structure of spores was observed at 15 kV and photographed with a scanning electron microscope JEOL JSM-6700F.

The nomenclature of taxa is given according to Vánky (2011) and McTaggart (2010).

### List of species

The list of species of smut fungi recorded in Ukraine is given below followed by the descriptions and illustrations of new species for the country.

***Antherospora*** R. Bauer, M. Lutz, Begerow, Piątek & Vánky

1. *A. scillae* (Cif.) R. Bauer, M. Lutz, Begerow, Piątek & Vánky (*Scilla bifolia* L., *S. siberica* Haw.)
2. *A. tourneuxii* (A. A. Fisch. Waldh.) R. Bauer, M. Lutz, Begerow, Piątek & Vánky (*Bellevalia* sp.)
3. *A. vaillantii* (Tul. & C. Tul.) R. Bauer, M. Lutz, Begerow, Piątek & Vánky (*Muscari comosum* Mill., *M. neglectum* Guss. ex Ten.)

**Anthracocystis** Bref. emend. McTaggart & R. G. Shivas

4. *A. cenchri* (Lagerh.) McTaggart & R. G. Shivas (*Cenchrus longispinus* (Hack.) Fernald)
5. *A. destruens* (Schltdl.) Bref. (*Panicum miliaceum* L., *Panicum* sp.)

**Anthracoidea** Bref.

6. *A. angulata* (Syd.) Boidol & Poelt (*Carex hirta* L.)
7. *A. arenaria* (Syd.) Nannf. (*Carex colchica* subsp. *ligerica* (J. Gay) Egor., *C. praecox* Schreb.)
8. \**A. buxbaumii* Kukkonen (*Carex hartmanii* Cajander)
9. *A. capillaris* Kukkonen (*Carex capillaris* L.)
10. *A. caricis* (Pers.) Bref. (*Carex montana* L., *C. pilulifera* L.)
11. \**A. caryophylleae* Kukkonen (*Carex caryophyllea* Latour., *C. umbrosa* Host)
12. \**A. echinospora* (Lehtola) Kukkonen (*Carex acuta* L., *C. nigra* Reich.)
13. *A. fischeri* (P. Karst.) Kukkonen (*Carex vulpina* Carey ex Dewey)
14. *A. karii* (Liro) Nannf. (*Carex brunnescens* Boeckeler, *C. echinata* Murray)
15. *A. limosa* (Syd.) Kukkonen (*Carex limosa* L.)
16. *A. michelii* Vánky (*Carex michelii* Host)
17. *A. paniceae* Kukkonen (*Carex panicea* L.)
18. \**A. pilosae* Vánky (*Carex pilosa* Scop.)
19. \**A. pseudirregularis* U. Braun (*Carex pallescens* L.)
20. *A. sempervirentis* Vánky (*Carex sempervirens* Vill.)
21. *A. subinclusa* (Körn.) Bref. (*Carex acutiformis* Brot., *C. atherodes* Spreng., *C. riparia* Curt., *C. vesicaria* W. Boott)
22. *A. vankyi* Nannf. (*Carex muricata* L., *C. contigua* Hoppe)

**Doassansia** Cornu

23. *D. alismatis* (Nees) Cornu (*Alisma plantago-aquatica* L.)
24. *D. niesslii* (Nees) Cornu (*Butomus umbellatus* L.)
25. *D. sagittariae* (Westend.) J. C. Fisch. (*Sagittaria sagittifolia* L.)

**Doassansiopsis** (Setch.) Dietel

26. *D. hydrophila* (A. Dietr.) Lavrov (*Potamogeton gramineus* L.)

**Entorrhiza** C. A. Weber

27. *E. cypericola* (Magnus) Webber (*Cyperus flavescens* L.)

**Entyloma** de Bary

28. *E. achilleae* Magnus (*Achillea millefolium* L.)
29. *E. aposeridis* Jaap (*Aposeris foetida* Cass.)
30. *E. arnicale* Ellis & Everh. (*Arnica montana* L.)
31. *E. bellidis* Krieg. (*Bellis perennis* L.)
32. *E. calendulae* (Oudem.) de Bary (*Calendula officinalis* L.)
33. *E. chrysosplenii* J. Schröt. (*Chrysosplenium alternifolium* L., *C. oppositifolium* L.)
34. *E. cichorii* Wróbl. (*Cichorium intybus* L.)
35. *E. corydalis* de Bary (*Corydalis bulbosa* Pers.)
36. *E. crepidis-rubrae* (Jaap) Liro (*Crepis praemorsa* (L.) Tausch)
37. *E. dahliae* Syd. & P. Syd. (*Dahlia variabilis* Desf.)

