IDENTIFICATION OF A PERIDERMIAL STAGE ON THE SEEDLINGS OF ABIES MAYRIANA AND THE INJURY CAUSED THEREBY

BY

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(With 3 Text-figures)

Up to the present time it has already been learned that about 22 species of white-spored rusts out of 50 have their peridermial stages on the needles of Abies. If in any certain locality Abies is attacked by various kinds of such peridermia, the distinction between them is of great interest from the etiological as well as from the taxonomical point of view.

After a comparative study of the spermogonia of various species of rusts on *Abies balsamea* (L.) MILL., HUNTER (4) claimed that the morphology of spermogonia accompanying peridermia shows the most distinctive criteria. Moreover, FAULL (2), under whose direction HUNTER'S work was done, thus commented upon this fact: "in general there is a characteristic type of each genus, and these types are similar for genera that on other grounds might be considered more closely related. In some cases the forms within a type are distinctive for individual species".

The writer also has had the opportunity to compare the peridermial stages of various species of rusts on *Abies Mayriana* MIYABE et KUDO and other related species and is likewise able to admit that they can be classified into some similar groups by the morphology of spermogonia, and these groups may be subdivided by other criteria such as the characters of peridial cells and aecidiospores.

In this paper, the writer intends to report on a case in which he could identify a white peridermial stage on the needles of the seedlings of *Abies Mayriana* raised in the college nursery at Tomakomai to be of *Uredinopsis hirosakiensis* KAMEI et HIRATSUKA f. and how the host-plants suffered injury from the parasite.

Symptoms of the affected needles and seedlings. In the first part of July of last year, the writer happened to visit the Tomakomai Experimental Forest of our University, where in one plot (No. 4) of the nursery he saw many white

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peridermia attacking a considerable number of the young seedlings of *Abies Mayriana*. The affected parts were restricted to the new leaves made conspicuous by the maculae of pale discoloration or of a reddish colour and deformed to a certain extent. Careful observation of each affected needle showed that this discoloration occupied a half or more of the entire length but was sometimes restricted to a small portion in the middle of each leaf. The discoloured area was light yellow and more or less sharply delimited from the healthy deep green portions. The boundary between the affected and healthy areas was at times very abrupt or at times rather transient. Often on such a faded portion a more or less rosy to dark reddish coloration appeared which was extended to the entire discoloured area or often was limited to a narrow region at the leaf

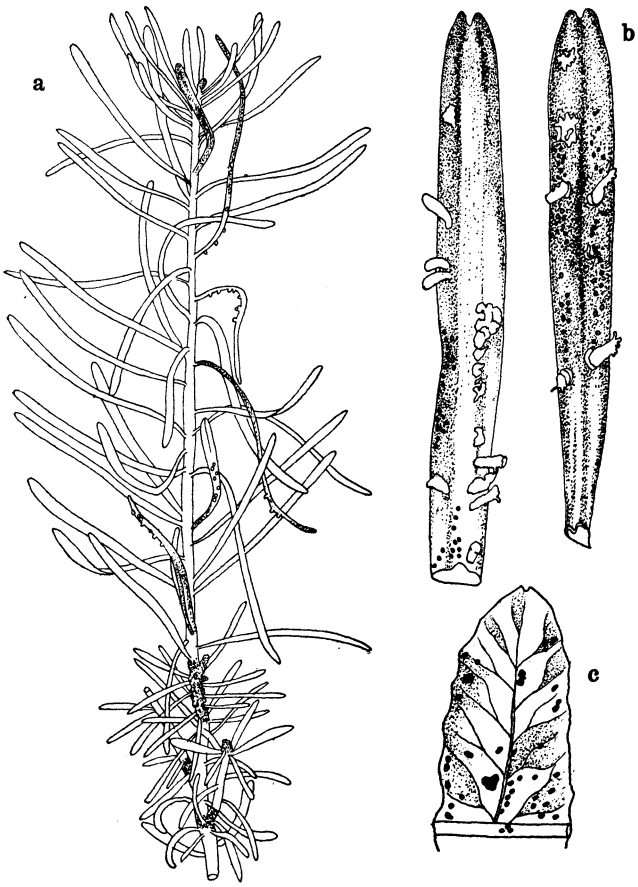

Fig. 1.

