Synchytrium shuteriae and other doubtful Species.

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With 9 Textfig.

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Synchytrium shuteriae was described by Henning (1895) as a parasite of *Shuteria africana* which G. Volkens collected near Kilimandscharo, in German East Africa, and he diagnosed it as follows: "maculis pallidis rotundatis, tuberculis amphigenis sparsis vel confluentibus, subhemisphaericis applanatis, dein irregulariter rugosis, flavescenti-viridulis dein subfuscescentibus, 0.3—1 mm diametro, plerumque e pluribus cellulis perdurantibus formatis; sporis globosis vel subellipsoideis, saepe acutangulis, flavosubfuscescentibus 10—15 ⇌ 9—13 μ, episporio levi, 1—1.5 μ crasso, subhyalino."

In 1912 Tobler studied specimens of this species in the Berlin herbarium and came to the conclusion that it may not be a valid species of *Synchytrium,* or that more than one fungus is present on the host. Recently, through the generosity of Dr. Sten Ahlner, the author received material of this species from the Riksmuseet in Stockholm, Sweden, which was collected by G. Volkens near Kilimandscharo, June 13, 1894, and a study of fixed and stained sections of this material has shown that *S. shuteriae* is a true *Synchytrium* species which is very similar to members of the subgenus *Woroninella.* Accordingly, this brief paper is presented to show the characteristics of this species.

The galls induced by *S. shuteriae* on its host are relatively sparse, separate and scattered, or crowded and confluent as described by Henning. With the exception of one resting spore gall which may not belong to *S. shuteriae,* only sporangial galls are present in the Stockholm material at hand, and most of these are unusually large. As shown in fig. 1 of an isolated gall, they are predominantly subhemispherical or dome-shaped with a slight apical depression, 186—300 μ high by 318—500 μ in longitudinal section with a sheath 3—5 cells thick. The sheath cells are markedly enlarged and vesicular when turgid, but as they dry out they collapse and become wrinkled to give the galls a rugose appearance, as noted by Henning. The

galls protrude conspicuously on the surface of the host, and because of the thinness of the leaf they frequently bulge out on the opposite side. In many cases a gall may protrude equally on both sides of the leaf. Confluent galls are usually quite large and may be up to 1000 μ or more in diameter. The sori in such galls may be elongate and irregular, and when they have dehisced confluent galls usually become dark-brown and often appear to be spongy and ramified by irregular cavities. Such galls apparently are the type illustrated by Tobler in her fig. 60.

As the isolated galls dehisce the upper portion of the sheath breaks open and sloughs off, leaving the gall cup-shaped and filled with the sorus of sporangia. The latter adhere closely together and do not appear loose and powdery like those of most members of the subgenus *Woroninella.* However, these observations are of dried herbarium material, and the appearance of the sporangia may be quite different in living material.

The sori are yellow or yellowish-golden in color with a thin hyaline, 1.5—1.8 μ thick, smooth wall, and predominantly oval in shape, 150—252 ⇌ 288—450 μ. They may often extend up in the narrow neck of the infected cell at the apex and become somewhat beaked or papillate in shape as shown in fig. 2. No evidence of a prosorus was found in any of the sporangial galls, and apparently the initial cell of the fungus is transformed directly into a sorus or sporangia at maturity. The sporangia are quite small and numerous so that up to and more than 1000 are present in a sorus. They are multinucleate, predominantly polyhedral in shape and vary from 9—15 μ in greatest diameter with a thin, 1.5 μ thick, hyaline wall and finely granular, yellowish content (fig. 3). In ruptured and largely empty sori where the forces of mutual contact and pressure are reduced or absent, the Sporangia are oval, 9—13 ⇌ 10—15 μ, or almost spherical, 8—13 μ (fig. 4). In some of these cleavage segments or incipient zoospores are present, but because of their shrunken condition, it is difficult to measure them accurately.

