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REASSESSMENT OF THE SMUT FUNGI INFECTING *ANEMONE* IN SOUTHERN SOUTH AMERICA

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Abstract. Two smut fungi infecting species of *Anemone* L. in southern South America are described, illustrated and discussed. *Tuburcinia antucensis* Liro on *Anemone antucensis* Poepp. in Chile is re-evaluated taxonomically and transferred to the genus *Urocystis* Rabenh. *ex* Fuckel. A collection of *Urocystis anemones* (Pers.) G. Winter infecting *Anemone decapetala* Ard. in Chile is taxonomically re-assessed. *Urocystis antucensis* (Liro) M. Piątek is an endemic smut confined to Chile, while *U. anemones* is a widespread smut fungus in the Holarctic, but in South America known only from Chile so far.

Key words: Ustilaginomycotina, Urocystales, *Urocystis*, *Anemone*, Chile, South America

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INTRODUCTION

Although no doubt far from complete, knowledge of the smut fungi in the neotropical part of South America lying north of the Tropic of Capricorn is relatively good (Piepenbring 2003). By contrast, Ustilaginomycotina of the remaining part of South America are not well known. There are only a few reports or incomplete inventories of smut fungi of Argentina, Chile, Paraguay and Uruguay, which do not cover the whole area of these countries (e.g., Zundel 1953; Mujica *et al.* 1980; Hirschhorn 1986; Vánky 2001; Gossmann *et al.* 2007; Vánky & Begerow 2007, and literature cited therein). The taxonomic concepts used in publications dealing with smuts from austral South America are not always up-to-date and require revision. The present study is a reassessment of smut collections known on species of *Anemone* L. (Ranunculaceae) in southern South America.

MATERIAL AND METHODS

Sori and spore characteristics were studied using dried herbarium material. The acronyms of herbaria are according to *Index Herbariorum*, available online (http://sciweb.nybg.org/science2/IndexHerbariorum.asp). All specimens were examined by standard light and phase contrast microscopy (LM) and by scanning electron microscopy (SEM). Morphological observations and spore measurements were made by light microscopy (LM) from material mounted in lactophenol, heated to boiling point and then cooled. A Nikon Eclipse E600 light microscope with a Nomarski differential interference contrast optical system was used for LM studies. At least 30 spores were measured; measurements include the usual range and extreme values given in parentheses. LM micrographs were taken with a Nikon Coolpix 995 camera. For SEM studies, dry spore balls were dusted on carbon tabs and fixed to an aluminum stub with double-sided transparent tape. The stubs were sputter-coated with carbon using a CRESSINGTON sputter-coater and viewed with a Hitachi S-4700 scanning electron microscope, with a working distance of *ca* 12 mm. SEM micrographs were taken in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University, Kraków (Poland). Descriptions and nomenclatural novelties are registered in MycoBank (www.MycoBank.org, see Crous *et al.* 2004).

TAXONOMY

Urocystis antucensis (Liro) M. Piątek, ***comb. nov***. Figs 1 & 2

[MycoBank MB511084]

BASIONYM: *Tuburcinia antucensis* Liro, Ann. Univ.

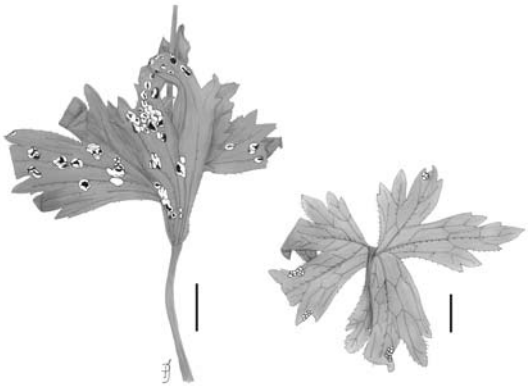

Fig. 1. Sori of *Urocystis antucensis* (Liro) M. Piątek on leaves of *Anemone antucensis* Poepp. (from isotype, BPI 181305). Scale bars = 1 cm.

Fenn. Aboëns., Ser. A **1**(1): 62. 1922. – Type on *Anemone antucensis* Poepp. (Ranunculaceae), Chile: Cordillera de Villarica, Feb. 1897, *leg. F. W. Neger* (type where?, isotypes in Vestergren, Micr. rar. sel. no. 1210, sub *Urocystis anemones* (Pers.) Wint., among others in BPI 181305!).

