Synchytrium namae Karl.*

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With 15 textfigures.

Synchytrium namae was created by the author (1956) for a parasite on *Nama hispidum* which Constance and Lundell collected in Starr Co., Texas. Subsequently, in studying herbarium specimens from W. H. Long's collection at Cornell University I found that it occurs on *Nama jamaicense* also. The latter specimens were collected in Texas in 1901, but the collector and locality are not listed on the herbarium sheet. Inasmuch as the material is from Long's collection I am assuming that he collected it at or near Austin, Texas in Travis County.

Only resting spores were found in both of these collections, and for this reason *S. namae* was described as a short-cycled, simply monogallic species and placed in the subgenus *Pycnochytrium*. In April 1958, I found it abundantly on *Nama jamaicense* near Austin, Texas, and a study of living material showed that it is a longcycled, simply dihomeogallic species which forms both sporangial sori and resting spores. Accordingly, my previous description and classification are incomplete, and this contribution is presented to supplement them and to diagnose and classify *S. namae* more accurately. On the basis of this new data, it may be diagnosed as follows:

Prosori usually solitary, rarely 2 in a cell, ovoid, 44—60 × 58—70 μ, subspherical, 45—80 μ, to almost hemispherical or reniform with amber walls, 1.5—2 μ thick; usually lying at one side of sori when empty. Sori subspherical 52—86 μ, or ovoid, 50—60 × 63—78 μ; plugs between empty prosori and sori disc-shaped and oval, 8—11 × 12—16 μ, or almost circular 9—18 μ in outline. Sporangia 4—20 per sorus, polyhedral, 30—50 μ in greatest diameter, small ones 18—26 μ, exceptionally large ones 55—60 μ with golden-red content; usually bursting out of gall and lying in a powdery mass on host around gall at maturity. Zoospores ovoid to oblong and elongate while actively swimming, 2—3 × 4—5 μ, with a golden-red globule and a 11—14 μ long whip-lash flagellum. Resting spores usually solitary, sometimes 2 in a cell, spherical, 36—78 μ or ovoid, 24—50 × 32—72 μ, with a

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smooth dark amber-brown wall, 4—6 μ thick; enveloping residue abundant and dense or sparse or lacking; germination unknown.

Simply dihomeogallic, galls abundant on stems, petioles and both surfaces of leaves but causing no malformation of host. Spo-