a. A three-year old seedling of *Abies Mayriana* in the Tomakomai college nursery affected by *Uredinopsis hirosakiensis* collected in July 10 1933. ×3/4.

b. Two affected needles of the same, on the undersurface distributed by several peridermia and many spermogonia, discoloured and slightly deformed. ×4.

c. A pinna of *Dryopteris Thelypteris* affected by uredo- and teleutostages, on the undersurface distributed by uredo-pustules and discoloured. Enlarged.

margin. Such a coloration was more conspicuous on the upper surface. The deformation of leaves was sometimes slightly hypertrophic or sometimes showed a considerable shrinkage which was especially distinct where the peridermia were formed close together. Sometimes this shrinkage was seen to occur very suddenly from the middle portion or sometimes on the basal portion of an affected leaf. The affected leaves were mostly curved flexuously and seemed to be slightly more elongated than the healthy leaves. The diseased needles were seen not only amongst those of well grown seedlings but also appeared in the poorly developed ones. One of these affected seedlings and two diseased leaves are shown in Figure 1.

Identification of the peridermial stage in question. It is reasonable to think that there may be a difference in the time of the appearance of peridermia in the field according to the species. Considering from the writer's own experience, the most abundant appearance of the white peridermia on the leaves of *Abies Mayriana* grown in the field of our locality occurs in the later part of the year, namely from September to November. However, FRASER (3) when he performed his experiments to determine the generic relations of the five species of Uredinopsis to *Peridermium balsameum* PECK in Nova Scotia, must have collected the fresh inocula from the field in the later part of June, as his experiments were recorded to have been carried out from June 27 to July 3. Also in the writer's experiments the aecidiospores of the white peridermial stage on the needles of *Abies Mayriana* used in the inoculation to obtain the characteristic uredospores of *Uredinopsis ossaeiformis* KAMEI were collected in Chitose and Nopporo on July 4 and July 9 respectively. So the writer at first thought that this peridermium in Tomakomai may also belong to the species mentioned above before he saw them under the microscope. Quite contrary to his expectation, however, the aecidiospores are much smaller and more roundish. Measurements of 100 fresh aecidiospores range from 14 to 25 μ in length, 11–23 μ in width, and the biometric mean is 18.90 ± 0.12 in length, and 17.55 ± 0.14 μ in width. Moreover the inner wall of the peridial cell is finely striated or alveolated. These special markings of peridial cells are very characteristic as shown in Fig. 2, c. Besides, the spermogonia accompanying the peridermia are colourless, subcuticular, smaller and slightly raised from the surface, more or less depressing the epidermal cells or even the subepidermal tissue, and subconoidal to lenticular in shape. Twenty spermogonia in the longitudinal sections measured 80–140 μ in length and 50–80 μ in width, and the average 105.9 μ in length and 64.2 μ in width. None of these characters of the aecidial phase agree with those of *Uredinopsis ossaeiformis* in which the aecidiospores are more oblong, more thin-walled, the peridial cells have more distinct verruculose markings and the spermo-

gonia are subepidermal, larger sized, deeply immersed into the mesophyll and more or less globose. On the other hand, considering from the results of the writer's comparative study of the morphology of various white peridermial forms, such characters of the spermogonia as in the case of the Tomakomai specimens agree with the type of Uredinopsis, especially represented by such species as *Uredinopsis filicina* MAGN., *U. Pteridis* DIET. et HOLW., *U. Struthiopteridis* STOERMER, *U. Adianti* KOMAROV, *U. Woodsiae* KAMEI, *U. Athyrii* KAMEI and *U. hirosakiensis* KAMEI et HIRATSUKA f.

The characters of peridial cells and aecidiospores in the fungus in question reminded the writer at once of those of *Uredinopsis hirosakiensis*, with which he was familiar from having studied several specimens obtained from cultures. A comparison of materials obtained both from the field and from cultures is shown in the following table.