38. *E. erigerontis* Syd. & P. Syd. ex Cif. (*Erigeron acris* L.)  
 39. *E. eryngii* (Corda) de Bary (*Eryngium campestre* L.)  
 40. *E. eryngii-plani* Cif. (*Eryngium planum* L.)  
 41. *E. fergussonii* (Berk. & Broome) Plowr. (*Myosotis scorpioides* L.)  
 42. *E. ficariae* A. A. Fisch. Waldh. (*Ranunculus ficaria* L.)  
 43. *E. fuscum* J. Schröt. (*Papaver dubium* L., *P. somniferum* L.)  
 44. \**E. gaillardianum* Vánky (*Gaillardia bicolor* Lam.)  
 45. *E. hieracii* Syd. & P. Syd. (*Hieracium alpinum* L., *H. murorum* L., *H. vulgatum* Fr., *Hieracium* sp.)  
 46. *E. linariae* J. Schröt. (*Linaria vulgaris* Mill.)  
 47. *E. maireanum* Cif. (*Hypochaeris radiata* Falk, *H. uniflora* Hoffm., *Hypochaeris* sp.)  
 48. *E. matricariae* Rostr. (*Tripleurospermum inodorum* (L.) Sch. Bip.)  
 49. *E. microsporium* (Unger) J. Schröt. (*Ranunculus carpathicus* Herbich, *R. lanuginosus* L., *R. repens* L.)  
 50. *E. picridis* Rostr. (*Picris hieracioides* L.)  
 51. *E. plantaginis* A. Blytt (*Plantago lanceolata* L.)  
 52. *E. ranunculi-repentis* Sternon (*Ranunculus acris* L., *R. auricomus* L., *R. bulbosus* L., *R. cassubicus* L., *R. polyanthemus* L., *R. repens* L., *R. sceleratus* L.)  
 53. *E. serotinum* J. Schröt. (*Symphytum cordatum* Willd., *S. officinale* L., *S. tuberosum* L.)  
 54. *E. thalictri* J. Schröt. (*Thalictrum minus* L.)  
 55. *E. tragopogonis* Lagerh. (*Tragopogon pratensis* L.)  
 56. *E. urocystoides* Bubák (*Corydalis bulbosa* Pers.)  
 57. *E. verruculosum* Pass. (*Ranunculus lanuginosus* L.)  
**Jamesdicksonia** Thirum., Pavgi & Payak  
 58. *J. dactylidis* (Pass.) R. Bauer, Begerow, A. Nagler & Oberw. (*Holcus lanatus* L., *Koeleria* sp., *Poa* sp.)  
**Macalpinomyces** Langdon & Full.  
 59. *M. neglectus* (Niessl) Vánky (*Setaria pumila* Roem. & Schult., *S. viridis* P. Beauv., *Setaria* sp.)  
**Melanopsichium** Beck  
 60. *M. pennsylvanicum* Hirschh. (*Persicaria lapathifolia* (L.) Delarbre)  
**Melanotaenium** de Bary  
 61. *M. cingens* Bref. (*Linaria genistifolia* (L.) Mill.)  
**Melanustilospora** Denchev  
 62. *M. ari* (Cooke) Denchev (*Arum elongatum* Steven, *A. orientale* M. Bieb., *A. maculatum* L.)  
**Microbotryum** Lév.  
 63. *M. anomalum* (J. Kunze ex G. Winter) Vánky (*Fallopia convolvulus* (L.) A. Löve, *F. dumetorum* (L.) Holub)  
 64. *M. bistortarum* (DC.) Vánky (*Bistorta officinalis* Delarbre)  
 65. *M. cardui* (A.A. Fisch. Waldh.) Vánky (*Carduus acanthoides* L.)  
 66. *M. chloranthae-verrucosum* M. Lutz, Göker, Piątek, Kemler, Begerow & Oberw. (*Silene chlorantha* Ehrh.)



67. *M. cordae* (Liro) G. Deml & Prillinger (*Persicaria hydropiper* Opiz, *P. maculosa* S. F. Gray)
68. *M. dianthorum* (Liro) H. Scholz & I. Scholz (*Dianthus arenarius* L., *D. borbasii* Vandas, *D. pseudoarmeria* Bieb., *D. pseudoserotinus* Błocki, *Dianthus* sp.)
69. *M. holostei* (de Bary) Vánky (*Holosteum umbellatum* L.)
70. *M. lagerheimii* Denchev (*Steris viscaria* (L.) Raf.)
71. *M. lychnidis-dioicae* (DC. ex Liro) G. Deml & Oberw. (*Melandrium album* (Mill.) Garcke)
72. *M. major* (J. Schröt.) G. Deml & Oberw. (*Otites borysthenicus* (Gruner) Klokov, *O. helmannii* (Claus) Klokov, *Otites* sp.)
73. *M. pustulatum* (DC.) R. Bauer & Oberw. (*Bistorta officinalis* Delarbre)
74. *M. reticulatum* (Liro) R. Bauer & Oberw. (*Persicaria lapathifolia* (L.) Delarbre)
75. *M. saponariae* M. Lutz, Göker, Piątek, Kemler, Begerow & Oberw. (*Saponaria officinalis* L.)
76. *M. scabiosae* (Sowerby) G. Deml & Prillinger (*Knautia arvensis* Coult.)
77. *M. scorzonerae* (Alb. & Schwein.) G. Deml & Prillinger (*Scorzonera humilis* L., *S. purpurea* L.)
78. *M. silenes-inflatae* (DC. ex Liro) G. Deml & Oberw. (*Oberna behen* (L.) Ikonn)
79. *M. stellariae* (Sowerby) G. Deml & Oberw. (*Stellaria graminea* L., *S. holostea* L.)
80. *M. superbum* (Liro) Denchev, T. Giraud & M.E. Hood (*Dianthus superbus* L., *D. stenocalyx* (Trautv.) Juz.)
81. *M. tragopogonis-pratensis* (Pers.) R. Bauer & Oberw. (*Tragopogon pratensis* L., *T. ucrainicus* Artemczuk)
82. *M. violaceum* (Pers.) G. Deml & Oberw. (*Silene nutans* L.)
- Moesziomyces** Vánky
83. *M. bullatus* (J. Schröt.) Vánky (*Echinochloa crus-galli* (L.) P. Beauv.)
- Schizonella** J. Schröt.
84. *S. cocconii* (Morini) Liro (*Carex halleriana* Asso, *C. humilis* Leyss., *C. melanostachya* Willd.)
- Note. *Carex melanostachya* is a new host for *S. cocconii*.
85. *S. melanogramma* (DC.) J. Schröt (*Carex brevicollis* DC., *C. curvula* Steven, *C. digitata* L., *C. diversicolor* Crantz, *C. ericetorum* Pollich, *C. flacca* Schreb., *C. michelii* Host, *C. muricata* L., *Carex* sp.)
- Note. Another species, *S. intercedens* Vánky & A. Nagler parasitizes *C. michelii* throughout Europe (e.g., Vánky 2004). The Ukrainian record of *Schizonella* on this host is likely to be *S. intercedens*, but we were not able to confirm this because there are no specimens in any Ukrainian herbaria.
- Schroeteria** G. Winter
86. *S. delastrina* (Tul. & C. Tul.) G. Winter (*Veronica triphyllos* L., *V. officinalis* L., *V. verna* L.)

