

The Identity of the Potato Smut

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Summary

A new genus, *Angiosorus*, is proposed for the organism causing smut on potatoes in South America. The genus is characterized by locular sori. These are formed in the host in the manner similar to the sorus formation in the smut genus *Melanopsichium* G. Beck. The spore balls are differentiated from the sporiferous hyphae lining the cavity. All the spores are fertile and are held together by mutual appression on their contiguous sides and are easily separable into free spores. They are thus similar to the spore balls of *Sorosporium* Rudolphi in structure. They differ from those of *Thecaphora* Fingerh., in which genus the smut spore balls are multicellular and are formed by septation so that the separating wall is common for both cells. *Angiosorus* also differs from the monotypic genus *Polysaccopsis* P.Henn., in which genus *P. hieronymi* parasitizes another *Solanum* species in South America. Both these genera have locular sori with spores differentiated from marginal sporiferous hyphae. However, in *Polysaccopsis* the spore balls are as in *Urocystis* Rab. with the central group of fertile spores surrounded by outer sterile cells, whereas in *Angiosorus* all the spores are fertile.

Introduction

In 1943 Barrus and Muller (2) described an Andean disease of potato tubers from the original home of potatoes, Peru. In 1944 Barrus (1) made a detailed study of the causal organism and described it as a new smut disease of potato, naming it *Thecaphora solani* Barrus, but failed to publish a Latin description for *T. solani*. He based his name on the appearance of the spores; these were in the form of firm spore balls that were angular in shape.

This smut disease occurs widely in Venezuela, Peru, Ecuador, and a few other places. It has never been reported outside South America. Several collections of potato material intercepted by the U. S. Department of Agriculture, Agricultural Quarantine Inspection Division, are deposited in the National Fungus Collections at Beltsville, Maryland.

