

The smut fungi (*Ustilaginomycotina*) of *Rhynchospora* (*Cyperaceae*)

Kálmán Vánky

Herbarium *Ustilaginales* Vánky (H.U.V.), Gabriel-Biel-Str. 5, D-72076 Tübingen, Germany (e-mail: vanky.k@cityinfonetz.de)

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Abstract. The smut fungi of *Rhynchospora* are revised. Twenty-eight species in seven genera are recognised and presented. Keys to the genera and species are given.

Key words: *Cintractia*, *Kuntzeomyces*, *Leucocintractia*, *Moreaua*, *Rhynchospora*, smut fungi, *Testicularia*, *Trichocintractia*, *Ustanciosporium*

Introduction

Rhynchospora Vahl (*Cyperaceae*) is a genus of over 250 species with a cosmopolitan distribution. On these 28 smut fungi are recognised belonging to the following seven genera: *Cintractia* (1 sp.), *Kuntzeomyces* (2), *Leucocintractia* (4), *Moreaua* (3), *Testicularia* (3), *Trichocintractia* (1), and *Ustanciosporium* (14).

Key to the genera of smut fungi on *Rhynchospora*

- 1 Spores in balls 2
- 1* Spore single, rarely in balls (in some *Ustanciosporium*) . . 3
- 2 Spore balls composed of a central mass of sterile cells surrounded by a cortex of spores *Testicularia*
- 2* Spore balls composed of spores only *Moreaua*
- 3 Spore wall separated in two layers by a middle, gelatinous layer *Kuntzeomyces*
- 3* Spore wall not separated in two layers 4
- 4 Sori with a sac-like peridium; spores mixed with long hyphal cells *Trichocintractia*
- 4* Sori not so; spores not mixed with long hyphal cells . . 5
- 5 Sori surrounding internodes of the culms or floral pedicels *Leucocintractia*
- 5* Sori in the flowers or spikelets 6
- 6 Sori in the flowers; spores single or in balls, foveolate *Ustanciosporium*
- 6* Sori in spikelets; spores single, very finely verruculose *Cintractia*

Descriptions of the smut fungi on *Rhynchospora*

1. *Cintractia amazonica* Syd. & P. Syd., Ann. Mycol. 14: 73, 1916.

Lectotype on *Rhynchospora* sp. (= *R. barbata*, det. Piepenbring 2003: 48), Brazil, Serra do Mel, Rio Branco, VIII.1909, E. Ule 3345, S (design. by Vánky, in press). Syntypes on *Rhynchospora* sp., Brazil, San Marcos, Rio Branco, I.1909, E. Ule 3344; BPI 170 335!, 170 336!

Cintractia rhynchosporae Cif., Ark. Bot. 23A(14): 9, 1931.

— Type on *Rhynchospora barbata*, Dominican Rep., Santo Domingo Prov., Llano Costero, Guerra, Cuenca, Sabana de la Ceiba, 13.VIII.1929, E.L. Ekman 2515 & R. Ciferri, BPI 194 442; isotypes in Ciferri, Mycofl. doming. exs. no. 7, BPI 172 117-172 119, H.U.V. 2589! (syn. by Ling 1950: 504; confirmed).

Sori usually infecting all spikelets of an inflorescence, globose to ovoid, 1–1.5 × 1–2 mm, initially isolated, later more or less confluent, black, agglutinated, with a powdery surface. Peridium and sterile stroma lacking. **Spores** globose, subglobose, more or less flattened, in side view (7–) 8–12 µm wide, in plane view circular, subcircular or slightly irregular, 13–17.5 × (13.5–) 14–18.5 µm, reddish brown; wall 0.5–1 µm thick, thinner on the flattened sides, in LM smooth, in SEM finely, irregularly verruculose, the warts confluent, forming an irregular pattern. **Spore germination** (Piepenbring 2000: 302) results in phragmobasidia, the basidial cells conjugate, producing two large, dikaryotic conidia.

On *Rhynchospora barbata* (Vahl) Kunth (*R. pterocarpa* Roem. & Schult.), *R. corymbosa* (L.) Britton, *R. heterochaeta* S.T. Blake, *R. leae* C.B. Clarke, *R. longisetis* R. Br., *R. rubra* (Lour.) Makino, *R. submarginata* Kük., *R. wightiana* Steud., *Rhynchospora* sp.

Distribution: S Asia (India), Australasia (Australia, Papua New Guinea), W Indies (Dominican Rep.), C America (Nicaragua), S America (Brazil, Colombia).

The morphology of the sori of *C. amazonica* is similar to that of species of *Ustanciosporium*, but the ornamentation of its spores and molecular phylogenetic data show that *C. amazonica* is a species of *Cintractia* s. str. (Piepenbring 2000: 302).

Key to the species of *Kuntzeomyces*

- 1 Spores 20–28 µm long *K. ruiziana*
 1* Spores 24–35 µm long *K. ustilaginoideus*

2. *Kuntzeomyces ruiziana* M. Piepenbr., Mycol. Res. 105[2000]: 759, 2001.

Type on *Rhynchospora ruiziana*, Colombia, Dpto. Cundinamarca, Fómeque, Chingaza Ntl. Park, alt. 3500 m, 12.IX.1998, A. Gil, E. Barrera & M. Piepenbring 47, COL; isotypes in M, TUB, BPI 747 293, H.U.V. 19 779!

Sori as in *K. ustilaginoideus*, from which it differs by smaller spores, measuring 20–26 × 20–28 µm. **Spore germination** (Piepenbring 2003: 68) results in phragmobasidia producing elongate, sessile basidiospores laterally and terminally.

On *Rhynchospora ruiziana* Boeck.

Distribution: S America (Colombia).

3. *Kuntzeomyces ustilaginoideus* (Henn.) Henn. ex Sacc. & P. Syd., in Saccardo, Syll. fung. 14: 430, 1899.

Didymochlamys ustilaginoidea Henn., Hedwigia 36: 246, 1897. — *Cintractia ustilaginoidea* (Henn.) Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. 1, 119: 879, 1910. — Type on *Rhynchospora* sp., Brazil, St. Cathar, near Blumenau, E. Ule 1885, FH.

Cintractia occulta Mol.-Val., Caldasia 13: 70, 1980. — Type on *Rhynchospora* sp., Colombia, Dpto. Huila, between La Plata and Puracé, alt. 3150 m, 21.I.1976, L.A. Molina, P. Buriticá, K.P. Dumont & J. Lutein, COL; isotype H.U.V. 8888! (syn. by Vánky 1987: 52).

Sori in some spikelets of the inflorescence, slightly hypertrophied, ovoid, 2–4 × 3–6 mm, initially hidden by the glumes and also covered by a dirty-white to pale brown peridium, later protruding between the glumes, the peridium ruptures irregularly apically exposing the black, agglutinated spore mass. The spore mass develops on the surface of the aborted floral axis and innermost floral organs. The peridium is composed of a network of longitudinally arranged rows of globose, polyangular, pyriform or fusiform fungal cells, like necklaces of pearls, subhyaline to pale yellow; wall 2.5–7 µm thick. Spores globose to subglobose 24–32 × 24–35 µm, with a peculiar wall structure of three layers. The inner layer, the

endospore, is uniformly 2–2.5 µm thick, yellow, smooth. The middle layer is hyaline, gelatinous, of variable thickness. The outer, membranous layer, the exospore, is finely verruculose, 1–1.5 µm thick, reddish brown, with a long germ slit, where the wall is thinner, c. 0.5 µm and paler. Under pressure or in humid conditions the exospore ruptures, permitting the true spore, covered only by the endospore, to pass freely (comp. also Ling & Stevenson 1949; Piepenbring *et al.* 1998: 181). **Spore germination** is not known.

On *Rhynchospora hieronymi* Boeck. subsp. *montevicensis* (Barros) Guagl., *R. macrochaeta* Steud. ex Boeck., *Rhynchospora* sp.

Distribution: S America (Bolivia, Brazil, Colombia, Ecuador, Peru).

