Rev. Biol. Trop., 49(2): 411-428, 2001
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# Smut fungi (Ustilaginomycetes and Microbotryales, Basidiomycota) in Panama

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Received 6-V-2000. Corrected 30-X-2000. Accepted 31-X-2000.

**Abstract:** This is the first publication dedicated to the diversity of smut fungi in Panama based on field work, the study of herbarium specimens, and references taken from literature. It includes smuts parasitizing cultivated and wild plants. The latter are mostly found in rural vegetation. Among the 24 species cited here, 14 species are recorded for the first time for Panama. One of them, *Sporisorium ovarium*, is observed for the first time in Central America. *Entyloma spilanthis* is found on the host species *Acmella papposa* var. *macrophylla* (Asteraceae) for the first time. *Entyloma costaricense* and *Entyloma ecuadorense* are considered synonyms of *Entyloma compositarum* and *Entyloma spilanthis* respectively. For the new conbination *Sponsorium panamensis* see note at the end of this publication. Descriptions of the species are complemented by some illustrations, a checklist, and a key.

**Key words:** Checklist, neotropics, Panama, smut fungi, *Sponsorium panamensis*, Tilletiales, Ustilaginales

Smut fungi (Ustilaginomycetes and Microbotryales, Urediniomycetes; Basidiomycota; Bauer *et al*. 1997, 2001) are parasites of plants, especially herbs belonging to the Poaceae and Cyperaceae. Species causing economic losses on crops, *e.g. Tilletia barclayana* (Bref.) Sacc. & Syd. on rice, *Ustilago maydis* (DC.) Corda on corn, and *Ustilago scitaminea* Syd. on sugar cane, are well known, but the majority of species of smut fungi which parasitize plants growing in the wild have rarely been studied, especially in tropical regions.

Checklists of smut fungi for neotropical countries are published for Mexico (Durán 1987; 125 species), Costa Rica (Piepenbring 1996a-c; 54 species), Colombia (Molina-Valero 1980; 40 species), and Cuba (Piepenbring and Rodríguez 1998 a-b; Piepenbring 1999; 39 species). For Panama, the records of 10 species of smut fungi were found scattered in the literature (Zundel 1939, 1953, Toler *et al.* 1959, Dennis 1970, Comstock *et al*. 1983).

The check list in the present publication is far from complete, being based on only about two months of field work by the author and some data taken from the literature. This investigation is part of extensive studies on smut fungi in the neotropics, carried out to elaborate a volume of the Flora Neotropica on smut fungi. With this publication the author hopes to stimulate further research on Panamanian smut fungi, which will yield many interesting results since the flora of Panama is highly diverse.

## MATERIALS AND METHODS

The author spent about two months looking for smut fungi in different provinces of Panama during collecting trips in 1994 to

1998. In addition to the recently collected specimens, which were herbarium-dried like higher plants, some smut fungi were found on specimens of their host plants deposited in PMA (Herbario de la Universidad Nacional de Panamá, Ciudad de Panamá, Panamá).

Specimens collected in Panama are kept in PMA (Herbario del Departamento de Botánica, Universidad de Panamá, Panamá), in USJ (Herbario de la Escuela de Biología, Universidad de Costa Rica, San José, Costa Rica), and in the personal herbarium of the author.

Herbarium-dried spores were measured by light microscopy (LM) in lactophenol after heating. Spore measures include two size ranges, *i.e*. the smaller and the larger diameter, for globose spores and for flattened ones the thickness as well as the smaller and the larger diameter of the spores, as seen in plane view. The values of size ranges are the means of at least 20 spores ± 1 S.D. Extreme values are given in brackets. Spore measurements include ornamentation, but not hyaline appendages.

For scanning electron microscopy (SEM), herbarium-dried spores were dusted onto double-sided adhesive tape, fixed on specimen stubs, and sputter coated with gold-palladium, *ca* 20 nm. The spores were studied with a Cambridge Stereoscan 250 MK 2.

Germinations of teliospores were obtained on 1 % water agar (WA) supplemented with the antibiotic tetracycline. Germinating spores were observed using LM on sections of WA covered by a cover slip. Times of germination given in the legends refer to how much time had passed from the moment when the teliospores were spread in the petri dishes until the drawing was executed.

Species are presented according to the classification proposed by Bauer *et al.* (1997, 2001). Synonyms are placed in angular brackets ([]). The "!" following the acronym of a herbarium means that the respective specimen has been studied by the author.

## RESULTS AND DISCUSSIONS OF SPECIES

### 1. Ustilaginomycetes

### 1.1 Ustilaginomycetidae
### 1.1.1 Ustilaginales
### 1.1.1.1 Ustilaginaceae

**1. *Cintractia axicola*** (Berk.) Cornu, Ann. Sci. Nat. Bot. VI **15:** 279. 1883; *Ustilago axicola* Berk., Ann. Mag. Nat. Hist. II **9:** 200. 1852. Type. On *Fimbristylis dichotoma* (L.) Vahl (some scirpoid plant). Santo Domingo. *Sallé* 74; Herb. Berkeley 4 745 (holotype, K!).

*Ustilago peribebuyensis* Speg., Anales Soc. Ci. Argent. **17:** 89. 1884; *Cintractia peribebuyensis* (Speg.) Speg., Anales Soc. Ci. Argent. **26:** 11. 1888; *Cintractia peribebuyensis* (Speg.) Sawada, Dept. Agric. Gov´t. Res. Inst. Formosa Report **2:** 80. 1922; *Cintractia axicola* (Berk.) Cornu *f. peribebuyensis* (Speg.) Zambett., Bull. Soc. Mycol. France **95:** 414. 1979 (the material he studied was *C. limitata*). Type. On *Fimbristylis dichotoma* [*F. diphylla*] (*Cyperus*). Paraguay. Cordillera de Peribebuy, 25 Mar 1883, Balansa 3 775 (holotype, LPS!).

*Sori* around the bases of peduncles, sometimes around the axes of spikelets or around floral organs; when young, covered by whitish brown, early rupturing peridia. *Spore mass* agglutinated; dark. *Spores* single; globose, mostly flattened; 10-12 x 2-14(-16) x (12-)14-17(-18)µm; light to medium reddish brown. Wall ca 1 µm thick; as seen by LM, smooth to finely warty; as seen by SEM, covered by irregular, dense, fine warts. *Germination* with phragmobasidia; basidial cells mostly conjugate and develop two large, dikaryotic conidia or basidial cells develop basidiospores.

In Panama on ***Fimbristylis dichotoma*** [*F. annua* (All.) Roemer & Schultes, *F. diphylla* (Retz.) Vahl] (Cyperaceae):

**Coclé:** La Pintada, *alt. ca* 420 m, 14 Feb 1995, *Piepenbring and Domínguez 1 462* (PMA, USJ 53 534); El Caño, *alt. ca.* 50 m, 29 Nov 1996, *Piepenbring & Domínguez* 2 211 (PMA).

**Colón:** Ciudad Colón, Barriada Sagrada Resurrección, *alt. ca.* 50 m, 15 Feb 1995, *Piepenbring & Domínguez 1 480* (PMA).

**Panamá:** Canal zone, 1.5 km NW of Paraíso, *alt. ca* 70 m, 17 Nov 1994, *Piepenbring 1 231* (PMA); 1 km S of Jardín Botánico Summit, *alt. ca*. 70 m, 17 Sept 1994, *Piepenbring 1 234*, *1 235* (PMA); Jardín Botánico Summit, *alt. ca.* 80 m, 18 Nov 1994, *Piepenbring 1265* (PMA); Jardín Botánico Summit, *alt. ca* 80 m, 27 Sept 1996, *Piepenbring & Stein* (*formerly Wiech*) *2 208* (PMA).

Reported for Panama by Zundel (1953) and Dennis (1970). The host species *Scirpus brizoides* Benth, mentioned by Dennis (1970), is doubtful.

**2. *Cintractia fimbristylicola*** Pavgi & Mundk., Indian Phytopathol. **1:** 108. 1949. Type. On *Fimbristylis complanata* (Retz.) Link. India. Near Chatrapur, Ganjam, Orissa, 30 Aug 1904, Butler (type, ND, n. v.).

*Sori* few to numerous in an infected inflorescence; around ovaries; when young, covered by whitish brown, early rupturing peridia. *Spore mass* agglutinated; dark. *Spores* single; spherical to globose, sometimes flattened or bluntly angular; (7-)8-10 x (9-)10-12(-13) µm; light reddish brown. Wall ca 1 µm thick; as seen by LM, irregularly warty; as seen by SEM, warts partly confluent forming an irregular reticulum. *Germination* with phragmobasidia carrying basidiospores on sterigmata or growing with hyphae.