Only one subhemispherical, 240 μ high by 250 μ broad, resting spore gall with a sheath 2—3 cells thick, was found in sections of infected leaves. This gall contained a single oval, 86 ⇌ 129 μ, resting spore with a 3 μ thick, reddish-brown wall which was slightly rough from a sparse amount of adhering residue (fig. 5). No sporangial galls were present in association with this resting spore and its gall, and it is not certain that they relate to *S. shuteriae.* After the discovery of this gall the author examined all galls present on the leaves in the Stockholm collection without finding another resting spore. In view of this the author is inclined to believe that this gall and spore are extraneous or relate to another species. As noted previously this

species resembles very closely members of the subgenus *Woroninella.* Its galls are quite large and become cupulate when dehisced, and the sporangia are unusually numerous and small. Furthermore, it occurs on a genus of the Leguminosae, which is the host family of all known species of *Woroniella.* Its large galls and beaked sori are quite similar to those of *S. minutum,* but its sporangia are smaller than those of any other members of the subgenus. On the basis of the above characteristics the author is placing *S. shuteriae* temporarily in the subgenus *Woroninella,* but it is obvious that if the resting spore gall and spore noted above belong in its life cycle it is not a member of this subgenus.

In connection with this study of *S. shuteriae* several other questionable species were examined carefully in the Stockholm collection with the objective of determining their validity. These include *S. dendriticum* Fuckel, *S. centranthi* Rabenhorst, *S. bupleuri* Kunze, *S. trifolii* Passerini, *S. groenlandicum* Allescher, and *S. montanum* Zopf. As in the case of *S. shuteriae* the herbarium specimens were carefully studied in toto after which small heavily infected areas were thoroughly soaked in water, fixed in a vacuum to remove air, embedded, sectioned and stained to determine the structure of the galls and fungus.

Synchytrium dendriticum was collected by Fuckel on *Dentaria bulbifera* in Oestrich (Nassau) Germany and described by him (1866) as *Chytridium dendriticum* in the following manner: "tuberculis in foliorum paginae superioris in macula flavescenti, minutissimis dendriticoseratis, fuscis; soris solitariis, globosis, griseis; zoosporis globosis mnutissimis, hyalinis." In 1869 he transferred it to *Synchytrium* and gave the same diagnosis with the exception that the description of the zoospores was omitted. Since Fuckel's time it was reported from Switzerland on *Dentaria pinnata* by Cruchet (1906), but he did not describe it further. Tobler studied specimens of Fuckel's collection from Kew and found that the fungus occurs in the tissues between the lower and upper epidermis of the leaf. She regarded the reported sori as resting spores and believed that this is a valid species that might be related to *S. endobioticum* because of its deep-seated position in the host tissue. The author has studied part of Fuckel's original collection and confirms Tobler's observations on the position of the fungus, and its characteristics.

The fungus occurs in golden-yellow patches which may sometimes follow the veins and veinlets of the leaves and form rather well-defined spots or discolored areas. In the latter symptoms it is unlike most species of *Synchytrium.* As shown in fig. 6, the resting spores (?) occur in greatly enlarged palisade and mesophyll cells which are polyhedral, globular, 30—48 μ diam., or broadly pyriform

irregular vacuole (fig. 6, 7). Sections of more than a hundred spores in shape. The walls may be up to 3 μ in thick ness and are hyaline, but these may appear yellowish-golden from the color of the resting spore content when viewed *in toto*. The resting spores (?) usually fill the host cell only partly (fig. 7) and are sperical, 18—38 μ, or oval, 17—20 ⇌ 22—30 μ, with a 2—2.8 μ thick hyaline wall. The latter