Table 1. Comparison of the size of the spermogonia and aecidiospores of *Uredinopsis hirosakiensis* obtained from the field and from cultures.

		Spermogonia			Aecidiospores		
		Number	from the field (Tomakomai)	from cultures (*Abies Mayriana* X2)	Number	from the field (Tomakomai)	from cultures (*Abies Mayriana* VIII5
Length	Range (μ)	20	80—140	74—137	100	14—25	13—21
	Average (μ)	20	105.9	109.3	100	18.90±0.12	17.86±0.10
Width	Range (μ)	20	50—80	37—93	100	11—23	12—20
	Average (μ)	20	64 2	64.9	100	17.55±0.14	16.48±0.10

The inoculation experiments with the aecidiospores in question on *Dryopteris Thelypteris* A. GRAY by the usual methods were successful showing the resulting uredospores to be identical with those of *Uredinopsis hirosakiensis*. The results of the experiments are shown in the following table.

Table 2. Results of inoculation experiments with the aecidiospores of *Uredinopsis hirosakiensis* collected from Tomakomai on *Dryopteris Thelypteris*.

Experiment No.	Plants inoculated	Date of inoculation	Date of first appearance of uredosori	Remarks
I	*Dryopteris Thelypteris*	July 12 1933	July 22 1933	Potted plants were used for inoculation. After the inoculation covered by bell-jar for two to three days. Then the pot was laid in cooler place.
II	"	July 16 "	July 21 "	Pinnae of host plant were used for inoculation. They were laid on moistened paper lined inside of a glass-dish. Then the dish was laid on the laboratory desk.
III	"	July 22 "	July 29 "	Same as No. I

Considering from these results of the artificial inoculation experiments with the aecidiospores it is believed that the aecidial stage in question may safely be admitted to be the antithetic phase of *Uredinopsis hirosakiensis* which is parasitic on *Dryopteris Thelypteris*.

Actually when the writer visited Tomakomai on Oct. 31 last year, though somewhat late in the season, he was able to see many fronds of *Dryopteris Thelypteris* near the nursery beds as well as in the immediate neighbourhood attacked by this rust presenting the characteristic discoloration and many uredosori. An affected pinna in such condition is illustrated in Fig. 1. c.

Remarks on the taxonomy and life-cycle of Uredinopsis hirosakiensis. As has already been mentioned by the writer (6), the uredo- and teleutostages of *Uredinopsis hirosakiensis* were first discovered by Dr. NAOHARU HIRATSUKA early in 1897 at Hirosaki in Prov. Mutsu. In Hokkaido it has also been collected by several botanists such as N. HIRATSUKA, T. MIYAKE, T. FUKUSHI, K. TOGASHI and N. HIRATSUKA f. from the Provinces of Ishikari, Iburi, Kushiro and Tokachi. Moreover it was also collected by Miss. Y. HOMMA from Prov. Echigo in Honshu. The writer himself also collected many specimens from the vicinity of Sapporo and other localities and studied the taxonomy and life-cycle of this rust for many years.

The uredospores are colourless and usually pushed out as powdery masses from the sori which are formed on the undersurface of the frond as well as on

