On the Relationship of *Chrysomyxa expansa* Diet. to *Peridermium Piceæ-hondoensis* Diet.

By

Kingo Miyabe.

Up to the present time, *Chrysomyxa expansa* Diet. (5) has only been known to infect the species of *Rhododendron* belonging to the Section *Eurhododendron* (10, 13). The species is nearly related to *Chrysomyxa himalensis* Barcl. (1, 2), from which it differs by its sori being strictly foliicolous and more or less closely and evenly arranged in a roundish discolored spot.

The type specimen is on *Rhododendron japonicum* Schneid. (13) (*R. Metternichii* S. et Z. (10), *R. Hymenanthes* Mak. (9)) collected by Prof. S. Kusano in Nikko in the latter part of May, 1899. The teleutosporic sori were then almost fully developed, although none were seen to have germinated. In the same locality, in the summer of 1900, Profs. G. Yamada and J. Hanzawa collected the same fungus on *R. brachycarpum* G. Don. (10, 13).

In Hokkaido, *Rhododendron brachycarpum* is very widely distributed, extending even to the Islands of Kunajiri and Etorofu. And with the host, *C. expansa* seems also to have a wide distribution. So far, however, we have received the specimens only from the Provinces of Kushiro, Tokachi, Hidaka and Ishikari. In the Prov. of Kushiro, the late Mr. Takiya Kawakami collected the fungus on Mt. Meakan at the altitude of 4000 ft. in the latter part of July in 1897. The spores had already germinated, the sori becoming fused together into irregular masses, some showing a netted appearance. In the autumn
of 1913, the author collected the fungus at the isthmus of the Peninsula Oyakot in the Lake Kutcharo. The spots as well as the sori had already become blackened.

In Prov. Tokachi the only specimen we have is from Mt. Memoro collected by Mr. S. Nishida on July 22, 1914. The most of the sori presented an appearance that the spores had already sprouted. In the Prov. of Hidaka, it was collected by Mr. Kingo Kondo on Mt. Apoi as well as at Samani in the month of August in 1912. The sori had all fused together, and some even had already dropped off. On April 1, 1913, Prof. Y. Niijima collected it at Fuyushima, Samani. The leaves shew simply the yellowish spots, on which the formation of the uredo-sori had not apparently taken place.

In Prov. Ishikari all the specimens we have in our Herbarium are from the Kamikawa- and Sorachi-gun. Mr. Hideo Koizumi collected it in the spruce forest zone on Mt. Ishikaridake in the middle of July in 1911. The spores had just germinated, and the sori still retained their characteristic forms. But by far, the most beautiful specimens of the fungus we have on hand, are those collected by Mr. Naoji Hiratsuka in the spruce forest near Ochiai on June 12, 1907. The sori were fully developed, and only a few of them showed a slight powdery appearance on their surface, indicating the germination of the spores had just begun to take place. In the same locality, the author himself collected the fungus on Oct. 9, 1908 and July 28, 1912. The sori in the latter case had then all fused together into irregular masses, and some even had already dropped off.

Among the hosts of the fungus in question Rhododendron chrysanthum Pall. (10, 13) should also be included. Last year toward the end of June, Mr. Bunzaburo Ishida of our College Botanic Garden ascended a mountain called the Sapporo-Dake to collect living alpine plants for cultivation. Among the collection, there were several clumps of R. chrysanthum, on the leaves of which we found not only the teleuto- but also a few uredo-sori.

From the foregoing statements, we may infer that the ger-
mination of the teleutospores in *Chrysomyxa expansa* takes place in the middle portion of Honshu in about the first part of June, while in Hokkaido from the latter part of June to about the middle of July, varying according to the difference in the altitude of the locality.

On the specimens collected in the latter part of June on *Rhododendron chrysanthum*, the uredo-sori with the spores still retained, as well as already shed, could be recognized. The sori are roundish or more or less elongated in shape, and solitary or in small groups. On one side of or surrounding the uredosorus or sori a group of the teleutospore-sori is generally to be found. On the leaves of *R. brachycarpum* yellowish spots are observable from August and September of the previous year, but we have not seen so far any sign of the formation of the uredo-sori during the autumn. Unlike *Chrysomyxa Rhododendri* (4, 7, 8), our species seems to form its uredospores only in spring and not both in autumn and spring.