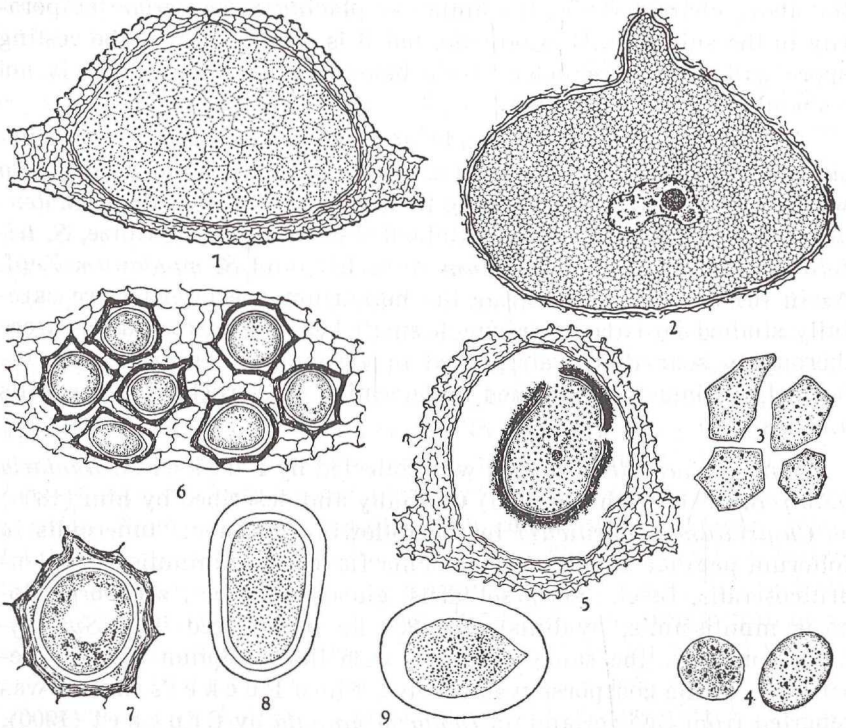

Fig. 1—5. *Synchytrium shuteriae;* fig. 6, 7. *S. dendriticum;* fig. 8, 9. *S. montanum.* Fig. 1. Sporangial gall with sorus of sporangia. × 145. Fig. 2. Unusually large beaked incipient sorus with collapsed primary nucleus. ×145. Fig. 3. Variations in polyhedral sporangia. × 733. Fig. 4. Oval and subspherical sporangia. × 733. Fig. 5. Questionable resting spore gall and spore of *S. shuteriae.* × 145. Fig. 6. Section of leaf with spores in thick-walled cells. × 180. Fig. 7. Enlarged thick-walled cell with oval spore. × 471. Fig. 8, 9. Oval and oblong hyaline bodies found in protuberances on leaves. ×177.

also may appear yellowish-golden from the content of the spore when examined *in toto*. Tobler reported that both the wall of the infected cell and spore are golden-yellow in color, but in the material examined by the author they are hyaline. In fixed and stained sections the content of the spore is not coarsely granular like that of *Synchytrium* spores, and the center is usually occupied by an

have been examined, but in none of them was a large *Synchytrium*-like primary nucleus found.

In view of these differences and characteristics the authors does not regard *S. dendriticum* as a valid member of *Synchytrium*. Fuckel (1866) reported the presence of minute, globose hyaline zoospores, but omitted them in his 1869 diagnosis. He did not describe their origin, size and structure, and it is, therefore, impossible to determine whether or not they are typical of *Synchytrium* zoospores. This fungus may possibly be an endophytic unicellular chytrid like *Olpidium,* or a small spored species of *Protomyces*. However, no unmistakable evidence of a mycelium was found in relation to the spores.

Synchytrium centranthi was collected by Hausknecht on *Centranthus elatus* at Achyrdagh, Marasch in Persia, Mar. 19, 1865, and diagnosed by Rabenhorst as follows: "hypnosporangiis plerumque 3—4 raris singulis, polyedricis, angulis plus minus rotundatis, aurantico fuscis, diam. 0.0213—0.033 mm." The material studied by the author is part of the original collection. No evidence of *Synchytrium* was visible on this material, but some of the leaves and petitioles were covered with white flat blisters which resemble those caused by *Albugo*. However, no spores were found in them. Tobler believed that the hypno-sporangia described by Rabenhorst might be immature sori or sporangia. She found only a few empty galls without sori, sporangia or resting spores in the original material deposited in the Berlin herbarium. In light of Tobler's and the author's observations, it is very doubtful that Rabenhorst's fungus is a species of *Synchytrium*.

Synchytrium bupleuri was collected by J. Kunze on *Bupleurum falcatum* in Saxony and Bohemia and described as a species of *Synchytrium* by Rabenhorst (1873). The author examined specimens of the original material collected by Kunze, Sept. 1872 in Saxony and found no evidence of *Synchytrium*. Several dark spots were present on the leaves, and these contained the mycelium of another fungus. The author thus confirms the observations of Magnus (1874) that this fungus is not a member of *Synchytrium*.