Sori in leaves as conspicuous pustular swellings 1–2.5 mm in diameter, at first covered by epidermis, which later ruptures exposing the blackish, powdery mass of spore balls. Spore balls yellow-brown, globose, subglobose, ovoid or ellipsoid, 20–38 × 15–30 µm, composed of (0–)1–3(–4) central spores (0 = 3%, 1 = 37%, 2 = 46%, 3 = 13%, 4 = 1%), completely or incompletely surrounded by a layer of sterile cells. Spores yellow-brown, globose,

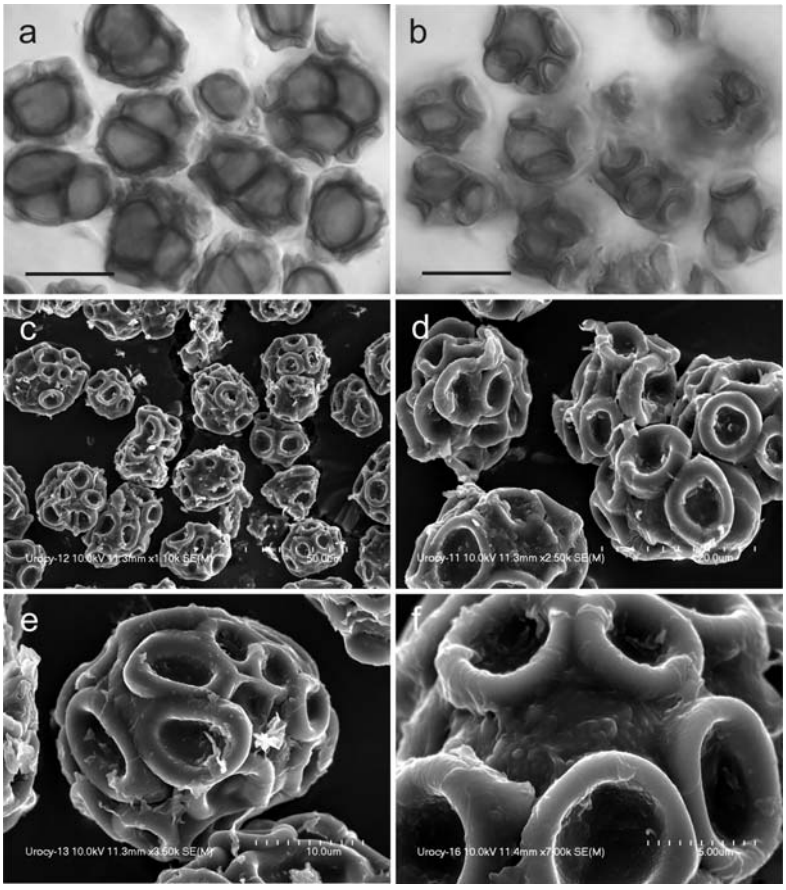

Fig. 2. *Urocystis antucensis* (Liro) M. Piątek on *Anemone antucensis* Poepp. (from isotype, BPI 181305). a–b – spore balls, spores and sterile cells seen by LM, c–e – spore balls, spores and sterile cells seen by SEM, f – wall of spore and sterile cells seen by SEM. Scale bars: a–b and d = 20 µm, c = 50 µm, e = 10 µm, f = 5 µm.

