# A GYMNOSPORANGIUM WITH REPEATING SPORES[1]

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The group of rusts now known under the generic designation of Gymnosporangium was the first to receive attention from systematic botanists. The earliest taxonomic record of any rust is that of a species on Juniperus described and figured by the pre-Linnaean author Micheli, to which he gave the generic name Puccinia. For a time this name was used for all rusts having the same general form of teliospore, then became shunted over to rusts of the general characteristics of *Puccinia graminis*, while the name Gymnosporangium was applied to the cedar rusts.

It has been easy to recognize the members of this latter genus in the telial stage by the gelatinous matrix arising from the pedicels of the teliospores coupled with occurrence on Juniperaceae, and in the aecial stage by a distinctive roestelioid peridium enclosing spores with colored walls and evident germ-pores, coupled with occurrence on Malaceae. These generic characters have been taken to indicate a highly specialized development parallel to the group represented by *Puccinia graminis*.

The genus Gymnosporangium has also been especially notable among the rusts by the utter absence of a repeating stage, either of uredinoid or aecidioid nature.

The bridging of the gap between the two groups of rusts was recently begun by finding aecia lacking the roestelioid characteristics and possessing all the features of a true Aecidium such as belong with rusts of the *P. graminis* group, as illustrated by *Aecidium Blasdaleanum* of the Pacific coast, found by cultures to go to *Gymnosporangium Libocedri*.[2] This aecidioid form, however, showed its Gymnosporangial relationship by occurring on the Malaceous genera Amelanchier and Crataegus.

A further advance was made in finding gradations between the two

[1] Presented before the American Phytopathological Society at the Philadelphia meeting, January 1, 1915.

[2] Arthur, Cultures of Uredineae in 1908. Mycologia 1: 252. 1909.

groups when Gymnosporangial aecia were found on the Rosaceous host Porteranthus,[3] a herbaceous plant somewhat of the habit of Agrimonia. This species was *G. exterum*. The gap was next narrowed by cultures of *G. speciosum* on Philadelphus,[4] belonging to the Hydrangiaceae, and the latest advance was made by using telia of *G. Ellisii* and growing aecia on the far more removed host genus Myrica,[5] belonging to the family Myricaceae.

So far as the aecial stage is concerned a complete alliance between the two groups of rusts has been established, shown in both morphological structure of the fungus and relationship of hosts. So far as the telial stage is concerned no species has yet been found in which the initial diagnostic characters of gelatinized pedicels and Juniperaceous hosts do not occur; that is to say, no advance has been made on the telial side in joining the two groups of rusts.

We now turn to a consideration of the curious lack of a repeating stage. It might be inferred that the occurrence of the sporophyte on gymnospermous hosts indicates an ancient segregation of the group, which during a long course of specialization has dropped out the repeating stage. Furthermore, there may be something inhibitive in the nature of the gymnospermous host, although it would be difficult to guess what it might be. Or, the long-lived sporophytic mycelium, often persisting for many years and never quite annual, may have rendered the repeating stage unnecessary, and thus led to its suppression.

It has been suggested that the repeating stage occurs on the aecial host, being aecidioid, similar to that in *Puccinia ambigua* on Galium. The failure to find what might be considered secondary Aecidia, that is Aecidia unaccompanied by pycnia, seemed to negative this view. Nevertheless, more than one attempt has been made to infect the aecial host by sowing aeciospores, but uniformly without success.

For some years an apparently genuine Uredo of the general form of that belonging to *P. graminis* has been known on a Juniperaceous host. In 1899 while on the Harriman Expedition to Alaska Professor Trelease obtained a small amount of what he named *Uredo nootkatensis*[6] on *Chamaecyparis nootkatensis*, the yellow or Alaska cedar of the

[3] Arthur, Cultures of Uredineae in 1908. Mycologia 1: 253. 1909.
[4] Arthur, Cultures of Uredineae in 1911. Mycologia 4: 63. 1912.
[5] Fromme, A new Gymnosporangial connection. Mycologia 6: 226. 1914.
[6] Trelease, in Alaska. Harr. Exped. 5: 36. 1904.