Key to the species of *Leucocintractia*

- 1 Sori surrounding all the peduncles of an inflorescence 2
 1* Sori surrounding the culms; spores 14–20 µm long . . . 3
 2 Spores (11–) 12–16 (–17) µm long; wall 0.5–1 µm thick *L. scleriae*
 2* Spores 20–28 µm long; wall 2.5–5 µm thick *L. pachyderma*
 3 Spore wall 1–2.5 µm thick, with 5–8 parallel ridges *L. leucoderma*
 3* Spore wall (1–) 1.5–2.5 (–3) µm thick, with 8–10 parallel ridges *L. portus-argentei*

4. *Leucocintractia leucoderma* (Berk.) M. Piepenbr., Nova Hedwigia 70: 313, 2000.

Ustilago leucoderma Berk., Ann. Mag. Nat. Hist., Ser. 2, 9: 200, 1852. — *Cintractia leucoderma* (Berk.) Henn., Hedwigia 34: 335, 1895. — Type on ‘some sedge’ (= *Rhynchospora* sp.), Dominican Rep., Santo Domingo, leg. M.A. Sallé 76, Herb. Berkeley no. 4735, K!

Cintractia junci (Schwein.) Trel. f. *cylindrica* G. Winter, Hedwigia 26: 11, 1887. — Type on ‘*Carex* sp.’ (doubtful identification), Uruguay, Montevideo, II.1882, J. Arechavala. — *C. cancellata* Liro, Ann. Bot. Soc. Zool.-Bot. Fenn. ‘Vanamo’ 6: 6, 1935 (nom. inval., no Latin diagnosis, et nom. nov. pro *C. junci* var. *cylindrica*) (syn. by Ling 1951: 311).

Cintractia affinis Peck, New York State Mus. Bull. 67: 28, 1903. — *Leucocintractia affinis* M. Piepenbr., Nova Hedwigia 70: 312, 2000. — Type on *Rhynchospora macrostachya*, USA, New York, Long Island, Suffolk Co., Smithtown, 8.VIII.1902, C.H. Peck & F.S. Earle, NY; isotypes BPI 170 331!, 170 332!, 194 441! (syn. by Clinton 1904: 407; Ling 1951: 311; confirmed).

Cintractia amicta Cif., Ark. Bot. 23A(14): 10, 1931. — Type on *Rhynchospora barbata*, Dominican Rep., Santo Domingo Prov., Sabana de Guerra, 13.VIII.1929, E.L. Ekman 2513 & R. Ciferri; isotypes BPI 170 337–170 342, 194 436, and in Ciferri, Mycofl. doming. exs. no. 6, H.U.V. 1949! (syn. by Ling 1951: 311).

Cintractia leucoderma (Berk.) Henn. var. *chacoensis* Hirschh., Revista Argent. Agron. 6: 193, 1939. — Type on *Rhynchospora* sp. vel. *Scleria* sp., Argentina, Santa Fé, Lanteri, II.1936, M. Job, LPS 3157; isotypes in Herb. Hirschhorn 34, H.U.V. 15 949! (syn. by Ling 1951: 311; Kukkonen & Gjørnum 1977: 90).

Leucocintractia leucodermoides M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 315, 2000. — Type on *Rhynchospora holoschoenoides*, Brazil, Copacabana-Rio, XII.1897, E. Ule, M; isotypes in Rbh., Fgi. eur. no. 4401, H.U.V. 422! (syn. by Vánky 2006: 61).

Sori surrounding the culms, long-cylindrical, 1–2.5 mm wide, 1–4 (–5) cm long, initially covered by a thick, white peridium that flakes away exposing the black, agglutinated spore mass with a powdery surface. Infection systemic; diseased plants remain sterile or with rudimentary inflorescence. **Spores** subglobose, ovoid, ellipsoidal, laterally slightly flattened, c. 12 µm wide, in plane view 13–18.5 × 14–20 µm, dark reddish brown; wall even or slightly uneven, 1–2.5 µm thick, densely, irregularly verrucose which, on the flattened sides, in SEM partly fusing into irregular meshes, on the equatorial circumference forming 5–8, irregular, more or less parallel ridges.

On *Rhynchospora barbata* (Vahl) Kunth (*R. pterocarpa* Roem. & Schult.), *R. corniculata* (Lam.) A. Gray, *R. corymbosa* (L.) Britton (*R. aurea* Vahl), *R. holoschoenoides* (L.C. Rich.) Herter (*R. cyperoides* (Seward) Mart.), *R. macrostachya* Torr. ex A. Gray, *R. tracyi* Britton.

Distribution: Africa (Congo, Madagascar, Mauritius, S Africa, Tanzania), S & SE Asia (Malaysia), Philippines, N America (Mexico, USA), W Indies (Cuba, Dominican Rep., Puerto Rico, Santo Domingo), C America (Belize, Costa Rica, Nicaragua, Panama), S America (Argentina, Brazil, Guiana, Uruguay, Venezuela).

5. *Leucocintractia pachyderma* (Syd.) M. Piepenbr., Nova Hedwigia 70: 317, 2000.

Cintractia pachyderma Syd., Ann. Mycol. 22: 282, 1924. — Type on *Rhynchospora laxa* (= *R. corniculata*), USA, Florida, Miami, 15.XII.1903, A.A. Eaton; isotypes in Seymour & Earle, Econ. fgi., Suppl. C. no. 104, H.U.V. 9693!

Sori similar to those of *L. scleriae*, surrounding all peduncles of an inflorescence with rudimentary spikelets, cylindrical, 2–3 × 8–15 mm, initially covered by a thick, white peridium that later ruptures and flakes away exposing the black, agglutinated spore mass, powdery on its surface. **Spores** globose, subglobose to ellipsoidal, slightly flattened, 16–26.5 × 20–28 µm, yellowish brown; wall 2.5–5 µm thick, in the centre of the flattened sides verruculose, parallel to the equatorial circumference provided with narrow, irregular, dense, 9–16, sparsely anastomosing and ramifying striae.

On *Rhynchospora corniculata* (Lam.) A. Gray (*R. laxa* Vahl).

Distribution: N America (USA).

6. *Leucocintractia portus-argenti* (Cif.) M. Piepenbr., Nova Hedwigia 70: 318, 2000.

Cintractia portus-argenti Cif., Ark. Bot. 23A(14): 14, 1931. — Type on *Rhynchospora* sp., Dominican Rep., Puerto Plata Prov., Cordillera Septentrional, Sosúa, Cabarete, 26.III.1930, E.L. Ekman 3448, S; isotype in M! (The isotypes I have seen, distributed in Ciferri, Mycofl. Doming. exs. no. 84, contains *Ustanciosporium majus* s. lat.)

Cintractia striata G.P. Clinton & Zundel, in Zundel, North American Flora 7: 1004, 1939. — *C. leucoderma* (Berk.) Henn. var. *striata* (G.P. Clinton & Zundel) L. Ling, Mycologia 43: 312, 1951. — Type on *Rhynchospora tracyi* (= *R. holoschoenoides*), USA, Florida, Fort Pickens, 31.V.1903, S.M. Tracy 8355, BPI 172 153!; isotypes in BR, NHES, NY (syn. by Piepenbring 2000: 318).

Sori similar to those of *L. leucoderma*, surrounding the culms, long-cylindrical, 2–3 × 5–20 mm, initially covered by a white peridium that flakes away exposing the black, agglutinated spore mass with a powdery surface. Infection systemic; diseased plants remain sterile or develop only rudimentary inflorescence. **Spores** globose, subglobose to broadly ellipsoidal, slightly flattened, 13–18 × 14.5–20 µm, medium dark reddish brown; wall even or slightly uneven, (1–) 1.5–2.5 (–3) µm thick, on the polar (or flattened) sides covered by few, irregular, coarse warts, on the equatorial circumference with 8–10, shorter or longer parallel ridges.

On *Rhynchospora holoschoenoides* (L.C. Rich.) Herter (*R. cyperoides* (Seward) Mart.), *R. tracyi* Britton, *Rhynchospora* sp.

Distribution: N America (USA), W Indies (Dominican Rep.).

7. *Leucocintractia scleriae* (DC.) M. Piepenbr., Begerow & Oberw., Mycologia 91: 497, 1999.

Uredo scleriae DC., in Poiret, Encycl. Méth. Bot. 8: 228, 1808. — *Ustilago scleriae* (DC.) Tul. & C. Tul., Ann. Sci. Nat. Bot., Sér. 3, 7: 89, 1847. — *Cintractia scleriae* (DC.) L. Ling, Mycologia 43: 314, 1951. — Type on *Scleria* sp. (= *Rhynchospora corymbosa*), French Guyana, Cayenne, Herb. de Candolle 555, G!