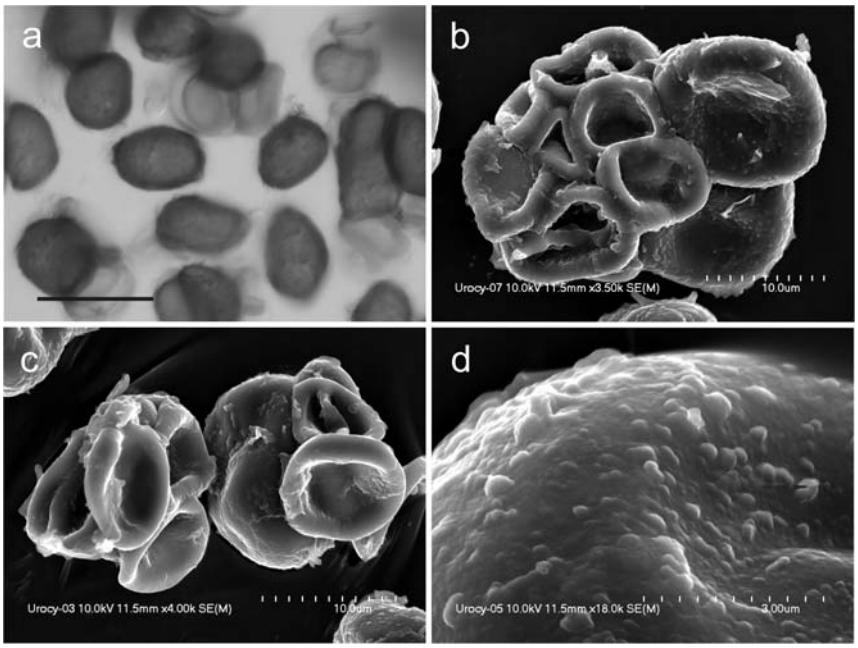

Fig. 3. *Urocystis anemones* (Pers.) G. Winter on *Anemone decapetala* Ard. (from BPI 182524). a – spore balls, spores and sterile cells seen by LM, b–c – spore balls, spores and sterile cells seen by SEM, d – spore wall seen by SEM. Scale bars: a = 20 μm, b–c = 10 μm, d = 3 μm.

subglobose, ovoid, ellipsoid to slightly irregular, (11–)12–17(–18) × (8–)11–14 μm; wall even, *ca* 1 μm thick, surface in LM smooth, in SEM minutely verruculose. Sterile cells hyaline, globose, subglobose, ovoid, ellipsoid to irregular, with flattened contact sides, 7–13 × 5–11 μm, surface in LM smooth, in SEM smooth or finely rough.

ADDITIONAL SPECIMEN EXAMINED. [CHILE]: Anden von Valdivia, on *Anemone antucensis* Poepp., *leg. F. Neger* (BPI 181303, sub *Urocystis anemones* (Pers.) Wint.).

Urocystis anemones (Pers.) G. Winter Fig. 3

Hedwigia **19**: 160. 1880.

Uredo anemones Pers., Tent. Disp. Fung.: 56. 1797. – *Tuburcinia anemones* (Pers.) Liro, Ann. Univ. Fenn. Aboëns., Ser. A **1**(1): 55. 1922. – Type on *Anemone nemorosa* L. (Ranunculaceae), Germany (L).

Sori in leaves and petioles as conspicuous blister-like swellings or elongated pustules, at first covered by epidermis which later ruptures exposing the blackish, powdery mass of spore balls and spores. Spore balls yellow-brown, globose, subglobose or irregular, 17–33 × 13–26 μm, composed of (0–)1–2(–3) spores (0 = 5%, 1 = 76%, 2 = 16%, 3 = 3%), incompletely surrounded by a layer of sterile cells; the layer is usually composed of only a few sterile cells, or sterile cells are completely absent. Spores yellow-brown or reddish-brown, globose, subglobose, ovoid, irregular or elongated, (12–)13–18(–19) × 10–15 μm; wall uneven, two-layered, 1–2.5 μm thick, surface in LM smooth, in SEM finely verruculose. Sterile cells yellowish, globose, subglobose or irregular, with flattened contact sides, 6–16 × 6–14 μm, surface in LM smooth, in SEM smooth or finely rough.

SPECIMEN EXAMINED. CHILE: in valle fluminis Biobio, on *Anemone decapetala* Ard., 1896, *leg. F. Neger* (BPI 182524, sub ?*Urocystis sorosporioides* Koern.).

DISCUSSION

The genus *Urocystis* Rabenh. *ex* Fuckel embraces species occurring in various host plant organs such as leaves, stems, flowers, seeds or roots, with sori

Table 1. Synopsis of *Urocystis* Rabenh. *ex* Fuckel species infecting *Anemone* L. species.

Species	Spore balls	Spores	Number of spores per spore ball	Sterile cells	References
U. anemones (Pers.) G. Winter	15–35 µm long	13–22 × 10.5–15 µm	1(–3)	6–16 µm long, incompletely surrounding the spores	Vánky 1994
U. antipolitana Magnus	23–50 × 20–40 µm	13–21 × 11–16 µm	1–6(–7)	8–16 µm long, almost completely surrounding the spores	Vánky 1994
U. antucensis (Liro) M. Piątek	20–38 × 15–30 µm	(11–)12–17(–18) × (8–)11–14 µm	(0–)1–3(–4)	7–13 × 5–11 µm, completely or incompletely surrounding the spores	this paper
U. japonica (Henn.) L. Ling	22–56 × 19–55 µm	10.5–18 × 8.5–15 µm	(1–)2–6(–10)	5–12 µm long, completely surrounding the spores	Denchev *et al.* 2000
U. novae-zelandiae (G. Cunn.) G. Cunn.	up to 60 µm long	16–22 × 12–16 µm	2–20(–30)	8–14 µm long, completely or incompletely surrounding the spores	Vánky & McKenzie 2002
U. pseudoanemones Denchev, Kakish. & Y. Harada	19–57 × 14–40 µm	11–22 × 9–17.5 µm	1–5(–11)	5.5–12(–17) µm long, incompletely surrounding the spores	Denchev *et al.* 2000
U. sinensis L. Guo	19–58(63) × 15–43 µm	10–17 × 8.5–12.5 µm	1–8(–14)	7–11 × 5–8 µm, completely or incompletely surrounding the spores	Guo 2005

