

CORRELATION OF CERTAIN LONG-CYCLED AND SHORT-CYCLED RUSTS.

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When in 1897 Dietel, in his work "The Uredinales" for "Die natürlichen Pflanzenfamilien" of Engler and Prantl, pointed out the remarkable similarity between the teliospores of *Puccinia Mesneriana* Thüm., on *Rhamnus* and those of *Puccinia coronata* Cda. and *Puccinia coronifera* Kleb. on grasses, which have their æcia on *Rhamnus*, he established the first observation on correlations between rusts of widely different species. He also called attention to the fact that a similar condition obtains between the teliospores of *Puccinia ornata* Arth. & Holw. on *Rumex* and the teliospores of the grass rust, *Puccinia Phragmitis* (Schum.) Körn. which has *Rumex* for its æcial host. In both of these cases we note the teliospores of a short-cycled rust appearing on the æcial host of a long-cycled heteroecious rust. The teliospores of the two species are morphologically alike although appearing on host plants of quite different families.

About this same time (1898) Fischer stated* that quite independently of Dietel, he found by his researches a list of similar relationships. He reported five heteroecious species of *Puccinia*, two of *Chrysomyxa*, one of *Melampsora* and one of *Coleosporium*, all having short-cycled forms appearing on their æcial hosts, agreeing with their teliospores. He also listed three *Uromyces* and one *Puccinia* which show this sort of a relationship with certain micro- or hemi-forms.

It is worthy of note here that the complete life history of all the forms correlated in this manner were known at the time the observations were made.

When in 1903 and 1904 Tranzschel connected into a heteroecious life history two rust forms which until that time had never been suspected of bearing any relationship to each other, he made a wonderful advance along the line of this sort of investigation. His method was as unique as it was important, and on account of the interesting field it opens for investigators is worthy of detailed mention.

He had an unconnected *Aecidium*, *A. punctatum* Pers., on *Anemone ranunculoides*, and was endeavoring to find its alternate host. He observed that on *Anemone nemorosa* there appeared a short-cycled *Puccinia*, *P.*

*Beiträge zur Kryptogamenflora der Schweiz. 1:109. 1898.

fusca (Pers.) Wint., whose morphological aspects were strikingly similar to those of the *Accidium*, i. e., the sori of the two rusts were arranged in the same manner; the effects on the host plant were the same, and the macroscopic characters of the two were alike. He concluded that the two forms were closely related phylogenetically. Then his problem was: How find the alternate stage of the *Accidium* form?

On examining the teliospores of the short-cycled form microscopically he found them to possess very striking features, having a roughly warty wall, and being strongly constricted at the septum. A careful examination of his unconnected *Puccinias* revealed one having spores similar to those of the short-cycled form on *Anemone*, *Puccinia Pruni-spinosæ* Pers., the plum rust. He cultured the æciospores from *Anemone* on the leaves of plum and peach trees and grew the uredinia and telia of the plum rust. In his investigations at this time he combined, in this way, five heterœcious species. Three of these species he proved by cultures; namely,

1. *Puccinia Pruni-spinosæ* Pers. with *Accidium punctatum* Pers.
2. *Uromyces Veratri* (DC.) Schroet. with *Accidium Adcnostylis* Sydow.
3. *Uromyces Rumicis* (Schum.) Wint. with *Accidium Ficariæ* Pers.

The correlation, then, of two rusts of distinct species depends upon several things: first the family relationship of the host plants. The rusts are usually on the same or closely allied species of host plants. The macroscopic characters of the two rusts are also of decided importance. They can usually be expected to have similar effects on the common host plant; and the location and disposition (i. e., whether they are amphigenous, epiphyllous, hypophyllous, caulicolous; numerous or few, scattered or crowded; circular, oblong or irregular, etc.) of the sori are important factors.

The most important thing, however, is the agreement of the microscopic characters of the analagous spore forms. The teliospores of the short-cycled and long-cycled forms are compared for thickness, color and markings of the walls; the condition of the apex (thickened or not); measurements of the spores; length, color and type of pedicels; and the general conformation of the spores.

Owing to the fact that the knowledge of the rust fungi of very many regions is not complete, the geographic distribution can not be considered as extremely important. Nevertheless many interesting comparisons are shown by a study of the distribution of the correlated forms.