**Sphacelotheca** de Bary

87. *S. hydropiperis* (Schumach.) de Bary (*Persicaria hydropiper* Opiz, *P. maculosa* S. F. Gray, *P. minor* (Huds.) Opiz)

**Sporisorium** Ehrenb. ex Link

88. *S. andropogonis* (Opiz) Vánky (*Andropogon ischaemum* L.)  
 89. *S. cruentum* (J. G. Kühn) Vánky (*Sorghum bicolor* (L.) Moench)  
 90. *S. montaniense* (Ellis & Holw.) Vánky (*Eragrostis minor* Host)  
 91. *S. reilianum* (J. G. Kühn) Langdon & Full. (*Sorghum bicolor* (L.) Moench, *Zea mays* L.)  
 92. *S. sorghi* Ehrenb. ex Link (*Sorghum bicolor* (L.) Moench)

**Stegocinctria** M. Piepenbr., Begerow & Oberw.

93. *S. luzulae* (Sacc.) M. Piepenbr., Begerow & Oberw. (*Luzula pilosa* Willd., *L. luzuloides* (Lam.) Dandy & Willmot, *L. maxima* DC., *L. sylvatica* (Huds.) Gaudin)

**Thecaphora** Fingerh.

94. *T. affinis* A. Schneid. (*Astragalus glycyphyllos* L.)  
 95. *T. cerastii* M. Lutz & Vánky (*Cerastium arvense* L.)  
 96. *T. leptideum* (Syd. & P. Syd.) Zundel (*Chenopodium album* L.)  
 97. *T. melandrii* (Syd.) Vánky & M. Lutz (*Melandrium album* (Mill.) Garcke)  
 98. *T. oxalidis* (Ellis & Tracy) M. Lutz, R. Bauer & Piątek (*Xanthoxalis stricta* (L.) Small)  
 99. *T. saponariae* (F. Rudolphi) Vánky (*Saponaria officinalis* L.)  
 100. *T. seminis-convolvuli* (Duby) Liro (*Convolvulus arvensis* L.)

**Tilletia** Tul. & C. Tul.

101. *T. anthoxanthi* A. Blytt (*Anthoxanthum odoratum* L.)  
 102. *T. caries* (DC.) Tul. & C. Tul. (*Triticum aestivum* L., *Triticum* sp.)  
 103. *T. controversa* J. G. Kühn (*Elymus repens* (L.) Gould, *Triticum aestivum* L., *Hordeum bulbosum* L.)  
 104. *T. vulpiae* Magnus (*Vulpia ciliata* Link)

Note. Vánky (2011) considers *T. fusca* the correct name for *Vulpia*-infecting bunts and considers *T. vulpiae* Magnus a synonym of *T. fusca*. The latter species was described by Ellis & Everhart (1887) from *Vulpia microstachys* (Nutt.) Munro, which is endemic in North America in southern Idaho. However, some phylogenetic analyses that included collections of *Tilletia* from European and North American *Vulpia* C. C. Gmel. species showed that they clearly are not conspecific. It could mean that *Tilletia* infecting Eurasian *Vulpia* species is distinct from *T. fusca* on North American *Vulpia* species (L. M. Carris, pers. comm.).

105. *T. laevis* J.G. Kühn (*Triticum aestivum* L.)  
 106. *T. secalis* (Corda) J. G. Kühn (*Secale cereale* L.)

**Tolyposporium** Woronin ex J. Schröt.

107. *T. junci* (J. Schröt.) Woronin (*Juncus bufonius* L.)

**Tranzscheliella** Lavrov

108. *T. hypodytes* (Schltdl.) Vánky & McKenzie (*Agropyron dasyanthum* Ledeb., *Calamagrostis epigeios* Steud., *Elymus repens* (L.) Gould, *E. uralensis* subsp. *viridiglumis* (Nevski) Tzvelev, *Elytrigia intermedia*



