Seven new species of smut fungi (*Ustilaginomycotina*)

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Abstract. Seven new species, *Anthracoidea breweri* on *Carex breweri* and *C. subnigricans* from USA, *Anthracoidea griseae* on *Carex grisea* from USA, *Farysia echinulata* on *Carex fischeri* from Kenya, *Tilletia avenastri* on *Avenastrum turgidulum* from Lesotho, *Urocystis anemonae-narcissiflorae* on *Anemone narcissiflora* from Canada, *Ustanciosporium venezuelanum* on *Rhynchospora* sp. from Venezuela, and *Ustilago buchloëformis* on *Bouteloua repens* from Mexico are described and illustrated.

Key words: *Anemone, Anthracoidea, Avenastrum, Bouteloua, Carex, Farysia echinulata*, *Rhynchospora*, smut fungi, *Tilletia avenastri, Urocystis anemonae-narcissiflorae, Ustanciosporium venezuelanum, Ustilago buchloëformis*

Introduction

Scrutinising the Herbarium Ustilaginales Vánky (H.U.V.), several new species of smut fungi were discovered between unidentified specimens, e.g. an *Anthracoidea* on *Carex breweri* and one on *Carex grisea,* both from the USA, a *Farysia* on *Carex fischeri* from Kenya, a *Tilletia* on *Avenastrum turgidulum* from Lesotho, a *Urocystis* on *Anemone narcissiflora* from Canada, a *Ustanciosporium* on *Rhynchospora* sp. from Venezuela, and a *Ustilago* on *Bouteloua* from Mexico, which are described below.

Materials and methods

The materials studied are indicated below, at the descriptions of the new species, as well as in Table 1. For the methods see Vánky & Salo (2010).

Results and discussion

In a recent paper, Vánky & Salo (2010) shortly characterised the genus *Anthracoidea* Bref., and described two new species from North America, *A. multicaulis* Vánky & Salo on *Carex geyeri* and *C. multicaulis* (subgen. *Psyllophora,* sect. *Firmiculmes*), and *A. praegracilis* Salo & Vánky, on *Carex praegracilis* (subgen. *Vignea,* sect. *Divisae*).

In H.U.V. there is a collection of *Anthracoidea on Carex breweri* Boott. (subgen. *Psyllophora,* sect. *Inflatae*). Further infected collections are in phanerogam herbaria on the same host plant and on *C. subnigricans* Stacey (from the same sect.). On members of the subgen. *Psyllophora* nine *Anthracoidea* species are known. **1.** *A. caricis-pauciflorae* (Lehtola) Kukkonen, on *C. pauciflora* Lightf. (sect. *Leucoglochin*), **2.** *A. caryophylleae* Kukkonen, on *C. obtusata* Lilj. (sect. *Obtusatae*), **3.** *A. externa* (Griffiths) Kukkonen, on *C. filifolia* Nutt. (sect. *Filifoliae*), **4.** *A. multicaulis* on *C. multicaulis* and *C. geyeri* (sect. *Firmiculmes*), **5.** *A. nardinae* (Kukkonen) Nannf., on *C. elynoides* T.Holm (sect. *Filifoliae*) and *C. nardina* Fr. (sect. *Nardinae*), **6.** *A. ortegae* Kukkonen, on *C. caduca* Boott (incl. *C. ortegae* Phil.; sect. *Aciculares*), **7.** *A. pulicaris* Kukkonen, on *C. pulicaris* L. (sect. *Psyllophora*), **8.** *A. rupestris* Kukkonen, on *C. rupestris* All. (sect. *Rupestres*), and **9.** *A. scirpoideae* Kukkonen, on *C. scirpoidea* Michx. (sect. *Scirpinae*). The *Anthracoidea* found on *C. breweri* and *C. subnigricans* differs from all these species, and is described as:

Anthracoidea breweri Salo et Vánky, ***sp. nov.***
MycoBank # MB 561044

Typus in matrice Carex breweri *Boott, USA, California, Fresno Co., Three Sisters, lowest trib. North Fork Kings River,*

headwaters of Dinkey Creek, on NW side of easternmost 10 612' peak, E of saddle to 10 445' peak, narrow rock and grave chute, 5.VIII.1953, C. & S. Quibell 3065. Holotypus H 6019140.