The uredospores are variable in shape, ranging from oval to ellipsoidal, ovate-oblong or irregular. They are larger than in the case of *Chrysomyxa Rhododendri* (4, 7), measuring 22–38 μ in length and 16–24 μ in diameter. The membrane is prominently and densely warty, the length of the projection being 1–2 μ.

The teleutospore sori are formed in a close group on the underside of a yellowish red or brown spot, which turns to a blackish color in a later season. The size and shape of the maculae are variable. They are roundish, elliptical or irregularly angular, the margin being always limited by veinlets. Dietel mentions that the largest spot has the diameter of 15 mm. Of our materials, the largest we could find is 11×9 mm. and the smallest 1×1 mm. the average size being 6×5 mm.

The teleutospore-sorus projects conspicuously out of the tissue of the host and expands into a subglobose or ellipsoidal head with a narrowed short stalk. In general, the sori are more or less closely and evenly disposed in a macula; while some having coalesced form allantoid or irregular masses. The heads, when seen from above, measure .33–.60 mm in length.
and .22–.45 mm in width. The average of twenty measurements is .44 × .33 mm.

The number of the sori in a given macula is quite considerable. A fair idea may be formed from the following enumerations. In a spot 9 × 7 mm, 110 sori were counted; in 4 × 4 mm spots, 58, 65 and 68 sori; in 4 × 3 mm, 36 and 53; in 3 × 3 mm, 42; in 2 × 2 mm, 22; and in 1 × 1 mm, 13.

The teleutospores are cylindrico-prismatic, and in their lateral view are oblong, elliptical or ovate, measuring 14–25 μ in length and 8–13 μ in width. They are arranged in very long chains with the length of about .35 mm at the middle of the sorus, where the chain is composed of about 14 to 18 cells. From the nature of the cell contents, the upper 8 or 10 cells should be considered as the teleutospores, and the rest as the sterile stalk cells. The stalk cells have narrower diameters (7–8 μ) and lighter colored or hyaline contents. Sporidia are elliptico- or oblong-reniform, 4–6 μ in length and 2.5–4 μ in width.

In 1879, De Bary (4) by his painstaking researches proved that Chrysomyxa Rhododendri is a heteroecious species and forms its Aecidium stage on the leaves of Picea excelsa. It would be quite natural for any one to regard our species as being also heteroecious and look for the host of its Aecidium stage among the species of our spruce. In 1908, Mr. Otosaku Saito kindly sent us a specimen of Peridermium on the leaves of Picea Glehni (12), which had been collected by him in the Kusunai National Forest not far from Ochiai. When the author examined the specimen, the idea at once arose in his mind, that this Peridermium might be a stage of Chrysomyxa on Rhododendron brachycarpum, which Mr. Hiratsuka had collected at about the same place in the previous year. So the author went to Ochiai and Kusunai in the October of the same year to obtain for the infection experiments the seedlings of R. brachycarpum, whose leaves had already been affected. By that time, the affected leaves of the spruce had already dropped off.

Some of the seedlings survived the winter and produced the teleutospore sori in the following spring, when the infection
was made on the young leaves of *Picea Glehni* and *excelsa* in the Botanic Garden. The experiments all ended in negative results, and so the matter was left till 1912.

In 1912, Mr. Masamori Arita kindly sent us an excellent specimen of a Peridermium on *Picea ajanensis* which was collected also at a National Forest near Ochiai. He informed us, that the air of the forest, when he went there at about the middle of July, was literally full of the dusty orange-colored spores in a windy day.

On hearing this report, the author started at once and reached the forest on the 28th of July. The forest is famous for the stately trees of *Picea ajanensis* and *Glehni*, and also of *Abies sachalinensis* (3, 11, 12). As their undergrowth, *Rhododendron brachycarpum* is growing luxuriantly. When we reached there, the acidiospores had almost all been dispersed, leaving white peridial walls behind. One thing which struck the author as most remarkable is the fact, that *Picea Glehni* is perfectly immune to the species of Peridermium which affects *Picea ajanensis*. Of small trees of these two species of *Picea* growing side by side among the Rhododendron bushes, the Ajan spruce alone was badly affected, while the Glehn’s spruce remained perfectly sound.

A comparatively study of the peridial cells and acidiospores of these two forms of Peridermium on *Picea ajanensis* and *Glehni* revealed the fact, that they are of two different species. They differ from each other in the size and shape of the acidiospores as well as in the marking on the wall of the peridial cells.