- (Host) Nevski × *E. trichophora* (Link) Nevski, *Elytrigia* sp., *Leymus racemosus* var. *sabulosus* (M. Bieb.) Tzvelev, *L. ramosus* (Trin.) Tzvelev, *Stipa capillata* L.)
109. *T. minima* (Arthur) Vánky (*Stipa capillata* L.)
110. *T. williamsii* (Griffiths) Dingley & Versluys (*Stipa capillata* L., *Stipa* sp.)
- Urocystis** Rabenh. ex Fuckel
111. *U. agropyri* (Preuss) A. A. Fisch. Waldh. (*Agropyron* sp., *Elymus hispidus* (Opiz) Melderis, *E. repens* (L.) Gould, *Elytrigia intermedia* (Host) Nevski)
112. *U. agrostidis* (Lavrov) Zundel (*Agrostis gigantea* subsp. *maeotica* (Klokov) Tzvelev)
113. *U. anemones* (Pers.) G. Winter (*Anemone nemorosa* L., *A. ranunculoides* L., *A. sylvestris* L., *Anemone* sp.)
114. *U. bromi* (Lavrov) Zundel (*Bromopsis erecta* (Huds.) Fourr., *B. riparia* (Rehm.) Holub)
115. *U. calamagrostidis* (Lavrov) Zundel (*Calamagrostis epigeios* Steud.)
116. *U. coralloides* Rostr. (*Lepidium perfoliatum* L.)
117. *U. ficariae* (Unger) Moesz (*Ranunculus ficaria* L.)
118. *U. gladiolicola* Ainsw. (*Gladiolus imbricatus* L.)
119. *U. leimbachii* Oertel (*Adonis aestivalis* L., *A. vernalis* L.)
120. *U. magica* Pass. (*Allium cepa* L.)
121. *U. miyabeana* Togashi & Onuma (*Polygonatum odoratum* (Mill.) Druce)
122. *U. muscaridis* (Niessl) Zundel (*Muscari comosum* Mill., *M. neglectum* Guss. ex Ten., *Muscari* sp.)
123. *U. occulta* (Wallr.) Rabenh. (*Secale cereale* L.)
124. *U. ornithogali* Körn. ex A. A. Fisch. Waldh. (*Ornithogalum umbellatum* L.)
125. *U. orobanches* (Mérat) A. A. Fisch. Waldh. (*Orobanche racemosa* Schleich.)
126. *U. pulsatillae* (Bubák) Moesz (*Pulsatilla grandis* Wender., *P. patens* (L.) Mill., *P. pratensis* Mill., *Pulsatilla* sp.)
127. *U. ranunculi* (Lib.) Moesz (*Ranunculus lanuginosus* L., *R. oxyspermus* Willd., *R. pedatus* Waldst. & Kit., *R. repens* L.)
128. *U. ranunculi-auricomis* (Liro) Zundel (*Ranunculus auricomus* L.)
129. *U. secalis-sylvestris* (Uljan.) Schwarzman (*Secale sylvestre* Host)
130. *U. sorosporioides* Körn. ex Fuckel (*Thalictrum minus* L.)
131. *U. syncocca* (L. A. Kirchn.) B. Lindeb. (*Hepatica nobilis* Schreb.)
132. *U. trientalis* (Berk. & Broome) B. Lindeb. (*Trientalis europaea* L.)
133. *U. tritici* Körn. (*Triticum aestivum* L.)
134. *U. violae* (Sowerby) E. Fisch. (*Viola ambigua* Waldst. & Kit.)
- Ustanciosporium** Vánky
135. *U. montagnei* (Tul. & C. Tul.) M. Piepenbr., Begerow & Oberw. (*Rhynchospora alba* Vahl.)
- Ustilago** (Pers.) Roussel
136. *U. aeluropodis* (Trotter) Vánky (*Aeluropus littoralis* Parl.)
137. *U. avenae* (Pers.) Rostr. (*Arrhenatherum elatius* P. Beauv., *Avena sativa* L.)

138. *U. bromivora* (Tul. & C. Tul.) A. A. Fisch. Waldh. (*Bromus arvensis* Lam., *B. hordeaceus* L., *B. madritensis* L., *B. secalinus* L., *B. squarrosus* L., *B. sterilis* L., *B. tectorum* L.)
139. *U. calamagrostidis* (Fuckel) G. P. Clinton (*Calamagrostis epigeios* Huds.)
140. *U. crameri* Körn. (*Setaria italica* (L.) P. Beauv., *S. viridis* P. Beauv.)
141. *U. cynodontis* (Pass.) Henn. (*Cynodon dactylon* (L.) Pers.)
142. *U. echinata* J. Schröt. (*Phalaris arundinacea* L.)
143. *U. filiformis* (Schrank) Rostr. (*Glyceria arundinacea* Kunth, *G. fluitans* (L.) R. Br., *G. maxima* (Hartm.) Holmb., *Glyceria* sp.)
144. *U. grandis* Fr. (*Phragmites australis* (Cav.) Steud.)
145. *U. hordei* (Pers.) Lagerh. (*Arrhenatherum elatius* P. Beauv., *Arrhenatherum* sp., *Avena sativa* L., *Hordeum distichon* L., *H. vulgare* L., *Hordeum* sp.)
146. *U. maydis* (DC.) Corda (*Zea mays* L.)
147. *U. nuda* (C. N. Jensen) Rostr. (*Hordeum distichon* L., *H. hexastichon* L., *H. vulgare* L.)
148. *U. scrobiculata* Liro (*Calamagrostis epigeios* Huds.)
149. *U. serpens* (P. Karst.) B. Lindeb. (*Elymus repens* (L.) Gould, *Elytrigia* sp.)
150. *U. striiformis* (Westend.) Niessl (*Agrostis alba* L., *A. tenuis* Vasey, *Alopecurus pratensis* L., *Brachypodium pinnatum* P. Beauv., *Bromus inermis* Leyss., *Dactylis glomerata* L., *Hierochlœ odorata* (L.) P. Beauv., *Holcus lanatus* L., *Lolium perenne* L., *Poa bulbosa* L., *P. trivialis* L.)
151. *U. syntherismae* (Schwein.) Peck (*Digitaria sanguinalis* (L.) Scop.)
152. *U. trebouxii* Syd. & P. Syd. (*Melica ciliata* L.)
153. *U. trichophora* (Link) Kunze (*Echinochloa crus-galli* (L.) P. Beauv.)
154. *U. tritici* (Pers.) E. Rostr. (*Aegilops triaristata* Willd., *Secale cereale* L., *S. sylvestre* Huds., *Triticum aestivum* L., *T. dicoccum* Schrank, *T. durum* Desf., *T. monococcum* L., *T. polonicum* L., *T. spelta* L., *T. turgidum* L.)