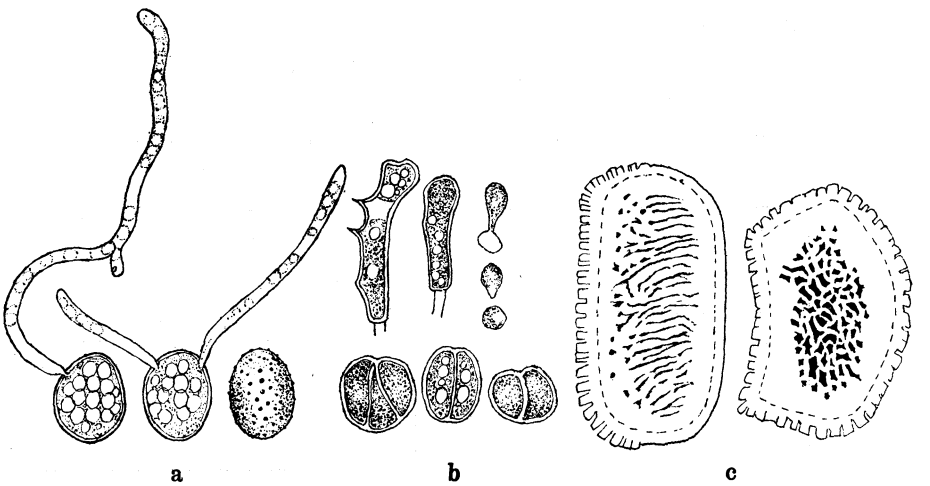

Fig. 2. a. Three uredospores of *Uredinopsis hirosakiensis* showing germination and markings of epispore. ×376. b. Three teleutospores, two promycelia and three sporidia. ×376. c. Peridial cells of a peridermium, the right shows the face view of the inner wall and the other the side view. ×1280.

the stipe. They are more or less globose, mostly ovoid, but often elliptic in shape and the epispore is evenly and sparsely covered with fine verrucose projections. They germinate usually by a slender germ-tube but often two tubes appear simultaneously from two germ-pores laid on both sides near the apex or on points near both ends of either side of the spores (Fig. 2 a). But the total number of pores could not be definitely determined, so that it can not be stated here whether these features do agree with those in the cases of *Uredinopsis mirabilis* MAGN. (3) and *Uredinopsis Phegopteridis* ARTH. (1) or of *Pucciniastrum Potentillae* KOMAROV and *Pucciniastrum arcticum* TRANZSCH. (8). On the other hand, these uredospores are adorned by neither beak nor ridges with which they are usually equipped in the case of the typical species of Uredinopsis, for instance, *Uredinopsis Atkinsonii* MAGN., by which rust one and the same species of the host plant is attacked in North America has a long beak and two longitudinal ridges quite distinct from the species now in question. So the morphology of the uredospores of this species is not quite similar to those typical species of Uredinopsis but apparently like to those of the species of Pucciniastrum, except that they are devoid of a coloured pigment even in fresh condition. Besides, the subepidermal and colourless teleutospores which are often compactly aggregated just under the epidermis are surely like those of *Uredinopsis Osmundae* MAGN. and *Uredinospsis Phegopteridis* ARTH. regarding which

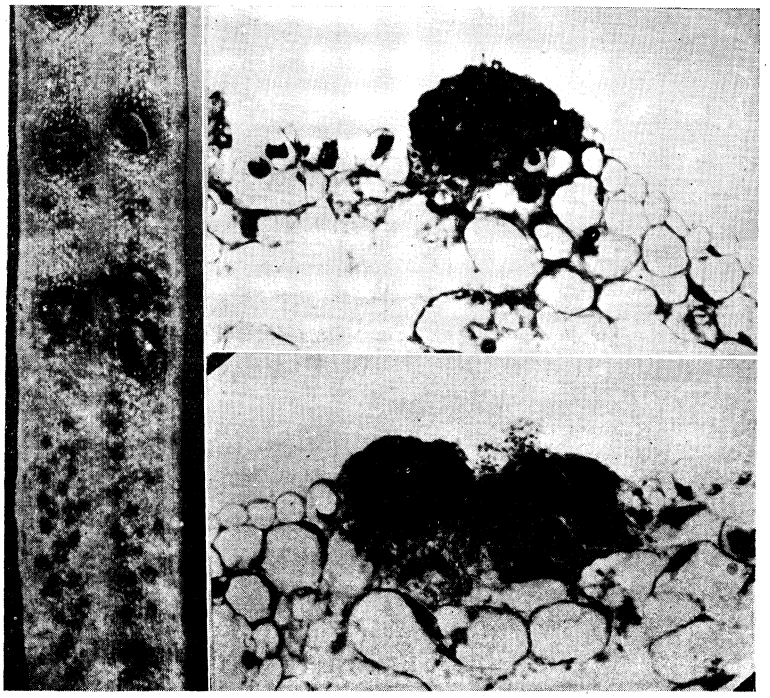

Fig. 3. a. An affected needle of *Abies Mayriana* VI_6, on the undersurface distributed by several peridermia and many spermogonia. ×17.
b, c. Three spermogonia seen in the transversal section of the needle of *Abies Mayriana* III_3. ×330.