It was found afterward that Peridermium on *Picea Glehni* is always associated with Chrysomyxa on *Rhododendron dahuricum*, and that it most likely corresponds to the European *C. Rhododendri*.

The only species of Peridermium already known to grow on the Japanese spruces is *P. Piceew-hondoensis* Diet. (6), which was collected for the first time by Prof. Kusano on the leaves of *Picea hondoensis* Mayr (11) on Mt. Fuji in Aug. 1903. According to Masters and Beissner (3), *Picea hondoensis* Mayr should be considered as a variety of *P. ajanensis*. It is now
known by the name of \textit{P. ajanensis} var. \textit{microsperma} Mast. (3). They belong to the Section Omorica, the flat-leaved spruces (3).

By the kindness of Prof. Kusano, the author was able to examine the type specimen of \textit{Peridermium Piceæ-hondoensis} and thus to compare it with our Ochiai specimens. As had been expected, they were exactly the same.

Aecidia are formed on the undersurface of the leaf arranged in a series on both sides of the midrib. The portion affected turns to a yellow color and is sharply limited from the green healthy portions. In most cases, the discolored portion forms a distinct zone at about the middle of the leaf. The aecidia are tubular, which are more or less flattened laterally, or several of them coalescing form flattened sack-like bodies elongated in the direction of the long axis of the leaf. They are 0.4–0.7 mm high, and 0.35–1.6 mm wide in the longer diameter. The peridial wall is white, inflated, rather rigid, and is torn at the apex into shallow irregular pieces, and is also cut into a few rather deep lobes. The large lobes are reflexed, exposing the orange red aecidiospores.

Peridial cells are rhombic or oblong in shape, 25–55 \( \mu \) in length and 15–28 \( \mu \) in width, thick walled, densely and finely verrucose. Aecidiospores are subglobose or ellipsoidal, 19–22 \( \mu \) long and 14–20 \( \mu \) wide. With the exception of a smooth elongated spot, the entire surface of the spore is rather thickly and finely warty. Some of the warts are in the form of short irregular ridges.

In order to prove the genetic relation between \textit{Chrysomyxa expansa} and \textit{Peridermium Piceæ-hondoensis}, the following infection experiment was carried out in the spring of 1913. For the purpose, a large number of young seedlings of \textit{Rhododendron brachycarpum}, whose leaves had already been infected, were collected at Ochiai in the summer of the previous year. They were all carefully potted and placed in a shady cool place in our Botanic Garden.

On May 21, we noticed the fully developed teleutospore sori on some potted plants. This was about a month earlier than
in the case of the native subalpine habitat. To induce the germination of the teleutospores, a few leaves were placed on that day in a Petri-dish containing sterilized wetted sand; and at the same time a Rhododendron pot, which had been thoroughly sprayed, was placed under a bell-glass.

On the following day, sporidia began to be formed on some sori. On that day and on the 24th, the young leaves of a small potted *Picea ajanensis* were infected with the sporidia. Bell glasses were taken off after two days.

On June 1, we noticed a slight yellow discoloration on the leaves of the spruce. On June 5, spermogonia were observed on the undersurface of the leaf. We noticed honey-colored exudation from some of them.

On June 24, we observed that the aecidia had grown conspicuously, some of them attaining the length of nearly 1.3 mm and some only 0.5 mm. A greater part of them took the tubular form, while the rest of them the elongated sack-like forms of various sizes.

The above mentioned experiments as well as the field observations at Ochiai have proved beyond all doubt, that *Péridermium Piceæ-hondoensis* DIET. (6) on *Picea ajanensis* is the Aecidium stage of *Chrysomyxa expansa* DIET. (5) on *Rhododendron brachycarpum*. It would be extremely interesting, if *Chrysomyxa himalensis* BARCL. (1), which is parasitic on *Rh. arboreum*, a member of the Eurhododendron, and which has also young mushroom-like sori, should happen to form also its Aecidium stage on some species of *Picea* belonging to the Section Omorica, as for instance *Piceas pinulosa* GRIFF. (3, p. 287).

The author wishes to express here his sincere thanks to Prof. S. KUSANO for his extreme kindness in sending him a part of the type specimens of the fungi under consideration. He wishes also to acknowledge his indebtedness to Messrs. SAITO, ARITA, HIRATSUKA and other gentlemen who favored him with valuable specimens, which were the incentive to the prosecution of the present work.
List of References.