***Ustilentyloma* Savile**

155. *U. brefeldii* (Krieg.) Vánky (*Phalaris arundinacea* L.)

***Vankya* Ershad**

156. *V. heufleri* (Fuckel) Ershad (*Tulipa biebersteiniana* Schult. & Schult. f., *T. gesneriana* L.)
157. *V. ornithogali* (J. C. Schmidt & Kunze) Ershad (*Gagea fascicularis* Salisb., *G. maeotica* Artemczuk, *G. minima* (L.) Ker Gawl., *G. pusilla* Schult. f., *Gagea* sp.)

Doubtful record

1. *Ustilago turcomanica* Tranzschel

Note. Morochkovskiy (1957) reported this species as new for Ukraine. According to him, it was collected on *Elymus repens*. However, *U. turcomanica* is restricted to grasses from the genus *Eremopyrum* Jaub. & Spach. Other than Morochkovski's report, this species has not been found in Ukraine. As we were not able to locate a specimen in Ukrainian herbaria, *U. turcomanica* is considered here as a doubtful record for the country.

### Descriptions of the six species new for Ukraine

#### *Anthracoidea buxbaumii* Kukkonen – Figs. 1, 2.

Sori in ovaries, scattered in inflorescences, black, globose, ovoid, 1.5–3 mm in diam.; immature sori covered by a silvery membrane; surface of mature sori is powdery. – Spores (17)18–22(23) × (12)13–20 μm,  $20.4 \pm 2.5 \times 16.3 \pm 2.1$  μm (av. ± SD, n = 50), globose, ovoid, occasionally some subpolyhedral, flattened, 10–13 μm thick, brown. – Spore wall evenly thickened, up to 1–3 μm thick, with 1–3 internal swellings. – Spore surface distinctly verruculose, warts often confluent, forming small groups or short rows with light-refractive streaks between the rows; in SEM surface moderately, sometimes densely verruculose by rounded warts 0.1–0.4 μm high.

Material examined. – On *Carex hartmanii*: UKRAINE, Kyiv region, Vyshgorod distr., Kozarovychi, 25 Jun 1929, leg. M. Pidoplichko (KW 5785F).

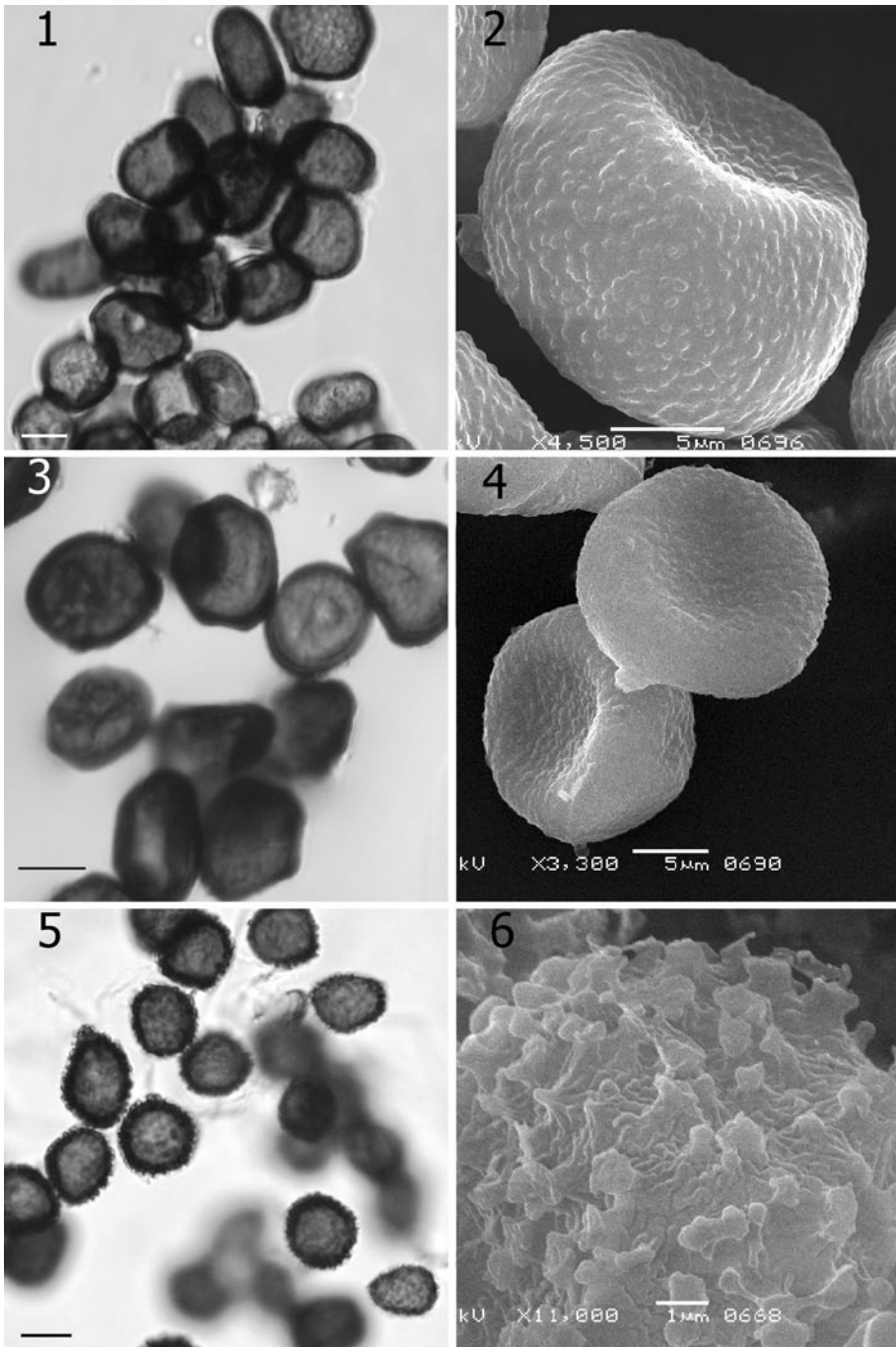
Note. – Kukkonen (1963) considered *Carex hartmanii* to be an accessory host for *Anthracoidea buxbaumii*, with *C. buxbaumii* being the principal host. Unfortunately he did not provide any information about differences in spore sizes on these sedges and apparently gives only extreme values, thus making a direct comparison of spore dimensions difficult. Our examination of a Ukrainian specimen on *C. hartmanii* revealed some morphological differences in that the spores of our specimen were smaller than those given by Kukkonen (1963) in the protologue: (17)18–22(23) × (12)13–20 vs (18)20–28 (30) × (13)14–23(26) μm. The smut on *C. hartmanii* is very rare and has been recorded from only two localities in Hungary and Sweden thus far (Kukkonen 1963).

