STUDIES ON SCLEROTIUM DELPHINII WELCH WITH A
CONSIDERATION OF ITS RELATIONSHIP TO SCLEROTIUM
ROLFSII SACC.

By

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Advisory Committee

[Signatures]

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The writer wishes to take this opportunity to express his sincerest thanks to Dr. A.J. Mix, head of the Department of Botany, without whose timely suggestions and helpful criticisms this work could not have been completed.
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PART I.

CONSIDERATION OF THE DISEASE CAUSED BY SCLEROTIUM DELPHINII.
STUDIES ON SCLEROTIUM DELPHINII WELCH WITH A
CONSIDERATION OF ITS RELATIONSHIP TO SCLEROTIUM ROLFSII
SACC.

Introduction.

Although not undertaken until some time later, this piece of research had its conception in the late summer of 1934. It was at this time that Dr. A.J. Mix isolated from Ajuga reptans L. a fungus that was causing severe wilting, and subsequent death to the plants attacked. In addition to Ajuga the organism was parasitizing Sedum acre L. and Lysimachia nummularia L.

The fungus produced numerous sclerotia both in nature and in culture. There were no fruiting bodies produced. It apparently belonged to the genus Sclerotium of the fungi imperfecti, resembling most closely the species Sclerotium delphinii Welch and S. rolfsii Sacc. To aid in identifying the pathogene, cultures of these two species were obtained from investigators in various parts of the country. As a result of comparisons made with cultures of the above two species this isolate from Ajuga was judged to be most similar to S. delphinii Welch. This marked the first record of this species in the state (34) although Bartholomew (3) includes S. rolfsii in his list of the Fungus Flora of Kansas.

Sclerotium delphinii was named by Welch in 1924 (55). It was never described, however, and technically the
name has no standing in the literature, although it has been rather generally accepted.

Among the cultures received of both Sclerotium delphini and S. rolfsii, considerable morphological variation was noted even among isolates of the same species. This was especially true with regard to sclerotial characteristics.

Although S. rolfsii has received wide mention in the literature as a most destructive soil inhabiting fungus since it was discovered by Rolfs in 1892, and described and named by Saccardo (43) in 1911, comparatively little work has been done with S. delphini.

Preliminary examinations referred to above suggested a rather fertile field for investigation; namely a more or less detailed pathological, morphological, and physiological study of S. delphini and, in the light of these studies, to consider its relationship to the more widely known S. rolfsii.
A. Hosts affected by \textit{S. delphini}\,i

In the course of a general study of this fungus from \textit{Ajuga} it was decided to investigate the host range and to make a few comparisons with \textit{S. rolfsii}. The latter, because of its wide geographical distribution and economic importance as a plant pathogene, has received considerable mention in the literature and is known to be parasitic on nearly two hundred hosts. \textit{Sclerotium delphini\,i} on the other hand has been reported on only about forty species. These have been compiled and are listed in Table 1. Unfortunately some workers gave only the common names for some of the hosts and where there is doubt as to the correct scientific name, either just the genus name or the common name is listed.

Inoculation-experiments conducted by the writer have shown that \textit{S. delphini\,i}, like \textit{S. rolfsii}, has a rather wide host range. These inoculation-experiments were conducted in a greenhouse. By means of a sterilized scalpel, a small amount of mycelium from a plate-culture was transferred to the soil adjacent to the roots of a potted plant. In no instance was the pathogene introduced directly either by puncturing or wounding the host plant in any way. While much of this work was carried out in a moist-chamber compartment, infection was also obtained in plants not kept in the chamber. The increased humidity of the moist chamber, however, did induce more rapid destruction of the parasitized plants.
<table>
<thead>
<tr>
<th>Hosts of Sclerotium delphini previously reported with reference by number to literature cited</th>
<th>Literature Cited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ajuga reptans L.</td>
<td>34, 55</td>
</tr>
<tr>
<td>Ambrosia sp.</td>
<td>45</td>
</tr>
<tr>
<td>Asimina triloba L. (seedlings)</td>
<td>36</td>
</tr>
<tr>
<td>Belamcanda chinensis DC.</td>
<td>45</td>
</tr>
<tr>
<td>Brassica oleracea var. capitata L.</td>
<td>36</td>
</tr>
<tr>
<td>Brassica sp.</td>
<td>36</td>
</tr>
<tr>
<td>Capsicum anuum L.</td>
<td>36</td>
</tr>
<tr>
<td>Cucumis sativus L.</td>
<td>46</td>
</tr>
<tr>
<td>Cucurbita maxima Duchesne</td>
<td>36</td>
</tr>
<tr>
<td>Delphinium sp.</td>
<td>18, 27, 45, 36, 46</td>
</tr>
<tr>
<td>Eupatorium sp.</td>
<td>55</td>
</tr>
<tr>
<td>Funkia sp.</td>
<td>45</td>
</tr>
<tr>
<td>Golden banded lily of Japan</td>
<td>45</td>
</tr>
<tr>
<td>Iris</td>
<td>49, 12, 13, 26, 27, 45, 55</td>
</tr>
<tr>
<td>Lagenaria leucantha Rusby</td>
<td>36</td>
</tr>
<tr>
<td>Lilium candidum L.</td>
<td>45</td>
</tr>
<tr>
<td>Lilium regale Wls.</td>
<td>27, 46</td>
</tr>
<tr>
<td>Linaria vulgaris L.</td>
<td>45</td>
</tr>
<tr>
<td>Luffa acutangula Roxb.</td>
<td>36</td>
</tr>
<tr>
<td>Lycopersicon esculentum Mill.</td>
<td>36</td>
</tr>
<tr>
<td>Lysimachia nummularia L.</td>
<td>34</td>
</tr>
<tr>
<td>Mangivera indica L.</td>
<td>36</td>
</tr>
<tr>
<td>Melon</td>
<td>46</td>
</tr>
<tr>
<td>Monordica charantia L.</td>
<td>36</td>
</tr>
<tr>
<td>Narcissus sp.</td>
<td>27</td>
</tr>
<tr>
<td>Oryza sativa L.</td>
<td>36, 46</td>
</tr>
<tr>
<td>Phlox sp.</td>
<td>45</td>
</tr>
<tr>
<td>Physostegia virginiana Benth.</td>
<td>27</td>
</tr>
<tr>
<td>Pyrethrum daisy (Chrysanthemum coccineum Willd.)</td>
<td>45</td>
</tr>
<tr>
<td>Raphanus sativus L.</td>
<td>36</td>
</tr>
<tr>
<td>Sedum acre L.</td>
<td>34</td>
</tr>
<tr>
<td>Sedum sp.</td>
<td>55</td>
</tr>
<tr>
<td>Solanum melongena var. esculentum Nees</td>
<td>36</td>
</tr>
<tr>
<td>Tradescantia spp.</td>
<td>55</td>
</tr>
<tr>
<td>Tulipa sp.</td>
<td>26, 49</td>
</tr>
<tr>
<td>Verbena sp.</td>
<td>45</td>
</tr>
<tr>
<td>Vigna sinensis Endl.</td>
<td>36</td>
</tr>
<tr>
<td>Viola sp.</td>
<td>45</td>
</tr>
<tr>
<td>Yellow daisy</td>
<td>45</td>
</tr>
</tbody>
</table>
Table 2. Results of inoculation of various host plants with *S. delphini*. Symbol "D" indicates infection and subsequent death of plant, "R" indicates infection but recovery of host plant, and "O" indicates no infection.