For some time past the writer has had access to the Arthur herbarium, and at the suggestion of Dr. J. C. Arthur, made a list of the heterœcious species of *Puccinia* having their teliospores on grasses, whose complete life histories are known. The teliospores of the short-cycled forms appearing on the æcial hosts of these rusts were compared with the teliospores of the long-cycled forms with the intention of compiling such a list as Fischer published. The following combinations were found to appear as good correlations:

LIST OF CORRELATIONS.

	RUST.	TELIAL HOST.	ÆCIAL HOST.
1.	{ <i>Puccinia Crandallii</i> Pammel & Hume <i>Puccinia Symphoricarpi</i> Hark.	{ <i>Festuca</i> <i>Poa</i> <i>Symphoricarpos</i>	<i>Symphoricarpos</i>
2.	{ <i>Puccinia sinillima</i> Arth. <i>Puccinia Anemones-virginiana</i> Schw. ...	{ <i>Phragmitis</i> <i>Anemone</i>	<i>Anemone</i>
3.	{ <i>Puccinia Stipæ</i> Arth. <i>Puccinia Grindeliæ</i> Peck.	{ <i>Koeleria</i> <i>Oryzopsis</i> <i>Stipa</i> <i>Bigelovia</i> <i>Chrysopsis</i> <i>Chrysothamnus</i> <i>Grindelia</i> <i>Gutierrezia</i>	{ <i>Aster</i> <i>Bigelovia</i> <i>Chrysopsis</i> <i>Chrysothamnus</i> <i>Erigeron</i> <i>Grindelia</i> <i>Gutierrezia</i> <i>Lugodesmia</i> <i>Nothocalais</i> <i>Senecio</i> <i>Solidago</i>
4.	{ <i>Puccinia Andropogonis</i> Schw. <i>Puccinia Seymeriæ</i> Burrill.	{  <i>Andropogon</i> <i>Dasystema</i>	{ <i>Castilleja</i> <i>Dasystema</i> <i>Penstemon</i>
5.	{ <i>Puccinia pustulata</i> (Curt.) Arth. <i>Puccinia Comandræ</i> Peck.	{ <i>Andropogon</i> <i>Comandra</i>	<i>Comandra</i>
6.	{ <i>Puccinia monoica</i> (Peck) Arth. <i>Puccinia Holboellii</i> (Horn.) Rostr. ...	{ <i>Koeleria</i> <i>Trisetum</i> <i>Arabis</i>	{ <i>Arabis</i> <i>Parrya</i> <i>Schœnocrambe</i> <i>Smelowskyia</i>
7.	{ <i>Puccinia Agropyri</i> Ell. & Ev. <i>Puccinia DeBaryana</i> Thuem.	{ <i>Agropyron</i> <i>Anemone</i>	<i>Anemone</i>
8.	{ <i>Puccinia rubella</i> Arth. <i>Puccinia ornata</i> A. & H.	{ <i>Phragmitis</i> <i>Rumex</i>	{ <i>Rheum</i> <i>Rumex</i>
9.	{ <i>Puccinia rhamnii</i> Wettst. <i>Puccinia Mesneriana</i> Thuem.	{ <i>Avena</i> <i>Rhamnus</i>	<i>Rhamnus</i>

The last two combinations in this list are the ones noted by Dietel.

Orton¹ dealt with quite a different type of correlation when he reported in detail the similarities between six species of heteroecious *Uromyces* and six species of heteroecious *Puccinia*. He also extended this study to include autoecious species of *Uromyces* and *Puccinia*. In every instance the host plants of the two rusts are of the same species, or of species closely related morphologically and phylogenetically. Because of the cellular difference in the teliospores (*Uromyces*, one-celled; *Puccinia*, two-celled) Orton laid special emphasis on the agreement of the microscopic characters of the aeciospores and urediniospores of the two rusts, remarking only in a general way similarities between the teliospores.

When we consider the differences in the number of spore forms in the life cycles of the various species of rusts, and take into consideration the morphological variation of the analogous spores, it is apparent that the possibilities of correlation are numerous. There are many problems presented in connection with such correlations. The choice of host plants, the similarity of analogous spore forms, and the like effects on the host all point to a common ancestor. What then is the primitive form? What is the evolutionary history of the derivative species? How great a range may be expected in the variations of correlated species? These and similar questions arise when a theoretical consideration of the condition is undertaken.

The practical application of knowledge gained by correlation studies will be along the lines of culture work, especially in forecasting the alternate host plants of unconnected aecial or telial forms.

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