In Panama on ***Fimbristylis spadicea*** (L.) Vahl (Cyperaceae):

**Herrera:** Parque Nacional Sarigua, *alt. ca.* 5 m, 30 Sep 1996, *Piepenbring & Domínguez 2 213* (PMA).

**3. *Cintractia limitata*** G. P. Clinton, Proc. Boston Soc. Nat. Hist. **31:** 399. 1904; *Cintractia utriculicola* (Henn.) G. P. Clinton var. *limitata* (G. P. Clinton) Hirschh., Farlowia **3:** 82. 1947. Type. On *Cyperus ligularis* L. Puerto Rico. Mayagüez, 23 Apr 1904, *Clinton s. n.* (holotype, BPI, according to Ling 1950, n. v.; isotypes, M!, NY!).

*Sori* around the bases of peduncles, sometimes around the axes of spikelets or around floral organs; when young, covered by whitish brown, early rupturing peridia. *Spore mass* agglutinated; dark. *Spores* single; globose, mostly flattened; (7-) 8-9 (-10) x 8-10 (-12) x (9-) 11-13 (-14) µm; medium reddish brown. Wall ca 1 µm thick; as seen by LM, almost smooth; as seen by SEM, covered by irregular, dense, fine warts. *Germination* with phragmobasidia; basidial cells mostly conjugate and develop two large, dikaryotic conidia, or basidial cells develop basidiospores.

In Panama on ***Cyperus ligularis*** (Cyperaceae):

**Los Santos:** 1 km W of Playa Monagre, *alt. ca.* 5 m, 1 Oct 1996, *Piepenbring & Domínguez 2 221* (PMA).

**On *Cyperus rotundus*** L.:

**Coclé:** El Caño, *alt. ca.* 50 m, 29 Sep 1996, *Piepenbring & Domínguez 2 212* (PMA).

**Los Santos:** Las Tablas, *alt. ca.* 15 m, 1 Oct 1996, *Piepenbring & Domínguez 2 219* (PMA).

**Panamá:** La Chorrera, *alt. ca.* 1 300 m, 25 Sep 1994, *Piepenbring 1 310 (*PMA).

**4. *Farysia chardoniana*** Zundel, Mycologia **35:** 171. 1943. Type. On *Carex* sp. Venezuela. Carabobo, mountain above Hacienda Cura, *Chardón and Alsten* (type, BPI 2 772!).

*Sori* in few to several spikelets of an infected plant; when young, covered by whitish, early rupturing peridia. *Spore mass* powdery; brown; permeated by strands of multicellular, dirty white bundles of sterile hyphae (elaters). *Spores* single; globose or subangular; (5-)6-7 x 6-8 µm; olive-brown. Wall *ca* 1 µm; covered by dense, fine, less than 0.5 µm high warts, which often fuse forming spirally arranged rows. *Germination* with phragmobasidia developing basidiospores; three-celled apical parts of the basidia often separate from the rest of the basidium.

In Panama on ***Carex polystachya*** Sw. ex Wahlenb. (Cyperaceae):

**Chiriquí:** East of Boquete, along road to Cerro Azul, *alt. ca.* 1 300-1 500 m, 11 Aug 1974, *Croat 26 765* (on PMA 10 160, PMA); At the road to the top of the volcano Barú, *alt. ca.* 2 100 m, 9 Feb 1995, *Piepenbring & Cueva 1 407* (PMA, USJ 53 531).

**5. *Leucocintractia scleriae*** (DC.) M. Piepenbr., Begerow & Oberw., Mycologia **91:** 497. 1999; *Uredo scleriae* DC., in Poir., Encycl. meth. bot. **8:** 228. 1808; *Ustilago*? *scleriae* (DC.) Tul. & C. Tul., Ann. Sci. Nat. Bot. III **7:** 89. 1847; *Cintractia scleriae* (DC.) L. Ling, Mycologia **43:** 314. 1951. Type. On *Rhynchospora corymbosa* (L.) Britton (quelques espèces de *Scleria*). French Guiana. Cayenne (no further data) (holotype, G!).

*Sori* around all the peduncles of a rudimentary inflorescence; cylindrical, often curved; when young, covered by thick, shining white, relatively late rupturing peridia. *Spore mass* agglutinated; dark. *Spores* single; globose to flattened; (9-)10-15 x (11-)12-16(-17) µm; light reddish brown. Wall 0.5-1 µm thick; covered by irregular, coarse warts and labyrinthiform to reticulate ridges in a band around the spore. *Germination* with phragmobasidia developing basidiospores; two- to four-celled apical parts of the basidia usually separate from the spore.

In Panama on ***Rhynchospora corymbosa*** [*R. aurea* Vahl] (Cyperaceae):

**Colón:** Ciudad Colón, Billa Catharina, *alt. ca.* 60 m, 16 Feb 1995, *Piepenbring and Domínguez 1 476* (PMA, USJ 53 536); Puerto Pilón, *alt. ca* 20 m, 17 Feb 1995, *Piepenbring and Domínguez 1 487* (PMA).

**On *Rhynchospora* sp.**:

Mindi (?), 28 Feb 1905, *Cowell 188* (NY!) (incomplete and badly written label).

Reported for Panama by Zundel (1953) and Dennis (1970) as *Cintractia leucoderma* (Berk.) Henn. on *Rhynchospora corymbosa*. They certainly refer to *Leucocintractia scleriae* because *Cintractia leucoderma*, now *Leucocintractia leucoderma* (Berk.) M. Piepenbr., does not infect *R. corymbosa* (Piepenbring 2000). For the delimitation of the genus *Leucocintractia* from the genus *Cintractia* see Piepenbring *et al.* (1999).

**6. *"Sphacelotheca" panamensis*** Zundel and Dunlap, in Zundel, N. Amer. fl. **7:** 995. 1939. Type. On *Cymbopogon* sp. Panamá. Chiriquí (Cherique): near "El Bogrete" (= Boquete?), Sep – Oct 1911, *Hitchcock s. n.* (type *ubi*?, not in BPI).

*Sori* in the ovaries; hidden by enveloping glumes; about 3 mm long; with peridia, which rupture disclosing the spore mass and a slender-pointed columella. *Spore mass* dusty. *Spores* single; chiefly subspheric or spheric; 14-18 µm; reddish-brown. Wall thin; smooth to minutely granular, as seen by LM. (Description based on the diagnosis)

In Panama on ***Cymbopogon* sp.** (Poaceae). This species is known only from the type specimen collected in Panama. The identification of the host species is very doubtful, because *Cymbopogon citratus* (DC.) Stapf is the only species of *Cymbopogon* known from Panama and it flowers only rarely (Davidse and Pohl 1994). In addition to this, the type material, which could not yet be checked, is meagre (Zundel 1939) and the species is only known from the type collection. The validity of this species is therefore very doubtful.

This species belongs to the genus *Sporisorium* because it is described from a species of Poaceae and because species of *Sphacelotheca* infect only dicotyledons (Langdon and Fullerton 1978, Vánky 1987).

**7. *Sporisorium holwayi*** (G. P. Clinton and Zundel) Vánky, Mycotaxon **48**: 40. 1993; *Sphacelotheca holwayi* G. P. Clinton & Zundel, in Zundel, Mycologia **22:** 143. 1930. Type. On *Andropogon bicornis* L. Bolivia. Sur Yungas: Villa Aspiazu, 31 May 1920, *W. E. D. & M. M. Holway 686* (type, BPI 177 831!).

*Sori* in dense groups in congested partial inflorescences (witches' brooms); long cylindrical, curved; 0.7 x 15-40 mm; a single sorus has one central columella of host tissue and an early rupturing peridium. *Spore mass* powdery; dark. *Spores* single; spherical to globose or cylindrical; (9-)10-12(-13) x (11-)12-15(-17) µm; dark reddish-brown. Wall 1.5-2.5 µm; with germ pore and ca 0.5 µm high warts; seen by SEM, with smaller warts between the large ones. *Germination* with phragmobasidia developing basidiospores.

In Panama on ***Andropogon bicornis*** (Poaceae):

**Chiriquí:** Road from Gualaca to Chiriquí Grande, *alt. ca.* 650 m, 22 Aug 1998, *Piepenbring, Arrocha, Caballero and Cáceres 2 385* (PMA).