<table>
<thead>
<tr>
<th>Host Plant</th>
<th>Degree of Susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achillea ptarmica L.</td>
<td>R</td>
</tr>
<tr>
<td>Ajuga reptans L.</td>
<td>D</td>
</tr>
<tr>
<td>Agrostemma coronaria L.</td>
<td>D</td>
</tr>
<tr>
<td>Althea rosea Cav.</td>
<td>D</td>
</tr>
<tr>
<td>Alyssum saxatile L.</td>
<td>R</td>
</tr>
<tr>
<td>Amaranthus tricolor L.</td>
<td>R</td>
</tr>
<tr>
<td>Angallis grandiflora Andr.</td>
<td>D</td>
</tr>
<tr>
<td>Anchusa caepensis Thunb.</td>
<td>D</td>
</tr>
<tr>
<td>Anemone sp.</td>
<td>D</td>
</tr>
<tr>
<td>Antirrhinum sp.</td>
<td>D</td>
</tr>
<tr>
<td>Aquilegia canadensis L.</td>
<td>D</td>
</tr>
<tr>
<td>Aquilegia (single mixed)</td>
<td>D</td>
</tr>
<tr>
<td>Aquilegia sp.</td>
<td>D</td>
</tr>
<tr>
<td>Apium graveolens L.</td>
<td>D</td>
</tr>
<tr>
<td>Arabis alpina L.</td>
<td>D</td>
</tr>
<tr>
<td>Begonia sp.</td>
<td>D</td>
</tr>
<tr>
<td>Boltonia latiscruma Gray</td>
<td>R</td>
</tr>
<tr>
<td>Brassica oleracea botrytis L.</td>
<td>D</td>
</tr>
<tr>
<td>Calceolaria sp.</td>
<td>D</td>
</tr>
<tr>
<td>Campanula carpatica Jacq.</td>
<td>D</td>
</tr>
<tr>
<td>Campanula persicifolia L.</td>
<td>D</td>
</tr>
<tr>
<td>Centaurea americana Nutt.</td>
<td>D</td>
</tr>
<tr>
<td>Centaurea montana L.</td>
<td>D</td>
</tr>
<tr>
<td>Cerastium tomentosum L.</td>
<td>D</td>
</tr>
<tr>
<td>Cheiranthus cheiri L.</td>
<td>D</td>
</tr>
<tr>
<td>Chenopodium sp.</td>
<td>D</td>
</tr>
<tr>
<td>Chrysanthemum maximum Ram.</td>
<td>D</td>
</tr>
<tr>
<td>Chrysanthemum sp.</td>
<td>D</td>
</tr>
<tr>
<td>Cobaea scandens Cav.</td>
<td>D</td>
</tr>
<tr>
<td>Coreopsis grandiflora Nutt.</td>
<td>D</td>
</tr>
<tr>
<td>Cymbalaria muralis Gaertn., Mey and Scherb..</td>
<td>D</td>
</tr>
<tr>
<td>Dahlia sp.</td>
<td>D</td>
</tr>
<tr>
<td>Delphinium ajacis L.</td>
<td>D</td>
</tr>
<tr>
<td>Delphinium chinensis Fisch.</td>
<td>D</td>
</tr>
<tr>
<td>Delphinium (Gold Medal Hybrids)</td>
<td>D</td>
</tr>
<tr>
<td>Dianthus barbatus L.</td>
<td>R</td>
</tr>
<tr>
<td>Dianthus caryophyllus L.</td>
<td>R</td>
</tr>
<tr>
<td>Dianthus deltoides L.</td>
<td>R</td>
</tr>
<tr>
<td>Dianthus plumarius L.</td>
<td>R</td>
</tr>
<tr>
<td>Host Plant</td>
<td>Degree of Susceptibility</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Digitalis purpurea L.</td>
<td>D</td>
</tr>
<tr>
<td>Digitalis purpurea glomeriflora Vilm.</td>
<td>D</td>
</tr>
<tr>
<td>Felicia amelloides Voss.</td>
<td>B</td>
</tr>
<tr>
<td>Gaillardia aristata Pursch.</td>
<td>D</td>
</tr>
<tr>
<td>Gilia capitata Doug.</td>
<td>D</td>
</tr>
<tr>
<td>Gypsophila muralis L.</td>
<td>D</td>
</tr>
<tr>
<td>Gypsophila paniculata L.</td>
<td>D</td>
</tr>
<tr>
<td>Gypsophila repens L.</td>
<td>D</td>
</tr>
<tr>
<td>Helianthemum vulgare Gaertn.</td>
<td>D</td>
</tr>
<tr>
<td>Helichrysum sp.</td>
<td>D</td>
</tr>
<tr>
<td>Hesperis matronalis L.</td>
<td>D</td>
</tr>
<tr>
<td>Impatiens balsamina L.</td>
<td>D</td>
</tr>
<tr>
<td>Ionopsisium acaule Reichb.</td>
<td>D</td>
</tr>
<tr>
<td>Lactuca sativa capitata L.</td>
<td>D</td>
</tr>
<tr>
<td>Lantana sp.</td>
<td>D</td>
</tr>
<tr>
<td>Lathyrus odoratus L.</td>
<td>R</td>
</tr>
<tr>
<td>Lavendula spica L.</td>
<td>D</td>
</tr>
<tr>
<td>Leptosiphon sp.</td>
<td>D</td>
</tr>
<tr>
<td>Lobelia erinus L.</td>
<td>R</td>
</tr>
<tr>
<td>Lunaria annua L.</td>
<td>D</td>
</tr>
<tr>
<td>Lupinus hartwegii Londl.</td>
<td>D</td>
</tr>
<tr>
<td>Lupinus sp.</td>
<td>D</td>
</tr>
<tr>
<td>Lychnis chalcedonica L.</td>
<td>R</td>
</tr>
<tr>
<td>Lychnis coronaria Desv.</td>
<td>R</td>
</tr>
<tr>
<td>Lychnis viscaria L.</td>
<td>R</td>
</tr>
<tr>
<td>Lycopersicon esculentum Mill.</td>
<td>D</td>
</tr>
<tr>
<td>Lysimachia nummularia L.</td>
<td>D</td>
</tr>
<tr>
<td>Mesembryanthemum crystallinum L.</td>
<td>D</td>
</tr>
<tr>
<td>Mesembryanthemum tricolor Willd.</td>
<td>D</td>
</tr>
<tr>
<td>Myosotis sylvatica Hoffm.</td>
<td>R</td>
</tr>
<tr>
<td>Narcissus tazetta L.</td>
<td>D</td>
</tr>
<tr>
<td>Oxalis rubra St. Hil.</td>
<td>D</td>
</tr>
<tr>
<td>Oenothera missouriensis Sims.</td>
<td>D</td>
</tr>
<tr>
<td>Papaver nudicaule L.</td>
<td>D</td>
</tr>
<tr>
<td>Papaver orientale L.</td>
<td>D</td>
</tr>
<tr>
<td>Parthenocissus tricuspidata Planch.</td>
<td>R</td>
</tr>
<tr>
<td>Pelargonium hortorum Bailey.</td>
<td>O</td>
</tr>
<tr>
<td>Petunia hybrida Vilm.</td>
<td>D</td>
</tr>
<tr>
<td>Phaseolus limensis Macf.</td>
<td>R</td>
</tr>
<tr>
<td>Physostegia virginiana Benth.</td>
<td>D</td>
</tr>
<tr>
<td>Platycodon grandiflorum DC.</td>
<td>O</td>
</tr>
<tr>
<td>Polemonium caeruleum L.</td>
<td>D</td>
</tr>
<tr>
<td>Portulaca grandiflora Hook.</td>
<td>D</td>
</tr>
<tr>
<td>Primula sp.</td>
<td>D</td>
</tr>
<tr>
<td>Host, Plant</td>
<td>Degree of Susceptibility</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Riginaeus, comminis, L.</td>
<td>D</td>
</tr>
<tr>
<td>Rosmarinus officinalis L.</td>
<td>D</td>
</tr>
<tr>
<td>Saponaria occidentes L.</td>
<td>R</td>
</tr>
<tr>
<td>Santavitalis procumbens Lam.</td>
<td>D</td>
</tr>
<tr>
<td>Sedum acre, L.</td>
<td>D</td>
</tr>
<tr>
<td>Sedum mixed.</td>
<td>D</td>
</tr>
<tr>
<td>Solanum tuberosum L.</td>
<td>D</td>
</tr>
<tr>
<td>Solanum triflorum Nutt.</td>
<td>D</td>
</tr>
<tr>
<td>Tagetes, lucida, Cav.</td>
<td>R</td>
</tr>
<tr>
<td>Tagetes, sigmoida, Bartl.</td>
<td>R</td>
</tr>
<tr>
<td>Taraxacum officinale, Weber</td>
<td>D</td>
</tr>
<tr>
<td>Trachymene caerulea R. Graham</td>
<td>D</td>
</tr>
<tr>
<td>Turnica, saxifrage, Scop.</td>
<td>D</td>
</tr>
<tr>
<td>Verbena, hybrida, Voss.</td>
<td>R</td>
</tr>
<tr>
<td>Veronica, incana, L.</td>
<td>R</td>
</tr>
<tr>
<td>Veronica, longifolia, L.</td>
<td>R</td>
</tr>
<tr>
<td>Veronica, tenuissimum, L.</td>
<td>R</td>
</tr>
<tr>
<td>Veronica, repens, DC</td>
<td>R</td>
</tr>
<tr>
<td>Veronica, sp.</td>
<td>R</td>
</tr>
<tr>
<td>Viola, cucullata, Ait.</td>
<td>D</td>
</tr>
<tr>
<td>Viola, rafinesqui, Greene</td>
<td>D</td>
</tr>
<tr>
<td>Viola, tricolor, hortensis, DC</td>
<td>D</td>
</tr>
<tr>
<td>Zea, mays, indentata, Bailey</td>
<td>0</td>
</tr>
</tbody>
</table>
Those species inoculated are listed alphabetically in Table 2. The scientific names are taken from Bailey's Manual of Cultivated Plants and Rydberg's Flora of the Prairies and Plains of Central North America.

Of the 106 host species listed in Table 2, only three were found to be completely resistant to the pathogen. These were *Platycodon grandiflorum*, *Zea mays indentata* and *Pelargonium hortorum*. A limited number of plants such as various species of *Dianthus* and *Arabis*, *Lathyrus odoratus* and *Tagetes sigmata* are listed as being only weakly susceptible, in that while they became infected and showed some symptoms, these plants did not succumb. Of this list of host plants only six are included in Table 1, thus adding a hundred hosts to the list for this organism.

It is apparent that *S. Delphini* has potentially as long a host list as that of *S. rolfsii*. The symptoms induced by the two species, as will be seen in the following page, are practically identical and in this connection it is also of interest to note that some of the dissimilarities of these two species so apparent on culture media are not so noticeable on diseased plants. Plate II, Fig. 4 shows *S. delphini* on *Sedum acre*. The numerous uniformly small and globose shaped sclerotia observed here are characteristic of *S. rolfsii*. This appearance of *S. Delphini* when parasitizing a plant,
together with the fact that several intermediate forms have been isolated by other investigators, raises some doubt as to whether these two fungi should be regarded as separate species. Stevens (45) after comparative studies of *S. rolfsii* and *S. delphiniii*, and Palo (36) who studied *S. delphiniii* on mango, were of the opinion that the two fungi should be so regarded. Takahasi (46) and others agree.

Under the conditions reported on the preceding pages *Zea mays indentata* proved to be immune from attack by *S. delphiniii*. In a later experiment however, in which conditions more favorable for the growth of the fungus were employed, seedlings of corn were easily parasitized by *S. delphiniii*.

Seeds of corn were sterilized and then grown on agar as pictured on Pl. VII, Fig. 1. After the seedlings had reached a height of about three inches the medium of some of the tubes was inoculated with sclerotia of the fungus. Mycelium growing from the sclerotia killed the seedlings within a week's time. Corn seedlings killed by the fungus are pictured in Pl. VII, Fig. 2.

Of course, in this experiment, conditions for infection by the fungus were much more favorable than would likely ever be encountered in nature, and in the field there would be little danger of *S. delphiniii* proving to be a menace to corn. It is interesting from the standpoint of immunity, however, in that it suggests that certain plants, ordinarily not attacked by the
fungus in the field and showing resistance in greenhouse inoculation-experiments may be attacked under optimum conditions.

Whether this would hold true with woody plants the writer cannot say. *S. delphini* is not known to be parasitic on any woody plants although *S. rolfsii* is known to attack apple (4) and peach (21).

The optimum conditions afforded *S. delphini* in the test tube experiment included a relatively high humidity and an abundant food supply. The latter enabled the fungus to develop well as a saprophyte and presumably to develop toxins necessary to kill the host plant. Furthermore the fungus was able to attack the roots of the corn seedlings while in nature it generally attacks the base of the stem.
1. Gross Symptoms

In parasitizing a plant this pathogene generally attacks the stem at soil-level either by completely enclosing the stem-base with a weft of mycelium, as shown in Plate II, Fig. 1, or by sending out rather thick strands of mycelium that only partially envelope the stem (Pl. II, Fig. 3); the latter method of attack being the more common. In either event the results are the same. The surface of the affected area assumes a brown water-soaked discoloration; the parts above this soft-rotted region wilt, and as infection progresses, the whole plant dies. These stages usually all take place within a week’s time.

The soil surrounding the affected plant may, if sufficiently moist, become covered with a luxuriant growth of mycelium from which numerous sclerotia may develop as seen in Plate II, Fig. 4. Sclerotia developed on parasitized plants are invariably smaller than those produced on artificial media.
2. Histological Symptoms

Since no information concerning the pathological histology of *Sclerotium delphini* appears in the literature, and since such information would offer further opportunity for comparison of *S. delphini* with *S. rolfsii*, it seemed desirable to make sections of infected tissues for microscopic examination. Sections were taken from plants in both early and late stages of infection.

Regardless of whether the fungus attacks the stem at soil-level by enclosing the stem base with a weft of mycelium (Plate 2, Fig. 1) or merely by sending out rather thick strands of mycelium that only partially envelege the stem, (Plate 2, Fig. 3) contact to the stem, and subsequent penetration, is effected by short compact holdfast-cells. (Plate VII, Fig. 4. This figure shows a number of these holdfast-cells in contact with the epidermis in addition to a few intracellular hyphae.) In early stages of infection cells underlying the epidermis are killed before their actual penetration which, in the case of *Sclerotium delphini*, appears to be by mechanical means. This opinion is arrived at by noting a bulging of the holdfast-cell where it is about to penetrate an epidermal cell (Plate VII, Fig. 5). As can also be seen from Pl. VII, Fig. 3 the fungus, at least in early stages of infection does not dissolve out
the middle lamellae between cell walls, but is intracellular in habit. Sections like the one pictured when mounted in calcium chloride solutions to test for oxalic acid, all gave positive tests indicating that oxalic acid or oxalates may play a role in the parasitism of *S. delphini*. 
PART II.

MORPHOLOGICAL STUDIES
1. Repetition of Stevens' Work

Only one investigator, Stevens (45) has made any careful attempt to distinguish between the two species in question. He worked with four strains of *S. delphini* and one of *S. rolfsii*, growing them on different media including carrot-, potato-destrose-, corn meal-, and tap-water-agar in addition to mush, rice and halved oranges. He recorded the average size of the sclerotia and type of mycelium developed on the various media. His observations led him to make the following conclusions as to the distinguishing characteristics of the two species.