Sori *in nonnullis ovariis inflorescentiae eiusdem, circum nuces corpora nigra, globoidea, dura, diametro circa 1,5 mm formantes, primo membrana valde tenui, transparenti, fungali cooperti, qua decessa massas sporarum agglutinatas, superficie pulvereas ostendentes.* ***Sporae*** *complanatae, in visu laterali ellipticae, 12–14,5 µm latae, in visu plano circulares usque late ellipticae, 18,5–22,5 × 20–27 µm, rubrobrunneae; pariete aequaliter circa 1,5 µm crasso, sine incrassationibus internis, superficie conspicue verruculosae, verruculis tantum per occasionem fusis, imago obliqua sporarum levis usque undulata.*

Sori (Fig. 1) in some ovaries of an inflorescence, forming black, globoid hard bodies around the nuts, c. 1.5 mm in diameter, at first covered by a very thin, transparent fungal membrane which flakes away disclosing the agglutinated spore masses with powdery surface. **Spores** (Figs 3, 4) flattened, in side view elliptic, 12–14.5 µm wide, in plane view circular to broadly elliptic, 18.5–22.5 × 20–27 µm, reddish brown; wall evenly c. 1.5 µm thick, no internal swellings, surface distinctly verruculose, warts only occasionally fusing, spore profile smooth to wavy.

On *Cyperaceae, Carex* (subgen. *Psyllophora,* sect. *Inflatae*): *C. breweri* Boott, *C. subnigricans* Stacey.

Distribution: North America (USA).

Typical for *Anthracoidea breweri* are the regular shape, ornamentation and wall of the spores, lacking internal swellings, protuberances and light-refractive spots.

The hosts, *Carex breweri* and *C. subnigricans* are alpine plants of high altitudes in western North America with distribution areas restricted to the USA (Cronquist *et al*. 1977; Standley 2002). Interestingly, the smut has been found only in the southernmost areas of their hosts' geographical range.

In H.U.V. there are also two collections of an *Anthracoidea* on *C. grisea* Wahlenb. This sedge belongs to the subgen. *Carex*, sect. *Griseae* (L.H. Bailey) Kük. According to Naczi and Bryson (2002), 21 species of *Carex* belong to this section, all from North America. No *Anthracoidea* was yet described from any species belonging to this section. A sister group is the sect. *Careyanae* Tuckerman ex Kük., with 8 species. No smut fungus was reported from these species, either. The *Careyanae* was earlier included in the sect. *Laxiflorae*, now with 16 species. On one species, *Carex blanda* Dewey, *Anthracoidea blanda* Vánky & H. Alexander was described (Vánky 2005: 252). The smut on *Carex grisea* differs from *A. blanda* and is described as:

Anthracoidea griseae Vánky, **sp. nov.**
MycoBank # MB 561045

Typus in matrice Carex grisea *Wahlenb., USA, Kansas, Douglas Co., 3 km N urbe Baldwin, Breidenthal Biological Reserve, 38°48'37" N, 95°11'25" W, alt. 288 m.s.m., 31.V.2004, leg. H. Alexander. Holotypus in Herbario Ustil. Vánky, H.U.V. 20784!; isotypus in KANU. Paratypus: Kansas, 4 km E of Republic, Pawnee Indian Village State Historic Site, 2.VI.1995, leg. S. Price, H.U.V. 20809!*

Anthracoidea griseae *differt ab* A. blandae *Vánky & H. Alexander (Mycotaxon 91: 252, 2005; typus in matrice* Carex blanda *Dewey, USA) sporis irregularibus, 9,5–20 × 10,5–24 µm magnitudine; pariete sporarum inaequale, 0,5–2 (–3) µm crasso, saepe cum tumoribus internis bene evolutis, cum protuberationibus et raro etiam maculis lucem refringentibus, superficie sporarum leve usque verrucose.*

Sori (Fig. 2) in some ovaries of an inflorescence forming globose to ovoid, hard, black bodies around the nutlets, 2–3 mm in diameter, partly hidden by the glumes, at first covered by a thin, greyish fungal membrane which early dehisces

Table 1. Examined specimens of *Anthracoidea breweri*

Host plant	Locality, date of collection, collector	Herb.
Carex breweri	California, Siskiyou Co., Mt. Shasta, 16 Sep 1862, W.H. Brewer 1422	H 6017352
	USA, California, Tuolumne Co., Sierra Nevada, northwest slope of Mt. Dana, alt. 11 300 ft, 18 Sep 1936, C.W. Sharsmith 2369	S WS 200393
	California, Inyo Co., Big Pine Lakes, west of Sixth Lake, *ca* 11 200 ft, 7 Aug 1947, J.T. Howell (in Flora of California 23877)	S
	USA, California, Fresno Co., Three Sisters, lowest trib. North Fork Kings River, headwaters of Dinkey Creek, on NW side of easternmost 10 612' peak, E of saddle to 10 445' peak, 5 Aug 1953, C. & S. Quibell 3065.	???
	California, Fresno Co., Upper French Canyon Basin, N of Moon Lake on lower lake terrace on S side of Basin, alt. *ca* 11 000 ft., 11 Aug 1955, C.H. Quibell 5593	WSU
	California, Siskiyou Co., Sierra Nevada Mts., Mt. Shasta, south slope, c. 41°21' N, 122°12' W, alt. *ca* 2600 m., 8 Aug 1988, F. Oberwinkler, M. Berbee & K. Vánky	H 6017354 H.U.V. 21568 TUB
Carex subnigricans	USA, Nevada, Washoe Co., 1 mi. SW of Slide Mt., alt. 8500 ft, 10 Aug 1936, H.S. Yates 6012	H 6017353
	Nevada, White Pine Co., Snake Range, Humboldt National Forest, Snake Creek drainage, Johnson Lake, Twp. 13 N., R. 68 E., alt. *ca* 10 800 ft, 11 Aug 1964, N.H. Holmgren & J.L. Reveal 1598	WS 256027