**Coclé:** La Pintada, Corregimiento Harino, El Copé, 2-4 km N of La Chata, *alt. ca.* 400 m, 22 Sep 1994, *Piepenbring & Lorenzo 1 271* (PMA, USJ 44 251); La Pintada, Corregimiento Harino, El Copé, close to El Alto, Aserradero, *alt. ca.* 780 m, 23 Sep 1994, *Piepenbring & Domínguez 1 282* (PMA); El Copé, from El Copé to Alto Calvario 5-7.2 km, *alt. ca.* 800-1 100 m, 13 Feb 1995, *Piepenbring and Domínguez 1 451-1 453* (1 451-1 453 PMA, 1 452 USJ 53 533); El Copé, 1 km N of Alto Calvario, *alt. ca.* 1 160 m, 13 Feb 1995, *Piepenbring & Domínguez 1 454* (PMA); La Pintada, 4-5 km behind the entrance of Coclecito on the way to Bolteadero, *alt. ca.* 500-600 m, 14 Feb 1995, *Piepenbring and Domínguez 1 458-1 459* (PMA); Valle de Antón, *alt. ca.* 660 m, 15 Feb 1995, *Piepenbring & Domínguez 1 470* (PMA).

**Colón:** Ciudad Colón, Santa Rita Arriba, *alt. ca.* 260 m, 15 Feb 1995, *Piepenbring & Domínguez 1 473* (PMA).

**Panamá**: 2.6 km N from the Interamerican highway direction Cerro Campana, *alt. ca.* 450 m, 23 Feb 1995, *Piepenbring 1 493* (PMA); Chicá, 4.4 km N of INRENARE direction Cerro Campana, *alt. ca.* 800 m, 23 Feb 1995, *Piepenbring 1 494* (PMA).

**8. *Sporisorium ovarium*** (Griffiths) Vánky, Mycotaxon **65:** 138. 1997; *Sorosporium ovarium* Griffiths, Bull. Torrey Bot. Club **34:** 209. 1907. Lectotype (designated by Zundel 1953) on *Urochloa reptans* (L.) O. Stapf in Prain [*Brachiaria reptans* (L.) C. Gardner and C. E. Hubb., *Panicum caespitosum* Sw.]. Mexico. Dublan, Hidalgo, 9 Sep 1905, *Griffiths* (type, BPI 180 088!).

*Sori* usually in all the spikelets of an inflorescence (Fig. 1); globose to cylindrical; 3-5 mm long; a single sorus with one central columella of host tissue and a longitudinally rupturing peridium (Fig. 2), which opens in wet environment exposing the spore mass (Fig. 1, comp. Piepenbring *et al.* 1998). *Spore mass* mixed with sterile cells; powdery; dark brown. *Spores* in loose groups (Fig. 3); single spores globose or subangular; (8-)10-12 x 11-13 µm; light reddish-brown. Wall ca 0.8 µm; covered by *ca* 0.7 µm high warts; seen by SEM, with smaller warts between the large ones (Fig. 4). *Germination* with phragmobasidia of three to


Fig. 1. *Sporisorium ovarium* on *Urochloa fasciculata* in rainy weather. Note the lobes of the white peridia which are extended and expose the spore mass due to the wet environment (Piepenbring 2 214).

numerous cells forming hyphal branches without prior conjugation (Figs. 5-9).

In Panama on ***Urochloa fasciculata*** (Sw.) R. Webster [*Brachiaria fasciculata* (Sw.) Parodi] (Poaceae):

**Herrera:** Parque Nacional Sarigua, *alt. ca.* 5 m, 30 Sep 1996, *Piepenbring & Domínguez 2 214* (PMA).

Further material illustrated: **Mexico. Yucatán:** Sisal, 7 Oct 1995, *Piepenbring 1 871* (XAL).

*Sporisorium ovarium* was hitherto only known from Mexico (see type; Durán 1987). This is its first observation in Central America.


Fig. 2. Two spikelets of *Urochloa fasciculata* with dry sori of *Sporisorium ovarium.* The peridium of the lower one is just rupturing, the one of the upper sorus alredy opened exposing the spore mass and the columella (Piepenbring 2 214).

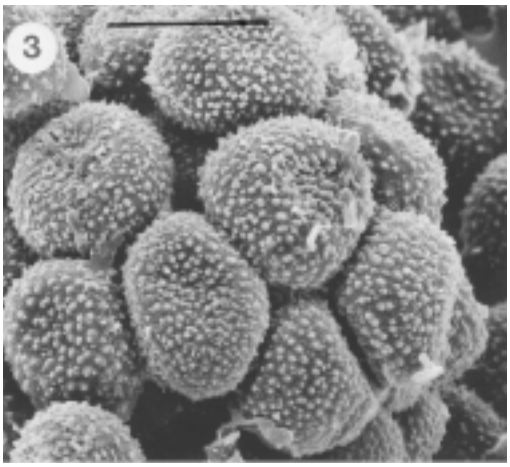




Fig. 3-4. Teliospores of *Sporisorium ovarium* as seen by SEM (Piepenbring 2 214). Fig. 3: Part of a ball of teliospores. Scale bar: 10 µm. Fig. 4: Teliospores. Scale bar: 5 µm.

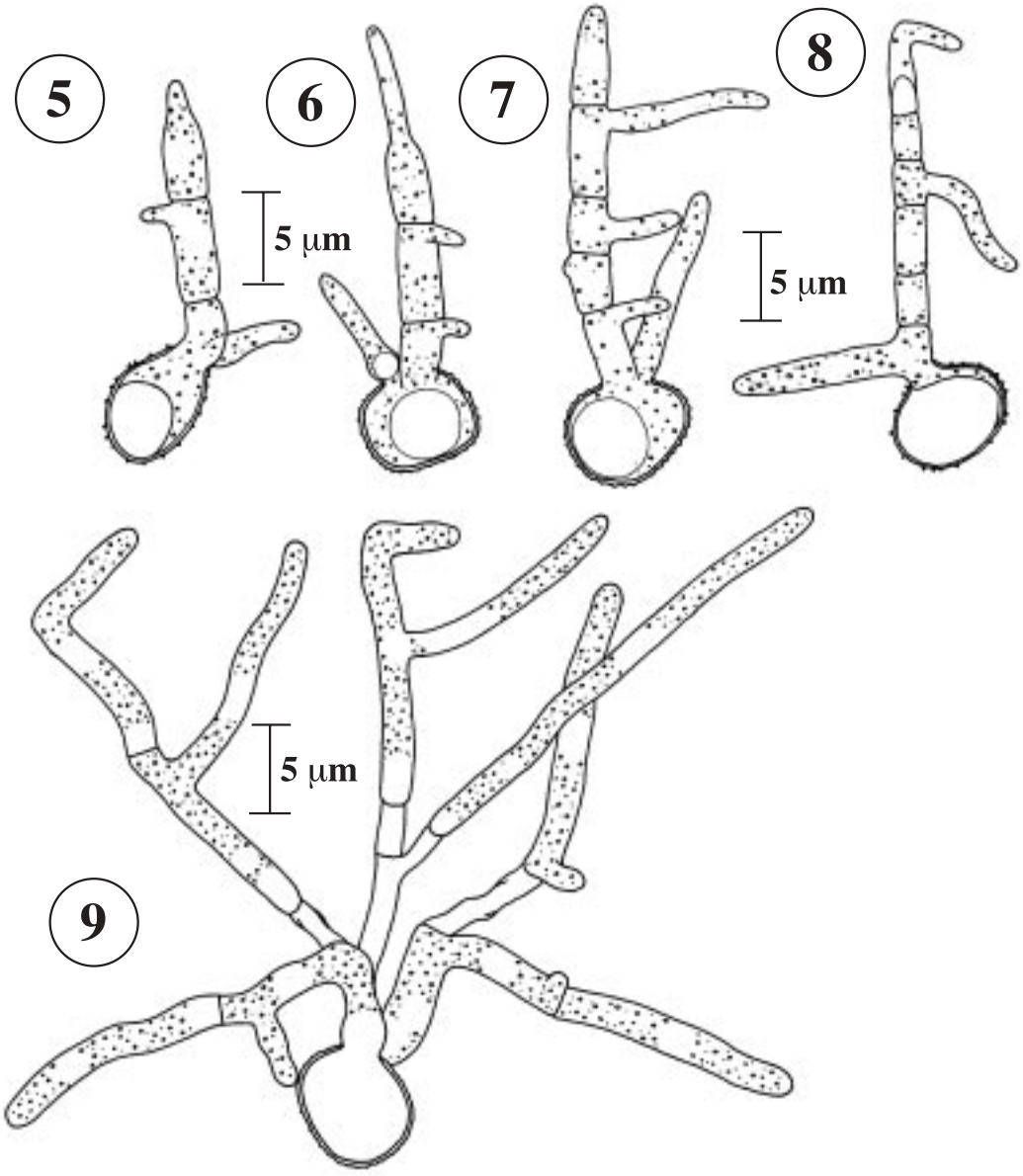



Fig. 5-9. Teliospores of *Sporisorium ovarium* which germinated with basidia (Piepenbring 1 871). Figs. 5-6: After 2 d on WA. Figs. 7-8: After 3 d on WA. Fig 9: After 6 d on WA.