<table>
<thead>
<tr>
<th>Feature</th>
<th>S. rolfsii</th>
<th>S. delphini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycelium</td>
<td>densely floccose 2.</td>
<td>not floccose 1.</td>
</tr>
<tr>
<td></td>
<td>not ropy 2.</td>
<td>ropy 2.</td>
</tr>
<tr>
<td>Sclerotia</td>
<td>not concave 1.</td>
<td>concave 2.</td>
</tr>
<tr>
<td></td>
<td>very numerous 2.</td>
<td>surface marked 2.</td>
</tr>
<tr>
<td></td>
<td>not surface marked 1.</td>
<td>color ochraceous buff to tawny to (\text{Hays brown 1.})</td>
</tr>
<tr>
<td></td>
<td>color pinkish buff to olive brown to clove brown 1.</td>
<td>less numerous 2.</td>
</tr>
<tr>
<td>Germination</td>
<td>small 1.</td>
<td>larger 2.</td>
</tr>
</tbody>
</table>

**Germination**

- single threads 2.
- fascicled 2.

1. constant
2. is not constant
Of all the characteristics listed on the preceding page only one, sclerotial-solor was found to be constant. Other differences usually observed were the number of sclerotia produced and the presence or absence of markings on these bodies. Stevens found that growing the different strains on media of low nutritive value made them lose nearly all of their differential characters. He also found the four races of _S. delphini_ which he studied to be antagonistic to each other as well as to the one strain of _S. rolfsii_ he used.

Part of Stevens' work was duplicated using the following isolates of _S. rolfsii_: Nos. 99, 100 and 102 and of _S. delphini_: Nos. 91, 106, 110 and 111. The results of this study are reported in Table 3 and 4.
Table 3. Growth of four isolates of *S. delphini* and three isolates of *S. rolfsii* in five media.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Floccose</td>
<td>Best medium</td>
<td>Rank growth</td>
<td>Dense mycelium</td>
<td>Mycelium</td>
<td>Floccose</td>
<td>Mycelium</td>
<td>Floccose</td>
</tr>
<tr>
<td>Mycelium</td>
<td></td>
<td></td>
<td>of mycelium</td>
<td>floccose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sclerotia</td>
<td>very</td>
<td></td>
<td>very</td>
<td>floccose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>large</td>
<td></td>
<td>pitted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>smaller</td>
<td></td>
<td>maturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Mush</td>
<td>Fewer but</td>
<td>Larger than present</td>
<td></td>
<td></td>
<td>Clove brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some pits produced</td>
<td></td>
<td></td>
<td></td>
<td>in color.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>other media</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sclerotia</td>
<td>Lighter</td>
<td>Dense mycelium</td>
<td>About the</td>
<td>Radiate</td>
<td>Floccose</td>
<td>As in much</td>
<td>More scl.</td>
</tr>
<tr>
<td></td>
<td>in color</td>
<td></td>
<td>in color with same</td>
<td>Sclerotia in number</td>
<td>mycelium</td>
<td>but with</td>
<td>than in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>as in mush.</td>
<td>slow to mature</td>
<td>mycelium</td>
<td>fewer scl.</td>
<td>mush though</td>
</tr>
<tr>
<td></td>
<td>Mycelium</td>
<td></td>
<td>tendency to fuse</td>
<td></td>
<td></td>
<td></td>
<td>they mature</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>than in mush.</td>
<td></td>
<td></td>
<td></td>
<td>slower.</td>
</tr>
<tr>
<td></td>
<td>than in rice</td>
<td></td>
<td>Fewer scl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mycelium</td>
<td></td>
<td>Mycelium</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pitted</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Potato or mush</td>
<td>Scl. darker and</td>
<td>Sclerotia larger</td>
<td>Sclerotia</td>
<td>Mycelium</td>
<td>Mycelium</td>
<td>Mycelium</td>
<td>Mycelium</td>
</tr>
<tr>
<td></td>
<td>also</td>
<td>than on rice or</td>
<td>than on</td>
<td></td>
<td></td>
<td></td>
<td>fine.</td>
</tr>
<tr>
<td>Dextrose</td>
<td></td>
<td>mush or</td>
<td>Clove brown</td>
<td></td>
<td></td>
<td></td>
<td>Sclerotia</td>
</tr>
<tr>
<td>Agar.</td>
<td></td>
<td>stalks</td>
<td>mush.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mycelium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>woolly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Corn and smaller</td>
<td>Same as in potato-dex-</td>
<td>Mycelium same as</td>
<td></td>
<td>Mycelium</td>
<td>Mycelium</td>
<td>Mycelium</td>
<td>Mycelium</td>
</tr>
<tr>
<td>meal</td>
<td>than above potato</td>
<td>potato-dex</td>
<td>like proceeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>agar</td>
<td>trotose agar</td>
<td>proceeding</td>
<td>Scl. slow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Tap Water</td>
<td>No growth</td>
<td>No growth</td>
<td>No growth</td>
<td>Sparse mycelium</td>
<td></td>
<td>Sparse mycelium</td>
<td>No scl.</td>
</tr>
<tr>
<td>Agar.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In addition to the five media in Table 3 the isolates were grown on the following five agars: Saubouraud's Krainsky's, Czapek's modified, onion-peptone, and Gorodkowa's. Comparative growths of isolates of *S. delphini* and *S. rolfsii* on all ten media are reported in Table 4.

Table 4. Comparative value of different media for growth of isolates of *S. rolfsii* and *S. delphini*. (Asterisks refer to comparative values: x poorest and xxxxxx best)

<table>
<thead>
<tr>
<th>Medium</th>
<th>Growth</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mush</td>
<td>xxxxxx</td>
<td>Mostly floccose mycelium, numerous sclerotia.</td>
</tr>
<tr>
<td>2. Rice</td>
<td>xxxxxx</td>
<td>Less floccose mycelium, numerous sclerotia.</td>
</tr>
<tr>
<td>3. Potato-dextrose agar</td>
<td>xxxx</td>
<td>Fine counterclockwise, radiate or dendritic mycelium.</td>
</tr>
<tr>
<td>4. Saubouraud's agar</td>
<td>xxx</td>
<td>Finer mycelium and fewer sclerotia.</td>
</tr>
<tr>
<td>5. Onion-peptone agar</td>
<td>xxx</td>
<td>&quot;</td>
</tr>
<tr>
<td>6. Corn-meal agar</td>
<td>xxx</td>
<td>&quot;</td>
</tr>
<tr>
<td>7. Gorodkowa's agar</td>
<td>xxx</td>
<td>&quot;</td>
</tr>
<tr>
<td>10. Tap-water agar</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

1. Mush offers the best medium for mycelial-growth and for sclerotium-formation by the majority of isolates employed.
2. Sclerotia mature soonest on potato-dextrose agar.
3. Sclerotia are lighter in color on rice than on the other media.
4. Tap-water agar is a very poor medium.
5. Mycelium is more floccose on mush than on any other medium employed.
6. In general these results agree with those of Stevens.
2. Additional observations on a number of isolates of *S. delphinii* and *S. rolfsii*.

A. Isolates studied.

All in all, a total of 46 different isolates of *S. delphinii* and of *S. rolfsii* were obtained and used for comparative studies. Though most of the cultures were isolated in this country, all continents, with the exception of Australia, were represented in the collection. The writer is indebted to H. H. Whetzel, C. F. Weber, L. D. Leach, C. W. Edgerton, G. Goto and C. M. Tucker for their kindness in sending cultures used in this study. Four cultures were obtained from the Centraalbureau voor Schimmelcultures of Baarn, Holland.

These isolates with their K. U. numbers, donor and original number, host from which isolated, and locality of isolation are listed in Tables 5 and 6. The original numbers of some of these isolates are included because some of them appear in the literature.

Table 5 Isolates of *S. delphinii* obtained.

<table>
<thead>
<tr>
<th>K.U. No.</th>
<th>Donor and Orig. No.</th>
<th>Host</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>87-98</td>
<td>Mix</td>
<td>Bugle</td>
<td>Lawrence, Ks.</td>
</tr>
<tr>
<td>106</td>
<td>Leach</td>
<td>Canterbury Bells</td>
<td>California</td>
</tr>
<tr>
<td>110</td>
<td>Whetzel S 965</td>
<td>Delphinium</td>
<td>New York</td>
</tr>
<tr>
<td>111</td>
<td>Whetzel S 10385</td>
<td>Delphinium</td>
<td>Kentucky</td>
</tr>
<tr>
<td>113</td>
<td>Whetzel S 52</td>
<td>Bean</td>
<td>Texas</td>
</tr>
<tr>
<td>114</td>
<td>Whetzel S 117</td>
<td>Sugar cane</td>
<td>Philippines</td>
</tr>
<tr>
<td>115</td>
<td>Whetzel S 250</td>
<td>Carrot</td>
<td>Formosa</td>
</tr>
<tr>
<td>116</td>
<td>Whetzel S 390</td>
<td>Amaryllus</td>
<td>Brazil</td>
</tr>
<tr>
<td>117</td>
<td>Whetzel S 498</td>
<td>Peanut</td>
<td>Ceylon</td>
</tr>
<tr>
<td>118</td>
<td>Whetzel S 621</td>
<td>Iris</td>
<td>New York</td>
</tr>
<tr>
<td>119</td>
<td>Whetzel S 653</td>
<td>Scilla Siberica</td>
<td>Holland</td>
</tr>
<tr>
<td>126</td>
<td>Whetzel (C.B.S.)</td>
<td></td>
<td>Illinois</td>
</tr>
<tr>
<td>127</td>
<td>Whetzel (C.B.S.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>153</td>
<td>Whetzel S 625</td>
<td>Potato</td>
<td>California</td>
</tr>
<tr>
<td>538</td>
<td>Tucker</td>
<td>Calendula</td>
<td>Missouri</td>
</tr>
</tbody>
</table>
Table 6 Isolates of *S. rolfsii* obtained.

<table>
<thead>
<tr>
<th>K.U. No.</th>
<th>Donor and Orig. No.</th>
<th>Host</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>Weber</td>
<td>Violet</td>
<td>Florida</td>
</tr>
<tr>
<td>100</td>
<td>Weber</td>
<td>Carrot</td>
<td>Florida</td>
</tr>
<tr>
<td>101</td>
<td>Edgerton</td>
<td>Zinnia</td>
<td>Louisiana</td>
</tr>
<tr>
<td>102</td>
<td>Edgerton</td>
<td>Snapdragon</td>
<td>Louisiana</td>
</tr>
<tr>
<td>103</td>
<td>Edgerton</td>
<td>Potato</td>
<td>Louisiana</td>
</tr>
<tr>
<td>104</td>
<td>Leach</td>
<td>Bluegrass</td>
<td>California</td>
</tr>
<tr>
<td>105</td>
<td>Leach</td>
<td>Sugar Beets</td>
<td>California</td>
</tr>
<tr>
<td>120</td>
<td>Whetzel (G R-14)</td>
<td>Bean</td>
<td>Phil. Is.</td>
</tr>
<tr>
<td>121</td>
<td>Whetzel S 363</td>
<td>Aster</td>
<td>Italy</td>
</tr>
<tr>
<td>122</td>
<td>Whetzel S 140</td>
<td></td>
<td>Phil. Is.</td>
</tr>
<tr>
<td>123</td>
<td>Whetzel S 642</td>
<td>Xanthosoma Sp</td>
<td>Porto Rico</td>
</tr>
<tr>
<td>124</td>
<td>C.B.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>C.B.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>146</td>
<td>Whetzel S 769</td>
<td>Eleusino</td>
<td>Ceylon</td>
</tr>
<tr>
<td>147</td>
<td>Whetzel S 810</td>
<td>Orchids</td>
<td>Germany</td>
</tr>
<tr>
<td>148</td>
<td>Whetzel S 810</td>
<td>Sugar Beets</td>
<td>Spain</td>
</tr>
<tr>
<td>149</td>
<td>Goto R-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>Goto R-11 Whetzel S 862</td>
<td></td>
<td></td>
</tr>
<tr>
<td>151</td>
<td>Whetzel S 333</td>
<td>Potatoes</td>
<td>Africa</td>
</tr>
<tr>
<td>152</td>
<td>Whetzel S 374</td>
<td>Ambrosia</td>
<td>Florida</td>
</tr>
<tr>
<td>153</td>
<td>C.B.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>154</td>
<td>Nakata (C.B.S.)</td>
<td>Egg Plant</td>
<td>Japan</td>
</tr>
<tr>
<td>522</td>
<td>Goto Rnk 3</td>
<td></td>
<td>Phil. Is.</td>
</tr>
<tr>
<td>523</td>
<td>Goto R-21</td>
<td>Sugar Cane</td>
<td>Japan</td>
</tr>
<tr>
<td>524</td>
<td>Goto RD</td>
<td>Wheat</td>
<td>India</td>
</tr>
<tr>
<td>525</td>
<td>Goto R-42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>526</td>
<td>Goto R-11</td>
<td>Corchorus</td>
<td>Japan</td>
</tr>
</tbody>
</table>