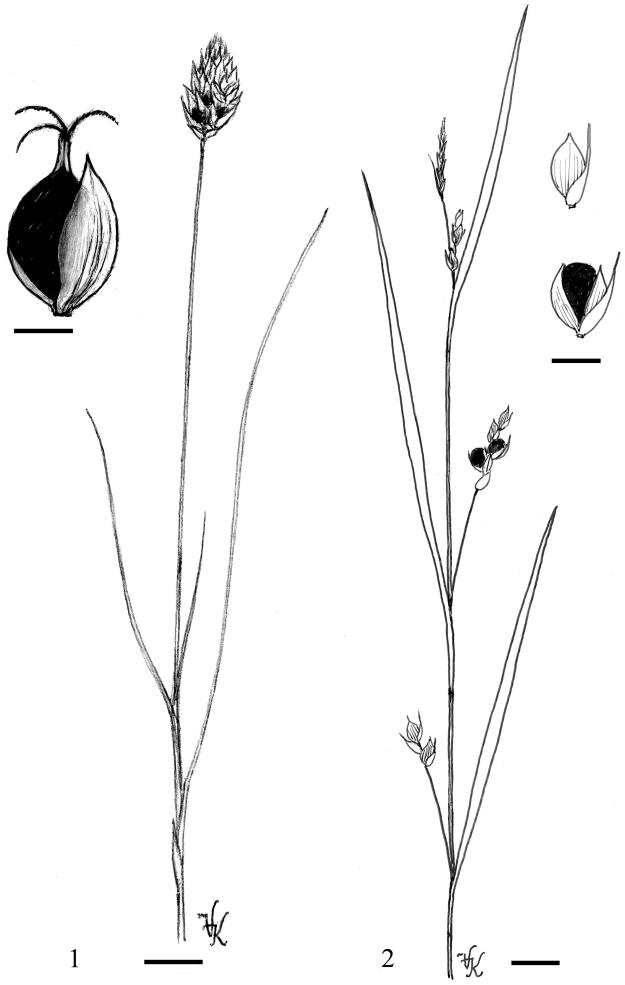


Fig. 1. *Anthracoidea breweri* on *Carex breweri* (type). Sori in some ovaries of an inflorescence. Habit, and enlarged a sorus. Bars = 1 cm for habit, and 1 mm for detail drawing. **Fig. 2.** *Anthracoidea griseae* on *Carex grisea* (type). Sori in some ovaries of an inflorescence. Habit, and enlarged a sorus and a healthy spikelet. Bars = 1 cm for habit, and 3 mm for detail drawings

disclosing the black, agglutinated mass of spores with powdery surface. **Spores** (Figs 5–6) extremely variable in shape, size and ornamentation, globose, subglobose, ellipsoidal, elongated or subpolyhedrally irregular, 9.5–20 × 10.5–24 µm, globose or subglobose spores 10.5–18 µm in diam., medium dark reddish brown; wall evenly or unevenly 0.5–2 (–3) µm thick, thickest at the angles and protuberances, 1–3 well-developed internal swellings often present, protuberances rather common, light-refractive spots rare, spore surface from apparently smooth to densely, prominently verrucose, spore profile smooth to wavy or finely serrulate.

On *Cyperaceae: Carex,* subgen. *Vigneastra* (*Indocarex*), sect. *Griseae, C. grisea* Wahlenb.

Distribution: North America (USA).

Anthracoidea griseae differs from *A. blanda,* in which the spores are more uniform, (12–) 14.5–18.5 (–20) × (14–) 16–22.5 (–24) µm, the spore wall is unevenly (0.5–) 1–2.5 (–3) µm thick, with weak to well-developed internal swellings and rather densely verruculose surface.