Pacific Coast. It was found at the hot springs on Baranof Island in southeastern Alaska. When I began studying the material of this collection, through the kindness of Professor Trelease, I felt confident that a knowledge of the complete life history would throw light upon the evolution or affinities of the Juniperaceous rusts. As the collection was made the middle of June it seemed probable that telia might be found on the same host later in the season. I wrote to Professor C. C. Georgeson of the Experiment Station at Sitka, Baranof Island, and to other Experiment Station men in Alaska, and to botanists going to Alaska, asking them to look out for such a hypothetical rust, but without returns. When Dr. Kern prepared his monograph on the

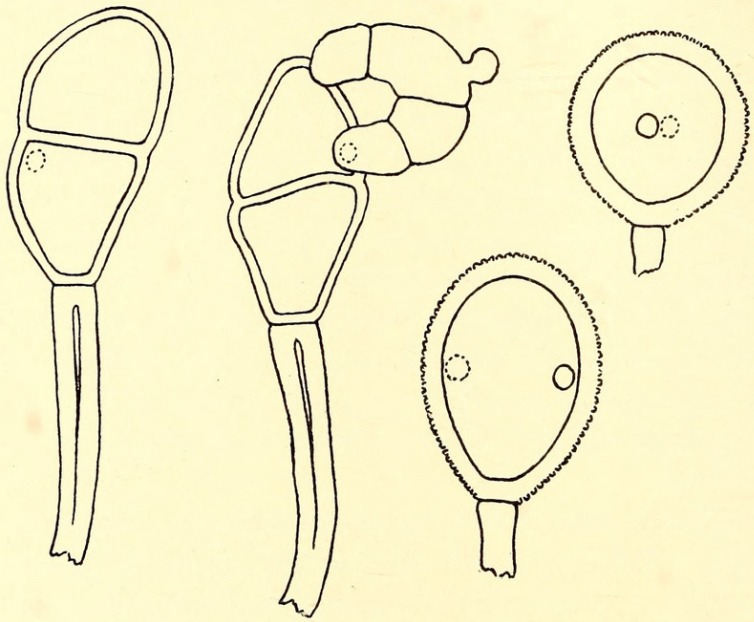

FIG. 1. Two teliospores, one germinating, and two urediniospores of *Gymnosporangium nootkatensis*. Drawn with camera lucida from material sent by Prof. H. S. Jackson from Oregon. × 625.

genus Gymnosporangium in 1911, he made good use of the ideas brought together up to that time, and predicted that telia would eventually be found of the foliicolous form, causing no hypertrophy. He also predicted that *Aecidium Sorbi* would be shown to be the aecial stage.[7]

The collection, which finally gave the key to the problem, came

[7] Kern, A biologic and taxonomic study of the genus Gymnosporangium. Bull. N. Y. Bot. Gard. 7: 408. 1911.

from Professor H. S. Jackson of the Oregon Agricultural College, having been made by H. P. Barss and G. B. Posey August 15, 1914, on the north slope of Mount Jefferson, along the trail to Hanging Valley, at an altitude of 5,000 feet. The green sprays of *Chamaecyparis nootkatensis* were abundantly dotted beneath with the conspicuous, golden-yellow sori of the rust. Upon microscopic examination the sori were found to contain many teliospores, some of which were in process of germination at time of gathering (fig. 1), although six weeks later, when they had reached me, both urediniospores and teliospores had lost their viability. The teliospores in a sorus probably did not exceed one teliospore to a hundred urediniospores, the condition apparently being that of the early stage in the transformation of a uredinial into a telial sorus.

It still seems probable that true telial sori will eventually be found. There would, however, evidently be no difficulty in producing the aecial stage from such teliospores as those found in the present instance; and cultures could confidently be attempted with similar material, should circumstances favor.

It is now some five years since Dr. Kern[8] suggested "the possibility of a relationship between the cedar-rust, *Uredo nootkatensis*, and *Aecidium Sorbi*." This prediction was supported by "inferences drawn from analogy, homology and geographic distribution," as he explained in his monograph (p. 408) of the following year. Without taking time to review the grounds of the argument, it may be said that time has added items of strength, without detecting flaws. The argument from geographic distribution has the present basis. The following list embraces all collections now known to the writer:

Alaska, Baranof Island: I on *Malus rivularis*, Aug. 2, 1914, *J. P. Anderson*, on *Sorbus scopulina*, Aug. 30, 1897, *C. S. Sargent*, on *S. sitchensis*, Aug. 2, 1914, *J. P. Anderson*, II on *Chamaecyparis nootkatensis*, June 15, 1899, *Wm. Trelease*.

British Columbia, Vancouver Island: I on *Sorbus occidentalis*, Aug. 8, 1905, *F. K. Butters*, on *M. rivularis*, Aug. 4, 1907, *F. K. Butters*.

Washington, Mount Rainier (Tacoma): I on *S. occidentalis*, Aug. 24, 1901, *E. W. D. Holway*, II on *C. nootkatensis*, August, 1913, *C. von Tubeuf;*—Goat Mountains (near Mt. Rainier): I on *S. occidentalis*, Sept. 11, 1895, *J. A. Allen;*—Olympic Mountains: I on *S. occidentalis*, June, 1900, *A. D. E. Elmer*, Aug. 15, 1907, *T. C. Frye*.