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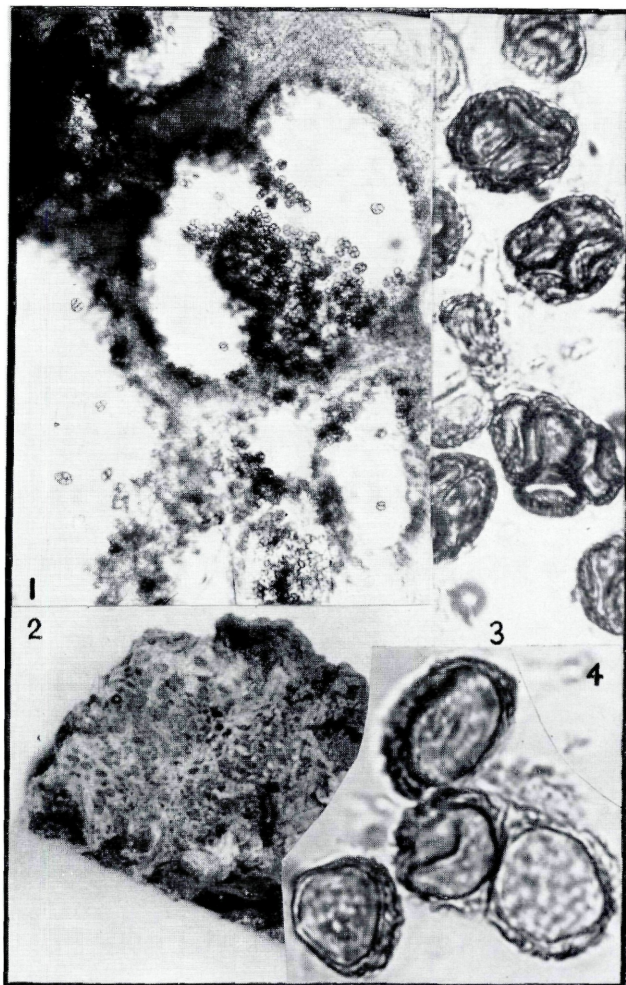
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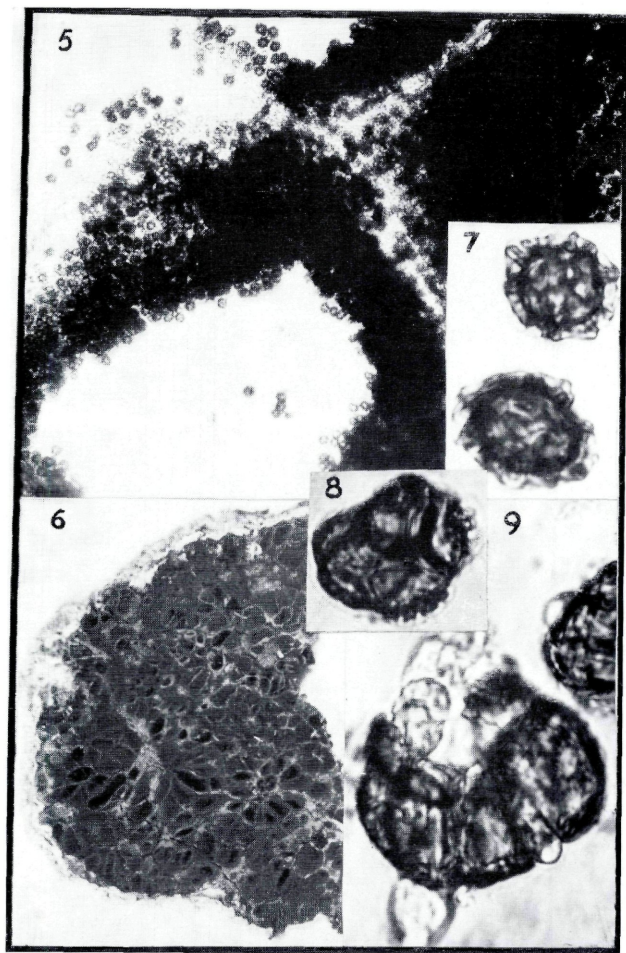
These interceptions provided the material to study this fungus; numerous other specimens of this smut were examined by us at various herbaria in the United States and Europe. The smut occurs on *Solanum tuberosum* L. and *S. tuberosum* ssp. *andigena* (Juz. & Buk.) Hawkes. The type specimen is on *S. tuberosum* ssp. *andigena* that was collected by B a r r u s and M u l l e r in Mucuchies, State of Merida, Venezuela.

Because this smut can incite serious damage to potato tubers, it remains a potential threat to the potato crop. The smut infects the tubers by transforming the cortex into a sorus with dark, powdery spore mass. In most cases, the entire tuber is affected; sometimes partially infected tubers are found. B a r r u s (1) studied the morphology of the sorus and, assuming it to be a species of *Thecaphora*, described the rusty-brown spore balls with 2 to 8 adherent spores that are somewhat angular, smooth on the contiguous side and abundantly verrucose on the free side. We made a detailed study of the type material, as well as of numerous other collections on *S. tuberosum* and *S. tuberosum* ssp. *andigena* and found unique characters which warranted placing the smut under an undescribed genus.

D I S C U S S I O N

In the morphology of the sorus and in spore development in general, the smut closely resembles the monotypic genus *Polysaccopsis hieronymi* (Schroet.) P. Henn. on tubers of wild *Solanum* species (*S. lilacinum* Rusby) that occurs only in South America in Argentina, Brazil, and Bolivia. As in the case of potato smut, very little is known about *P. hieronymi* except from the original descriptions. The morphology of this fungus was studied from an infected tuber collected by E. U l e in Rio de Janeiro in January, 1898 (Rabenhorst-Pazschke "Fungi Europaei et extra-Europaei" 4302). Figure 1 illustrates the cross-section of potato smut affecting *S. tuberosum* (Cornell University, Plant Pathology, Chupp Collection 33295; collected by J. S o n k u p in April, 1940, in Puno, Peru) showing the entire tuber traversed by locular sori (Fig. 2). The same features are indicated in *Polysaccopsis hieronymi* (Fig. 5, 6), where the entire tuber is converted into locular sori. Upon sectioning, both the potato smut (Fig. 1) and *P. hieronymi* (Fig. 5) show that the locules are bounded by thick, sporiferous hyphae and that the spore balls are differentiated *en masse* and pushed to the center. The locular nature of the sorus was well-described for *P. hieronymi* by Hennings when he stated that the spore mass is produced in numerous sac-like cavities formed by the mycelium. The outer, yellowish-brown membrane referred to in Hennings' description as covering the sorus was found to be that of the host tissue only. Locular sori are also present in the smut genus *Melanopsichium* G. Beck, but the spores are not in spore balls.