Cintractia krugiana Magnus, in Bresadola, Hennings & Magnus, Bot. Jahrb. Syst. 17: 490, 1893. — Type on *Rhynchospora gigantea*, Puerto Rico, Manati, on the banks of Laguna Tortugero, 12.V.1887, P. Sintenis 6672, NY (syn. by Ling 1951: 314).

Cintractia krugiana Magnus var. *usambarensis* Henn., Hedwigia 34: 336, 1895; in Engler, Pflanzenwelt Ost-Afrikas, etc., C: 48, 1895. — *C. usambarensis* (Henn.) Cif., Ark. Bot. 23A(14): 7, 1931. — Type on *Rhynchospora aurea* (= *R. corymbosa*), Tanzania, Usambara Mts., Vikindo, leg. Stuhlmann 640, HBG; isotypes in BM, FH, K, NY (syn. by Ling 1951: 314).

Cintractia javanica Racib., Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. Nat. 1909: 351, 1909. — Type on *Cyperus* sp. (= *Rhynchospora corymbosa*), Indonesia, Java, Preanger,

Soekanegara, 1900, M. Raciborski, FH; isotypes in PC, H.U.V. 430! (syn. by Ling 1951: 314).

Cintractia albida S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 93, 1935. — Type on *Rhynchospora corymbosa*, China, Taiwan, Taipei, Taihoku Prov., Mt. Shichisei, V.1932, T. Suzuki, SAPA; isotypes BPI 194 435, H.U.V. 16 632! (syn. by Ling 1951: 316).

Sori surrounding all the peduncles of an inflorescence with rudimentary spikelets, cylindrical, often curved, 2–3 × 5–20 mm, at first covered by a thick, white peridium that later ruptures irregularly exposing a black, agglutinated spore mass with a powdery surface. **Spores** solitary, globose, subglobose or broadly ellipsoidal, (9–) 10–15 × (11–) 12–16 (–17) µm, slightly flattened, 8–12 µm wide, light reddish brown, without appendages; wall 0.5–1 µm thick, covered by irregular, coarse warts and coarse, irregular ridges that are often connected by small, transverse ridges or warts. **Spore germination** results in phragmobasidia of which cells separate readily, producing ellipsoidal basidiospores (comp. also Viégas 1940, as *C. leucoderma*).

On *Rhynchospora asperula* (Nees) Steud., *R. corniculata* (Lam.) A. Gray (*R. laxa* Vahl), *R. corymbosa* (L.) Britton (*R. aurea* Vahl), *R. gigantea* Link, *R. spectabilis* Hochst., *R. triflora* Vahl, *Rhynchospora* sp.

Distribution: cosmopolitan and common in the tropics.

Key to the species of *Moreaua*

- 1 Spores apparently smooth; spore balls of 1–20 (–25?) spores *M. fischeri*
- 1* Spores conspicuously ornamented; spore balls of up to 35–50 spores 2
- 2 Spore balls irregular, mainly 25–40 µm long, composed of (1–) 4–25 (–35?) subglobose, hemispherical or subpolyhedral spores *M. rhynchosporae-cephalotis*
- 2* Spore balls more regular, mainly 30–45 µm long, composed of (6–) 10–30 (–50?), mainly subcuneiform spores *M. rhynchosporae*

8. *Moreaua fischeri* (Vánky) Vánky, Mycotaxon 74: 352, 2000.

Thecaphora rhynchosporae G.W. Fisch., Res. Stud. St. Coll. Wash. 20: 5, 1952. — *Tolyposporium fischeri* Vánky, Mycotaxon 48: 29, 1993 (nom. nov., not *T. rhynchosporae* (Henn.) Vánky). — Type on *Rhynchospora plumosa*, USA, Mississippi, Cooplis, 15.VI.1898, S.M. Tracy, no. 5225, NY!

Sori on the surface of internal floral organs, naked, black, granular, concealed by the glumes. **Spore balls** firm, variable in shape and size, 15–35 × 16–45 µm, reddish brown, composed of 2–20 (–25?) spores, frequently spores single. **Spores** subglobose, cuneiform, elongate or irregular, 8–13 × 9.5–16 (–20) µm, dark reddish brown, free surface in LM apparently smooth to very finely punctate-verruculose, in SEM finely, densely verruculose, warts often confluent in smaller or larger, irregular groups.

On *Rhynchospora plumosa* Elliott.

Distribution: N America (USA). Known only from the type collection.

9. *Moreaua rhynchosporae* (Henn.) Vánky, Mycotaxon 74: 353, 2000.

Sorosporium rhynchosporae Henn., Hedwigia 35: 222, 1896. — *Tolyposporium rhynchosporae* (Henn.) Vánky, Mycotaxon 48: 29, 1993. — Type on *Rhynchospora glauca* (= *R. rugosa*), Brazil, Rio de Janeiro, VII.1887, E. Ule 1614, HBG; isotypes in M, BPI 180 205, 180 206, H.U.V. 1703!

Sori in flowers, on the surface of internal floral organs, concealed by the glumes, forming a black, granular-powdery mass of spore balls. **Spore balls** subglobose, ellipsoidal or somewhat irregular, 20–25 (–40) × (25–) 30–45 (–55) µm, dark reddish to blackish brown, opaque, composed of (6–) 10–30 (–50) or more firmly agglutinated spores. **Spores** subcuneiform to hemispherically or subpolyhedrally irregular, 8–12 × 12–19 µm, dark reddish brown, prominently verrucose on the free surface, smooth on the contact sides.

On *Rhynchospora rugosa* (Vahl) Gale (*R. glauca* Vahl).

Distribution: S America (Brazil).

10. *Moreaua rhynchosporae-cephalotis* (Vánky & T. Vánky) Vánky, Mycotaxon 74: 353, 2000.

Tolyposporium rhynchosporae-cephalotis Vánky & T. Vánky, in Vánky, Mycotaxon 48: 29, 1993. — Type on *Rhynchospora cephalotes*, Costa Rica, Alajuela Prov., 1.5 km SE Los Chiles, near San Jerónimo, alt. 50 m, 24.III.1991, T. & K. Vánky, H.U.V. 15 199!; isotypes in Vánky, Ust. exs. no. 862.

Sori in flowers, on the surface of internal floral organs, especially around the stamens whereas glumes and bristles remain intact, forming a black, initially agglutinated, later granular-powdery mass of spore balls completely concealed by the glumes. Infection systemic; all spikelets of an inflorescence affected. **Spore balls** irregular, spherical, ovoid or elongate, 16–30 (–36) × 25–40 (–50) µm, blackish brown, composed of (1–) 4–25 (–35), firmly agglutinated spores. **Spores** subglobose, ellipsoidal, hemispherical or subpolyhedrally irregular, rarely subcuneiform, with rounded free side, 9–12 (–13.5) × 12–16 (–17.5) µm, blackish brown but rather transparent; wall of the contact sides c. 0.5 µm thick, smooth, that of the free surface 1–2.5 (–3) µm thick, including the dense, fine to coarse, irregular, often partly confluent warts.

On *Rhynchospora cephalotes* (L.) Vahl.

Distribution: C America (Costa Rica).

Key to the species of *Testicularia*

- 1 Sori up to 20 mm long; spore balls 75–320 (–350) µm long; spore wall 1–3 µm thick; sterile cells polyhedral *T. cyperi*
- 1* Sori smaller; spore balls 50–110 µm long; spore wall 0.5–1 µm thick; sterile cells globoid or ellipsoidal 2

- 2 Spores 11–21.5 (–25) μm long *T. minor*
 2* Spores 11.5–14.5 μm long *T. africana*

11. *Testicularia africana* Vánky & Piatek, Mycol. Balcan. 3: 164, 2006.

Type on *Rhynchospora corymbosa*, W Africa, Guinea (French), Reg. Macenta, margin of a small lakelet at Macenta, 28.XI.1962, S. Lisowski, KRAM-F 55 901; isotype H.U.V. 21 265!