forming brown or black streaks, swellings or galls containing masses of spore balls. The spore balls are persistent, composed of one or several central, dark spores surrounded by paler and smaller sterile cells (Vánky 2002).

The greatest number of *Urocystis* species are known on *Ranunculus* L. (10 species) and *Anemone* L. (7 species). Several previous studies have dealt with *Urocystis* spp. occurring on *Anemone* spp. in various parts of the world (Vánky 1994; Denchev *et al.* 2000; Vánky & McKenzie 2002; Guo 2005). However, no attempts have been made to re-examine the collections of *Urocystis* (including *Tuburcinia* Woronin) on this host plant genus from South America. Such collections are very scarce on this continent and are, in fact, known only from Chile.

Tuburcinia antucensis on *Anemone antucensis* was described by Liro (1922) based on material collected by F. W. Neger in the Cordillera de Villarica in 1897. This collection was distributed in Vestergren's *Micromycetes rariores selecti* no. 1210, under the name '*Urocystis anemones* (Pers.) Wint.', and also published as '*Ustilago anemones* (Pers.) Schroet.' (Neger 1899). The other, non-type collection on *A. antucensis* from Valdivia reported previously as '*Urocystis anemones* (Pers.) Schroet.' (Dietel 1898) also has the same morphological characters as the studied isotype of *T. antucensis*. Since it was described by Liro (1922), *T. antucensis* has been completely forgotten and not reassessed by any smut taxonomist. Although I originally expected this species to represent one of the already known *Urocystis* species on various *Anemone* species described from elsewhere, I was surprised to find that it is a distinct and separate species. The genus *Tuburcinia* is now considered to be synonymous with the earlier-described genus *Urocystis*, and therefore *T. antucensis* is here transferred to the latter genus. *Urocystis antucensis* is easily distinguished from all six *Urocystis* spp. on *Anemone* spp., primarily on the basis of the number of spores per spore ball. It has more spores per spore ball than *U. anemones*, but fewer than *U. antipolitana* Magnus, *U. japonica* (Henn.) L. Ling, *U. novae-zelandiae* (G. Cunn.) G. Cunn., *U. pseudoanemones* Denchev, Kakish. & Y. Harada and *U. sinensis* L. Guo. There are

also further characters (sizes of spore balls, spores and sterile cells, the continuity of the layer of sterile cells) the combination of which differentiates *U. antucensis* from other *Urocystis* spp. known on *Anemone* spp. (for diagnostic characters see Table 1). The morphological characters of *U. antucensis* are very similar to those of *U. ficariae* (Unger) Moesz., but the latter smut occurs exclusively on *Ficaria verna* Huds. As the delimitation of species in the genus *Urocystis* is based on host plant taxonomy, usually at the genus level, I accept *U. antucensis* as a separate species. *Urocystis antucensis* is known only from two stations in Chile and presumably is endemic to this country.

Urocystis anemones on *Anemone decapetala* was reported from Chile under this specific name by Dietel (1898). *Urocystis anemones* used to be treated very broadly as a species occurring on numerous host plants from various genera of Ranunculaceae. It is now commonly accepted that the name *U. anemones* is restricted to species infecting several *Anemone* spp., characterized by spore balls composed mostly of 1 or rarely 2–3 spores, by having spore balls incompletely surrounded by a layer of sterile cells, and sometimes even completely lacking sterile cells (Vánky 1994). Re-examination of the Chilean material revealed that it indeed belongs to *U. anemones* defined this way. This is somewhat surprising as *U. anemones* is rather a Holarctic species, widely distributed in the Northern Hemisphere, where it is one of the most commonly occurring smuts. The collection of this species in Chile is the only one in South America.

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