#### *Anthracoidea caryophylleae* Kukkonen – Figs. 3, 4.

Sori in ovaries, scattered in the inflorescences, black, globose, 1–2 mm in diam.; young sori covered by a grayish-silvery membrane, partly hidden by the glumes; surface of mature sori powdery. – Spores 16–21 × (13)14–19 μm,  $18.9 \pm 1.7 \times 16.1 \times 1.8$  μm (av. ± SD, n = 150/3), subglobose, ovoid to subangular, irregular, flattened, 10–12 μm thick, dark reddish-brown. – Spore wall 1–3 μm thick, thicker on the angles, with 1–3 internal swellings. – Spore surface finely and densely verruculose, sparsely punctate; in SEM surface sparsely to densely verruculose with rounded, low warts 0.1–0.3 μm high. Between the warts the surface is minutely verruculose.

Material examined. – On *Carex caryophylleae*: UKRAINE, Zakarpattia region, Rachiv distr., south-east slopes of the Mt. Menchul, 5 Jul 1984, leg. A. Prokopiv (LW). On *C. umbrosa*: Cherkasy region, Kaniv distr., Buchak, 21 Jun 1950, leg. Z. Lavitska (KWHU); Cherkasy distr., Moshny, 14 Jun 1950, leg. Z. Lavitska (KWHU).

Note. – Records of *Cintractia caricis* (Pers.) Magnus on *Carex caryophylleae* in the west part of Ukraine (Zerova *et al.* 1971) and on *C. supina* in the Cherkasy region (Kaznovskyi 1915) perhaps belong to this species.



**Figs. 1–6.** Spores of *Anthracoidea* species. 1–2. *Anthracoidea buxbaumii* on *Carex hartmannii* (KW 5785F). 3–4. *Anthracoidea caryophylleae* on *Carex caryophyllea* (LW). 5–6. *Anthracoidea echinospora* on *Carex acuta* (KW 36585F). 1, 3, 5 in LM, 2, 4, 6 in SEM. Bars: 1, 3, 5 = 10 µm, 2, 4 = 5 µm, 6 = 1 µm.

***Anthracoidea echinospora*** (Lehtola) Kukkonen – Figs. 5–6.

Sori in ovaries, scattered in the inflorescences, black, carbonaceous, 2–4 mm in diam.; young sori covered by a thin grayish-silvery membrane; sorus surface with maturation cracking and small fragments of the spore mass then uncovered. – Spores (13)15–18 × 12–17 μm, 16.6 ± 1.4 × 14.9 ± 1.5 μm (av. ± SD, n = 150/3), subglobose to ovoid, olivaceous-brown. – Spore wall 0.5–1.5 μm thick, without internal swellings. – Spore surface echinate, with apically elongated and flattened spines, up to 1 μm wide and 1.5 μm high, often aggregated, forming small groups or rows, often 2–3 spines partly confluent; in SEM the base of the warts and the spore surface between separated or confluent warts more or less wrinkled.

Material examined. – On *Carex acuta*: UKRAINE, Volhynian region, Ratne distr., near Zalukhiv, canal to Sviate lake, 3 Aug 2009, leg. K. G. Savchenko (KW 36585F). On *C. nigra*: Cherkasy region, Kaniv distr., Kaniv Nature Reserve, Zaricchia island, 20 Jul 1950, leg. Z. Lavitska (KWHU); Kyiv, Rybne lake, 03 Jul 1945, leg. Z. Lavitska (KWHU).

Note. – The report of *Anthracoidea caricis* on *Carex nigra* in Desniansko-Starogutskyyi National Park (Dudka *et al.* 2009) perhaps belongs to *A. echinospora*.

***Anthracoidea pilosae*** Vánky – Figs. 7, 8.

Sori in ovaries, scattered in the inflorescences, black, globose, 2–3 mm in diam.; surface powdery. – Spores 18–26 (29) × 15–21 μm, 22.3 ± 2.6 × 18.2 ± 1.8 μm (av. ± SD, n = 100/2), subglobose, ovoid, occasionally subpolygonal, flattened, 13–14 μm thick, reddish-brown. – Spore wall 1–3 μm thick, thicker in the angles, low internal swellings and light-refractive spots occasionally present. – Spore surface finely verruculose; in SEM densely verruculose, warts up to 0.1–0.4 μm high; the spaces between the warts are also finely verruculose.