Sori in some spikelets of an inflorescence, often several in groups, more rarely around the basal part of inflorescence branches, subglobose, ovoid, elongate, subcylindrical, 1.5–6 \times 2–8 mm, covered by a thick, whitish to yellowish brown peridium with granular or densely, polyangularly, irregularly cracked surface. **Spore balls** globose, subglobose, ovoid, ellipsoidal, 40–90 \times 50–110 μm , composed of a rather loose external layer of spores that separate under pressure, and a central mass of sterile fungal cells. **Spores** slightly flattened, in side view elliptic, 8–10.5 μm wide, in plane view circular or elliptic, 10.5–12.5 \times 11.5–14.5 μm , yellowish brown; wall smooth, 0.5–1 μm thick, with two rounded thinner areas in the middle of the flattened sides, 3–4 μm in diam. (germ pores?), in SEM finely, densely verruculose. **Sterile cells** globose, ellipsoidal or irregular, 6.5–13.5 \times 8–17 μm , subhyaline; wall 0.5–1 μm thick, smooth.

On *Rhynchospora corymbosa* (L.) Britton.

Distribution: W Africa (Cameroon, Guinea, ?Sierra Leone).

12. *Testicularia cyperi* Klotzsch, Linnaea 7: 202, 1832.

Type on *Rhynchospora* sp., North America (no closer data), herb. Hooker, K; isotype BPI 711 939.

Milleria herbatica Peck, Rep. (Annual) New York State Mus. 31: 40, 1879. — Type on *Rhynchospora macrostachya*, USA, New York, Wading River, E.S. Miller; isotypes in Ellis, N. Amer. fgi. no. 805, H.U.V. 2039!

Sori comprise some spikelets of an inflorescence, forming conspicuous, subglobose, ellipsoidal or ovoid swellings, 5–20 mm long, covered by a thick, whitish peridium composed of hyaline, firmly united fungal cells, variable in shape and size, subglobose, ellipsoidal, elongate or irregular, 7–16 \times 8–25 μm ; wall variable in thickness, 1.5–6.5 μm wide, often with gelatinised external layer. The surface of the peridium is granular. At maturity, the peridium ruptures irregularly at the apex, becoming sac-like, and the black, agglutinated or granular-powdery mass of spore balls is exposed. The sori comprise all flowers of a spikelet, leaving intact the basal glumes and rarely also the tip of the distal floral envelopes. In some sori there is a well-developed, irregular columella, the axis of the spikelet. In young sori, between the spore balls, more or less radially arranged sterile hyphae can be seen. **Spore balls** subglobose, ovoid to irregular, (60–) 70–200 (–260) \times 75–320 (–350) μm , dark chestnut brown, opaque, composed of an external, often incomplete layer of spores and an internal mass

of sterile, parenchymatous cells. **Spores** radially slightly flattened, in side view elliptic or slightly irregular, 9–13.5 μm wide, in plane view circular or subcircular, 13–16 (–17) μm in diam., reddish to chestnut brown; wall uneven, 1–3 μm , thinner on the flattened, outer surface, smooth, in SEM finely, densely granular-verruculose. **Sterile cells** irregularly polyhedral, 5–12 \times 6–13.5 μm , wall thin, c. 0.3 μm , yellowish to brownish tinted, smooth. **Spore germination** (Vánky 2002: 146–147, Fig. E) results in phragmobasidia, 3–4 \times 30–45 μm , composed of 3–6 cells. On the basidia, on sterigmata, laterally and terminally, narrowly ellipsoidal to subfusiform basidiospores are produced, (1.5–) 2–3 \times 8–16 μm . Basidiospores one- or two-celled, germinating by similar but smaller secondary and tertiary spores often on sterigmata, and also producing yeast colonies in nutrient media.

On *Rhynchospora careyana* Fernald, *R. corniculata* (Lam.) A. Gray (*R. laxa* Vahl), *R. macrostachya* Torr. ex A. Gray.

Distribution: N America (USA).

13. *Testicularia minor* (Juel) L. Ling, Lloydia 14: 109, 1951.

Testicularia cyperi Klotzsch var. *minor* Juel, Bih. Kongl. Svenska Vetensk.-Akad. Handl. 23: 9, 1897. — Type on *Rhynchospora* sp., Brazil, Rio Grande do Sul, Pôrto Alegre, 6.X.1892, G.O.A. Malme, S!

Sori in some spikelets of an inflorescence, similar to those of *T. cyperi* but smaller, 2–4 \times 3–6 mm, covered by a scurfy-verruculose peridium. In the sori, between the young spore balls, thin, sinuous fascicles of long, sterile, fungal cells can be seen, arranged more or less radially, extending from the host plant tissue to the peridium. **Spore balls** globose, subglobose or ellipsoidal, 50–90 \times 50–110 μm , composed of a loose external layer of spores that separate easily, and a central mass of sterile fungal cells. **Spores** globose, subglobose, ovoid, ellipsoidal, not or only slightly flattened, 10.5–20 \times 11–21.5 (–25) μm , yellowish brown; wall even, 0.5–0.8 μm thick, smooth, in SEM finely granular. **Sterile cells** subglobose, ellipsoidal or slightly irregular, collapsed in old specimens, 8–25 μm long, subhyaline to pale yellow; wall even, 1–1.5 μm thick, smooth.

On *Rhynchospora corymbosa* (L.) Britton, *R. gigantea* Link, *Rhynchospora* sp.

Distribution: W Indies (Cuba, Puerto Rico), S America (Bolivia, Brazil, Colombia).

For details of sorus structure and spore ball formation see Juel (1897: 10–11, Plate II, Figs 6–10), and Vánky & Piatek (2006: 165, Fig. 2).

14. *Trichocintractia utriculicola* (Henn.) M. Piepenbr., Canad. J. Bot. 73: 1095, 1995.

Cintractia leucoderma (Berk.) Henn. f. *utriculicola* Henn., Hedwigia 34: 336, 1895. — *C. utriculicola* (Henn.) G.P. Clinton, J. Mycol. 8: 143, 1902. — Type on *Rhynchospora gigantea*, Brazil, Sta. Catharina Prov., Blumenau, leg. A. Möller.

Ustilago conglobata Cooke (? nom. herb.) on *Rhynchospora aurea* (= *R. corymbosa*), without locality, 11.XII.1885, Clarke, K!

Cintractia axicola (Berk.) Cornu forma *spicularum* Juel, Bih. Kongl. Svenska Vetensk.-Akad. Handl. 23: 7, 1897. — *C. spicularum* (Juel) Racib., Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. Nat. 1909: 353, 1909. — Type on *Rhynchospora* sp., Brazil, Rio Grande do Sul, Pôrto Alegre, 7.XI.1892, C.A.M. Lindman (syn. by Zundel 1953: 38).

Sori in some spikelets of an inflorescence, starting from the top of spikelet axis, replacing the flowers, ovoid, 2–2.5 × 3–5 mm, covered by a greyish white, thick peridium of fungal origin, initially closed, later rupturing apically exposing the black, powdery mass of spores. **Spores** when young in globose groups between the sterile fungal cells, later single, slightly flattened, in side view broadly elliptic to slightly irregular, 10–13 µm wide, in plane view circular to broadly elliptic, 11–15 × (11–) 12–16 (–17.5) µm, medium olive-brown; wall 1–2 (–2.5) µm thick, with a c. 0.5 µm thin, rounded area of 4–6.5 µm diam. on the flattened sides, where the spore colour is also lighter, surface in LM apparently smooth to minutely, densely punctate, in SEM finely, densely verruculose. **Sterile fungal cells**, originating from the host tissue at the base of the sorus, radiating into the spore mass, numerous, in groups but not sticking together, long-cylindrical, without septa, 5 µm wide and up to 600 µm long; wall up to 2 µm thick, less at the cell tip, smooth. **Spore germination** results in phragmobasidia producing basidiospores or hyphae.

On *Rhynchospora asperula* (Nees) Steud., *R. corymbosa* (L.) Britton (*R. aurea* Vahl), *R. gigantea* Link, *R. holoschoenoides* (L.C. Rich.) Herter (*R. cyperoides* (Seward) Mart.), *R. triflora* Vahl.

Distribution: cosmopolitan in the tropics.

For detailed description and illustration of sorus structure and spore formation see also Juel (1897: 7–9, Pl. I, Fig. 2, Pl. II, Figs 6–7; as *C. axicola* f. *spicularum*).