Smutted *Carex fischeri,* collected in Kenya by Prof. Nils Lundqvist, were given to me several years ago. The smut turned out to be an unknown species of *Farysia,* which is described as:

Farysia echinulata Vánky, **sp. nov.**
MycoBank # MB 561046

Typus in matrice Carex fischeri *K. Schum. (det. O. Hedberg, UPS), Kenya, Central Prov., Nanyuki Distr., Mt. Kenya, W slope, National Park Road, Naro Moru Track, 0°10' S, 37°13' E, alt. c. 3200 m.s.m., 23.I.1970, leg. N. Lundqvist 6634. Holotypus in Herbario Ustil. Vánky, H.U.V. 5467!, isotypus in BPI.*

Sori *in nonnullis floribus inflorescentiae, massas sporarum globoideas vel ovoideas, atrobrunneas, 2-3 mm longas, primo agglutinatas, postea pulvereas, mixtas cum fasciculis pluribus radiate redactis hypharum sterilium formantes.* ***Sporae*** *globosae, subglobosae, ellipsoidales usque elongatae, (6,5–) 7–9 × 7–20 (–24) µm, olivaceo-brunneae, surfacie conspicue verrucosa-echinulata, verrucis 0.8–1 µm altis, apice complanatis.*

Sori (Fig. 9) in some flowers of an inflorescence, forming globoid or ovoid, dark brown spore masses, up to 2–3 mm long, first covered by a thin fungal membrane, agglutinated, later exposed, powdery, mixed with numerous, radially arranged fascicles of sterile hyphae. **Spores** (Figs 7–8) globose, subglobose, ellipsoidal to elongated, (6.5–) 7–6 × 7–20 (–24) µm, olivaceous brown, surface prominently verrucose-echinulate, warts 0.8–1 µm high with flattened tip.

On *Cyperaceae: Carex fischeri* K. Schum.

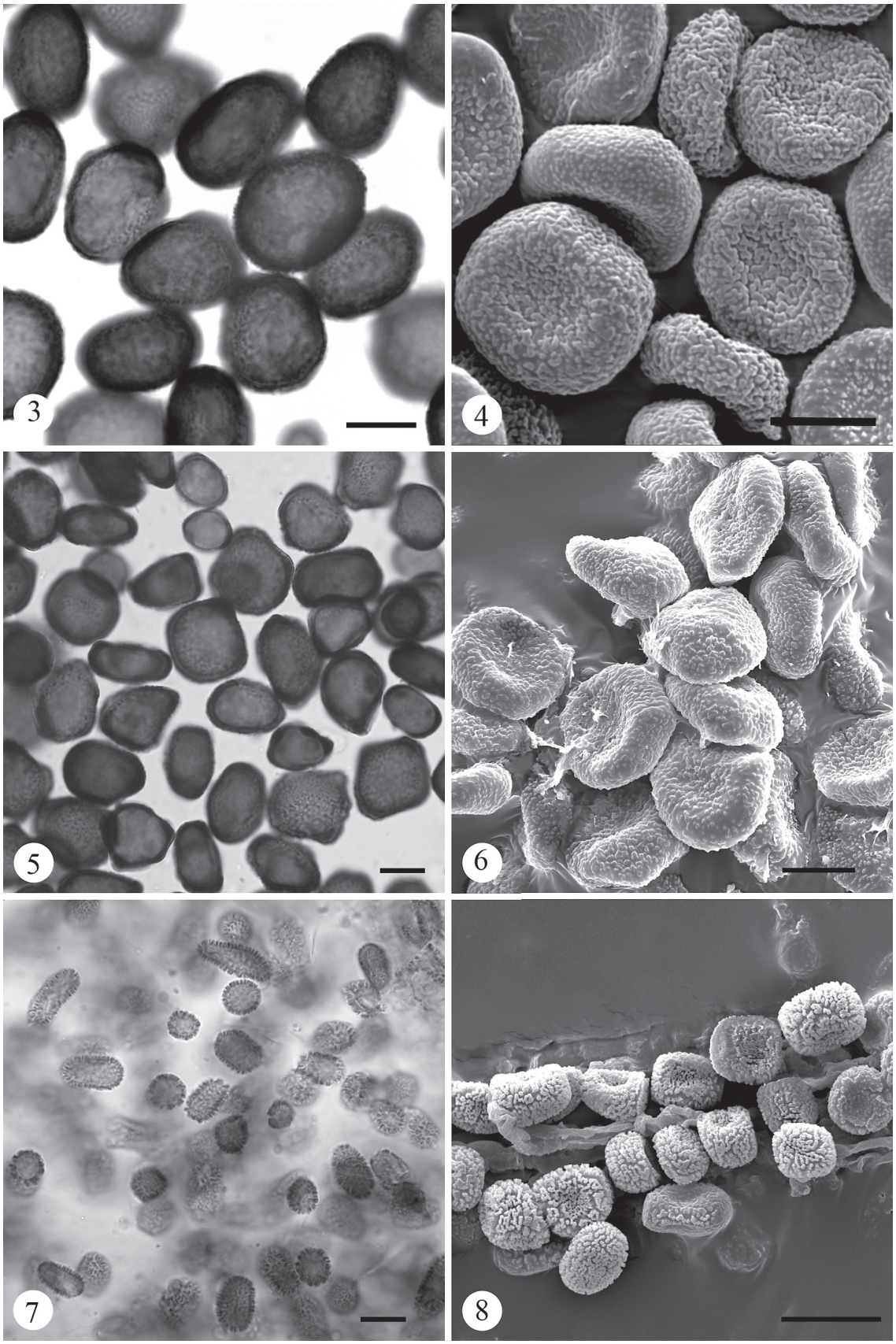
Distribution: Africa (Kenya). Known only from the type collection.