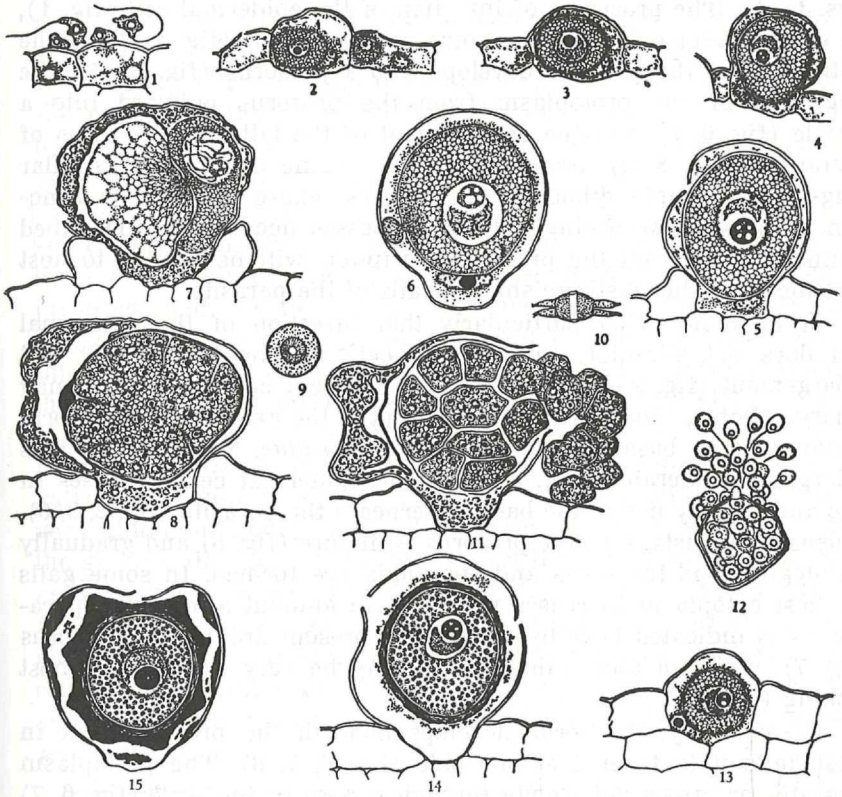

Fig. 1—15. *Synchytrium namae*. Fig. 1. Infection of living epidermal cells. × 280. Fig. 2, 3. Young parasites in enlarging host cells; host nucleus in base of cells. × 240. Fig. 4, 5. Later stages in development of gall and initial cell or prosorus of parasite. × 240. Fig. 6. Mature prosorus; protoplasm beginning to grow out at left. × 240. Fig. 7. Later stage in sorus development from prosorus; primary nucleus has migrated into incipient sorus. × 240. Fig. 8. Cleavage in sorus; collapsed prosorus, plug and residue at left. × 240. Fig. 9, 10. Surface and cross sections of plug. × 500. Fig. 11. Bursting of sorus and gall walls, liberating sporangia on surface of host. × 260. Fig. 12. Discharge of zoospores from sporangium. × 460. Fig. 13. Young stage of resting spore development. × 240. Fig. 14, 15. Mature resting spores with sparse and abundant enveloping residue. × 280.

rangial galls orange-colored, subspherical, 80—150 μ, to broadly obpyriform, 85—100 × 95—120 μ, or broadly clavate with a hyaline wall, 2.8—4 μ thick. Resting-spore galls dark-brown, subspherical 60—130 μ, ovoid, 48—65 × 52—84 μ, broadly obpyriform, 36—38 × 60—

80 μ, or oblong, 52—60 × 80—110 μ, with a hyaline wall, becoming cups-shaped, or potyhedral, or wrinkled after drying oul.

On *Nama hispidum* and *N. jamaicense,* Starr and Travis Counties, Texas, U.S.A.

The basic developmental phases of *S. namae* are shown in figs. 1—15. The processes of infection of the epidermal cell (fig. 1), its enlargement outward to become a simple gall (fig. 2, 3) as the initial cell of the parasite develops into a prosorus (fig. 3—5), the migration of the protoplasm from the prosorus outward into a vesicle (fig. 6, 7), and the development of the latter into a sorus of sporangia (fig. 8, 9) are essentially the same as those of similar long-cycled, simply dihomeogallic species whose initial cells function as prosori. Accordingly, these processes need not be described again in detail, and the present description will be limited to host reaction and other distinguishing details of the parasite.

It is to be noted particularly that infection of the epidermal cell does not stimulate mitosis and cell division but merely cell enlargement (fig. 2—6). Occasionally, adjacent epidermal cells may enlarge slightly outward (fig. 7), but not to the extent that they form a rudimentary basal sheath as in *S. potentillae.* The host nucleus enlarges considerably (fig. 3, 6) as the epidermal cell increases in size and usually lies in the base underneath the parasite (fig. 2, 3, 6). It usually persists until the prosorus is mature (fig. 6) and gradually disintegrates as the sorus and sporangia are formed. In some galls the host cytoplasm increases markedly in amount around the parasite, as is indicated later by the residue present around the prosorus (fig. 7), while in others the residue may be very scarce or almost lacking (fig. 6).

Occasionally, the sorus develops beneath the prosorus, but in most galls it is formed at one side (fig. 6, 7, 8). The protoplasm migrates or grows out slowly through a pore in the wall (fig. 6, 7) to form a vesicle which develops a walls of its own and eventually becomes the sorus. The prosorus and sorus, however, remain attached at the pore, and this attachment is accomplished by the formation of a dense staining plug in this region (fig. 8) as I (1955 a, b) have described in several species whose initial cell functions as a prosorus. In *S. namae* this plug is quite conspicuous, and in median sections has the appearance of an oval or circular discus whose thickness decreases towards the periphery. In surface views of carefully fixed and stained preparations of the plug three concentric zones are visible — an outer lightly-stained zone, a median denser zone, and a small almost hyaline central zone (fig. 9). Cross sections (fig. 10) of the plug indicate that these zones correspond to differences in degree of thickening of the prosorus and sorus walls.