B. Examination of Individual Cultures

Triplicate plate-cultures of each isolate were grown and examined critically both macro- and microscopically. Sclerotia were measured by means of micrometer-calipers and the diameters reported in the tables represent the average of measurements of one hundred sclerotia except in the case of a few strains which did not produce sclerotia abundantly. The colors listed in the following tables are taken from Ridgway’s color Manual (41). These sclerotium-sizes as well as observations on their number, shape, color,
pits, fusion, comparative number of immature and mature sclerotia, presence of stalks, type of mycelium and comments are recorded in Tables 7 and 8.
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>K.U. 88-98</td>
<td>50</td>
<td>yes variable</td>
<td>4.5 mm.</td>
<td>.82 mm.</td>
<td>1.85 mm.</td>
<td>Tawny</td>
<td>46</td>
<td>4</td>
<td>2</td>
<td>Globose</td>
<td>Several</td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 106</td>
<td>256</td>
<td>no uniform</td>
<td>1.89 mm.</td>
<td>.67 mm.</td>
<td>1.24 mm.</td>
<td>Chocolate</td>
<td>111</td>
<td>0</td>
<td>0</td>
<td>Mostly globose</td>
<td>Few</td>
<td>Fine</td>
<td>III</td>
<td>Borderline</td>
<td></td>
</tr>
<tr>
<td>K.U. 110</td>
<td>41</td>
<td>yes variable</td>
<td>3.52 mm.</td>
<td>1.46 mm.</td>
<td>2.14 mm.</td>
<td>Tawny</td>
<td>31</td>
<td>10</td>
<td>2</td>
<td>G. &amp; C. 0</td>
<td></td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 111</td>
<td>27</td>
<td>yes variable</td>
<td>7.9 mm.</td>
<td>2.1 mm.</td>
<td>3.24 mm.</td>
<td>Russet</td>
<td>25</td>
<td>2</td>
<td>0</td>
<td>G. &amp; C. 0</td>
<td></td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 113</td>
<td>234</td>
<td>no uniform</td>
<td>2.24 mm.</td>
<td>.91 mm.</td>
<td>2.01 mm.</td>
<td>Dark sepia</td>
<td>279</td>
<td>16</td>
<td>0</td>
<td>Mostly globose</td>
<td></td>
<td>Densely</td>
<td>III</td>
<td>Borderline</td>
<td></td>
</tr>
<tr>
<td>K.U. 114</td>
<td>149</td>
<td>no mostly</td>
<td>2.1 mm.</td>
<td>.78 mm.</td>
<td>.91 mm.</td>
<td>Sepia</td>
<td>132</td>
<td>17</td>
<td>2</td>
<td>Globose</td>
<td>Few</td>
<td>Finely</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 115</td>
<td>75</td>
<td>yes variable</td>
<td>3.3 mm.</td>
<td>.15 mm.</td>
<td>1.9 mm.</td>
<td>Cinemon</td>
<td>73</td>
<td>2</td>
<td>2</td>
<td>G. &amp; C. Few</td>
<td></td>
<td>Finely</td>
<td>III</td>
<td>Sclerotia</td>
<td></td>
</tr>
<tr>
<td>K.U. 116</td>
<td>74</td>
<td>yes variable</td>
<td>3.6 mm.</td>
<td>1.2 mm.</td>
<td>1.64 mm.</td>
<td>Tawny</td>
<td>57</td>
<td>17</td>
<td>2</td>
<td>G. &amp; C. 0</td>
<td></td>
<td></td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 117</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Culture dead</td>
<td></td>
</tr>
<tr>
<td>K.U. 118</td>
<td>170</td>
<td>yes variable</td>
<td>3.4 mm.</td>
<td>1.6 mm.</td>
<td>2.34 mm.</td>
<td>Tawny</td>
<td>170</td>
<td>16</td>
<td>13</td>
<td>G. &amp; C. Several</td>
<td></td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 119</td>
<td>34</td>
<td>yes variable</td>
<td>4.1 mm.</td>
<td>1.8 mm.</td>
<td>2.82 mm.</td>
<td>Walnut</td>
<td>24</td>
<td>10</td>
<td>4</td>
<td>G. &amp; C. Few</td>
<td></td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 126</td>
<td>17</td>
<td>yes variable</td>
<td>3.3 mm.</td>
<td>.8 mm.</td>
<td>2.12 mm.</td>
<td>Sepia</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>Concave 0</td>
<td></td>
<td>Wooly</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 127</td>
<td>34</td>
<td>yes variable</td>
<td>4.8 mm.</td>
<td>1.2 mm.</td>
<td>2.3 mm.</td>
<td>Tawny</td>
<td>15</td>
<td>19</td>
<td>1</td>
<td>Concave 0</td>
<td></td>
<td>Finely</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 153</td>
<td>174</td>
<td>no uniform</td>
<td>2.1 mm.</td>
<td>.76 mm.</td>
<td>1.12 mm.</td>
<td>Tawny</td>
<td>153</td>
<td>22</td>
<td>12</td>
<td>Globose 0</td>
<td></td>
<td></td>
<td></td>
<td>Borderline</td>
<td></td>
</tr>
<tr>
<td>K.U. 538</td>
<td>30</td>
<td>yes variable</td>
<td>3.96 mm.</td>
<td>1.14 mm.</td>
<td>1.76 mm.</td>
<td>Tawny</td>
<td>30</td>
<td>0</td>
<td>3</td>
<td>G. &amp; C. Few</td>
<td></td>
<td>Fine</td>
<td>III</td>
<td>Typical</td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Morphological Characteristics of *S. delphini* strains
<table>
<thead>
<tr>
<th>Culture No.</th>
<th>No. in size</th>
<th>Types</th>
<th>Uniform size Max. Min.</th>
<th>Avr. size</th>
<th>Color</th>
<th>Mature sol.</th>
<th>Immature sol.</th>
<th>Stalks</th>
<th>Shape</th>
<th>Fusion</th>
<th>Mycelium Plate No.</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.U. 99</td>
<td>148</td>
<td>No</td>
<td>Yes</td>
<td>1.62 mm</td>
<td>.68 mm.</td>
<td>.34 mm.</td>
<td>Russet</td>
<td>138</td>
<td>10</td>
<td>14 Im.</td>
<td>Globose</td>
<td>No</td>
</tr>
<tr>
<td>K.U. 100</td>
<td>numerous</td>
<td>No</td>
<td>Yes</td>
<td>1.4 mm.</td>
<td>.34 mm.</td>
<td>.80 mm.</td>
<td>Walnut brown</td>
<td>Numerous</td>
<td>Numerous</td>
<td>Few Im.</td>
<td>No</td>
<td>Floccose</td>
</tr>
<tr>
<td>K.U. 101</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.1 mm.</td>
<td>.5 mm.</td>
<td>.74 mm.</td>
<td>Walnut brown</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Floccose</td>
</tr>
<tr>
<td>K.U. 102</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.44 mm.</td>
<td>.63 mm.</td>
<td>.86 mm.</td>
<td>Walnut brown</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Dense</td>
</tr>
<tr>
<td>K.U. 103</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.66 mm.</td>
<td>.44 mm.</td>
<td>.80 mm.</td>
<td>Walnut brown</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Radiate</td>
</tr>
<tr>
<td>K.U. 104</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.68 mm.</td>
<td>.44 mm.</td>
<td>.80 mm.</td>
<td>Many Im.</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Radiate</td>
</tr>
<tr>
<td>K.U. 105</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>2.22 mm.</td>
<td>.33 mm.</td>
<td>1.14 mm. Sepia</td>
<td>&quot;</td>
<td>Few Im.</td>
<td>sol.</td>
<td>No</td>
<td>&quot;</td>
<td>IV Zoner</td>
</tr>
<tr>
<td>K.U. 120</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.76 mm.</td>
<td>.78 mm.</td>
<td>1.48 mm. Sepia</td>
<td>&quot;</td>
<td>3</td>
<td></td>
<td>Few Dendritic</td>
<td>IV Typical</td>
<td></td>
</tr>
<tr>
<td>K.U. 131</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>2.1 mm.</td>
<td>.84 mm.</td>
<td>.97 mm.</td>
<td>Sepia</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Few Radiate</td>
<td>IV Typical</td>
</tr>
<tr>
<td>K.U. 122</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.49 mm.</td>
<td>.38 mm.</td>
<td>.83 mm.</td>
<td>Seal brown</td>
<td>&quot;</td>
<td>Few Im.</td>
<td>sol.</td>
<td>No</td>
<td>Floccose</td>
</tr>
<tr>
<td>K.U. 123</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.32 mm.</td>
<td>.48 mm.</td>
<td>.94 mm.</td>
<td>Sepia</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Woolly</td>
</tr>
<tr>
<td>K.U. 144</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.9 mm.</td>
<td>.78 mm.</td>
<td>.90 mm.</td>
<td>Sepia</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>No</td>
<td>Fine and dendritic</td>
</tr>
<tr>
<td>K.U. 125</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>2.12 mm.</td>
<td>.68 mm.</td>
<td>1.06 mm. Seal Brown</td>
<td>&quot;</td>
<td>0</td>
<td></td>
<td>No</td>
<td>Floccose</td>
<td>FF Typical</td>
</tr>
<tr>
<td>K.U. 146</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>2.0 mm.</td>
<td>.64 mm.</td>
<td>1.84 mm. Seal Brown</td>
<td>&quot;</td>
<td>Few Im.</td>
<td>sol.</td>
<td>6</td>
<td>Fine</td>
<td>IV Typical</td>
</tr>
<tr>
<td>K.U. 147</td>
<td>&quot;</td>
<td>No</td>
<td>Yes</td>
<td>1.6 mm.</td>
<td>.58 mm.</td>
<td>1.03 mm. Sepia</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>2</td>
<td>Woolly</td>
<td>Typical</td>
</tr>
<tr>
<td>Culture No.</td>
<td>No. sol.</td>
<td>Fizs Uniform in size</td>
<td>Max. size</td>
<td>Min. size</td>
<td>Atr. size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>----------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>K.U. 148</td>
<td>Numerous</td>
<td>No</td>
<td>Yes</td>
<td>1.38 mm.</td>
<td>.52 mm.</td>
<td>.86 mm.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>K.U. 149</td>
<td>No</td>
<td>Yes</td>
<td>2.20 mm.</td>
<td>.44 mm.</td>
<td>.92 mm.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>K.U. 150</td>
<td>No</td>
<td>Yes</td>
<td>2.05 mm.</td>
<td>.73 mm.</td>
<td>1.14 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>K.U. 151</td>
<td>No</td>
<td>Yes</td>
<td>2.41 mm.</td>
<td>.68 mm.</td>
<td>1.33 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 152</td>
<td>No</td>
<td>Yes</td>
<td>2.01 mm.</td>
<td>.77 mm.</td>
<td>1.22 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 154</td>
<td>Few</td>
<td>Yes</td>
<td>2.82 mm.</td>
<td>.52 mm.</td>
<td>1.04 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 155</td>
<td>No</td>
<td>Yes</td>
<td>3.02 mm.</td>
<td>.62 mm.</td>
<td>1.89 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 522</td>
<td>No</td>
<td>Yes</td>
<td>1.12 mm.</td>
<td>.50 mm.</td>
<td>.84 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 523</td>
<td>No</td>
<td>Yes</td>
<td>1.44 mm.</td>
<td>.69 mm.</td>
<td>1.18 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>K.U. 524</td>
<td>No</td>
<td>Yes</td>
<td>2.06 mm.</td>
<td>.81 mm.</td>
<td>1.38 mm.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>K.U. 525</td>
<td>No</td>
<td>Yes</td>
<td>2.13 mm.</td>
<td>.78 mm.</td>
<td>1.28 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>K.U. 526</td>
<td>No</td>
<td>Yes</td>
<td>1.96 mm.</td>
<td>.67 mm.</td>
<td>1.10 mm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**Table 8 Cont. Morphological Characteristics of S. rolfsii Strains.**