Tilletia avenastri Vánky, **sp. nov.**
MycoBank # MB 561047

Typus in matrice Avenastrum turgidulum *Stapf., South Africa, Bosutoland (= Kingdom of Lesotho), Leribe, no further data. Holotypus PREM 2543; isotypus Herb. Ustilag. Vánky, H.U.V. 18183!*

Tilletia avenastri *differt a* T. pallida *G.W. Fisch. (Mycologia 30: 393, 1938; typus in matrice* Agrostis palustris *Huds., USA) spinis minoribus connectis lineis subtilibus rete completum vel incompletum formantibus, in LM aspectu, spinis 18–22 in ambitu sporae. T. pallida: 21–35 spinis in ambitu sporae et lineis subtilibus non connectis.*

Sori (Fig. 10) in all ovaries of an inflorescence, ellipsoidal, 0.5–1 × 1–1.5 mm, completely hidden by the floral envelopes and covered by the brown pericarp enclosing the pale brown mass of spores. **Spores** (Figs 11–12) globose, subglobose to broadly ellipsoidal, 18.5–22.5 × 19–25 (–26.5) µm, pale lemon-yellow, coarsely echinulate, spines in surface view appear as darker spots connected by thin lines forming complete or incomplete meshes, 4–5 per spore diameter, in optical median view the spines are 2–3 (–3.5) µm high, 18–22 on the spore circumference, embedded in a hyaline sheath. *Sterile cells* few, much smaller than the spores, hyaline.



Figs 3–4. Spores of *Anthracoidea breweri* in LM and in SEM (type). Bars = 10 µm. **Figs 5–6.** Spores of *Anthracoidea griseae* in LM and in SEM (type). Bars = 10 µm. **Figs 7–8.** Spores of *Farysia echinulata* in LM and in SEM (type). Bars = 10 µm

On *Poaceae: Avenastrum turgidulum* Stapf. (*Helictotrichon turgidulum* (Stapf) Schweick.).

Distribution: South Africa (Lesotho). Known only from the type collection on this endemic host plant of South Africa.

Tilletia avenastri is close to *T. pallida* G.W. Fisch. (type on *Agrostis palustris* Huds., USA). However, in *T. pallida* there are more numerous spines, which are not connected by thin lines into complete or incomplete meshes as seen in LM, their number on the spore circumference is 21–35.

A specimen of *Urocystis* aff. *sorosporioides* Körn. on *Anemone narcissiflora* was obtained from DAOM in exchange. The study of this specimen showed that it is a still unknown smut which is described as:

Urocystis anemonae-narcissiflorae Vánky, **sp. nov.**
MycoBank # MB 561048

Typus in matrice Anemone narcissiflora *L. subsp.* interior *Hultén, Canada, Yukon Territory, Mountain E of Otter, 62°29' N, 130°24' W, 2.VIII.1960, leg. I. Kukkonen 568 & J.A. Calder. Holotypus in H.U.V. 3030!, isotypus DAOM 145084.*

Urocystis anemonae-narcissiflorae *differt ab* U. anemonae *(Pers. : Pers.) G. Winter (Hedwigia 19: 160, 1880; type on* Anemone nemorosa *L., Germany) glomerulis sporarum valde majoribus (30–100 µm longis), e sporis (3–) 5–40 (vel plus?) constructis. Glomeruli sporarum* U. anemonae *tantum 15–30 µm longi, e sporis (0–) 1–2 (–3) constructis.* U. anemonae-narcissiflorae *differt etiam ab* U. sorosporioides *Körn. (in Fuckel, Jahrb. Nassauischen Vereins Naturk. 29: 10, 1876; type on* Thalictrum minus *L., Germany) glomerulis sporarum 23–52 (–60) µm longis, e sporis 1–10 (–12) constructis.*