**9. *Trichocintractia utriculicola*** (Henn.) M. Piepenbr., Canad. J. Bot. **73:** 1095. 1995; *Cintractia leucoderma* (Berk.) Henn. f. *utriculicola* Henn., Hedwigia **34:** 336. 1895; *Cintractia utriculicola* (Henn.) G. P. Clinton, J. Mycol. **8**: 143. 1902. Type. On *Rhynchospora gigantea* Link. Brazil. Santa Catharina: Blumenau, *Möller 293* (type probably lost).

*Sori* in some spikelets of an infected inflorescence; globose to egg-shaped; 2-2.5 x 3-5 mm; with greyish white, persistent peridia which rupture with several lobes and form sacs. *Spore mass* dark brown; powdery; permeated by groups of long sterile fungal cells in the basal part. *Spores* single; spherical to globose; (9-)10-13 x (10-)11-15(-17) µm; light ochre-brown to dark brown. Wall 1-2.5 µm; two-layered; covered by fine warts. *Germination* with phragmobasidia; often two-celled parts of the basidia separate from the rest of the basidium, and plasma left in the teliospore germinates again; basidial cells develop basidiospores or hyphae.

In Panama on ***Rhynchospora corymbosa*** (L.) Britton [R. *aurea* Vahl] (Cyperaceae):

**Bocas del Toro:** 4 km SW of Chiriquí Grande, *alt. ca.* 5 m, 10 Feb 1995, *Piepenbring 1 437* (material lost).

**Colón:** Ciudad Colón, Billa Catharina, *alt. ca*. 60 m, 16 Feb 1995, *Piepenbring & Domínguez 1 475* (PMA, USJ 53 535); Ciudad Colón, Puerto Pilón, alt. ca. 20 m, 17 Feb 1995, Piepenbring and Domínguez 1 486 (PMA).

**10. *Ustilago hypodytes*** (Schltdl.) Fr., Syst. Mycol. **3:** 518. 1832; *Caeoma hypodytes* Schltdl, Fl. berol. **2**: 129. 1824; *Erysibe hypodytes* (Schltdl.) Wallr., Fl. crypt. Germ. **2:** 216. 1833; *Uredo hypodytes* (Schltdl.) Desm., Ann. Sci. Nat. Bot. II **13:** 182. 1840; *Cintractia hypodytes* (Schltdl.) Maire, Bull. Soc. Bot. France **53:** 198. 1906. Lectotype (sel. by Hirschhorn, Farlowia **3:** 74. 1947). On *Elymus arenarius* L. Germany. Near Berlin, "Meso Marchia", Oct 1884, *P. Sydow s. n.* (lectotype ubi?, isolectotypes in Rabenh., Fungi. eur. No. 3201, *e. g.* in H.U.V., the personal herbarium of K. Vánky, Tübingen).

*Sori* surrounding the internodes of culms; starting just below the node and extending almost down to the next node; when young, hidden by sheaths of leaves; upper internodes and leaves usually stunted; infected plants sterile. *Spore mass* dark brown; semi-agglutinated to powdery. *Spores* single; mostly globose, subglobose to globose; 3.5-5.5 x 4-6(-7) µm; medium to dark olive-brown. Wall ca 0.5 µm; smooth. *Germination* with phragmobasidia.

In Panama on ***Stipa setigera*** Presl, according to Zundel (1953).

**11. *Ustilago maydis*** (DC.) Corda, Icon. fung**. 5:** 3. 1842; *Uredo maydis* DC., Fl. franç. **6:** 77. 1815. Type. On *Zea mays* L. Europe (type *ubi*?).

*Sori* single to numerous in one plant; in vegetative and generative organs, *e. g*. partial inflorescences, kernels, or organs of male flowers; galls formed by hypertrophic, parenchymatic host tissue; sometimes more than 10 cm large; yellow-white to reddish; later rupturing. *Spore mass* powdery; dark brown. *Spores* single; spherical to globose; (9-)10-12(-13) µm; light reddish-brown. Wall ca 1 µm; covered by ca 0.5 µm high warts, smaller warts between the high cone-shaped ones, as seen by SEM. Germination with three- to four-celled phragmobasidia; two or three cells of a basidium can separate from the rest of the basidium.

In Panama on ***Zea mays*** (cult.) (Poaceae):

**Coclé:** Corregimiento Harino, below El Copé, *alt. ca*. 190 m, 24 Sep 1994, *Piepenbring & Domínguez 1 300* (PMA).

*Ustilago maydis* is reported for Panama by Toler *et al.* (1959), being of minor economic importance. Young white galls can be eaten after cooking (called "huitlacoche" in nahuat, Mexico; *e. g.* Valverde *et al.* 1995).

**12. *Ustilago schroeteriana*** Henn., Hedwigia **35:** 215. 1896. Type. On *Paspalum* sp. Brazil. Santa Catharina: near Itajahy, Sep 1887, *Ule 1 615* (type, CH, n. v.).

*Sori* usually destroying all the spikelets of an inflorescence including tissue of the

inflorescence axis; first covered by host tissue which flakes away. *Spore mass* powdery; dark brown. *Spores* single; spherical to globose; (11-)15-17(-20) µm; light reddish-brown. Wall 1-1.5 µm; often thinner and lighter at one spot; covered by dense, 0.8 µm high warts; smaller warts between the large warts, as seen by SEM. *Germination* with phragmobasidia forming basidiospores on short sterigmata.

In Panama on ***Paspalum virgatum*** L. (Poaceae):

**Chiriquí:** Ciudad David, *alt. ca.* 200 m, 30 Aug 1998, *Piepenbring & Cáceres 2 388* (PMA).

Reported for Panama by Zundel (1953) on *Paspalum repens* Bergius [*P. paniculatum* Walter].

**13. *Ustilago scitaminea*** Syd., Ann. Mycol. **22:** 281. 1924. Lectotype. On *Saccharum officinarum* (sel. by Vánky, Mycotaxon **41:** 492. 1991). India. Bhagalpur, Bengal, 26 Aug 1907, *Butler* (lectotype *ubi*?; isolectotypes in Sydow, Ustilagineen 384, *e. g.* H.U.V. 4 454, in the personal herbarium of K. Vánky, Tübingen).

*Sorus* as whip-shaped, elongated main axis; infected plants sterile; whip often more than 1 m long, the diameter decreasing from ca. 1 cm at the base to few millimeters in the distal part; young spore mass covered by host tissue which flakes away. *Spore mass* mixed with sterile cells; powdery; dark brown. *Spores* single; spherical to globose; (5-)6-7(-8) µm; reddish-brown. Wall ca. 0.8 µm; covered by few low warts; wall between the warts smooth, as seen by SEM. Sterile cells scattered between the spores; mostly in irregular groups of chains; larger than the spores; hyaline. Wall 1-1.5 µm, smooth. *Germination* with phragmobasidia; basidial cells often conjugate; dikaryotic cells grow with hyphae elaborating elongated dikaryotic blastoconidia.

In Panama on ***Saccharum* sp. cult.** (Poaceae):

**Chiriquí:** Distrito Alanje, Corregimiento Alanje, Central Azucarera de Alanje, 21 Mar 2000, *L. de Castillo s. n.* (*Piepenbring 2 733*; PMA).

*Ustilago scitaminea* can cause economic losses in sugar cane plantations, especially on susceptible cultivars. It is reported for Panama by Comstock *et al.* (1983).