<table>
<thead>
<tr>
<th>Color</th>
<th>Mature sol.</th>
<th>Immature Stalks</th>
<th>Shape</th>
<th>Fusion</th>
<th>Mycelium</th>
<th>Plate No.</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walnut brown</td>
<td>Numerous</td>
<td>Numerous</td>
<td>0</td>
<td>Globose</td>
<td>No</td>
<td>Fine and woolly</td>
<td>IV Typical</td>
</tr>
<tr>
<td>Seal Brown</td>
<td>Few Im. sol.</td>
<td>Few 0</td>
<td>8</td>
<td>Floccose</td>
<td>IV Typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal brown</td>
<td>Numerous Im. sol.</td>
<td>Few</td>
<td>several</td>
<td>Floccose</td>
<td>IV Typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sepia</td>
<td>Numerous Im. sol.</td>
<td>0</td>
<td>Fine</td>
<td>IV Typical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sepia</td>
<td>Few Im. sol.</td>
<td>Few 0</td>
<td>Few Floccose</td>
<td>Border-line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sepia</td>
<td>Few</td>
<td>Fine dense</td>
<td>IV mat.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut brown</td>
<td>Numerous Im. sol.</td>
<td>0</td>
<td>Fine</td>
<td>Typical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tawny</td>
<td></td>
<td>0</td>
<td>Fine dendritic</td>
<td>Border-line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate</td>
<td></td>
<td>7</td>
<td>IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut brown</td>
<td></td>
<td>3</td>
<td>Floccose</td>
<td>IV Typical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal brown</td>
<td>Few None</td>
<td>Few</td>
<td>Floccose IV Typical</td>
<td>IV Typical</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In compiling the data contained in Tables 7 and 8 certain difficulties were encountered because of the variability in both mycelial and sclerotial characteristics which certain strains demonstrated even though growing under the same conditions. This is well exemplified by culture No. 88 as shown in Plate III. Later work revealed that the age of the sclerotium used in the transfer determines to some extent the type of growth the culture will produce, but even when sclerotia of uniform color, size and shape were used in transferring it was not at all uncommon to observe variations within the same strain. Another example of variation can be seen with isolate No. 524 in Plate IV. In this case the mycelium of one culture was silky in nature and formed an almost transparent mat, while the other produced woolly mycelium forming an opaque mat. The latter culture also produced more and slightly larger sclerotia.

In short, the data presented can at best be only offered to represent an average cross section for the characteristics of the strains examined.

Included along with the strains that were typical for \textit{S. delphinii} and \textit{S. rolfsii} were other strains whose sclerotial characteristics made it difficult to decide which of the two species they should be included. This is well illustrated by Nos. 99 and 106, the former a strain of \textit{S. rolfsii} and the latter that of \textit{S. delphinii}. 
both of which have characteristics of both species, and hence in the tables are designated as borderline cases. These borderline cases will be discussed in a later section.
C. Comparative descriptions of *S. delphini* and *S. rolfsii*.

In addition to the studies discussed and tabulated on the preceding pages, additional microscopical examinations of both mycelium and sclerotia of these two species were made.

In order to obtain satisfactory mounts of the mycelium, which is fragile and difficult to mount by ordinary methods, a slide was placed in a petri dish in which the culture to be examined was growing. The mycelium grew over the surface of the slide and could be easily examined. The mycelium adhered sufficiently well to the slide to permit fixation and staining. The cultures were grown on potato-dextrose agar.

The following descriptions of the two fungi are here presented.

**Sclerotium delphini**

A. Mycelium

The texture of the mycelium of typical *S. delphini* was fine and not inclined to be floccose as was frequently the case with that of *S. rolfsii*. The types of growth-habit were observed radiate, dendritic and counter-clockwise. In the latter the free ends of the mycelium near the periphery of a growing colony curl in a counter-clockwise direction.

Most of the mycelium found covering the slide from a given culture corresponded to that referred to by Goto (17) in his studies with *S. rolfsii*, as "straightly-growing, leading hyphae." This mycelium averages
9μ in width with considerable variation both as to the number and type of septa. The latter would sometimes be rather frequent (every 30μ) though usually the septa are much more widely spaced and in some hyphae are entirely absent.

The mycelium branches freely, the branches sometimes coming off at a septum and at other times coming off some distance from a septum. The branches are often smaller in diameter than the parent hypha. This is especially true of hyphae that fuse in small fascicles to develop into sclerotia.

Mycelium when stained with hematoxylin was found to have multinucleate cells. In addition to the nuclei, there were numerous small inclusions which either did not take the stain or took it very lightly.

In addition to the mycelium described above, larger hyphae averaging 15μ in diameter could also be found. Clamp connections were noticed more frequently in these larger hyphae. (Pl. 7, Figs. 6, 7 and 8).

Another type of mycelium observed consisted of short cells rather similar to those observed in the central region of sclerotia. These cells are thick-walled and may be either circular or oblong in shape.

B. Sclerotia.

Typical strains of S. delphini do not produce sclerotia nearly so prolifically as do those of S.
rolfsii. Sclerotium-formation begins in a culture only a few days after inoculation of the medium. These characteristic bodies are produced when a given hypha or a group of closely associated hyphae, branch freely at their ends giving rise to numerous small branches that anastomose and under favorable conditions of temperature and nutrition develop into a mature sclerotium in less than a weeks time.

Macroscopically the sclerotia of *S. delphinii* vary in size from one to eight millimeters, the average diameter being a little over two millimeters. In contrast to the sclerotia of *S. rolfsii* which are invariably borne singly the sclerotia of *S. delphinii* frequently coalesce sometimes forming long bead-like sclerotial-masses. (Pl. VI, Fig. 3).

Typical sclerotia of *S. delphinii* are globose in shape when viewed from the dorsal surface but somewhat concave on the ventral surface, a scar often being evident on this surface if the sclerotium was produced on a stalk. Large sclerotia have the under side very markedly depressed so that the sclerotium resembles an inverted cup. Small sclerotia (those less than 1/2 mm.) usually are globose in shape without any depression on the underside, but nearly all sclerotia larger than this size are characterized by the concave ventral surface.

Most of the strains examined showed some tendency to develop a limited number of their sclerotia on mycelial stalks. These stalks are usually 4-5 milli-
meters high. Sclerotia produced on these stalks never reach maximum size, rarely exceeding 3 millimeters in diameter, and usually remaining lighter in color than typical mature sclerotia. A stalked sclerotium is pictured in Pl. VI, Fig. 2.

Another feature observed among the sclerotia, especially the larger specimens, was the development of small pits or depressions on the dorsal surface. This feature is well exemplified in Pl. VI, Fig. 1. No explanation for these pits could be found from microscopic examination. In cross section the cells in the cortex under these pits are no different from those below the surface where there are no pits. It is possible they may serve as germination centers, as hyphae on rare occasions have been seen to germinate from these pits, but in a great majority of cases germination takes place from the concave surface of the sclerotium.

The color of mature sclerotia of strains that may be considered typical of S. delphini is varies from tawny to Nays brown. Other colors observed among the S. delphini-strains, which were not so typical, included chocolate, russet, walnut and sepia. These latter strains are for the most part those that have been designated as intermediate forms.

In cross section the sclerotium may be divided into two parts; an outer cortex and a central medulla. This cortex may in turn be divided into two parts, a
dark brown outer part usually consisting of about three or four layers of cells, and a more transparent inner region averaging about six cells in thickness. It is difficult however to tell where the cortex leaves off and the medulla begins as the cells of the former merge into the cells of the medulla without any distinct line of demarcation. The cells of the cortex are angular, usually five or six sided, and compressed very closely together without intercellular spaces.

(Pl. VI, Fig. 6) These cells are from 7-10µ wide and 12-15µ in length. The walls of these cells are thick and colorless. The bulk of the sclerotium is occupied by the medulla. This consists of a heterogenous mass of cells varying in shape from circular to boomerang-shape. (Pl. VI, Fig. 6). These cells are loosely packed and more transparent than the cells making up the cortex.

Sclerotium rolfsii

A. Mycelium

The mycelium of this fungus has been described by a number of writers including Goto (17) and Higgins (21) and no detailed description will be submitted here. It is, in fact, unnecessary since it would agree almost precisely with the description just given for the mycelium of S. delphini. It is impossible to distinguish the two species by examination of mycelium under the microscope.
When growing in culture the mycelium of *S. rolfssii* can sometimes be distinguished from that of *S. delphini* in that it is often floccose and not inclined to be ropy as sometimes the case with mycelium of *S. delphini*.

**B. Sclerotia**

Turning however to the sclerotia of typical isolates of *S. rolfssii* several differences can be noticed from those of *S. delphini*.

The first feature to be observed from a typical culture of *S. rolfssii* is the large number of sclerotia produced, 300 or more in a single petri dish culture not being uncommon. This is 600% more than produced by typical *S. delphini* cultures growing under the same conditions.

As to color, the sclerotia of *S. rolfssii* are typically walnut to sepia brown. This is in contrast to the tawny to hay brown of the sclerotia of *S. delphini*.

Sclerotia of this species are uniform in size and shape, ranging in diameter from less than half a millimeter up to slightly more than two millimeters, the average being slightly less than one millimeter. The shape of the sclerotia is uniformly globose in contrast to the concave sclerotia of *S. delphini*.

When the sclerotia of *S. rolfssii* germinate hyphae push out from any place on the cortex instead of emerging from the ventral side as in the sclerotia of *S. delphini*. 
While some strains of *S. rolfssii* show a tendency to develop sclerotia on stalks these attempts are very feeble. The stalks are very fragile and the sclerotia that develop at their apices remain undersized, and never mature.

Another distinction between the two fungi is that among the sclerotia of *S. rolfssii* attempts at fusion almost never occur while this fusion is a common phenomenon among the sclerotia of *S. delphinii*.

Gross sections of the sclerotia of *S. rolfssii* do not differ markedly from those of *S. delphinii*. (Pl. VI, Fig. 5 and 6). There is little difference in the cortex-regions of the sclerotia of the two forms but in the medulla-region the cells of *S. rolfssii* are uniform in shape and not so loosely arranged as comparable cells of *S. delphinii*.

It is evident from these descriptions that one must rely mostly on sclerotial differences to distinguish these two species. Comparative studies, and correspondence with Dr. H. K. Whetzel, show that the local form isolated from *Ajuga* may be considered typical of *S. delphinii*.
Intermediate forms.