Synchytrium trifolii was collected by Passerini in May, 1877 on *Trifolium pratense* in Italy and described by Rabenhorst (1878) as follows: "sporae globosae, membrana exteriore luteo-fusca levi, interiore alba, gallae hemisphaericae epiphyllae." In 1885 Schroeter referred it to *Olpidium trifolii,* and later Magnus (1902) maintained that it belongs to *Physoderma (Urophlyctis) trifolii*. In a portion of the original material collected by Passerini the author found several large galls filled with resting sporangia of *Physoderma,* a few pustules with spores of a rust and numerous

minute black, necrotic, raised spores which are slightly gall-like in appearance. No evidence of *Synchytrium* was found in the latter spots, and they obviously do not relate to this group of fungi. Inasmuch as *Physoderma* is the most abundant fungus present, the author is inclined to agree with Magnus that Passerini mistook it for a species of *Synchytrium*. At any rate *S. trifolii* should be excluded from the genus as invalid.

Synchytrium groenlandicum was collected by E. Vanhöffen on *Saxifraga cernua* f. *ramosa* at Karajak-Nunatak, Umanakfjord, Greenland, Aug. 17, 1893, and established as a new species by Allescher (1897) who described it as follows: „Wärzchen in unreifem Zustande gelbgrünlich, halbkugelig, am Scheitel etwas niedergedrückt, oft vertieft, ca. 0.2—0.500 mm im Durchmesser. Dauersporen nicht gefunden." Although he was doubtful about its exact identity he was certain that it is a species of *Synchytrium* which resembles *S. mercurialis*. The author examined part of Vanhöffen's original collection in Stockholm and found numerous hyaline to greenish-yellow and greenish-golden protuberances with slight depressed centers which closely resemble galls. These occur abundantly on both surfaces of the leaf, and are usually separate but occasionally confluent and glistening in appearance. Even after thoroughly soaking in water they are extremely hard, and flinty, and include hyaline to yellowish bodies which look and feel like grains of sand. These bodies are oval to elongate and irregular in shape, extremely hard, and are very unlike thalli of *Synchytrium*. In fixed and stained sections of infected leaves such bodies are present in enlarged flattened epidermal cells as well in the palisade and mesophyll tissues. Tobler also studied part of Vanhöffen's collection in Berlin and reported that she found nothing that looked like *Synchytrium* on the host. In light of Tobler's and the present study, *S. groenlandicum* is regarded by the author as invalid.

Synchytrium montanum was collected and described by Zopf (1903) on *Brunella vulgaris* at altitudes of 1500 to 5000 ft. in Tirol, Salzburg and the Black Forest of Germany. He reported that it causes dark-violet to violet-brown, readily visible scattered spots which protrude only slightly above the surface of the epidermis. In each of the epidermal cells occur 1 to 4 egg-shaped or pyriform, 154 μ wide by 176 μ long, resting spores whose content is hyaline and rich in fatty material. The wall also is hyaline and composed of a thick endospore and exospore. The author studied part of the original collection from Innsbruck and found the spots to be as Zopf had described them. However, no *Synchytrium* spores were present in the epidermal cells. Instead, oblong, egg-shaped 96—120 ⇌ 115—140 μ or spherical 80—180 μ hyaline bodies with walls up to 12 μ

thick, and homogeneous hyaline content were found in enlarged epidermal cells as shown in fig. 8 and 9. Apparently, these are the bodies found by Zopf, but they do not relate to *Synchytrium*. Some of them resemble somewhat insect eggs, and others look like cysts of endophytic algae. Similar bodies in almost identical raised spots have been found by the author on numerous species of *Penstemon* from the Pacific northwest states of the U.S.A. Accordingly, if the sample of Zopf's collection which was studied by the author is representative, *S. montanum* is not a valid species.

Summary.

In a study of the original collections of several questionable species of *Synchytrium* at the Riksmuseet in Stockholm, Sweden, *S. shuteriae* was found by the author to be a valid species which appears to be related to members of the subgenus *Woroniella*. No conclusive evidence of *Synchytrium* was found in the herbarium specimens which bear the labels *S. dendriticum, S. centranthi, S. trifolii, S. bupleuri, S. groenlandicum,* and *S. montanum*. In specimens of the first four of these species other fungi instead of *Synchytrium* are present, and in the last two the bodies of spores present relate to other unknown organisms. Accordingly, if the material examined is representative, these six species should be excluded from the genus, in the author's opinion.

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