#### 1.1.1.2 Mycosyringaceae

**14. *Mycosyrinx cissi*** (DC.) Beck, Ann. K. K. Naturhist. Hofmus. **9:** 123. 1894; *Uredo cissi* (*cyssi*) DC., in Poir., Encycl. meth. bot. **8:** 228. 1808; *Ustilago*? *cissi* (DC.) Tul. and C. Tul., Ann. Sci. Nat. Bot. III **7:** 92. 1847. *Schroeteria cissi* De Toni, in Sacc., Syll. fung. **7:** 501. 1888; *Geminella exotica* var. *de candollei* A. A. Fischer v. Waldh. (nomen novum illegit.), Aperçu syst. Ustilag., p. 43. 1877. Type. On *Cissus sicyoides* L. Dominican Republic (Santo Domingo). *Poiteaux s. n.* (type *ubi*?).

*Sori* in witches' brooms with numerous branches; often more than 1 m long; sori 1-2 x 5-30 mm; tubes of host tissue enclose the spore mass; old tubes rupture laterally disclosing the spores. *Spore mass* dark; powdery. *Spores* in firmly united pairs; the two outer halves of the cells semi-spherical, the halves directed towards the contact point flat cone-shaped; one spore seen from the side 7-8(-9) x 12-13(-14) µm; dark olive-brown. Wall ca 1.5 µm; on the spherical half finely granular, on the conical side smooth. *Germination* with basidiospores successively developing directly from the teliospore; basidiospores folded and partly thickened; probably up to four basidiospores originate from one spore cell.

In Panama on ***Cissus sicyoides*** (Vitaceae):

**Colón:** Portobelo, Nuevo Torosí, on the way to More, Río Sucio, *alt. ca.* 10 m, 17 Feb 1995, *Piepenbring, Domínguez & Girón 1 488* (PMA, USJ 53 538).

**Darién:** Río Cocalito, on river island, 7 Feb 1982, *Whitefoord & Eddy 67* (on PMA 35 383, PMA).

Reported for Panama by Zundel (1953).

**1.1.2 Urocystales**
**1.1.2.1 Doassansiopsaceae**

**15**. ***Doassansiopsis limnocharidis*** (Cif.) Vánky, Mycotaxon **43:** 424. 1992; *Doassansia limnocharidis* Cif., Ark. Bot. **23(A):** 23. 1931. Type. On *Limnocharis flava* (L.) Buchenau. Dominican Republic. La Vega: Cordillera Central, Bonao, Aug 1929, *Ciferri 2 529* (type *ubi*?).

*Sori* as thickened leaf spots; often in rows parallel to the midrib; round to ovoid; *ca* 15 mm diam; when dry, brown; when old, breaking out of the leaf. *Spore balls* mostly in the air canals of the mesophyll; globose; flattened at contact to adjacent balls; 100-200 µm; firmly composed of central sterile pseudoparenchyma and a layer of fertile cells covered by a layer of sterile cortical cells. *Fertile cells* (teliospores) globose; their longest axis 11-14 µm; yellowish. Wall slightly thicker than the wall of sterile cells. *Central cells* very irregularly isodiametric. *Cortical cells* radially flattened; often collapsed. *Germination* of fertile cells with holobasidia carrying apically numerous filiform basidiospores; basidiospores develop yeast-like cells or hyphae.

In Panama on ***Limnocharis flava*** (Limnocharitaceae):

**Bocas del Toro:** Chiriquí Grande, close to the ferry station, *alt. ca.* 2 m, 11 Feb 1995, *Piepenbring 1 438* (PMA, USJ 53 532).

**1.2 Exobasidiomycetidae**
**1.2.1 Tilletiales**
**1.2.1.1 Tilletiaceae**

**16.** ***Tilletia ayresii*** Berk., in Massee, Bull. Misc. Inform. **1899:** 146. 1899; *Conidiosporomyces ayresii* (Berk.) Vánky, in Vánky & R. Bauer, Mycotaxon *43:* 429. 1992. Type on *Panicum maximum* Jacq. Mauritius. Mountains above Port Louis, *Ayres 4 754*, in Herb. Berkeley (type, K, n. v.).

*Sori* in several to numerous flowers of an inflorescence; sack-shaped galls formed by ovary tissue; when young, closed; early rupturing apically with stellate lobes; *ca* 3 x 3-5 mm; apically gray, at the base reddish. *Spore mass* powdery; olive; composed of spores, single sterile cells, and groups of conidia. *Spores* single; spherical; (12-)14-15(-16) µm; brown. Wall 2.5-3.5 µm; covered by up to 2 µm high warts. *Sterile single* cells spherical to globose; (9-)11-16(-19) x (10-)12-18(-21) µm; colorless. Wall 2 µm; covered by 1 µm high, dense warts. Transitional forms between single sterile cells and spores are present. *Groups of conidia* globose; up to 40 x 70 µm. *Conidia* loosely joined; mostly "y" –shaped; up to 20 µm long; hyaline; wall thin; smooth. *Germination of the spores* after several days; with holobasidia apically carrying numerous filiform basidiospores. *Germination of conidia* within one day; with hyphae, ballisto–, and blastoconidia.

In Panama on ***Panicum maximum*** (Poaceae):

**Chiriquí:** David, *alt. ca.* 50 m, 6 Feb 1995, *Piepenbring 1 390* (PMA); Boquete, Volcancito, 12 Mar 2000, *Piepenbring, Cáceres and students 2 717* (PMA).

**Coclé:** La Pintada, Corregimiento Harino, El Copé, La Chata, *alt. ca.* 390 m, 22 Sep 1994, *Piepenbring & Lorenzo 1 273* (PMA); Penonomé, El Chorrillo, *alt. ca.* 70 m, 29 Sep 1996, *Piepenbring & Domínguez 2 210* (PMA).

**Colón:** Ciudad Colón, Billa Catharina, alt. ca. 60 m, 16 Feb 1995, *Piepenbring & Domínguez 1 479* (PMA, USJ 53 537).

**Herrera:** Road to the Parque Nacional Sarigua, *alt. ca.* 15 m, 30 Sep 1996, *Piepenbring & Domínguez 2 218* (PMA).

**Los Santos:** Las Tablas, *alt. ca.* 15 m, 1 Oct 1996, *Piepenbring & Domínguez 2 220* (PMA).

**Panamá:** Jardín Botánico Summit, *alt. ca.* 80 m, 15 Sep 1994, *Piepenbring 1 229* (PMA); 1.5 km NW Paraíso, *alt. ca.* 70 m, 17 Sep 1994, *Piepenbring 1 232* (PMA).

On ***Setaria paniculifera*** (Steudel) Fourn. (Poaceae):

**Coclé:** La Pintada, Corregimiento Harino, El Copé, La Chata, 22 Sep 1994, *Piepenbring & Lorenzo 1 275* (sparse material only in USJ 44 245).

**17. *Tilletia barclayana*** (Bref.) Sacc. & Syd., in Sacc., Syll. fung. **14:** 422. 1899; *Neovossia barclayana* Bref., Unters. Gesammtgeb. Mykol. **12:** 170. 1895. Type on *Pennisetum triflorum* Nees. India. Himalaya, Simla, *Barclay s. n.* (type *ubi*?).

*Tilletia horrida* Tak., Bot. Mag. Tokyo **10:** 20. 1896; *Neovossia horrida* (Tak.) Padw. and A. Khan, Imp. Mycol. Inst. Mycol. Papers **10:** 2. 1944. Type on *Oryza sativa*. Japan. Kyoto, 1895 (type *ubi*?). (Synonym according to Tullis & Johnson 1952)

*Sori* in some to all the ovaries of an inflorescence; concealed by glumes. *Spore mass* powdery; black. *Spores* single; globose; *ca* (20)23-32 µm; dark olive brown. Wall covered by spines, ca 2.5-4 µm high; covered by hyaline sheath. *Germination* with holobasidia carrying numerous filiform basidiospores.

In Panama on ***Oryza sativa*** L. (Poaceae), according to Toler *et al.* (1959).

This species, called kernel smut or anublo del grano, is reported for Panama by Cralley (1954, cited in Toler *et al.* 1959) as *Neovossia barclayana*. Toler *et al.* (1959) and Panamanian phytopathologists consulted by the author consider it to be of minor economic importance in Panama. However, as rice from areas with infection by *T. barclayana* is imported to Panama, constant survey is necessary to detect infection as early as possible.

The delimitation of the genus *Neovossia* from the genus *Tilletia* is difficult, because the sets of character states of the different species show a morphologic continuum. Until further data are available, species of *Neovossia* other than the type species of the genus, *N. moliniae* Körn., are better cited in the genus *Tilletia*.