Among the isolates listed in Table 7, as *S. delphiniin* those numbered 106, 113, 114, and 153 are there designated as borderline cases. These isolates present a number of deviations from typical *S. delphiniin* as represented by the isolate from *Ajuga reptans*. Brief mention of the variations shown by each of the above isolates will follow.

1. K. U. 106. This isolate resembles *S. delphiniin* in that its sclerotia possess small pits and many are concave in shape. In color, size, and uniformity of size however they approach *S. rolfsii*.

2. K. U. 113. The sclerotia produced by this isolate resemble *S. delphiniin* in that many are not uniform in size and fusion is common. In the matter of color and size however, its sclerotia resemble those of *S. rolfsii*.

3. K. U. 114. Like the preceding form this strain has sclerotia more like those of *S. delphiniin* except in color and size.

4. K. U. 153. Because it tends to produce globose sclerotia in number far more than typical for *S. delphiniin* this isolate is listed among the borderline cases. Otherwise it is representative of the *S. delphiniin* type.

All four of these intermediate forms of *S. delphiniin* produce many more and on the average smaller sclerotia than typical for *S. delphiniin* but fewer than typical *S. rolfsii*. 
From Table No. 8 of the S. rolfsii isolates sent from different parts of the world the following are designated as borderline cases:

1. K.U. 99. This isolate varies from typical S. rolfsii in that it produces fewer sclerotia, some of which are borne on stalks.

2. K.U. 154. In cultures of this isolate some of the sclerotia were observed to be concave and possess pits although otherwise typical of the S. rolfsii type.

3. K. U. 155. This isolate produces fewer sclerotia than is typical for S. rolfsii (though more than typical for S. delphini).

4. K.U. 523. The sclerotia of this isolate are typical of the S. rolfsii-type except that many are tawny in color and a few are produced on stalks.

These borderline cases represent something of a problem in that they are not consistent in their deviations from their respective species. The one characteristic common to most of these borderline cases is the number of sclerotia produced. This number is usually intermediate between a number typical for S. rolfsii and that for S. delphini. Aside from this characteristic these isolates do not fall into a uniform group.

Since these intermediate forms are not uncommon their occurrence strengthens the point of view held by the writer that S. delphini should simply be designated
as a variant of the widely distributed *S. rolfsii*. However, as will be seen later, on the basis of geographical distribution of the two fungi there seems some justification for considering *S. delphinii* a valid species.
3. Correlation of sclerotial number and size with geographical localities from which isolates of \textit{S. delphinii} were obtained.

Studies with the intermediate forms of \textit{S. delphinii} brought up the question whether there might be some correlation between the locality from which they were isolated and the size and number of sclerotia produced in culture. In the following table are listed the isolates of \textit{S. delphinii} sent the writer, their host, their locality of isolation and the size and number of sclerotia.

Table 9 Correlation of sclerotial number and size with geographical locality of \textit{S. delphinii} isolates.

(Symbols $\times$=less than 35 sclerotia, $\times\times$=35-75 sclerotia $\times\times\times$=75-150 sclerotia and $\times\times\times\times$=more than 150 sclerotia.

<table>
<thead>
<tr>
<th>Culture No.</th>
<th>Host</th>
<th>Locality</th>
<th>Size</th>
<th>No. of scler.</th>
</tr>
</thead>
<tbody>
<tr>
<td>87-98</td>
<td>\textit{Ajuga reptans}</td>
<td>Kansas</td>
<td>typical</td>
<td>$\times\times$</td>
</tr>
<tr>
<td>106</td>
<td>\textit{Canterbury Bells}</td>
<td>California</td>
<td>smaller</td>
<td>$\times\times\times\times$</td>
</tr>
<tr>
<td>110</td>
<td>\textit{Delphinium}</td>
<td>New York</td>
<td>typical</td>
<td>$\times\times$</td>
</tr>
<tr>
<td>111</td>
<td>\textit{Delphinium}</td>
<td>Kentucky</td>
<td>typical</td>
<td>$\times$</td>
</tr>
<tr>
<td>113</td>
<td>Bean</td>
<td>Texas</td>
<td>smaller</td>
<td>$\times\times\times$</td>
</tr>
<tr>
<td>114</td>
<td>Sugar cane</td>
<td>Philippines</td>
<td>smaller</td>
<td>$\times\times$</td>
</tr>
<tr>
<td>115</td>
<td>Carrot</td>
<td>Formosa</td>
<td>smaller</td>
<td>$\times\times$</td>
</tr>
<tr>
<td>116</td>
<td>Amaryllus</td>
<td>Brazil</td>
<td>smaller</td>
<td>$\times\times\times$</td>
</tr>
<tr>
<td>118</td>
<td>Iris</td>
<td>New York</td>
<td>typical</td>
<td>$\times\times$</td>
</tr>
<tr>
<td>119</td>
<td>Scilia</td>
<td>Holland</td>
<td>typical</td>
<td>$\times$</td>
</tr>
<tr>
<td>126</td>
<td>Illinois</td>
<td>typical</td>
<td>$\times\times\times\times$</td>
<td></td>
</tr>
<tr>
<td>127</td>
<td>Potato</td>
<td>California</td>
<td>smaller</td>
<td>$\times\times\times$</td>
</tr>
<tr>
<td>523</td>
<td>Calendula</td>
<td>Missouri</td>
<td>typical</td>
<td>$\times\times$</td>
</tr>
</tbody>
</table>

On the accompanying map of the United States are indicated the localities from which the writer has received isolates of \textit{S. delphinii} and \textit{S. rolfsii}. A study of this map along with the information in Table No. 9 shows that these two fungi do have more or less
Localities from which cultures have been obtained.

- S. delphinii
- S. rolfsii

United States
definite geographical ranges. *S. rolfsii* is found almost exclusively south of the Mason-Dixon line. *S. delphinii* is found north of this line, for the most part, though occasionally overlapping *S. rolfsii*. Of the strains of *S. delphinii* that were isolated in this country, all those with intermediate characteristics were collected south of the Mason-Dixon line. Those collected north of this line were typical of *S. delphinii*, producing a limited number of large sclerotia. Cultures No. 106 and No. 153 from California, and No. 115 from Texas, where the mean temperatures are higher, fall into this intermediate group.
4. Perfect stage of *S. rolfsii* and *S. delphini*.  

A number of investigators, mostly foreign, have at one time or another succeeded in getting *S. rolfsii* to produce its perfect stage in culture. These include Nakata (31), Goto (18), Curzi (9), Mundkur (29), and Barrett (2). All of these investigators worked with *S. rolfsii* although Curzi is of the opinion that Nakata's strain was *S. delphini*. Nakata after comparing his strain with a large number of *S. rolfsii* and *S. delphini* strains had concluded that his strain was of the *S. rolfsii*-type.

To date the perfect stage of *S. delphini* has not been observed. Numerous attempts have been made by the writer to induce *S. delphini*-strains to produce the perfect stage through the use of the special medium recommended by Mundkur (29). This medium consists of the following ingredients:

- Cut onions: 100 grams
- Asparagin: 25 grams
- Proteose peptone: 50 grams
- Bacto agar: 15 grams
- Distilled water to make 1000 c.c.

Strains sent the writer by Goto (K.U. 522 and K.U. 527, Goto's GL4 and 11 respectively) produced basidiospores abundantly in culture. Basidiospores are not produced until the culture is about six weeks old after which time dense white cushions appear and on these the basidia are borne. Basidia produced by the above-mentioned strains were club-shaped and hyaline, bearing three
to four sterigmata. The basidiospores are globose to obovate, averaging 5 by 7 microns in size. On the basis of the perfect stage this organism was placed by Nakata (31) and others in the hymenomycetous genus Corticium of the Basidiomycetes.

Until the perfect stage of S. delphinii has actually been observed it seems hardly safe to regard the fungus as a valid species distinct from S. rolfsii. This is especially true when one considers the number of intermediate forms that exist in nature and the variability of growth obtained when many strains are grown on artificial media.
PART III.

PHYSIOLOGICAL STUDIES.
1. Temperature relations.

It has been shown that these two forms have rather well defined geographical ranges in this country, with *S. rolfsii* being limited to the area south of the Mason-Dixon line and *S. delphini* north of this line, although occasionally being found further south. It was thought that growing isolates in temperature-chambers and noting the minimum, optimum, and maximum temperatures for growth might throw some light on the question of their distribution.

Little has appeared in the literature on this subject and no comparative work has been done on the temperature relations of the two fungi. Higgins (21) has grown *S. rolfsii* in incubation chambers at different temperatures and Tucker (23) ascertained roughly the optimum and maximum temperatures for growth of an isolate of *S. delphini*.

In the work reported here cultures were grown in petri dishes of uniform size containing approximately 25 c.c. of potato-dextrose agar. After sterilisation and hardening, the agar was inoculated with a single sclerotium placed near the center of the plate. Duplicate, and in the first two tests triplicate, cultures were placed in each of the temperature chambers and examined daily over a period of two weeks.

Growth of mycelium, development of sclerotia, and comparative lengths of time required for the sclerotia
to germinate were the criteria used in determining the optimum temperature for the two fungi.

In the experiments reported in Table 10 the cultures were placed in a battery of seven temperature chambers modelled after those designed by Livingston and Fawcett (24), the cooling being accomplished by means of an electric refrigeration unit. In order to study comparative growths of these two fungi in a sufficient number of different temperatures, various ranges of temperature gradients had to be employed in the seven compartments. This accounts for the variety of temperatures listed in the different experiments in Table 10. In this table are reported the minimum, optimum and maximum temperatures for growth of *S. delphini* and *S. rolfsii*. 
Table 10 Temperature relations of *S. delphini* and *S. rolfsii*.

<table>
<thead>
<tr>
<th>Test No. 1.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture No.</td>
<td>4</td>
</tr>
<tr>
<td>97</td>
<td>0</td>
</tr>
<tr>
<td>98</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test No. 2.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture No.</td>
<td>14</td>
</tr>
<tr>
<td>97</td>
<td>x</td>
</tr>
<tr>
<td>98</td>
<td>x</td>
</tr>
<tr>
<td>102</td>
<td>x</td>
</tr>
<tr>
<td>104</td>
<td>x</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test No. 3.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture No.</td>
<td>11.5</td>
</tr>
<tr>
<td>97 <em>S. delphini</em></td>
<td>0</td>
</tr>
<tr>
<td>98 <em>S. delphini</em></td>
<td>0</td>
</tr>
<tr>
<td>102 <em>S. rolfsii</em></td>
<td>x</td>
</tr>
<tr>
<td>104 <em>S. rolfsii</em></td>
<td>x</td>
</tr>
<tr>
<td>126 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>110 <em>S. delphini</em></td>
<td>0</td>
</tr>
<tr>
<td>111 <em>S. delphini</em></td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test No. 4.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture No.</td>
<td>13</td>
</tr>
<tr>
<td>97 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>102 <em>S. rolfsii</em></td>
<td>x</td>
</tr>
<tr>
<td>106 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>113 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>115 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>116 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>119 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>153 <em>S. delphini</em></td>
<td>x</td>
</tr>
<tr>
<td>533 <em>S. delphini</em></td>
<td>x</td>
</tr>
</tbody>
</table>

0. no growth.

x weak mycelial growth only.

xx few immature sclerotia in addition to mycelial growth.

xxx Good development of both mycelium and sclerotia.

xxxxx Maximum growth of mycelium and sclerotia.
Summarizing briefly from the experiments reported in Table 10 we note the following results:

<table>
<thead>
<tr>
<th></th>
<th>Min. temp.</th>
<th>Optimum temp.</th>
<th>Max. temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. delphini</td>
<td>10-12</td>
<td>28-30</td>
<td>38-40</td>
</tr>
<tr>
<td>S. rolfsii</td>
<td>10-12</td>
<td>33</td>
<td>38-40</td>
</tr>
</tbody>
</table>

The most significant feature is the different optimum temperature of the two fungi. The optimum temperature for *S. rolfsii* is about four degrees higher than that of *S. delphini*. In view of the fact that *S. rolfsii* is found almost exclusively south of the Mason-Dixon line and *S. delphini* further north for the most part, this difference is significant. This difference is too small however to account in full for the distribution of the two fungi.