Key to the species of *Ustanciosporium* on *Rhynchospora*

- 1 Only groups of spikelets in the inflorescence infected, appearing as small witches' brooms 2
- 1* All spikelets in the inflorescence infected, no witches' brooms 5
- 2 Spores 9.5–12 µm long, transversally deeply impressed appearing as folded, densely, minutely, verruculose, no appendage *U. farlowii*
- 2* Spores larger, not folded, otherwise ornamented, with one appendage 3
- 3 Spores 16–27 µm long, with coarse, rounded warts *U. nova-guineae*
- 3* Spores smaller, foveolate 4
- 4 Spores 13–19 (–20) µm long, appendage conical, 5–7 (–8) µm high *U. conophorum*

- 4* Spores 13.5–17.5 µm long, appendage ovoid, 4–5 µm high *U. standleyanum*
- 5(1) Spores in more or less loose spore balls 6
- 5* Spores single 8
- 6 Spores 9.5–15 (–16) µm long; spore wall 0.5–1 (–1.5) µm thick *U. virginianum*
- 6* Spores larger; spore wall thicker 7
- 7 Spores extremely irregular, often bent and with acute tips, 14–22 (–25) µm long, medium reddish brown; spore wall 1–1.5 (–3) µm thick *U. rhynchosporae*
- 7* Spores less irregular, usually with blunt angles, (12–) 13.5–20 (–21.5) µm long, dark reddish brown; spore wall 1–3 µm thick *U. cubense*
- 8(5) Spores with two, 3.5–6.5 µm high appendages *U. appendiculatum*
- 8* Spores with shorter appendages or appendages lacking 9
- 9 Spore wall 1–2.5 µm thick, with few, deep foveolae only on the circumference *U. psilocaryae*
- 9* Spore wall thinner, foveolae not so 10
- 10 Spore wall 0.5–2 µm thick 11
- 10* Spore wall up to 1 µm thick 12
- 11 Spores 12–17 µm long, sparsely deep foveolate; spore wall often with wart-like thickenings . . . *U. ekmanii*
- 11* Spores 15–21 µm long, very finely, irregularly, verruculose foveolate; spore wall without wart-like thickenings *U. gigantosporum*
- 12 Spores (12–) 13–17.5 (–19) µm long, with two, often inconspicuous appendages *U. eximium*
- 12* Spores smaller, appendage one or lacking 13
- 13 Spores 9–13 (–14) µm long *U. montagnei* s. lat.
- 13* Spores (11–) 12–17 µm long *U. majus* s. lat.

15. *Ustanciosporium appendiculatum* M. Piepenbr., Nova Hedwigia 70: 331, 2000.

Type on *Rhynchospora capitellata*, USA, Massachusetts, Plymouth Co., Plymouth, small pond near Fearing Pond, 7.IX.1936, F.C. Seymour 4857 (as '*Cintractia montagnei*'), M; isotype in NY.

Sori in all flowers of a somewhat swollen and congested inflorescence. **Spores** single, flattened, in side view elliptic, 6.5–11 µm wide, with two, 3.5–6.5 µm high appendages on the flattened sides, in plane view often slightly subangular, 9.5–14.5 × 11–16 µm; wall uneven, 0.5–1 µm thick, finely, rather densely foveolate, spore profile smooth.

On *Rhynchospora capitellata* (Michx.) Vahl, *R. glomerata* (L.) Vahl).

Distribution: N America (USA).

16. *Ustanciosporium conophorum* M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 331, 2000.

Type on *Rhynchospora microcarpa*, USA, Florida, Everglades National Park, Long Pine Key, 12.III.1998, D. Begerow & M. Schmitz 575, M; isotypes in TUB, H.U.V. 18 765!

Sori in all flowers of some groups of congested, swollen spikelets in the inflorescence, forming witches' brooms of 8–10 mm in diam. Spore mass black, agglutinated to powdery, hidden by the glumes. **Spores** single, with one flattened side bearing a 5–7 (–8) μm high, conical, hyaline appendage, in side view semi-circular or reniform, 9.5–13.5 μm wide (without appendage), in plane view circular, elliptic or slightly irregular, 12–16 \times 13–19 (–20) μm , dark reddish brown; wall uneven, 1–3 μm thick, thinnest beneath the appendage, thickest on the opposite side, moderately densely, finely foveolate, spore profile finely wavy. **Spore germination** (Piepenbring 2000: 332, Fig. 81) results in phragmobasidia carrying ovoid basidiospores.

On *Rhynchospora microcarpa* Baldwin ex A. Gray.

Distribution: N America. Known only from the type locality.

Ustanciosporium conophorum is close to *U. standleyanum* but the spores of *U. conophorum* are slightly darker and larger, and the appendage is higher.

17. *Ustanciosporium cubense* (M. Piepenbr.) M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 332, 2000.

Cintractia cubensis M. Piepenbr., Mycol. Res. 103: 459, 1999. — Type on *Rhynchospora microcephala*, Cuba, Pinar del Río Prov., municipio Sandino, area Herradura, Laguna de la Culebra, alt. 10 m, 19.X.1996, C. Landeta, A. Urquiola & M. Piepenbring 2252, M; isotypes TUB ('H.U.P. 1106'), H.U.V. 18 508!

Sori in all flowers of a congested inflorescence, swollen. Spore mass black, powdery, composed of loose spore balls and single spores, more or less hidden by the glumes. Infection systemic; usually all inflorescences of a plant are infected. **Spore balls** irregular, easily disintegrate. **Spores** flattened, in side view ellipsoidal or with a flattened side, 9–13 μm wide, no or rarely one hyaline appendage, in plane view irregular, subpolyangular, usually with blunt angles, or elongate, rarely with an acute tip, 9.5–17.5 \times (12–) 13.5–20 (–21.5) μm , medium to dark reddish brown; wall uneven, 1–3 μm thick, finely, densely deep foveolate, spore profile smooth to finely wavy. **Spore germination** (Piepenbring 1999: 459, Figs 6–15) results in 2–4-celled basidia of which cells conjugate giving rise to large, ellipsoidal basidiospores.

On *Rhynchospora microcephala* (Britton) Britton.

Distribution: W Indies. Known only from the type locality.

18. *Ustanciosporium ekmanii* (Cif.) M. Piepenbr., Nova Hedwigia 70: 337, 2000.

Cintractia ekmanii Cif., Ark. Bot. 23A(14): 11, 1931. — Type on *Rhynchospora podosperma* (= *R. filiformis*), Dominican Rep., Llano Costero, Santo Domingo Prov., Guerra, Cuenca, road to La Ceiba, 13.VIII.1929, E.L. Ekman & R. Ciferri, S; isotypes in Cif., Mycofl. doming. exs. no. 8, H.U.V. 3889!

Sori in all flowers of an inflorescence, slightly swollen, congested or on spreading spikelet branches. Spore mass blackish brown, initially agglutinated later powdery, hidden by the glumes. **Spores** single, flattened, in side view elliptic or on one side impressed, 6–8 μm wide, rarely with hyaline appendage, in plane view circular, elliptic, elongate, usually irregular, subangular, 9–13.5 \times 12–17 μm , yellowish brown; wall even or uneven, with several thickened areas at the angles but also on the flattened sides, 0.5–2 μm thick, sparsely deep foveolate, in SEM wall between the foveolae finely verruculose, in the centre of the compressed side with dense, relatively large warts, spore profile smooth.

On *Rhynchospora filiformis* Vahl (*R. podosperma* C. Wright ex Sauvalle; *R. longispicata* Boeck.), *R. pilosa* (Kunth) Boeck. subsp. *arenicola* (Uittien) Koyama.

Distribution: W Indies (Dominican Rep.), S America (Venezuela).

Ustanciosporium ekmanii is close to *U. majus* from which it differs by somewhat smaller spores, by thicker spore walls in the angles, and less dense foveolae (comp. Piepenbring 2000: 337).

19. *Ustanciosporium eximium* (Cif.) M. Piepenbr., Nova Hedwigia 70: 337, 2000.

Cintractia eximia Cif., Ark. Bot. 23A(14): 12, 1931. — Type on *Rhynchospora eximia*, Dominican Rep., Azua Prov., Cordillera Central, El Tetero, near Constanza, alt. 1300 m, 10.X.1930 (on the label '1929'), E.L. Ekman 2639, S!; isotype BPI 171 391!