In the potato smut mature spores are rust-brown in color; they are black in *Polysaccopsis hieronymi*. The spore balls in the two genera are totally different. In the potato smut all the spores are fertile; they are held together as in *Sorosporium* (Fig. 3). On exertion of gentle pressure, the spores separate (Fig. 4). In contrast, in *P. hieronymi*, the spores are similar to those of *Urocystis*, with large, dark-colored fertile spores in the center surrounded by sterile cells (Fig. 7). In fact, the smut was first described by Schroeter as *Urocystis hieronymi*. The spore characters totally separate the two smuts.

The recent work of Thirumalachar (1972) on the genus *Thecaphora* well illustrates the fact that the potato smut is not a species of *Thecaphora*. He showed clearly that in *Thecaphora* the spores are multicellular and are produced by septation so that the separating wall is common for both the cells. Hence, when the spore ball is crushed, the cells do not separate but rupture at the opposite end, releasing the spore contents. This formation is illustrated in *Thecaphora seminis-convolvuli* (Desm.) Liro (= *T. hyalina* Fingerh.), the type of the genus. Fig. 8 shows the normal spore ball of *T. seminis-convolvuli*; Fig. 9 shows the ruptured spore releasing its contents. The cells of the spore do not separate. Therefore, the potato smut is not a species of *Thecaphora*. Also, it is distinct from *Polysaccopsis* which it resembles in sorus characters. We, therefore, place the potato smut under a new genus for which we propose the name *Angiosorus*.

Angiosorus Thirum. & O'Brien, gen. nov.

Sori ut loculi intra hospitem, ex hyphis sporogenis delimitati; globi sporarum ex hyphis sporogenis evolventes et cavitatem implentes; massa sporarum fusca pulverulenta; globi sporarum maturi 2 — pluricellulati; sporae aut suis lateribus aut membrana tenui circumdata inter se cohaerentes ut in *Soropsoria*, dein globis obtritis disjunctentibus et liberis.

Typus *A. solani* Thirum. & O'Brien.

Angiosorus solani Thirum. & O'Brien, sp. nov.

(Syn. *Thecaphora solani* Barrus, Phytopathology 34: 712—714, 1944).

Sori in cortice et medulla tuberum deformium durorum, tubero omino vel ex parte ut loculi 1—1.2 mm diam. penetrantes; globi sporarum numerosi, ex hyphis sporogenis intertextis ad marginem loculorum evoluti, centrum versus compressi et cavitatem implentes, 2—8 spori vel interdum monospori, in maturitate cinnamomeo- vel ferrugineo-brunnei, subglobosi vel angulares, 15—50 × 12—40 μ diam.; sporae appensione mutua ad latera contigua cohaesae, dein disjunctentes et tuberibus ruptis liberatae, maturaе fusco-brunneae, ad latus contiguum

laeves, ad latus liberum verrucosae, 7.5—20 × 8—18 μ . Germinatio non visa.

Typus: *Thecaphora solani* Barrus, CHUPP 29427.