Higgins (21) reported a minimum temperature of 8-10 degrees for *S. rolfsii*. His lower figure may be due to the fact that he allowed his sclerotia to germinate for 48 hours at room temperature before putting them in incubation chambers, whereas in this experiment, all cultures were placed in their respective chambers shortly after inoculation of the media.
2. Oxalic acid production by \textit{S. delphini}.  

The first important reference to oxalic acid production by fungi was in the publication of de Bary (10) working with \textit{Sclerotinia libertiana} Fekl. He reported that the older hyphae of the fungus were encrusted with crystals of oxalic acid, and he attributed some of the poisonous action of the parasite to the production of this substance. He concluded that an enzyme probably destroys the cell walls and may or may not be responsible for the death of the host cells, as organic acids (such as oxalic) and their salts are known to be toxic to plant cells.

Wehmer (52) and (53) stated that the only acids produced by \textit{Aspergillus} or \textit{Penicillium} species in significant quantities are oxalic and citric. He noted that \textit{Aspergillus niger} produced much more oxalic acid than did \textit{Aspergillus glaucus}, \textit{Penicillium glaucum}, \textit{Botrytis cinerea}, and \textit{Rhizopus nigricans}, which produced only traces of this acid. Wehmer also studied the various conditions favoring the production of oxalic acid. These included low temperature, abundant carbohydrate food, the presence of an insoluble calcium salt such as phosphate or carbonate, and the presence of substances from which the mold can produce basic materials such as organic nitrogenous compounds and salts of organic acids.

Smith (44) in his study of the parasitism of \textit{Botrytis cinerea}, on lettuce plants, found that the
cells were killed before penetration of the fungus hyphae, by a toxic substance, and expressed the opinion that this toxic substance was oxalic acid.

Peltier (37) working with a parasitic Botrytis on lettuce and pepper plants, found a thermostable toxic substance in extracts from the mycelium but failed to find oxalic acid in the extract. He decided that this toxic substance must be some organic acid other than oxalic.

Cooley (7) in his experimentation with Sclerotinia cinerea observed that the latter was capable of producing considerable quantities of oxalic acid from plum and peach juice and from peach fruits, but expressed no definite opinion as to the significance of his results.

Brown, (6) in his extensive work with Botrytis cinerea, obtained extracts from the medium in which his fungus was growing and then observed its macerating action on various plant tissues. He concluded that neither oxalic acid or oxalates play any part in the toxicity of the extract. If any special lethal substance is present it must be of colloidal nature. The only active substance in the extract appears to be the enzyme which produces a macerating action mainly by solution of the middle lamella. The enzyme also appears to be responsible for the lethal action of the extract, the death of the cells being brought about either by direct action of the enzyme on the protoplasmic membrane, or indirectly as a result of the action upon the cell wall.
Currie and Thom (8) working with several species of Penicillium observed that only one (P. oxalicium) produced enough oxalic acid for this product to become a significant factor in its food chemistry. This species produced oxalates and oxalic acid reaching nearly 40% of the weight of sugar employed. They concluded that in the case of the fungi they worked with that oxalate was a transient and not an end product of metabolism and that its production might be likened to the production of lactic acid among certain bacteria.

Higgins (21) in his physiological studies of S. rolfsii found that this organism produced large amounts of oxalic acid in culture growing in a number of different media. He made quantitative determinations of the amounts of oxalic acid produced by S. rolfsii in each of the different media. He also took filtrates of his cultures and observed their effect on seedlings placed in them. He found in examining plant tissues killed by S. rolfsii that there were significant quantities of oxalates and oxalic acid in the dead cells. He concluded that whatever the case may be with regard to other fungi, oxalic acid is produced in large quantities by S. rolfsii and is responsible for the death of the host tissue in the plants attacked by this organism.

The views expressed by Higgins in connection with S. rolfsii are at variance somewhat with those of Brown (6) who worked with Botrytis cinerea and are subject to
question on the following grounds:

1. The filtrates used by Higgins were from cultures a month old, while in nature the mycelium of _S. rolfsii_ which penetrates plant cells is young, vigorously growing mycelium. Further, in such old cultures many substances other than oxalic acid must be present and presumably some of these might be toxic. Oxalic-acid production is not peculiar to active parasites. Wehmer (52) and others having shown that significant quantities of oxalic acid are produced in culture by fungi that are saprophytes or weak parasites. This is true of forms like _Aspergillus niger_ and certain _Penicillium_ species.

2. The method used for the detection of oxalic acid: precipitation with calcium chloride, does not distinguish between free oxalic acid and soluble oxalates such as potassium oxalate which may be present. In fact there is no method that will separate oxalic acid from soluble oxalates and enable one to determine exactly how much free oxalic may be present in the culture-solution.

In spite of these criticisms it seemed worth while to make some studies of _S. delphiniï_ comparable to those of Higgins with _S. rolfsii_. It was observed that _S. delphiniï_ produced significant amounts of oxalic acid or soluble oxalates when growing in liquid media. While for the most part only qualitative tests were made for oxalic acid, quantitative tests were made in a series of six flask cultures in each of which the organism was
growing in 250 c.c. of potato-dextrose broth.

To determine the amounts of oxalic acid and oxalates present, the culture solution in which the fungus had been growing plus the washings from the mycelial mat that had been removed from the solution, were made slightly alkaline with ammonia and then the oxalate was precipitated by the addition of calcium chloride. The precipitate was collected on weighed filter paper and washed with acetic acid and distilled water, dried and weighed. The precipitates of all six flasks were collected on one filter paper and weighed 1440.2 mgs., making the average for the six flasks 240 mgs. of calcium oxalate. This would have been the equivalent of 206.38 mgs. of oxalic acid per flask.

Filtrates of liquid media in which S. delphinii had been growing were then used to note their effect on bean seedlings. Control-solutions containing comparable amounts of oxalic acid were used in similar manner. The results were comparable to those obtained by Higgins with tomato and soybean seedlings in filtrates from S. rolfsii. Lesions appeared on the stems in 48 hours and subsequent death of the seedlings followed.

While those results are not surprising, the literature on S. delphinii, which is quite limited, contains no mention of the ability of this organism to produce oxalic acid and oxalates and in a comparative
study of *S. delphini* and *S. malfai*, the production of these products by the former is at least worthy of mention.
3. Aversion Experiments

Haulin (39) was the first to demonstrate in 1869 that in the course of the development of a fungus on a culture medium changes are brought about in the latter which make conditions more favorable for subsequent growth of the same organism.

This was confirmed more recently by Nikitinsky (32) who has shown however that under certain conditions this effect may be masked by other influences such as change in reaction. On the other hand Duciaux (14) demonstrated that the growth of a fungus on a certain medium renders the latter more unfavorable for the same organism when it is freshly inoculated into the medium. These seeming discrepancies were explained by the work of Kuster (22) and Lutz (25) who found that fungi produce not only growth-promoting substances but growth-inhibiting substances.

Fulton (15) suggested that the tendency of fungus hyphae to turn from the region in which hyphae of the same kind were growing was due to negative reaction to chemical substances produced by the growing fungus.

De Bary (11) in 1879, was the first to emphasize the significance of the antagonistic relationship of micro-organisms when two organisms are grown on the same substrate, one was found to sometimes overgrow and kill the other. This relationship was designated by Ward (51) as "antibiosis."
Many organisms are capable of producing substances which are injurious to their own development (iso-antagonistic) which are injurious even more so to other organisms close to them (hetero-antagonistic). It is sufficient to cite the production of lactic and butyric acids by the corresponding bacteria, of citric acid by Aspergillus niger, of lactic acid by species of Rhizopus and of alcohol by yeasts. These substances as well as a great number of other compounds which for lack of more exact information are usually designated as lethal or growth-inhibiting have frequently been looked upon as a protective metabolic product produced by micro-organisms in their struggle for existence. They play a highly significant part in the life history of micro-organisms, especially those that grow parasitically upon living hosts.

Some of the antagonistic substances are destroyed by boiling, by exposure to light and by filtration whereas others are resistant to heat and ultra violet rays and are readily absorbed by certain filters from which they can be removed by solvents such as alcohol, chloroform, or acetone. By means of these procedures it has been possible to differentiate between the substances which are antagonistic and those that are stimulating.

Reinhardt (40) found that the hyphae of Peziza will kill certain Mucorales, whereas different species of Aspergillus (A. niger, A. flavus) and Penicillia are able to kill Peziza.
In the case of the mutualistic influences of S. rolf-sii and Fusarium vasinfectum, it was found by Rosen and Shaw (42) that pH values below 6.9 the former completely overgrew the latter and in alkaline media the opposite effect resulted.

Harder (19) in a study of the behavior in mixed cultures of fungi belonging to the Basidiomycetes and Ascomycetes, found that young colonies do not produce so much of the toxic principle as do older ones, hence they can grow close to one another. Coniophora cerebella was restricted in its growth by Penicillium glaucum, its mycelium being considerably modified; in time the former organism adapted itself to the latter and overgrew, its rate of growth being eventually more rapid than that of a pure culture. The toxic principle was produced in varying degrees by different fungi; it was either temporary or permanent and was found more among the lower fungi or molds than in the Basidiomycetes. The toxic principle either modified or actually killed the mycelium of the other fungus.

Porter (38) working with a large number of different fungi, arrived at five general types of inhibition or antagonism: 1. Mutually intermingling, 2. Growth superficial over the contending organism, 3. slight antagonism, 4. Growth around the contending organism, and 5. Mutual antagonism at considerable distance. He found Helminthosporium to be inhibited by various chemicals in a manner similar to that caused by other fungi. He observed also that the inhibitions were less marked in rich media and that the inhibiting qualities of a fungus could be of aid in the identification
of species.

In addition to the work of Rosen and Shaw (42) referred to already, most of the investigation on this subject with the two fungi in question has been carried on by Nakata (30) and Goto (16). Goto worked exclusively with various strains of _S. rolfsii_, while Nakata included one of _S. delphiniii_ along with his many strains of _S. rolfsii_. Nakata found aversion to be either mutual or one sided, occurring between different strains of the fungus inoculated on the same plate, but not between inocula of the same strain. The phenomenon was persistent through all stages of growth, differences in sizes of sclerotia, culture media, host, temperature, and light had no influence.

In order to observe antagonism between different strains of _S. delphiniii_ and between strains of _S. rolfsii_, a number of the isolates on hand were grown together in petri dishes containing potato-dextrose agar. The writer was interested to see whether there would be stronger aversion between strains of _S. delphiniii_ and _S. rolfsii_, than between two strains of _S. delphiniii_.

Results of tests with _S. delphiniii_ strains growing with various strains of _S. rolfsii_ were comparable to those obtained by Nakata and Goto with the latter fungus. These aversion-experiments were always run in duplicate. A few plates were inoculated with three isolates at the same time. A representative group of these matings can be seen in Plate V.
Table 11 Results of growing various isolates of *S. delphini* and *S. rolfsii* together.