### 1.2.2 Georgefischeriales
### 1.2.2.1 Eballistraceae

**18. *Eballistra oryzae*** (Syd. and P. Syd.) Bauer *et a*l. , Mycol. Res. in press. *Entyloma oryzae* Syd. & P. Syd., Ann. Mycol. **12:** 197. 1914. Type. On *Oryza sativa* L. Philippines. Laguna: Los Baños, 10 Dec 1913, *Raimundo* 2 202 (last number almost illegible), Baker 2 203 (holotype, BPI 176 141!).

*Sori* as spots on leaf blades and sheaths; numerous; 0.2-0.3 mm x 0.5-2 (-4) mm and larger by fusion; linear-rectangular by adjacent veins; on both sides of the leaf lead-colored; slightly raised; covered by the epidermis. *Spore mass* firmly agglutinated; dark. *Spores* adhere in irregular masses; mostly polyhedral by compression, subglobose, or flattened; (5-) 7-9 (-10) x (6-) 8-11 µm; light olive-greyish. Wall 0.5-1 µm; smooth.

In Panama on ***Oryza sativa*** (Poaceae) according to Cralley (1954, cited in Toler *et al.* 1959), not affecting yields.

### 1.2.3 Entylomatales
### 1.2.3.1 Entylomataceae

**19. *Entyloma bidentis*** Henn., in Engl., Pflanzenw. Ost-Afrikas C, p. 49. 1895. Type. On *Bidens pilosa* L. East Africa: Marangu, near the Kilimanjaro, Tanganyika Terr., 1 580 m, *Volk 2 283* (type *ub*i?).

*Sori* as leaf spots; few to several on a single leaf; circular; sometimes convex but not thickened; diam 1-2(-3) mm, sometimes larger by fusion; when fresh, yellow-greenish, sometimes with violet centre; when old, brown. *Spores* single; densely packed between the host cells; spherical to globose, sometimes subangular; (9-)11-13(-14) x (12-)13-15(-18) µm; hyaline or yellowish-brown. Wall two-layered; the inner layer 1 µm, the outer 1-2 µm; smooth. *Germination* with holobasidia carrying apically few sessile basidiospores; basidiospores and basidial cell conjugate and develop sickle-shaped and filiform conidia.

In Panama on ***Bidens pilosa*** (Asteraceae):

**Chiriquí:** Road from Gualaca to Chiriquí Grande, *alt. ca.* 840 m, 22 Aug 1998, *Piepenbring, Arrocha, Caballero* & *Cáceres 2 383* (PMA).

**20.** *Entyloma compositarum* Farlow, Bot. Gaz. **8:** 275. 1883. Type. On *Aster puniceus* L. USA. Massachusetts: White Montains, Woods' Hole, Sep 1881, *Trelease 1 085* (holotype BPI 195048!).

*Entyloma costaricense* Cif., Nuovo Giorn. Bot. Ital. **40:** 259. 1933. Type. On *Viguiera sylvatica* Klatt. Costa Rica. Alajuela: Grecia, 13 Jan 1925, H. *Sydow 383* (lectotype, M!; isolectotypes BPI 175119! and BPI 175120!; designated here).

*Sori* as leaf spots; numerous on a single leaf; angular by adjacent veins; diam 1-2(-2.5) mm; when fresh, whitish; when dry, adaxially green (almost invisible) and abaxially whitish-green. *Spores* single; not densely packed between the host cells; spherical to globose; (7-)8-10(-11) x (7-)9-11(-12) µm; hyaline. Wall, as seen by LM, mostly one-layered; *ca* 1 µm; smooth. *Germination* with holobasidia carrying apically few sessile basidiospores; basidiospores and basidial cell conjugate and develop hyphae with retraction septae.

In Panama on ***Viguiera* sp**. (Asteraceae):

**Chiriquí:** Road from Gualaca to Chiriquí Grande, *alt. ca*. 840 m, 22 Aug 1998, *Piepenbring, Arrocha, Caballero* & *Cáceres 2 384* (PMA).

*Entyloma costaricense* is a synonym of *E. compositarum* because the size and the shape of the sori as well as characteristics of the teliospores are similar in both species (comp. Sydow 1926, Savile 1947).

**21. *Entyloma dahliae*** Syd. and P. Syd., Ann. Mycol. **10:** 36. 1912. Type. On *Dahlia variabilis* Desf. (cult.). South Africa. Natal, Harden Heights, 11 Apr 1911, *Pole-Evans s. n.* (type, S!).

*Sori* as leaf spots; few to several on a single leaf; subcircular; limits mostly fading, rarely angular by adjacent veins; diam *ca* 10 mm, variable depending on the age and degree of fusion with adjacent spots; when fresh, adaxially light green and abaxially whitish-green; when old, brown to whitish-ochre, abaxially sometimes with whitish centre. *Spores* single; densely packed between the host cells; spherical to globose or irregularly shaped, subangular by contact to other spores; (11-)12-14(-16) x (11-)13-16(-17) µm; light yellow to brown. Wall two-layered; inner layer 0.7 µm; the outer up to 3.5 µm; smooth. *Germination* with holobasidia carrying apically few sessile basidiospores; basidiospores and basidial cell conjugate and develop sickle-shaped and filiform conidia.

In Panama on ***Dahlia* sp. cult.** (Asteraceae):

**Chiriquí:** Bajo Boquete, *alt. ca.* 1 500 m, 23 Aug 1998, *Piepenbring, Cáceres, Cueva* & *Esquivel 2 386* (PMA).

**22. *Entyloma spilanthis*** Speg., Anales Mus. Nac. Hist. Nat. Buenos Aires **12:** 292. 1909. Type. On *Spilanthes leptophylla* DC. [*S. arnicoides* DC.]. Argentina. Ensenada, La Plata, 28 Oct 1906 (type, LPS 3 351!, no sori could be found).

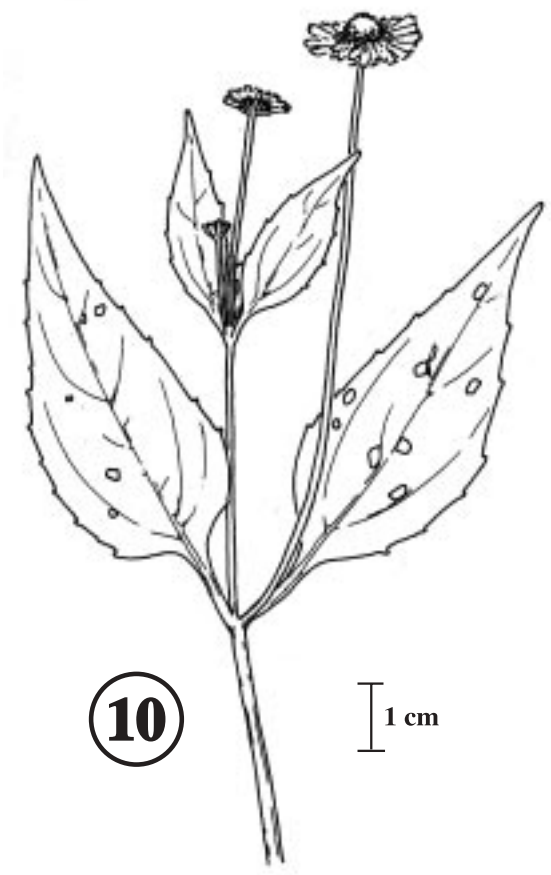
*Entyloma ecuadorense* Syd., Ann. Mycol. **37:** 328. 1939. Type. On *Acmella oppositifolia* (Lam.) R. K. Jansen var. *oppositifolia* [*Spilanthes americana* (Mutis) Hieron.]. Ecuador. Tungurahua: Hacienda San Antonio, near Baños, 1 Dec 1937, H. *Sydow 410* (lectotype, H.U.V. 819!, designated by Piepenbring 1996a: 66); 4 Dec 1937, *H. Sydow 435* (paratype).

*Sori* as leaf spots (Fig. 10); irregularly circular or angular by adjacent veins; diam 1-4 mm; when fresh, light yellow-green to brownish; when dry, ochre. *Spores* (Fig. 11) single; densely packed between the host cells; spherical, globose, or subangular; (9-)10-13(-16) µm; colorless, sometimes yellowish brown. Wall two-layered; inner layer *ca* 0.7 µm; the outer up to 2 µm; smooth. *Germination* with holobasidia carrying apically few sessile basidiospores; basidiospores and basidial cell conjugate and develop hyphae.