Sori in all flowers of an infected inflorescence. Spore mass blackish brown, semi-agglutinated to powdery, hidden by the glumes. **Spores** single, flattened, 8–10 μm wide, often with two hyaline appendages, 0.5–3 μm high, in plane view circular, elliptic or subangularly slightly irregular, 12–15 \times (12–) 13–17.5 (–19) μm , pale reddish brown; wall 0.5–1 μm thick, finely, densely, shallow foveolate.

On *Rhynchospora eximia* (Nees) Boeck.

Distribution: N America (Mex.), W Indies (Dominican Rep.).

Ling (1950: 508) considered *Cintractia eximia* to be a synonym of *C. montagnei* var. *major*. Piepenbring (2000: 339) wrote that *Ustanciosporium eximium* is close to *U. majus* from which it differs by somewhat larger, more regularly shaped spores, which more often have hyaline appendages, and the wall is less locally thickened than in *U. majus*. It is questionable if it merits specific rank.

20. *Ustanciosporium farlowii* (G.P. Clinton) M. Piepenbr., Nova Hedwigia 70: 339, 2000.

Cintractia farlowii G.P. Clinton, in Zundel, in North American Flora 7: 1000 & 1029, 1939. — Type on *Rhynchospora capitellata*, USA, Massachusetts, Magnolia, 27.IX.1911, C.H. Clarke, NHES; isotypes BPI 171 540–171 542, H.U.V. 17 695!

Sori in congested flowers of groups of spikelets of an inflorescence forming witches' brooms, single sori more or less

hidden by the enveloping glumes, filling them with a blackish brown, initially agglutinated later powdery spore mass. **Spores** single, deeply, transversally impressed in one half so that the spores appear folded, in side view reniform, 6.5–9.5 µm, no hyaline appendage, in plane view elliptic to slightly irregular, 7–10.5 × 9.5–12 µm, yellowish brown to reddish brown; wall uneven, 0.5–1 µm thick, thin on the impressed side, in LM smooth, in SEM very finely, densely verruculose.

On *Rhynchospora capitellata* (Michx.) Vahl (*R. glomerata* (L.) Vahl var. *leptocarpa* Chapm.; *R. leptocarpa* (Chapm.) Small), *R. glomerata* (L.) Vahl.

Distribution: N America (USA).

The deeply reniform, 'folded' spores are typical for *U. farlowii*. The description above is in discordance with the description and illustration given by Piepenbring (2000: 339, Fig. 102), but it is in accordance with the original description.

21. *Ustanciosporium gigantosporum* (Liro) M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 339, 2000.

Cintractia gigantospora Liro, Mycoth. fenn. no. 26, 1934. — *Ustilago gigantospora* (Liro) Lehtola, Ann. Bot. Soc. Zool.-Bot. Fenn. 'Vanamo' 17: 23, 1942. — Type on *Rhynchospora alba*, Finland, Åland, Finström, Storträsk, 26.VII.1897, A.S. Kajava & J.I. Liro; isotypes in Mycoth. fenn. no. 26, H.U.V. 4413!

Ustilago rhynchosporae Sauter, in Rabenh., Herb. viv. myc. no. 1896, 1854; Bot. Zeitung (Berlin) 12: 190, 1854 (not *Ustanciosporium rhynchosporae* Vánky 1999: 31). — Lectotype on *Rhynchospora alba*, Austria, near Salzburg, 1853, A.E. Sauter (design. by Vánky 1994: 373), H.U.V. 4411!; isolectotypes in Rbh., Herb. viv. myc. no. 1896 (mixed with *Ustanciosporium montagnei*, hence the selection of a lectotype) (syn. by Liro 1938: 47).

Sori in all flowers of an inflorescence, hidden by the glumes. Spore mass black, semi-agglutinated to powdery, composed of single spores. Infection systemic, infected plants often dwarfed, with glumes and bristles that are shorter, more pointed and more spreading than those of healthy plants. **Spores** slightly flattened, in side view elliptic, 11–14.5 µm wide, hyaline appendages lacking, in plane view circular, oblong, occasionally slightly irregular, 14.5–18.5 × 15–21 µm, reddish brown; wall slightly uneven, 0.5–2 µm thick, thinnest in the middle of the flattened sides, where the spores are impressed, very finely, irregularly, verruculose foveolate, the warts usually confluent, giving the spore surface an irregularly reticulate, light-spotted aspect, spore profile smooth to finely wavy. **Spore germination** (Lehtola 1942: 22; Piepenbring 2000: 341, Figs 108–111) results in 4-celled basidia; their cells conjugate in pairs and develop two, large, dikaryotic basidiospores.

On *Rhynchospora alba* (L.) Vahl, *R. miliacea* (Lam.) A. Gray.

Distribution: C, W & N Europe, N America (Can., USA).

The spores in the H.U.V. 4413 copy of the type specimen of *Cintractia gigantospora* are very variable in size (11–23 µm long) and also a hyaline appendage may be present in some

spores, which denotes a probable hybrid origin. Description above is based on Vánky, Ust. exs. no. 369 (as '*Ustilago rhynchosporae*'), in which the spores are more uniform.

22. *Ustanciosporium majus* (Desm.) M. Piepenbr., Nova Hedwigia 70: 341, 2000, s. lat.

Ustilago montagnei Tul. & C. Tul. var. *major* Desm., in Desm., Pl. crypt. Fr., ed. 1, no. 2126 (= Ed. 2, no. 1726), 1851. — *Cintractia major* (Desm.) Liro, Ann. Acad. Sci. Fenn., Ser. A, 42(1): 46, 1938. — *Ustilago intercedens* Lehtola, Ann. Bot. Soc. Zool.-Bot. Fenn. 'Vanamo' 17: 23, 1942 (non *Ustilago major* J. Schröt., in Cohn 1887). — Type on *Rhynchospora alba*, France; isotypes in Desm., Pl. crypt. Fr., Ed. 1, no. 2126 (= Ed. 2, no. 1726), H.U.V. 12 733!

Ustilago juncicola Speg., Rev. Argentina Hist. Nat. 1: 170, 1891. — *Cintractia juncicola* (Speg.) Liro, Ann. Acad. Sci. Fenn., Ser. A, 42(1): 286, 1938. — Type on *Juncus chamissonis* Kunth (doubtful host), Paraguay, between Valenzuela and Guarapi, 18.I.1884, B. Balansa 4323 (syn. by Ling 1950: 508).

Ustilago taubertiana Henn., Bot. Jahrb. Syst. 17: 525, 1893. — *Cintractia taubertiana* (Henn.) G.P. Clinton, J. Mycol. 8: 142, 1902. — *Ustanciosporium taubertianum* (Henn.) M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 355, 2000. — Type on *Rhynchospora tenuis*, Brazil, State Minas Gerais, leg. Glaziou 20 034, B (lost). — Neotype (design. by Piepenbring 2003: 149) on *Rhynchospora tenuis*, Brazil, Estado de Sta. Catharina, Tubarão, I.1889, E. Ule 1038, HBG (syn. by Ling 1950: 506, as *Cintractia montagnei* var. *major*, confirmed).

Ustilago scleriae (DC.) Tul. & C. Tul. var. *dichromenae* Henn., Bot. Jahrb. Syst. 17: 526, 1893 (as '*dichronemae*'). — Type on *Dichromena minarum* (= *Rhynchospora nana*), Brazil, State Minas Gerais, leg. Glaziou 20 043.

Ustilago liebmanni Henn., Hedwigia 33: 229, 1894 (as '*liebmanni*'). — Type on '*Luzula* sp.' (= misidentified *Rhynchospora* sp., det. Ling 1950: 510; *R. tenuis*?, det. Piepenbring 2000: 355), Mexico, Mirador, leg. Liebmann 691, BPI 162 514; isotypes BPI 162 515, 162 516 (syn. by Ling 1950: 508 as *Cintractia montagnei* var. *major*).

Ustilago dichromenae Henn., Hedwigia 43: 78, 1904 (as '*dichronemae*'). — *Ustanciosporium dichromenae* (Henn.) M. Piepenbr., Flora Neotropica, Monograph 86: 143, 2003 — Type on *Dichromena minarum* (= *Rhynchospora nana*), Brazil, Rio de Janeiro, 1891, Glaziou 20 045, BPI 1601 89!; isotype in NHES (syn. by Ling 1950: 508, as *Cintractia montagnei* var. *major*, confirmed).