Hab. in tuberibus *Solani tuberosi* spp. *andigenae* (Juz. & Buk.) Hawkes, Muchuchies, State of Merida, Venezuela, November 19, 1939, leg. Barrus et Muller (TYPUS); Puno, Peru, March, 1940, leg. J. Sonkup (Chupp 33295); Muchuchies, State of Merida, Venezuela, April 23, 1943, leg. C. G. Sales et det. M. F. Barrus; Andes Mts., Peru, April, 1944, leg. Garcia Rada; on *S. tuberosum*, Colombia, S. A., May 29, 1962, leg. E. Y. Okasako et det. A. J. Watson; on *S. stoloniferum*, Mexico, September 23, 1963, leg. Williams & Lewis et det. A. H. Lewis; Mexico, April 4, 1964, leg. H. A. Mueller et det. C. H. W. & J. Kaiser; Mexico, leg. L. H. Whealdon et det. E. C. Heinrich; Villa Olampo, Mexico, March 2, 1965; leg. L. W. Parks et det. J. A. Baker, Mexico, March 1, 1966, leg. Ed. Ayers et det. E. C. Heinrich; Aguas Calientes, Mexico, November 2, 1966, leg. D. V. Akins et det. J. A. Baker; Mexico, January 3, 1967, leg. L. Garcia et det. E. C. Heinrich; Mexico, January 13, 1968, leg. R. Stevens et det. E. C. Heinrich; Mexico, January 17, 1969, leg. et det. A. H. Lewis; on *Solanum* sp., Aguas Calientes, Mexico, leg. R. O. Parson & J. Cramer et det. W. H. Wheeler; Mexico, February 10, 1964, leg. J. Kline et det. J. A. Baker; Mexico, March 4, 1964, leg. E. B. Gares et det. J. A. Baker; Mexico, March 1, 1966, leg. E. R. Stang & A. H. Lewis et det. A. H. Lewis; Mexico, January 19, 1967, leg. L. W. Parks et det. J. A. Baker.

Angiosorus Thirum. & O'Brien, gen. nov.

Sori as locules within the host, bounded by sporiferous hyphae from which spore balls are differentiated filling the cavity of the locule. Spore mass dark and powdery. Mature spore balls 2 to several-spored; spores held together by their contiguous sides or a thin enveloping membrane as in *Sorosporium* and separating off into free spores when spore balls are pressed. Germination not known.

Type species: *Angiosorus solani* Thirum. & O'Brien.

Angiosorus solani Thirum. & O'Brien, sp. nov.

(Syn. *Thecaphora solani* Barrus, Phytopathology 34: 712-714, 1944).

Sori in tubers which are misshapen and hard, sori pervading the cortex and pith of the tubers; infection partial or involving the entire tuber as 1 to 1.2 mm locules. Margins of locules with interwoven sporiferous hyphae from which numerous spore balls are developed and pushed towards the center and filling the cavity. Mature spores are dark, rusty-brown *en masse*, released by the disintegration of the tubers. Mature spore balls 2 to 8-spored, occasionally single, spores cinnamon to rust-brown, subglobose to angular in outline, 15—50 × 12—40 μ

in diameter, spores held together by mutual pressure on contiguous sides and separating off when teased, smooth on the contiguous side and densely verrucose on the free side, $7.5-20 \times 8-18 \mu$. Germination not observed.

Type: *Thecaphora solani* Barrus, CHUPP 29427.

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3. Thirumalachar, M. J. 1972. Studies on the genus *Thecaphora* Fin-gerh. /In press/.

Explanation of figures

Figs. 1-4. *Angiosorus solani*. Fig. 1. Enlarged view of locular sori showing marginal sporiferous layer $\times 75$. Fig. 2. Cut surface of *S. tuberosum* showing sori in locules $\times 2$ natural size. Fig. 3. Spore ball $\times 500$. Fig. 4. Spore ball teased out to show four free spores $\times 1000$.

Figs. 5-7. *Polysaccopsis hieronymi*. Fig. 5. Locular sori $\times 75$. Fig. 6. Cut tuber surface of *Solanum* sp. showing locular sori $\times 2$ natural size. Fig. 7. Spore balls with central fertile and outer sterile cell $\times 500$.

Figs. 8 and 9. *Thecaphora seminis-convolvuli*. Fig. 8. Spore ball $\times 500$. Fig. 9. Crushed spore ball showing rupture at the free end, the common wall between the spore cells remaining intact $\times 1000$.

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