Oregon, Mount Jefferson: II and III on *C. nootkatensis*, Aug. 15, 1914, *H. P. Barss* and *G. B. Posey*.

[8] Kern, Prediction of relationships among some parasitic fungi. Science 31: 833. May, 1910.

It will be seen from this list that there is a remarkable coincidence in the distribution of the two forms. The range of the cedar-rust is nearly co-extensive with the range of the host, but the similar restriction of the Malaceous rust can not depend upon the aecial hosts, which are far more widely distributed. To make the geographic argument even more convincing it should be stated that no other unattached Gymnosporangial aecia or telia are known from the region in question.

As the teliospores now found to be associated with the uredinia upon *Chamaecyparis nootkatensis* are of the general form and structure of certain other species of Gymnosporangium to be considered closely related, and as the structure and appearance of the uredinia conform to theoretical demands based upon analogy with the large group of rusts represented by *Puccinia graminis*, and furthermore as both structure and geographic distribution assure the probable association of *Aecidium Sorbi* as the alternate stage, it seems fitting to present the following synonymy and description of the species in its entirety.

**Gymnosporangium nootkatensis** (Trelease) comb. nov.

*Uredo nootkatensis* Trelease, Alaska Harr. Exped. **5**: 36. 1904.
*Aecidium Sorbi* Arthur, Bull. Torrey Club, **33**: 521. 1906.
*Gymnosporangium Sorbi* Kern, Bull. N. Y. Bot. Gard. **7**: 438. 1911.
*Uredo Chamaecyparidis-nutkaensis* Tubeuf, Nat. Zeits. Forst.-Landw. **2**: 91. 1914.

O and I. Described in N. Amer. Flora **7**: 190–191. 1912.

On Malaceae:

*Malus rivularis* (Dougl.) Roem. Alaska, British Columbia.
*Sorbus occidentalis* (S. Wats.) Greene, Washington; British Columbia.
*Sorbus scopulina* Greene, Alaska.
*Sorbus sitchensis* Roem. Alaska.

II. Uredinia foliicolous, on yellow spots covering the whole leaf, subepidermal, round, 0.5 mm. across, bright orange fading to light yellow, prominently pulvinate, somewhat pulverulent, ruptured epidermis generally noticeable; urediniospores globose or obovate-globoid, 28–32 $\mu$ in diameter; wall pale yellow becoming colorless, moderately thick, 3–4 $\mu$, finely and closely verrucose, appearing radiately striate, the pores 2, equatorial; pedicels colorless, somewhat persistent.

III. Telia not seen; teliospores in the uredinial sori 2-celled, ellipsoid, 23–29 by 42–48 $\mu$, narrowed below, rounded or narrowed above, slightly or not constricted at the septum; wall pale lemon-yellow, uniformly thin, 1–1.5 $\mu$, smooth, the pores one in each cell near the septum; pedicel colorless, evenly thick, 5–7 $\mu$, once to twice length of spore.

On Juniperaceae:

*Chamaecyparis nootkatensis* (Lamb.) Spach, Oregon, Alaska.

Distribution: From southeastern Alaska to northwestern Oregon, in cool localities upon the sea coast northward or 5,000–6,000 feet elevation southward.

A few words only need be said to point out that the completion of the life-cycle of this one species makes a long stride forward in firmly establishing the theoretical basis upon which the classification of the Uredinales presented at Vienna in 1905 was constructed.[9] That classification undertook to consider all rusts from the standpoint primarily of their life-histories, actual or potential, and secondarily of their comparative morphology. From lack of knowledge much had to be assumed, but as the passing years supply the desired information, the reasonableness of the original assumptions becomes more and more apparent.

According to this classification all rusts are either short-cycled, having only one sporophytic spore-form, or long-cycled, having (1) a primary (aecial) spore-form, (2) a repeating stage, in some species partly or wholly suppressed, and (3) a final (telial) spore-form. The cedar-rusts presented a highly differentiated group, possibly the most specialized of all the rusts, in which no repeating-spores were known. So long as the repeating-stage was unknown, some doubt attached to the true position of the group in the classification, and even more doubt to the genuineness of the basic assumptions of the whole scheme. Bringing to light this primitive species of Gymnosporangium with its very active repeating stage is, therefore, a matter of moment.

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[9] Arthur, Eine auf die Struktur und Entwicklungsgeschichte begründete Klassification der Uredineen. Résult. Sci. Congr. Bot. Vienne 331. 1906.

Arthur, Joseph Charles. 1916. "A Gymnosporangium with repeating spores." *American journal of botany* 3(1), 40–45. https://doi.org/10.1002/j.1537-2197.1916.tb05398.x.

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