Ustilago bipustulata Peck, in House, New York State Mus. Bull. 219–220: 235, 1921 (nom. nud.). — On *Rhynchospora glomerata*, USA, Monroe Co., IX.1912, M.S. Baxter 172, NY (syn. by Ling 1950: 508, as *Cintractia montagnei* var. *major*).

Sori in inner part of all flowers of an inflorescence as black, semi-agglutinated to powdery spore mass, protected by the glumes. Infection systemic, infected plants often dwarfed, with more congested flowers and shorter, more pointed glumes and bristles than the healthy ones. **Spores** single, flattened, in

side view elliptic, slightly irregular or reniform, 6.5–9.5 µm wide, rarely with one, flat, hyaline appendage, in plane view rounded subangularly or angularly irregular, occasionally subcircular or elliptic, 9–13 × (11–) 12–17 µm, yellowish brown; wall even or slightly uneven, 0.5–1 µm thick, thickest at the angles, finely, densely foveolate-reticulate, spore profile smooth, in SEM the wall between the shallow foveolae very finely verrucose. **Spore germination** (Lehtola 1942: 13–21) of hibernated spores results in 4-celled basidia bearing lateral and terminal, ellipsoidal basidiospores on sterigmata which conjugate in pairs, or two basidial cells conjugate and develop two, large, elongate, dikaryotic conidia.

On *Rhynchospora alba* (L.) Vahl, *R. fascicularis* (Michx.) Vahl, *R. glomerata* (L.) Vahl, *R. marisculus* Nees (*R. stipitata* Chapm.), *R. nana* (Boeck.) H. Pfeiff. (*Dichromena minarum* C.B. Clarke), *R. tenuis* Link.

Distribution: Europe, Asia, N, C & S America.

23. *Ustanciosporium montagnei* (Tul. & C. Tul.) M. Piepenbr., Begerow & Oberw., in Piepenbring, Nova Hedwigia 70: 344, 2000, s. lat.

Ustilago montagnei Tul. & C. Tul., Ann. Sci. Nat. Bot., Sér. 3, 7: 88, 1847. — *Microbotryum montagnei* (Tul. & C. Tul.) Lév., Ann. Sci. Nat. Bot., Sér. 3, 8: 372, 1847. — *Cintractia montagnei* (Tul. & C. Tul.) Magnus, Verh. Bot. Vereins Prov. Brandenburg 37[1895]: 79, 1896. — *Gymnocintractia montagnei* (Tul. & C. Tul.) M. Piepenbr., Begerow & Oberw., Mycologia 91: 496, 1999. — Type on *Schoenus* sp. (= *Sch. laxus*, = *Rhynchospora rugosa*; comp. Lindeberg 1959: 124), Algeria, La Calle, 2.VIII.1841, M.C. Durieu de Maisonneuve, PC.

Cintractia leveilleana Maire, Bull. Soc. Mycol. France 21: 143, 1905. — Type on *Rhynchospora glauca* (= *R. rugosa*), Japan, Pref. Aomori, near Aomori, leg. U. Faurie, comm. H. Lévillé, BPI 172 132 (syn. by Ling 1950: 506).

Cintractia samanensis Cif., Ark. Bot. 23A(14): 13, 1931. — *Ustanciosporium samanense* (Cif.) M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 350, 2000. — Type on *Rhynchospora oligantha*, Dominican Rep., Samaná Prov., Cordillera Central, Sabana de la Mar, El Valle, 11.VII.1930, E.L. Ekman 15 652, S! (Herb. Ciferri no. 3549) (syn. by Ling 1950: 506, confirmed).

Cintractia montagnei (Tul. & C. Tul.) Magnus var. *minor* L. Ling, Mycologia 42: 508, 1950. — *Ustilago montagnei* Tul. & C. Tul. var. *minor* (L. Ling) B. Lindeb., Symb. Bot. Upsal. 16: 125, 1959. — Type on *Rhynchospora alba*, Russia, Caucasus [= Georgia], Kobuleti near Batumi, 9.IX.1917, M. Woronow, BPI 172 002 (ex Herb. W. Sziemaszko). Paratype on *Rhynchospora alba*, Czech Rep., Bohemia, near Chlum, 26.VIII.1933, L. & A. Hilitzer; isoparatypes in Kavina & Hilitzer, Crypt. Cechoslov. exs. no. 114 (as '*Cintractia montagnei*') H.U.V. 9425! (syn. by Piepenbring 2000: 344).

Ustanciosporium neomontagnei M. Piepenbr. & Begerow, in Piepenbring, Nova Hedwigia 70: 346, 2000. — Type on *Rhynchospora globosa*, Costa Rica, Puntarenas Prov., Buenos Aires, 1.VII.1993, M. Piepenbring & G. Rivera 925, M;

isotypes in USJ, TUB, H.U.V. 15 946! (syn. by Vánky, in press).

Sori in all spikelets of a congested inflorescence, swollen, filled with a black, naked, semi-agglutinated to powdery mass of spores. Infection systemic, infected plants often dwarfed. **Spores** single, flattened, in side view elliptic, 5–7 µm wide, hyaline appendages small on one side of the spores or usually lacking, in plane view circular, elliptic to subangularly irregular, 9–12 × 9–13 (–14) µm, light to medium olive-brown or reddish brown; wall even or slightly uneven, 0.5–1 µm thick, finely, sparsely foveolate, in LM appearing as small, bright spots, spore profile smooth. **Spore germination** (Vánky 1994: 419, Fig. C) results in 4-celled basidia giving rise to lateral and terminal, ovoid to cylindrical basidiospores.

On *Rhynchospora alba* (L.) Vahl, *R. angolensis* Turrill, *R. barrosiana* Guagl., *R. ciliaris* (Michx.) C. Mohr (*R. ciliata* Vahl), *R. eximia* (Nees) Boeck. *R. fascicularis* (Michx.) Vahl, *R. fauriae* Franch, *R. fusca* (L.) Ait., *R. globosa* (Kunth) Roem. & Schult., *R. inexpansa* (Michx.) Vahl, *R. marisculus* Nees (*R. stipitata* Chapm.), *R. microcephala* (Britton) Britton, *R. nitens* (Vahl) A. Gray (*Psilocarya nitens* (Vahl) A.W. Wood; *P. rhynchosporoides* Torr.), *R. oligantha* A. Gray, *R. rugosa* (Vahl) Gale (*R. chinensis* Nees & Meyen; *R. glauca* Vahl; *Schoenus laxus* (R.Br.) Poir.), *R. scirpoides* (Torr.) Griseb. (*Psilocarya scirpoides* Torr.), *R. tenuis* Link, *R. yasudana* Makino, *Rhynchospora* sp.

Distribution: Cosmopolitan.

Ustanciosporium montagnei is a species complex with variations and intermediate forms (hybrids?). Its spores on different host plants, but also on the same host plant species may vary in shape, size, colour, frequency of appendages and density of foveolae (comp. also Piepenbring 2000). Here belong, i.a., *U. neomontagnei* (with slightly larger and darker spores), as well as *U. samanense* (with slightly smaller and more densely, finely pitted spores). Sequence data (Piepenbring *et al.* 1999: 493, fig. 37) show also a close relationship between *Cintractia montagnei*, *C. samanensis* and *C. aff. montagnei* (= *Ustanciosporium neomontagnei*). Therefore, I am considering these names synonyms of *U. montagnei* (comp also Ling 1950: 506). In some cases, attribution of a certain collection to *U. montagnei* or *U. majus* (*C. taubertiana*) may represent problems, as it can be seen also in numerous, often controversial literature.

24. *Ustanciosporium nova-guineae* (Zundel) M. Piepenbr., Nova Hedwigia 70: 347, 2000.

Cintractia nova-guineae Zundel, Mycologia 31: 589, 1939. — Type on *Rhynchospora glauca?* (= *R. rugosa?*), Papua New Guinea, Morobe Prov., near Samanzing, marsh meadows, 22.XII.1938, M.S. Clemens, BPI 172 057!