In Panama on ***Acmella papposa*** (Hemsl.) R. K. Jansen **var. *macrophylla*** (Greenm.) R. K. Jansen (Asteraceae):

**Chiriquí:** Boquete, Alto Chiquero, *alt. ca.* 2 000 m, 7 Feb 1995, *Piepenbring and Cueva 1 397* (PMA, USJ 53 529); Boquete, Alto Quiel, 12 Mar 2000, *Piepenbring, Cáceres and students 2 716* (PMA).

*Entyloma spilanthis* is known on *Acmella oppositifolia* var. *oppositifolia* from Costa



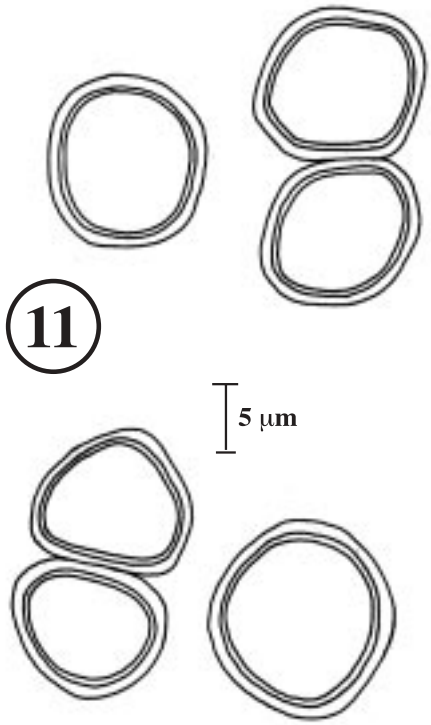




Fig. 10. *Acmella papposa* var. *macrophylla* with spots on the leaves caused by *Entyloma spilanthis* (Piepenbring 1 397).
Fig. 11. Teliospores of *Entyloma spilanthis* as seen by LM (Piepenbring 1 397).

Rica (Piepenbring 1996a) as *E. ecuadorense.* Soral morphology and the size of the spores [(9-)10-12 x (10-)11-13 μm] of the infection found on *A. papposa* var. *macrophylla* are very similar to those on *A. oppositifolia* var. *oppositifolia*. *Acmella papposa* var. *macrophylla* is therefore a new host species.

Sydow described *E. ecuadorense* as a new species differing from *E. spilanthis* Speg. by larger sori, slightly smaller spores (*E. spilanthis*: 11-14(-16) μm, *E. ecuadorense*: 11-14 μm), and a hyaline, *ca* 1 μm thick spore wall. According to him, the sori of *E. spilanthis* are very small and difficult to detect on herbarium material, the walls of its spores are yellow-brown and 1.5-1.8 μm thick. The author could not check soral morphology or the size of the spores of the type of *E. spilanthis* without destroying too much of the type specimen.

Material collected by the author in Costa Rica and Panama corresponds to *E. ecuadorense* by relatively large, conspicuous spots on the leaves and to *E. spilanthis* by the size of the spores and the thickness of the spore walls. The color of the spore walls varies from hyaline to slightly yellowish and definitely yellowish brown. It seems to be impossible to distinguish *E. ecuadorense* from *E. spilanthis*, so they are considered synonyms.

**2 Urediniomycetes**

**2.1 Microbotryales**
**2.1.1 Microbotryaceae**

**23. *Sphacelotheca* cf. *hydropiperis*** (Schumach.) de Bary, Vergl. Morph. Biol. Pilze, p. 187. 1884; *Uredo hydropiperis* Schumach., Enum. pl. Saell. **2:** 234. 1803; *Ustilago hydropiperis* (Schumach.) J. Schröter, in Cohn, Beitr. Biol. Pflanzen **2:** 355. 1877. Type. On *Polygonum hydropiper* L. Denmark. Sjaelland (type *ubi*?).

*Sori* in some to numerous flowers of an inflorescence; a single sorus with one central columella and a peridium, both made of fungal cells; columellae *ca* 4-7 mm long; peridia dirty white to brownish, rupturing with 3-4 lobes. *Spore mass* powdery; brown-violet. *Spores* single or in chains; spherical to globose; 8-10 x 10-14(-18) µm; reddish-brown; with 2(-3) short appendices, mostly on opposite sides of a spore. Wall *ca* 1.5 µm; covered by dense, fine, 0.5 µm high warts, which can fuse forming a more or less complete reticulation, visible only by SEM. *Germination* with phragmobasidia with sessile basidiospores, which can conjugate.

In Panama on ***Polygonum punctatum*** Elliott (Polygonaceae):

**Chiriquí:** Boquete, Bajo Chorro, *alt. ca.* 1 850 m, 8 Feb 1995, *Piepenbring and Cueva 1 400* (PMA, USJ 53 530); Bajo Boquete, *alt. ca.* 1 500 m, 23 Aug 1998, *Piepenbring, Cáceres, Cueva & Esquivel 2 387* (PMA).

On ***Polygonum persicarioides*** Humb., Bonpl. and Kunth:

Close to Baños, Hacienda San Antonio, 10 Dec 1937, H. *Sydow; Sydow, Fungi exotici exsiccati 1 043* ("*Sphacelotheca hydro piperis*", M!).

According to Vánky & Oberwinkler (1994), these specimens should be called *Sphacelotheca koordersiana* (Bref.) Zundel because they differ from typical *S. hydropiperis* by having sori in only some flowers of an inflorescence and warts on the spores mostly united in rows. Further investigation is necessary to ascertain whether these differences are enough to merit an additional species.

**2.1.2 Ustilentylomataceae**

**24**. ***Aurantiosporium subnitens*** (J. Schröter and Henn.) M. Piepenbr., Vánky and Oberw., Pl. Syst. Evol. **199:** 62. 1996; *Ustilago subnitens* J. Schröter & Henn., in Henn., Hedwigia **35:** 215. 1896; *Cintractia subnitens* (J. Schröter and Henn.) Castell. & Cif., Prodr. mycofl. Afric. Orient. Ital., p. 29. 1937. Type. On *Scleria melaleuca* Reichb. ex Schltdl. and Cham. [S. cf. *pratensis* Lindl. ex Nees]. Brazil. Rio de Janeiro: May 1887, *Ule 1 604* (the type specimen in BPI does not contain any spores; holotype, HBG!).

*Sori* in groups of spikelets of an inflorescence; as swellings of the pedicel in pistillate spikelets and as swollen rhachillae in staminate spikelets; when young, green, when old, orange colored; in old sori, vascular strands are visible as ramified threads. *Spore mass* crumbly; orange. *Spores* in irregular, subglobose to elongated groups, 30-70 x 50-110 µm, or single; a single teliospore mostly subglobose or bluntly angled; (8-)10-12(-13) x (10-)13-17(-19) µm; young light yellow; old orange colored. Wall *ca* 2 µm thick; in LM two-layered; in SEM with an irregularly folded surface. *Germination* with phragmobasidia with sessile basidiospores.

In Panama on ***Scleria melaleuca*** (Cyperaceae):

**Panamá:** N of Ipetí, *alt. ca.* 110 m, 19 Feb 1995, *Piepenbring & Domínguez 1 490* (PMA, USJ 53 539).

## DISCUSSION

This first account of smut fungi in Panama includes four species based only on literature and 20 species collected by the author. Among the latter are 14 new records for Panama, constituing 61% of the total of 24 species cited here. This high percentage is not surprising, because hitherto nobody had studied the diversity of Panamanian smut fungi.

Most wild host species of smuts grow in rural plant communities, mostly at roadsides and close to human settlements. This was also the case in Costa Rica (Piepenbring 1996b). *Tilletia ayresii*, the most often collected smut species in Costa Rica, is also one of the most common smut species in Panama. *Sporisorium holwayi*, however, was only rarely collected in Costa Rica (Piepenbring 1996a), while it was often collected at the pacific slopes of the Panamanian Cordillera.

In comparison with the lists of smut fungi for other neotropical countries (comp. introduction) the list of the species known for Panama is short and includes only four species which are not also known for Costa Rica (Table 1). *Sphaceloteca panamensis* is known only for Panama. The small size of the checklist of Panamanian smut fungi is mainly due to the very short time spent for the investigation of this group in Panama. The high similarity with the smut diversity in Costa Rica and the lack of new species in the present publication may be caused by the fact that the author finds species already known to her more easily than new ones. It may also be related to the fact that immigration of terrestrial species to Panamanian grounds was limited by the ocean covering most of it until the latter Tertiary (ca. 3.5 mio. yrs ago), when the mesoamerican land-bridge closed in the area of Panama (Stanley 1994). The high diversity of its present flora, however, is the best guarantee for interesting results which will be obtained by a more thorough investigation on Panamanian smut fungi.