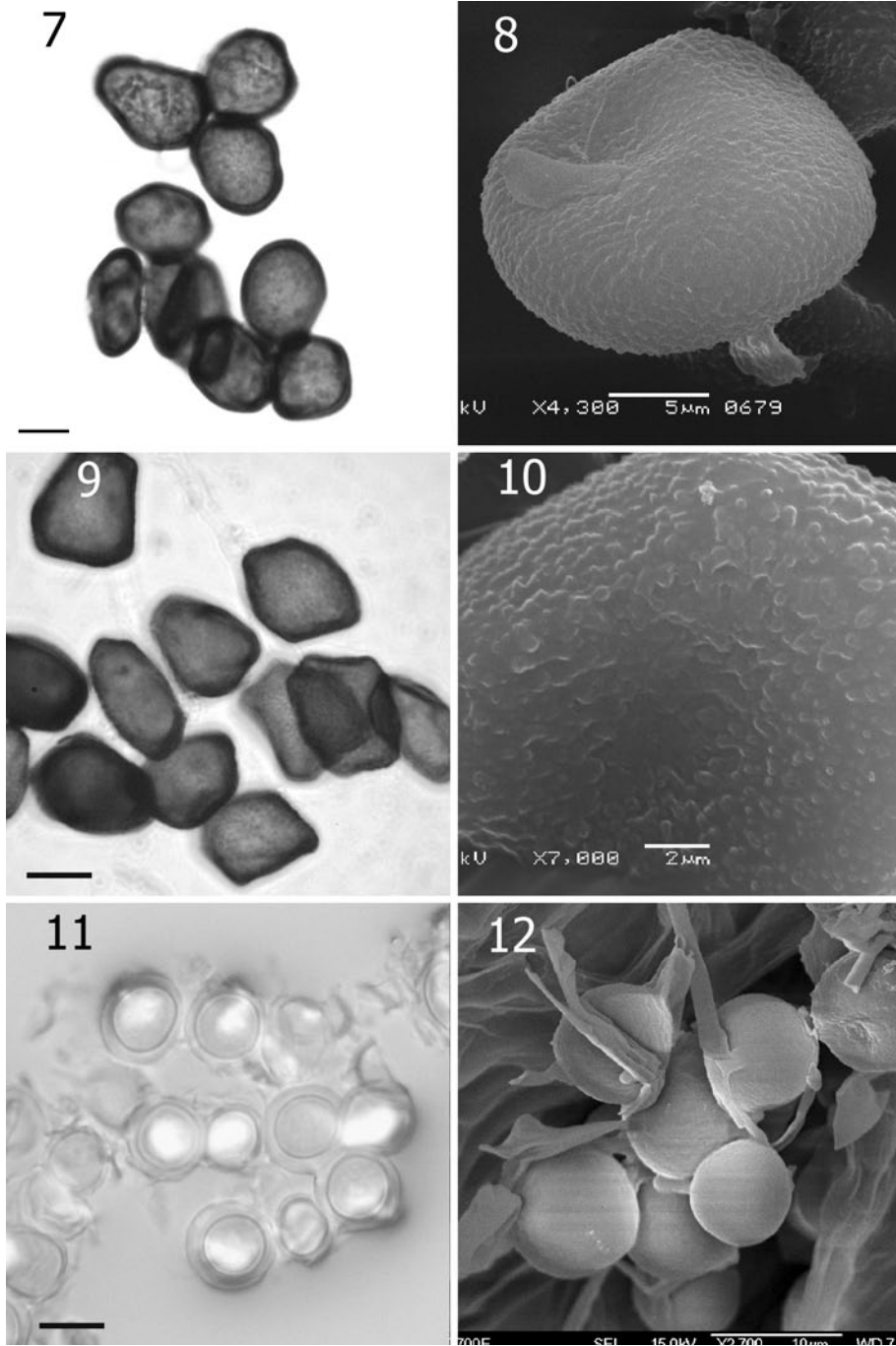
Material examined. – On *Carex pilosa*: UKRAINE, Chernivtsi region, Khotyn distr., Blyshchad, 23 Jun 1961, leg. Z. Gorohova & T. Kozlova (CHER); Storozhynets distr., Mizhrichynske forestry, fir-spruce forest, 07 Jun 1961, leg. T. Solodkova (CHER).

Note. – The record of *Cintractia caricis* on *Carex pilosa* in Lviv region (Krupa 1889) perhaps belongs to this species.

***Anthracoidea pseudirregularis*** U. Braun – Figs. 9, 10.

Sori in ovaries, scattered in the inflorescence, forming black, globose or subglobose bodies around the achenes, about 2–3 mm in diam.; at first covered by a whitish membrane that later disappear revealing powdery mass of spores. – Spores brown to medium reddish-brown, angular, irregular, (17)18–26(29) × (10)12–17.5(20) μm, 21.4 ± 2.8 × 15.3 ± 2.0 μm (av. ± SD, n = 50). – Spore wall uneven, 1.5–3(5) μm thick, thickest at the angles, darker than the rest of spores, light-refractive areas and weak internal swellings present. – Spore surface finely to moderately verruculose by low warts.