Sori in congested, swollen flowers of groups of spikelets of an inflorescence, forming small witches' brooms between healthy spikelets. On the tip of sterile flowers spherical to ovoid, c. 1 × 1–1.5 mm, black, naked, semi-agglutinated to powdery spore mass are produced completely hidden by the glumes. **Spores** single, flattened on one half, in side view

semi-circular or reniform, 12–16 µm wide, in the flattened side with a well-developed, 4–8 µm high, hyaline appendage, in plain view rounded, ovoid, elliptic or slightly irregular, variable in size, 15–25 × 16–27 µm, dark reddish brown; wall 1.5–3 µm thick, somewhat thinner on the flattened side, provided with coarse, rounded, elongate or irregular warts or small tubercles, in LM often forming irregular groups or rows radiating from the hyaline appendage, spore profile undulate to usually verrucose-tuberculate.

On *Rhynchospora rugosa?* (Vahl) Gale (*R. glauca?* Vahl).

Distribution: Australasia. Known only from the type collection.

25. *Ustanciosporium psilocaryae* (Tracy & Earle) M. Piepenbr., Nova Hedwigia 70: 349, 2000.

Ustilago psilocaryae Tracy & Earle, Bull. Torrey Bot. Club 26: 493, 1899. — *Cintractia psilocaryae* (Tracy & Earle) G.P. Clinton, J. Mycol. 8: 142, 1902. — Lectotype on *Psilocarya rhynchosporoides* (= *Rhynchospora nitens*), USA, Mississippi, Horn Island, 1.X.1898, S.M. Tracy 5226, (design. by Piepenbring 2000: 349) BPI 172 105; isolectotypes BPI 172 103, 172 104. Syntypes BPI 172 100!, 172 101!

Sori in all flowers of an inflorescence filled with a black, agglutinated to powdery mass of spores, hidden by the glumes. **Spores** single, flattened, in side view elliptic, 6–7.5 (–8) µm, hyaline appendages on both sides well-developed (up to 5 µm high), weak or often lacking, in plane view circular, elliptic or subpolyangularly irregular, 9.5–12 × 10.5–13.5 (–14.5) µm, medium dark reddish brown; wall uneven, 1–2.5 µm, thickest at the angles, on the circumference sparsely, deeply foveolate, spore profile wavy, on the flattened sides densely verrucose, especially seen in LM, foveolae absent.

On *Rhynchospora nitens* (Vahl) A. Gray (*Psilocarya nitens* (Vahl) A.W. Wood; *P. rhynchosporoides* Torr.), *R. scirpoides* (Torr.) Griseb. (*Psilocarya scirpoides* Torr.).

Distribution: N America (USA).

Typical for *Ustanciosporium psilocaryae* are the deep, sparse foveolae restricted to the wall seen from the side, missing from the flattened sides.

26. *Ustanciosporium rhynchosporae* Vánky, Mycotaxon 70: 31, 1999.

Type on *Rhynchospora rugosa*, South Africa, KwaZulu-Natal Prov., Drakensberg Mts., Loteni Nature Reserve, 1 km W of the Camp site, alt. c. 1620 m, 6.I.1997, C. & K. Vánky, H.U.V. 18 400!; isotypes PREM, BPI 845 446, and in Vánky, Ust. exs. no. 1042.

Sori in all flowers of an inflorescence filled with a black, granular-powdery mass of spore balls, completely hidden by the outermost glumes. The basal part of the sori is formed of host tissues of the more or less destroyed inner floral organs, permeated by hyphae. On the surface of the host tissues, the sporogenous hyphae concentrate into small groups of which spore balls develop. The proper sorus is a globoid, black, agglutinated body of 1–2 mm in diam., with mature, granular-powdery spore balls on its surface. Infection

systemic. Infected plants slightly stunted having somewhat smaller and congested flowers. **Spore balls** subglobose, ovoid, elongate, usually more or less irregular, 15–40 × 25–55 (–70) µm, reddish brown, composed of 2–25 or more, mostly 3–9 spores, under pressure separating into single spores. **Spores** extremely irregular, rounded, subpolyhedrally irregular, curved, elongate, often with 1 (–3) subacute or acute points, usually with one or several flattened or even concave sides, where a short, hyaline appendage may be present, 10–16 (–18) × 14–22 (–25) µm, medium dark reddish brown; wall uneven, 1–1.5 µm, at the points up to 3 µm thick, finely, rather sparsely, regularly foveolate. **Spore germination** unknown.

On *Rhynchospora angolensis* Turrill, *R. barrosiana* Guagl., *R. rugosa* (Vahl) Gale (*R. glauca* Vahl).

Distribution: C & S Africa (S Africa, Uganda), S America (Argentina, Brazil, Colombia).

27. *Ustanciosporium standleyanum* (Zundel) M. Piepenbr., Nova Hedwigia 70: 353, 2000.

Cintractia standleyana Zundel, Mycologia 35: 171, 1943. — *Ustilago standleyana* (Zundel) Vánky, Mycotaxon 54: 236, 1995. — Lectotype on *Rhynchospora glauca*, Guatemala, Dept. Alta Verapaz, E of Tactic, alt. 1450 m, 14.IV.1941, P.C. Standley (design. by Piepenbring 2003: 148), BPI 172 151!; isolectotype in BPI 141 633!

Cintractia vesiculata Mol.-Val., Caldasia 13: 69, 1980. — Type on *Rhynchospora caucana* Nees (nom. nud.; = *R. glauca*, = *R. rugosa*, det. M. Thulin, UPS), Colombia, Putumayo, Granja de la Secretaría de Agricultura en Colon, Valle de Sibundoy, alt. 2600 m, II.1976, L.A. Molina-Valero, P. Buritica & K.P. Dumont 23, COL; isotype H.U.V. 6394! (syn. by Piepenbring 2003: 353, confirmed).

Sori in densely packed flowers of some groups of spikelets, forming globoid witches' brooms in the inflorescence, 0.5–1.5 cm in diam. Sori destroying the inner part of the flowers filled with a black, powdery mass of spores hidden by slightly deformed glumes. **Spores** single, flattened on one half, in side view semi-circular, semi-elliptic or reniform, 8–12 µm wide, with a 4–5 µm high, ovoid, hyaline appendage on the flattened side, in plane view circular to elliptic, rarely slightly irregular, 11–16 × 13.5–17.5 µm, dark reddish brown; wall uneven, 1–3 µm thick, thinner on the flattened side, finely, densely, deeply foveolate, in LM giving a reticulate-foveolate appearance, spore profile finely wavy. **Spore germination** (Vánky 1995: 236, Fig. 25) results in septate basidia. The basidial cells separate easily continuing to produce, mostly apically, ovoid to long ellipsoidal basidiospores, 2–3 × 5–13 µm.

On *Rhynchospora marisculus* Nees (*R. stipitata* Chapm.), *R. odorata* C. Wright ex Griseb., *R. rugosa* (Vahl) Gale (*R. glauca* Vahl).

Distribution: C America (El Salvador, Guatemala), S America (Colombia, Venezuela), Bermuda Islands.

28. *Ustanciosporium virginianum* Vánky, Mycotaxon 95: 48, 2006.

Type on *Rhynchospora capitellata*, USA, Virginia, Giles Co., Appalachian Mts., Stony Creek Wally, road no. 635, near 'Interior', alt. 753 m, 25.VIII.2004, C. & K. Vánky, H.U.V. 20 782!; isotypes in Vánky, Ust. exs. no. 1251.

Sori in all spikelets of a somewhat congested inflorescence, completely hidden by the outermost glumes, filled with a black, agglutinated to granular-powdery mass of spore balls and spores, Peridium and sterile stroma lacking. **Spore balls** globose, ovoid, ellipsoidal, elongate or irregular, 25–50 × 25–80 µm, dark reddish brown to opaque, composed of a few to tens of spores that separate easily under pressure. **Spores** slightly flattened, in side view elliptic, 7–9.5 µm wide, hyaline appendages lacking, in plane view subcircular, ovate, elliptic to usually irregular or angular, 9–13.5 × 9.5–15 (–16) µm, reddish brown; wall uneven, 0.5–1 (–1.5) µm thick, finely, densely foveolate, spore profile smooth.

On *Rhynchospora capitellata* (Michx.) Vahl (*R. glomerata* (L.) Vahl var. *minor* Britton).

Distribution: N America. Known only from the type collection.

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