Sori (Fig. 17) on the stems, petioles and leaves forming bullate, rounded or fusiform, 1–15 mm long pustules, first covered by host tissues which rupture disclosing the black, agglutinated to granular powdery mass of spore balls. **Spore balls** (Figs 13–14) subglobose, ovoid, ellipsoidal, elongated or irregular, 20–80 × 30–100 µm, reddish brown, composed of (3–) 5–40 (or more?) spores incompletely or completely surrounded by sterile cells. **Spores** (Fig. 13) ovoid, elongated, subcuneiform or usually subpolyhedrally irregular, 11–16 × 13–21.5 (–24) µm, reddish brown; wall uniformly c. 0.5 µm thick, apparently smooth to very finely and densely punctate-verruculose. **Sterile cells** (Fig. 13) hemiglobose, hemiellipsoidal or irregular, 7–14 µm long, pale yellowish brown, wall 0.5–0.8 µm thick, smooth, collapsed in old specimen.

On *Ranunculaceae: Anemone narcissiflora* L. subsp. *interior* Hultén.

Distribution: North America (Canada). Known only from the type collection.

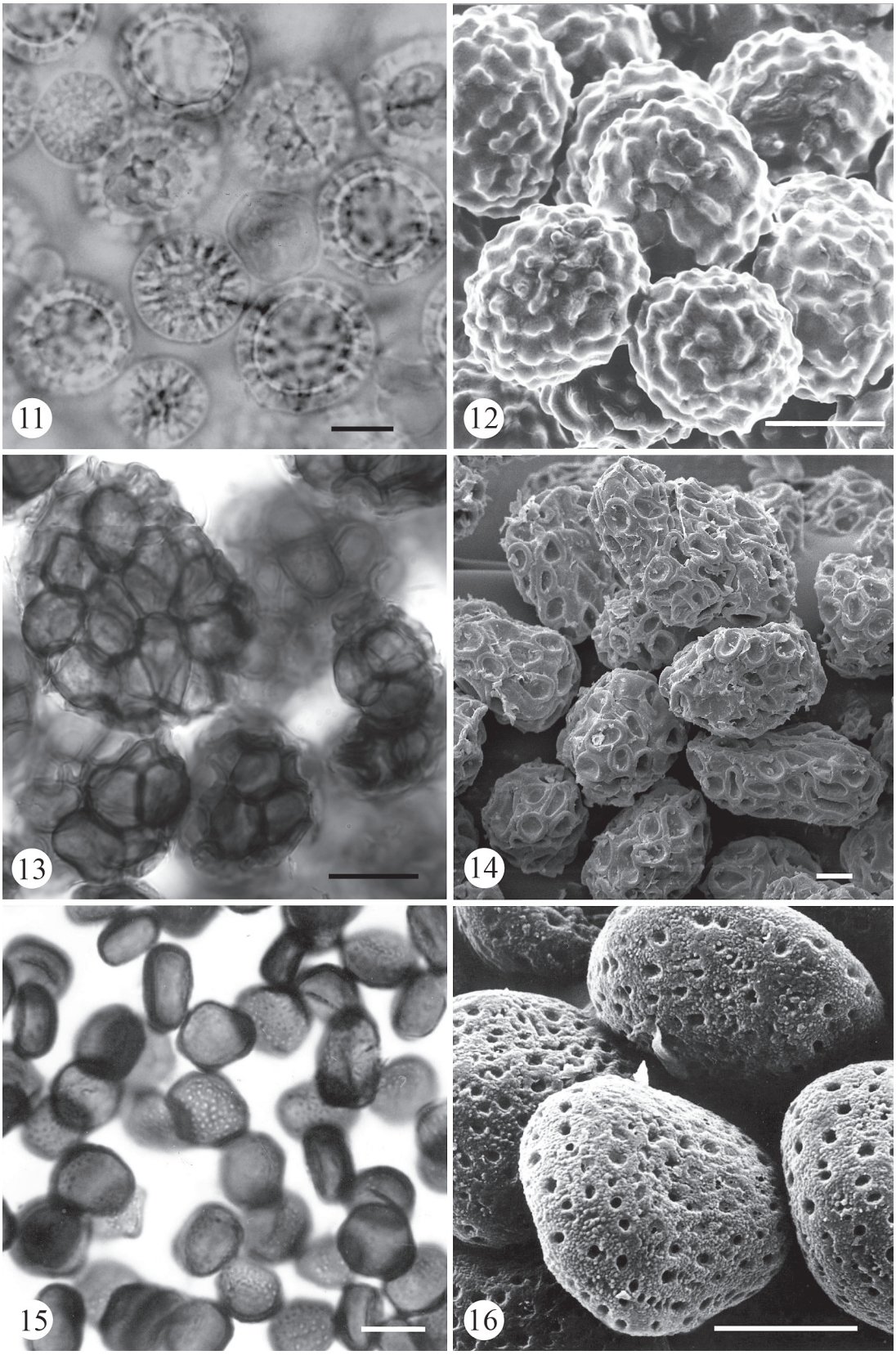
Of the *Urocystis* species of *Anemone, U. anemonae-narcissiflorae* is closest to *U. pseudoanemones* Denchev, Kakishima & Y. Harada (type on *Anemone flaccida* F. Schmidt, Japan), in which the spore balls are 20–60 (–70) µm long, with 1–7 (–11) spores. In *U. sinensis* L. Guo (type on *Anemone rivularis* Buch.-Ham. ex DC., China), the spore balls are 16–40 µm long, composed of 1–6 (–7) spores. In