As the sorus develops and its content cleaves into sporangia (fig. 8) it apparently expands, and this leads to a slight lateral elongation of the gall. As shown in fig. 8 of a median section of this stage the sorus lies slightly to one side with the collapsed prosorus and residue at the opposite side. Further expansion of the sorus and sporangia causes the walls of the sorus and gall to burst, and the sporangia are thereby released onto the surface of the host (fig. 11). As they dry out they appear as powdery golden red masses around the galls, and this is a characteristic appearance of *S. namae.* At this stage the portion of the gall containing the collapsed prosorus and residue appears as an invaginated cap at one side (fig. 11).

So far no gametic fusions have been seen in relation to resting spore formation. Its development and the reaction of the host cell to its presence are basically the same as described for the incipient prosorus. The resting spore may be distinguished fairly early (fig. 13) by its denser and more granular cytoplasm and a gradual thickening of its wall, and as it attains maturity the cytoplasm has the appearance of minute granular islands suspended in a hyaline background (fig. 14, 15). The amount of residue which envelops the mature spore varies markedly as in the case of the prosori. In some galls it is lacking almost entirely (fig. 14), while in others it may be very abundant and forms a dense broad layer closely adherent to the spore wall (fig. 15). In this respect the reaction of *Nama jamaicense* appears to be different from that of *N. hispidum* where I (1956) found the residue to be very abundant in most resting-spore galls. Attempts to induce resting spore germination by long refrigeration and alternate drying and wetting of the spores have failed, and it is not known whether they function as prosori or sporangia in germination *).

So far only five simply dihomeogallic species are known, and this study of *S. namae* adds a sixth one to the list. Of these only *S. maculans* is fully known and belongs in the subgenus *Microsynchytrium. Synchytrium amsinckiae* has been placed in this subgenus also, while the other three, *S. papillatum, S. trichophilum,* and *S. eremocarpae,* have been assigned to *Pycnochytrium.* However, resting spore germination has not been observed in any of these five species, and their classification is, accordingly, tentative. *Synchytrium namae* is placed temporarily in *Microsynchytrium,* pending discovery of the manner in which the resting spores germinate.

Insofar as its known life cycle is concerned it resembles *S. maculans* and *S. amsinckiae* which parasitize *Sida rhombifolia* and *Am-*

*) „Since this paper went to press the resting spores have been found to function as prosori in germination. Accordingly, *S. namae* belongs in the subgenus Microsynchytrium."

sinickiae intermedia, respectively, but its sori, sporangia and resting spores as well as the galls which it induces are generally smaller than those of these species. Also, its sorus is usually formed at one side of the prosorus instead of underneath as in *S. amsinckiae.*

McMurphy's (1913) and Lingappa's (1955) studies suggest that *S. amsinckiae* and *S. maculans* have very limited host ranges and will not infect any but their respective hosts. If this proves to be true it is not likely that either of them will be found on *Nama* species. So far, no host range studies have been made with *S. namae,* but in this connection it may be noted that it did not occur on any of the numerous species such as *Stachys agraria, Prunella vulgaris, Stellaria media, Cerastium viscosum, Geranium carolineanum, Dichondra repens, Abutilon theofrasti, Oenothera biennis, Trifolium repens* and other weeds growing among the infected *Nama jamaicense* plants.

Synchytrium stachydis was found in great abundance on *Stachys agraria* in the same locality as *S. namae,* but it did not occur on *N. jamaicens* or any of the other plants listed above. This species was reported from Louisiana by Cook (1945 a, b), and the discovery of its presence in Texas extends its range considerably. Doubtless, it will be found elsewhere in the southern and southwestern states where *Stachys agraria* occurs. In the space of an acre in Texas hundreds of plants were found to be infected with the characteristic symptoms of yellow swollen stems and branches. Such plants were transplanted to the greenhouses at Purdue and have been maintained for more than eight months. Zoospores from such infected plants were placed on the emerging leaves of *Stachys hispida* where they caused symptoms similar to those on *S. agraria.*

Summary.

Synchytrium namae, which was previously described by the author as a short-cycled species of the subgenus *Pycnochytrium,* has been found to be long-cycled on *Nama jamaicense* in Texas. It produces prosori, sori, sporangia, zoospores and resting spores in succession, and for this reason it is transferred tentatively to the subgenus *Microsynchytrium,* pending discovery of the method by which its resting spores germinate.

Synchytrium stachydis Cook was found in great abundance on *Stachys agraria* in the same locality as *S. namae* and transferred to *Stachys hispida* on which it caused symptoms similar to those on *S. agraria.*

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