**Figs. 7–12.** Spores of *Anthracoidea* and *Entyloma* species. 7–8. *Anthracoidea pilosae* on *Carex pilosa* (CHER). 9–10. *Anthracoidea pseudirregularis* on *Carex pallescens* (KW 39117F). 11–12. *Entyloma gaillardianum* on *Gaillardia aristata* (KWHU). 1, 3, 5 in LM, 2, 4, 6 in SEM. Bars: 1, 3, 5, 6 = 10 µm, 2 = 5 µm, 4 = 2 µm.



Material examined. – On *Carex pallescens*: UKRAINE, Ivano-Frankivsk region, Vorohta, Karpatskiy National Park, Pozhizhevskaya polonina, 24 Aug 2011, leg. K. G. Savchenko (KW 39177F).

Note. – The report of *Cintractia caricis* on *Carex pallescens* from Lviv region (Krupa 1889) probably should be referred to *Anthracoidea pseud-irregularis*.

***Entyloma gaillardianum*** Vánky – Figs. 11, 12.

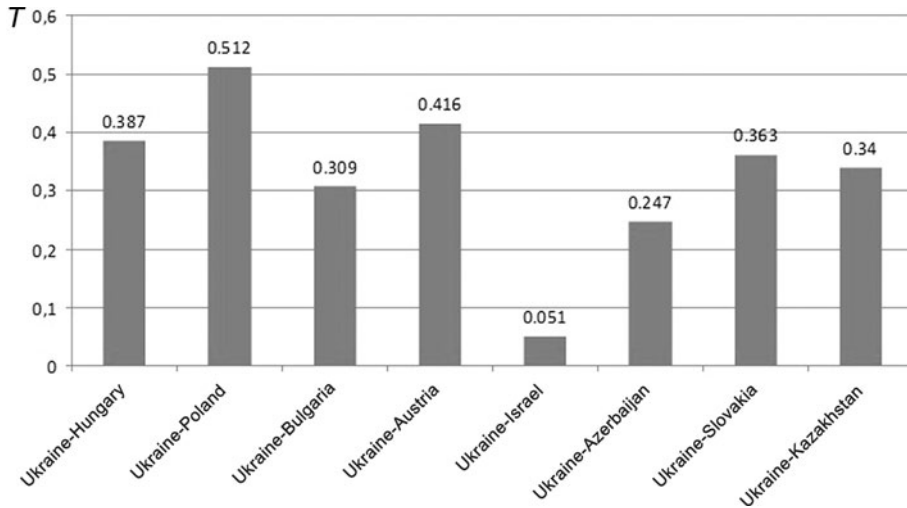
Sori in leaves, as rounded, circular spots, 1–5 mm in diam., or larger when confluent, first pale yellowish-green, later brownish-green, with a thin yellowish margin around the spots. – Spores globose, subglobose, subhyaline to yellowish,  $10\text{--}13 \times 9\text{--}13 \mu\text{m}$ ,  $11.9 \pm 1.3 \times 11.1 \pm 1.2 \mu\text{m}$  (av.  $\pm$  SD,  $n = 50$ ). – Spore wall 2-layered, ca. 1–3  $\mu\text{m}$ . – Spore surface smooth.

Material examined. – On *Gaillardia aristata*: UKRAINE, Kyiv, O. V. Fomin Botanical Garden, 18 Jul 1978, leg. Unknown collector (KWHU).

## Discussion

The 157 species of smut fungi reported from Ukraine are distributed among 27 genera, 17 families, eight orders, four classes, and two phyla (Basidiomycota and Ascomycota). The family most represented in this study is Ustilaginaceae (32 species), followed by Entylomataceae (30 spp.), and Urocystidaceae (27 spp.). The genus with the highest number of recorded species is *Entyloma* (30 spp.), followed by *Urocystis* (24 spp.), *Microbotryum* (20 spp.) and *Ustilago* (19 spp.). Smut fungi in Ukraine parasitize 229 species of host plants, belonging to 29 families. Most plants were reported on hosts from families Poaceae, with 69 infected species of plants and 43 species of parasites, Cyperaceae (35 plants / 20 parasites), Ranunculaceae (22 plants / 13 parasites), and Asteraceae (20 plants / 17 parasites). The host family distribution of Ukrainian smut fungi is in agreement with that reported for European smut fungi (Vánky 1994). There is reason to postulate that Ukrainian smut fungi developed as part of the broader Central European mycobiota despite the frontier location of Ukraine on the border between Europe and Asia. Thus, the aim of our statistical analysis was to show the connection of Ukrainian smut biota with those of other closely related and remote countries thereby trying to answer the question, whether Ukrainian smut biota is more closely related to Europe or to Asia. Indeed, Tripartite Similarity Index analysis performed to compare the Ukrainian smut composition with those of adjacent (Hungary, Poland, Slovakia) and relatively remote (Azerbaijan, Austria, Bulgaria, Kazakhstan, Israel) countries showed strong proximity to Central European smut mycobiota (Fig. 13). Among the regions studied here, the highest similarity to Ukraine was Poland ( $T = 0.512$ ), and the least was Israel ( $T = 0.051$ ). Moreover, the  $T$  values between Ukraine and Central European countries (Austria, Hungary, Poland, Slovakia) were greater than the values between Ukraine and Asian countries (Azerbaijan, Israel, Kazakh-

stan). The rather low similarity between Ukraine and Bulgaria is difficult to explain. However, the results reported here could be greatly influenced by the fact that the most highly explored region in terms of smut fungi diversity is western Ukraine, while the Steppe region and the Crimean peninsula are relatively poorly investigated. Our biogeographical results are a first step towards a comprehensive analysis of biogeography of smut fungi.



**Fig. 13.** Tripartite Similarity Index values for smut fungi. The height of the columns is relative to the  $T$  values.

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