TABLE 1

*Checklist of smut fungi known for Panama and their recorded presence in Costa Rica*

| Panama | | Costa Rica |
|---|---|---|
| 24. | *Aurantiosporium subnitens* | x |
| 3. | *Cintractia limitata* | x |
| 15. | *Doassansiopsis limnocharidis* | x |
| 19. | *Entyloma bidentis* | x |
| 20. | *Entyloma compositarum* | x |
| 21. | *Entyloma dahliae* | x |
| 18. | *"Entyloma" oryzae* | x |
| 22. | *Entyloma spilanthis* | x |
| 4. | *Farysia chardoniana* | x |
| 5. | *Leucocintractia scleriae* | x |
| 14. | *Mycosyrinx cissi* | x |
| 23. | *Sphacelotheca* cf. *hydropiperis* | x |
| 6. | "*Sphacelotheca*" *panamensis* | |
| 7. | *Sporisorium holwayi* | x |
| 8. | *Sporisorium ovarium* | |
| 16. | *Tilletia ayresii* | x |
| 17. | *Tilletia barclayana* | |
| 9. | *Trichocintractia utriculicola* | x |
| 10. | *Ustilago hypodytes* | |
| 11. | *Ustilago maydis* | x |
| 12. | *Ustilago schroeteriana* | x |
| 13. | *Ustilago scitaminea* | x |

*The record of a Panamanian smut species in Costa Rica is marked by "x" according to Piepenbring (1996b). The number of each species corresponds to its position in the chapter results and discussions of species.*

**Key for smut species known in Panama, based on families of host plants**

Families are listed in alphabetical order.

**On Asteraceae**

Sori as yellowish to whitish spots of leaf blades
- Sori 1-2 mm diam, numerous, angular; spores mostly 9-11 µm. On *Viguiera* sp. . . . . .20. ***Entyloma compositarum***
- Sori larger
  - Spores mostly 10-13 µm. On *Acmella papposa* var. *macrophylla* . . . . . .22. ***Entyloma spilanthis***
  - Spores larger
    - Spores mostly 13-15 µm. On *Bidens pilosa* . . . . . .19**.** ***Entyloma bidentis***
    - Spores mostly 13-16 µm. On *Dahlia* sp. . . . . .21. ***Entyloma dahliae***

**On Cyperaceae**

Sori as galls filled with orange-colored mass of spores. On *Scleria melaleuca* . . . . . .24. ***Aurantiosporium subnitens***

Sori not as galls filled with orange-colored mass of spores
- Spore mass permeated by conspicuous elaters. On *Carex polystachya* . . . . . .4. ***Farysia chardoniana***
- Spore mass not permeated by conspicuous elaters
  - Sori in single spikelets
    - Sori with sac-shaped, persistent peridia. On *Rhynchospora corymbosa* . . . . . .9. ***Trichocintractia utriculicola***
    - Sori covered by non sac-shaped peridia only when young. On *Fimbristylis spadicea*... 2. ***Cintractia fimbristylicola***
  - Sori not in single spikelets
    - Sori around all the peduncles of sterile inflorescences. On *Rhynchospora corymbosa* . . . .5. ***Leucocintractia scleriae***
    - Sori around some bases of peduncles of an inflorescence, sometimes also in the spikelets
      - Spores mostly 14-17 µm. On *Fimbristylis dichotoma* . . . . . .1. ***Cintractia axicola***
      - Spores mostly 11-13 µm. On *Cyperus ligularis* and *C. rotundus* . . . . . .3. ***Cintractia limitata***

**On Limnocharitaceae**

Sori as galls of leaf blades; spores form balls together with sterile cells. On *Limnocharis flava* . . . . . .15. ***Doassansiopsis limnocharidis***

**On Poaceae**

Sori as lead-colored stripes of leaf blades. On *Oryza sativa* . . . . . .18. ***"Entyloma" oryzae***

Sori not as lead-colored stripes of leaf blades
- Sori around the main axis
  - Around several internodes of one stem. On *Stipa setigera* . . . . . .10. ***Ustilago hypodytes***
  - Around a whip-shaped terminal part of the stem. On *Saccharum* sp. cult. . . . . .13. ***Ustilago scitaminea***
- Sori not around the stem
  - Sori as several cm large swellings of vegetative or generative organs. On *Zea mays* . . . . . .11. ***Ustilago maydis***
  - Sori not as several cm large swellings
    - Sori with columellae (elongated central host tissue)
      - Sori in congested partial inflorescences (witches´ brooms). On *Andropogon bicornis* . . . . . .6. ***Sporisorium holwayi***
      - Sori in ovaries
        - Spores mostly 11-13 µm. On *Urochloa fasciculata* . . . . . .7. ***Sporisorium ovarium***
        - Spores mostly 14-18 µm. On *Cymbopogon* sp. (doubtful) . . . . . .8. ***"Sphacelotheca" panamensis***
    - Sori without columellae
      - Sori affecting the entire inflorescence, not concealed by glumes. On *Paspalum* spp. . . . .12. ***Ustilago schroeteriana***
      - Sori not affecting the entire inflorescence
        - Sori as swollen ovaries filled with spores, sterile cells, and balls of conidia. On *Panicum maximum* and *Setaria paniculifera* . . . . . .16. ***Tilletia ayresii***
        - Sori not as swollen ovaries, without balls of conidia. On *Oryza sativa* . . . . . .17. ***Tilletia barclayana***

**On Polygonaceae**

Sori in flowers, with peridia and columellae. On *Polygonum persicarioides* and *P. punctatum* . . . . .23. ***Sphacelotheca* cf. *hydropiperis***

**On Vitaceae**

Sori as witches´ brooms carrying numerous tube-shaped sori. On *Cissus sicyoides* . . . . . .14. ***Mycosyrinx cissi***

## ACKNOWLEDGEMENTS

Q. Domínguez and further members of the INRENARE (now ANAM) and P. Caballero, C. Arrocha, and O. Cáceres from the UNACHI (Universidad Autónoma de Chiriquí) are thanked for help with organization and company during the field work in Panama. M. Correa supported this study as director of the herbarium PMA. In Germany, V. Uhle-Schneider is thanked for mounting the drawings, H. Schoppmann and F. Albrecht for technical assistance. R. Cropper is thanked for revising the English and S. T. Garnica for revising the Spanish of the manuscript. Curators of cited herbaria are thanked for loans of specimens. The DAAD (Deutscher Akademischer Austauschdienst) is thanked for financial support.

## RESUMEN

Esta es la primera publicación dedicada a la diversidad de carbones en Panamá. Tiene su base en trabajo de campo, estudio de especímenes herborizados y referencias de la literatura. Se incluyen carbones patógenos de plantas cultivadas y silvestres. Las últimas se encontraron sobre todo en zonas rurales. Entre las 24 especies citadas en este estudio, 14 especies son primeros registros para Panamá y una de éstas, *Sporisorium ovarium*, para América Central. Se encontró *Entyloma spilanthis* por primera vez en la planta hospedera *Acmella papposa* var. *macrophylla* (Asteraceae). *Entyloma costaricense* y *Entyloma ecuadorense* son sinónimos de *Entyloma compositarum* y *Entyloma spilanthis* respectivamente. "*Sphacelotheca*" *panamensis* es una especie dudosa. Se complementan las descripciones de las especies con algunas ilustraciones, una lista de especies y una clave.

## NOTE

The type of "*Sphaceloteca*" *panamensis* was recently located in BPI. It differs from other species known on *Cymbopongon* and related genera of Poaceae by the precense of sori in spikelets and relatively large teliospores with several germ areas each. It belongs to the genus *Sporisorium* because of columellae and fungal peridia in the sori.

***Sporisorium panamensis*** (Zundel & Dulap) M. Piepenbr., **comb. nov.**

Basionym: *Sphaceloteca panamensis* Zundel and Dulap, in Zundel, N. Amer. fl. 7: 995. 1939. Type. On *Cymbopogon citratus* (DC.) Stapf. Panamá. Chiriquí, *Hitchcock 8295* (holotype, BPI 190260!).

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