<table>
<thead>
<tr>
<th>Isolates used</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 (<em>S. delphini</em>) X 90 (<em>S. delphini</em>)</td>
<td>No aversion</td>
</tr>
<tr>
<td>100 (<em>S. rolfsii</em>) X 100 (<em>S. rolfsii</em>)</td>
<td>No aversion</td>
</tr>
<tr>
<td>110 (<em>S. delphini</em>) X 110 (<em>S. delphini</em>)</td>
<td>No aversion</td>
</tr>
<tr>
<td>103 (<em>S. rolfsii</em>) X 103 (<em>S. rolfsii</em>)</td>
<td>No aversion</td>
</tr>
<tr>
<td>96 (<em>S. delphini</em>) X 147 (<em>S. rolfsii</em>)</td>
<td>Pronounced aversion</td>
</tr>
<tr>
<td>90 (<em>S. delphini</em>) X 148 (<em>S. rolfsii</em>)</td>
<td></td>
</tr>
<tr>
<td>96 X 104 (<em>S. rolfsii</em>) X 116 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>96 X 104 (<em>S. rolfsii</em>) X 527 (<em>S. rolfsii</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 523 (<em>S. rolfsii</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 116 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 110 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 111 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 113 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>97 (<em>S. delphini</em>) X 115 (<em>S. delphini</em>)</td>
<td></td>
</tr>
<tr>
<td>104 (<em>S. rolfsii</em>) X 523 (<em>S. rolfsii</em>)</td>
<td></td>
</tr>
</tbody>
</table>

From the preceding table and Plate V, it can be seen that non-aversion is the rule from cultures started from sclerotia of the same strain while aversion is consistently observed when different strains are in the same dish together. This holds true regardless of whether the opposing strains are both *S. rolfsii*, both *S. delphini*, or one of each of the two species. It is also worthy of noting that aversion is no stronger when a strain of *S. rolfsii* is mated with a strain of *S. delphini* than when two strains of the same species are growing together.

In passing it should be noted from Plate V that none of the strains used tended to produce sclerotia particularly at the line of demarcation between the two colonies. This is in contrast to an observation made by Taubenhaus (47) who in a mating experiment with *S. rolfsii*-strains stated that numbers of sclerotia were formed especially this zone which he ascribed as due to a sexual act of
some sort and suggested there were plus and minus strains involved. In all the mating tests of the writer sclerotia are produced indiscriminantly at random and least of all where the two growths approached each other. Since sclerotia are asexual bodies there is, of course, no point to Taubenhaus' suggestion regarding plus and minus strains.
4. Viability of Sclerotia

A number of investigators including Leach (23), Tucker (28), Palo (36), Higgins (21) and Wolf (57) have made short-term (two years or less) observations concerning the viability of sclerotia of *S. rolfsii* and to a less extent of those of *S. delphinii*.

During the winter of 1936 several hundred sclerotia of both *S. rolfsii* and *S. delphinii* were obtained from plate-cultures and a long-time viability experiment undertaken. This study, which is still in progress, is now in its sixth year. Some of the sclerotia were kept indoors at room-temperatures while others were wrapped in fine screen so that they would be easily obtainable when desired, and buried in the soil to a depth of about 6 inches. This depth was sufficient to prevent germination of the sclerotia and yet make them easy to obtain when desired. Sclerotia from the *S. delphinii* isolates were pooled together when placed in the soil as were those of *S. rolfsii*. The sclerotia of the different isolates kept in the laboratory however were kept in separate containers. The isolates of *S. delphinii* used in this study were Nos. 96, 106, 113, 118 and 153; of *S. rolfsii* Nos. 100m 101, 152, and 526.

At the same time of this writing sclerotia kept both inside and outdoors are still viable and capable of producing growth in culture. Tests for viability of the sclerotia have been made at intervals ranging in length from two to six months. At first the practice was to
bring in the sclerotia to be tested, sterilize them in a 1-1000 solution of mercuric chloride, and then germinate them either in tap water or on potato-dextrose agar slants. The writer obtained confusing results from this procedure in that sometimes the sclerotia would not germinate. On other occasions the percentage of germination was very low, especially in the tap water. This led to the erroneous conclusion that some sclerotia were no longer viable which judging from later experiments, must have been capable of germination. Filtrates from old cultures proved to be the most satisfactory medium in which to induce dormant sclerotia to germinate. Tap water poured over a dried up petri dish culture and allowed to stand a few days before being filtered and sterilized, made a very satisfactory medium. For sclerotia that have been dormant for a number of years liquid media are far superior to agar for inducing germination.

This study, covering to date a period of more than five years, suggests that the sclerotia of these two fungi can remain alive for long periods either in the laboratory or in the soil. No distinction in the ability of the sclerotia of the two species to germinate has been observed. Size of the sclerotia is not a factor in determining the period of their viability. This is not surprising inasmuch as the cortex of sclerotia of S. rofesi is just as thick as that found in most of the sclerotia of S. delphini even though the sclerotia of
the latter average three times in size that typical of
the former.

This information applied to the field would tend to
reduce the practibility of crop rotation as recommended
by Bottomley (5) and others as an aid in eliminating
the disease caused by these fungi. If a very suscep-
tible crop is again planted to a field in which it has
been severely attacked, after an absence of two or three
years, it can again be attacked if proper conditions of
moisture and humidity prevail for the growth of the fungi.

These viability experiments are being continued to
determine if possible the total length of time, sclerotia
of these two species can remain viable under field and
laboratory conditions.
SUMMARY

1. Although the literature shows *S. rolfsii* to have a host-list of some 200 species that for *S. delphini* is relatively short. Extensive host studies with the latter form conducted in the greenhouse added more than a hundred new hosts to this fungus indicating that it too has a wide host range.

2. A study of the pathological histology of *S. delphini* revealed that like *S. rolfsii* it produces hold-fast cells which attach themselves to the epidermis of the host plant. Host-cells are killed in advance of the advancing mycelium.

3. A detailed pathological, morphological and physiological study of *S. delphini* has been made in an effort to clarify the uncertain systematic status of this fungus.

4. For this comparative study, isolates of both *S. delphini* and *S. rolfsii* were obtained from various parts of the world where these fungi are found. While there was little or no difference in the mycelium of these two species they differed markedly in sclerotial characteristics. On the latter score however there were some intermediate forms not constant in their variations which were difficult to place either under *S. delphini* or *S. rolfsii*.

5. Much of the work of Stevens (45) who is the only investigator to date to have made any detailed comparisons
between the two species in question was repeated with seven of the isolates. Results were the same as those obtained by him.

6. There was a marked correlation in the number and size of sclerotia produced by the strains of \( S. \) delphinii and the geographical localities from which they originated. In this country those forms from north of the Mason-Dixon line produced relatively few and large sclerotia in culture while those from south of this line in addition to isolates from Formosa, Philippines and Brazil, where the mean temperature is relatively high, produced numerous, globose sclerotia and darker colored than is typical for this species.

7. The perfect stage of \( S. \) rolfsii has been observed by a few investigators but has yet to be reported for \( S. \) delphinii. Repeated efforts by the writer to observe the perfect stage of the isolates of \( S. \) delphinii failed although a few cultures of \( S. \) rolfsii produced basidiospores. Since the perfect stage of \( S. \) delphinii remains to be observed, the occurrence of intermediate forms is not uncommon, and since the strains often behave differently in nature than on culture, it seems unwise to consider \( S. \) delphinii a separate species. Its designation as the "large-sclerotium-producing form of the widely variable species \( S. \) rolfsii" would be safer. However, if the perfect stage is ever observed, and found to be different, this evidence along with the fact that the
two forms differ somewhat in their geographical range, and in culture show differences in their sclerotial characteristics (which is sometimes not so evident in nature), would be ample justification for declaring it a valid species. In this event it should be described and this description put in the literature, a status which this form technically lacks at the present time.

8. Temperature experiments showed little difference between the minimum and maximum temperatures for these two fungi but *S. rolfsii* had a higher optimum temperature than did *S. delphinii*. This may account in part for the fact that the former prefers and is found in warmer climates than *S. delphinii*.

9. Like *S. rolfsii*, *S. delphinii* was found capable of producing oxalic acid or oxalates in culture in considerable quantities. Seedlings placed in filtrates in which the fungus had been growing were killed, but there is no proof that free oxalic acid is responsible for the killing action of either *S. delphinii* or *S. rolfsii*.

10. Aversion-experiments with the various isolates of both fungi showed a noticeable antagonism between all combinations of matings employed. Non-aversion was obtained only when cultures were started from sclerotia of the same strain.

11. Viability experiments conducted over a period of
five years, and still being continued, show that scler-
otia of both S. rolfsii and S. delphinii are capable
of remaining alive either in the laboratory or in the
soil for this length of time. This minimizes the
importance of crop rotation as a control measure.


54. Beitrage zur kenntnis einheimlicher pilze. Hanover and Liezsig. 1893.


Plate I.

Fig. 1. Solerotium delphinii on Ajuga reptans
Fig. 2. Solerotium delphinii on Sedum acre.
Plate II.

Fig. 1. Helichrysum sp. attacked by Sclerotium delphinii, showing white weft of mycelium enclosing the base of the stem.

Fig. 2. Sclerotium delphinii attacking Didiscus sp.

Fig. 3. Sclerotium delphinii attacking Lunaria annua.

Fig. 4. Sclerotium delphinii attacking Sedum acre.
Plate III.

Photographs of representative isolates of *Solerotium delphinii* accompanied by their K.U. numbers referred to in the body of the paper. X .46. No. 111 X.75.
Plate IV.

Photographs of representative isolates of *Sclerotium rolfsii* accompanied by their K.U. numbers referred to in the body of this paper. X .4
Plate V.

Photographs of some of the strains of
*S. delphini* and *S. rolfsii* used in aversion experiments. X.45

First row:

K.U. 96 *(S. delphini)* X K.U. 147 *(S. rolfsii)*.

Second row:

K.U. 96 *(S. delphini)* X K.U. 104 *(S. rolfsii)*
& K.U. 116 *(S. delphini)*.
Same as preceding but taken after sclerotia had matured.

Third row:

K.U. 523 *(S. rolfsii)* X K.U. 97 *(S. delphini)*.
K.U. 97 *(S. delphini)* X K.U. 110 *(S. delphini)*.

Fourth row:

K.U. 97 *(S. delphini)* X K.U. 111 *(S. delphini)*.
K.U. 97 X K.U. 113 *(S. delphini)*.
K.U. 97 X K.U. 115 *(S. delphini)*.
Plate VI.

Fig. 1. Pitted sclerotia of *Sclerotium delphinii*. X10.

Fig. 2. Single sclerotium of *Sclerotium delphinii* on stalk. X 10.

Fig. 3. Coalescing sclerotia of *Sclerotium delphinii*. X 10.

Fig. 4. Large, abnormally shaped sclerotia produced by *Sclerotium delphinii*.

Fig. 5. Microphotograph of a cross section through a sclerotium of *Sclerotium rolfsii*. X 333.

Fig. 6. Microphotograph of a cross section through a sclerotium of *Sclerotium delphinii*. X 333.
Plate VII.

Fig. 1. Corn seedlings growing on potato-dextrose agar prior to be inoculated with S. delphinii.

Fig. 2. Corn seedlings parasitized by S. delphinii.

Fig. 3. Photomicrograph of cross section of corn root showing contact of hyphal weft with the epidermis. X 333.

Fig. 4. Holdfast cells on epidermis of corn. X 333.

Fig. 5. Holdfast cells and intracellular mycelium of S. delphinii.

Figs. 6, 7, & 8. Various types of clamp connections observed in mycelium of S. delphinii. X 500.

Fig. 9. Branching habit of mycelium of S. delphinii. X 500.
Plate VII.