Fig. 9. *Farysia echinulata* on *Carex fischeri* (type). Sori in some flowers of an inflorescence. Habit. Bar = 1 cm. **Fig. 10.** *Tilletia avenastri* on *Avenastrum turgidulum* (type). Sori in all ovaries of some spikelets. Habit. Bar = 1 cm

U. novae-zelandiae McKenzie & Vánky (type on *Anemone tenuicaulis* (Cheeseman) Parkin & Sledge, New Zealand), the spore balls are up to 60 µm long and are composed of 2–30 spores.

Smutted *Rhynchospora* specimens were collected by Dr. Reinhard Berndt in Venezuela. The smut turned out to be an undescribed species of *Ustanciosporium,* which is described as:

Ustanciosporium venezuelanum Vánky, **sp. nov.**
MycoBank # MB 561049



Figs 11–12. Spores of *Tilletia avenastri* in LM and in SEM (type). Bars = 10 µm. **Figs 13–14.** Spore balls, spores and sterile cells of *Urocystis anemonae-narcissiflorae* in LM and in SEM (type) Bar = 10 µm. **Figs 15–16.** Spores of *Ustanciosporium venezuelanum* on *Rhynchospora* sp. in LM and in SEM (type). Bars = 10 µm

Fig. 17. *Urocystis anemonae-narcissiflorae* on *Anemone narcissiflora* (type). Sori on the stem, petiole and leaf forming pustules. Habit. Bar = 1 cm

Typus in matrice Rhynchospora *sp. (det. K.A. Lye, NLH, Aas), Venezuela, Estado Bolivar, at the "La Escalera" section of the Gran Sabana Highway, c. 10 km S of the "Piedra de la Virgen", c. 9°44' N, 69°30' W, alt. c. 670 m.s.m., 2.I.1994, leg. R. Berndt. Holotypus in H.U.V. 17158!, isotypus BPI.*

Ustanciosporium venezuelanum *differt ab* U. majus *(Desm.) M. Piepenbr. (Nova Hedwigia 70: 341, 2000; type on* Rhynchospora alba *(L.) Vahl, France) praecipue ornamentatione superficiale sporarum moderate dense, prominenter foveolata, donec eadem* U. majoris *leniter foveolata-reticulata.*

Sori (Fig. 18) in all flowers of a somewhat swollen and congested inflorescence, filling the flowers with a black, agglutinated to semipowdery mass of spores, hidden by the floral envelopes. **Spores** (Figs 15–16) single, flattened, in side view elliptic, 7–9 µm wide, no appendages on the flattened sides, in plane view circular, elliptic or subpolygonally irregular, (9.5–) 10.5–14.5 × 11–16 µm; wall even or slightly uneven, 0.8–1 (–1.5) µm thick, thickest at the angles, moderately densely, expressedly foveolate, spore profile smooth or very finely wavy.

On *Cyperaceae: Rhynchospora* sp.

Distribution: South America (Venezuela). Known only from the type collection.

Fig. 18. *Ustanciosporium venezuelanum* in the flowers of *Rhynchospora* sp. Habit. To the left a healthy inflorescence. Bar = 1 cm

A smut fungus, collected in Mexico on *Bouteloua repens* is different from all known smut fungi on this and related host plant genera. It is described as:

Ustilago buchloëformis Vánky, **sp. nov.**
MycoBank # MB 561050

Typus in matrice Bouteloua repens *(Kunth) Scribn. & Merr. (det. H. Scholz, B), Mexico, Guerrero State, 73 km W of Iguala, Hwy no. 51, 18°24'59" N, 99°55'11" W, 23.XI.2003, leg. T. & K. Vánky. Holotypus in H.U.V. 21098!, isotypus in BPI.*

Ustilago buchloëformis *distinctus ab* Ustilago buchloës *Ellis & Tracy (J. Mycol. 6: 77, 1890; lectotype on* Buchloë dactyloides, *USA), sporis majoribus, (9–) 10–16 (–17) × (11–) 13–26.5 (–28) µm, magis irregularibus, atrioribus, et pariete crassiore 1–2 (–2.5) µm crasso, clare ornamentato. Sporae* U. buchloës *11–16 µm longae, plerumque globosae, ovoideae vel ellipsoidales, pariete sporae c. 1 µm crasso, disperse usque moderate dense echinulato.*

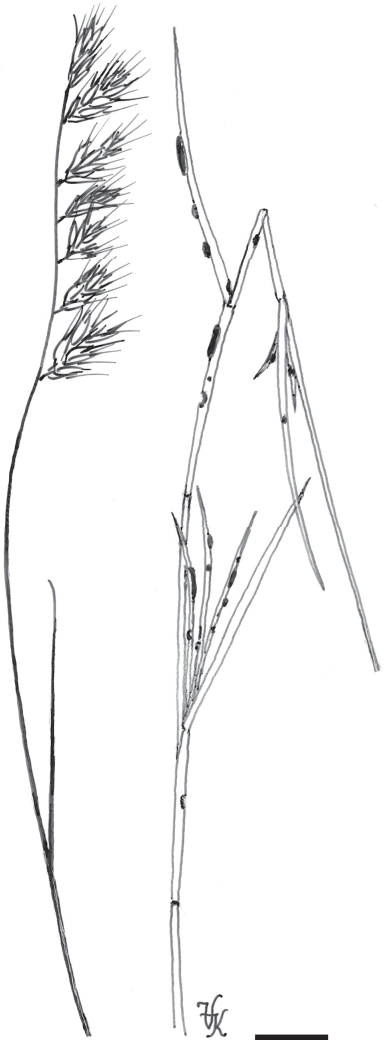
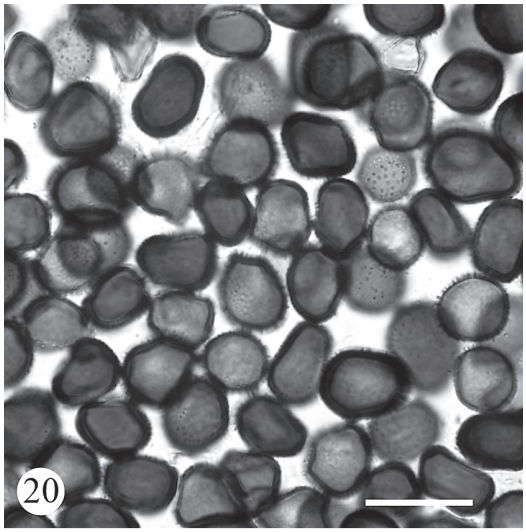
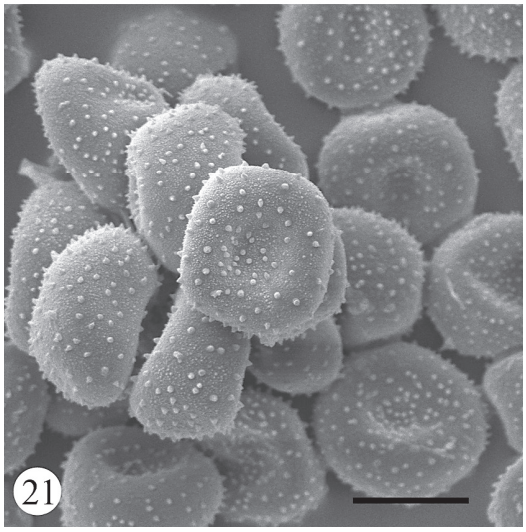


Fig. 19. *Ustilago buchloëformis* on *Bouteloua repens* (type). Habit. To the left an inflorescence. Bar = 1 cm





Figs 20–21. Spores of *Ustilago buchloëformis* in LM and SEM (type). Bars = 10 µm

Sori (Fig. 19) as in *Ustilago buchloës* Ellis & Tracy, forming bullate, globose to elongated, sausage-shaped pustules on the leaves and stems, c. 0.5 × 0.5–7 mm, initially covered by the greyish host epidermis which ruptures irregularly exposing the blackish brown, semi-agglutinated to powdery mass of spores. **Spores** (Figs 20–21) usually subpolyhedrally irregular, often elongated and also with a subacute tip, more rarely subglobose, ovoid or ellipsoidal, (9–) 10–16 (–17) × (11–) 13–26.5 (–28) µm, yellowish to dark reddish brown; wall 1–2 (–2.5) µm thick, sparsely, evidently echinulate, spines 0.3–0.5 µm high, spore profile sparsely serrulate.

On *Poaceae: Bouteloua repens* (Kunth) Scribn. & Merr.

Distribution: North America (Mexico). Known only from the type collection.

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