MAGNUS (7) and BELL (1) respectively have already reported. Each teleutospore is commonly two-celled but sometimes three- to more celled (Fig. 2 b). It germinates after hibernation issuing a promycelium from each cell. Sporidia produced on the promycelium infect the young needles of *Abies Mayriana* in the early summer to produce spermogonia after about two weeks and peridermia after about three to four weeks. The writer successfully obtained such a peridermial stage on the needles of seven seedlings (X_2, III_3, VIII_5, VI_6, II_8, II_{10} and X_{10}) out of eight inoculated ones. These spermogonia and peridermia were invariably colourless and unlike those of *Fucciniastrum Tiliae* MIYABE, *P. Styracinum* HIRATSUKA and *P. Epilobii* OTTH. Magnified photographs of an affected needle and spermogonia obtained from the cultures are shown in Fig. 3. Moreover in this species the amphispores which in other species of Uredinopsis usually accompany the ordinary uredospores are not found so far as the writer is aware.

After a careful perusal on every stage of life-cycle in this rust it seems to preferable to consider the fungus in question to be a species of Uredinopsis

in spite of the peculiar characters furnished in its uredospores. So, the writer has already published its technical description based on this idea.

Damage to the seedlings. When the writer first saw this peridermium on the needles of the seedlings of *Abies Mayriana* at the nursery bed (Plot No. 4) at Tomakomai, he attempted to count number of the affected seedlings taking three different standard areas (1 square meter) and obtained from each area 58.7, 56.4 and 41.1 percent as the number of diseased seedlings respectively. Mr. SHIGEJI ITO of whom was requested further surveying of these injuries over the entire area of the nursery beds, reported with several packets of specimens and the accompanying table (Table 3). A considerable number of the affected needles selected from each specimen were soon inspected and were determined to be the same fungus as those from plot No. 4 above mentioned. So, if these seedlings counted by Mr. ITO were invariably attacked by this rust in question, the total number of diseased young seedlings of 2 to 10-years old, attained to 20368, varying 6 to 51 percent according to the plot. Moreover the writer saw the same peridermium also on the needles of numbers of seedlings (11-years old) grown in the plantation plot at XXI division of this college forest.

Secondly, to estimate the amount of the diseased leaves per seedling, careful inspection was made of each of 50 seedlings taken from plot No. 4. It was ascertained that 1 to 11 leaves were attacked per seedling. As the total number of the needles of a new shoot count 20 to 239, the percentage of attacked needles remains only 19 percent at most. However, in the case of such small seedlings as those of only 4 cm. height even such a grade of injury may surely offer a considerable damage to their vigour.

Table 3. General features of damage of seedlings of *Abies Mayriana* attacked by *Uredinopsis hirosakiensis* in the plots of the college nursery at Tomakomai.

Plot No.	Area (tsubo)*	Year of sowing	Total number of seedlings	Age of seedlings (years)	Average height (cm.)	Average diam. (mm.)	Total number of diseased seedlings	Percentage of diseased seedlings
4 a	20.0	1931	23200	3	9.1	2.9	6278	27
4 b	30.0	1931	6240	3	4.7	1.4	1260	20
II	7.5	1924	207	10	55.0	9.0	69	33
IV. A	23.0	1931	28244	3	6.0	1.5	3389	12
IV. B	6.0	1924	200	10	35.0	7.5	76	38
V. A	5.5	1924	111	10	50.0	9.5	57	51

Plot No.	Area (tsubo)*	Year of sowing	Total number of seedlings	Age of seedlings (years)	Average height (cm.)	Average diam. (mm.)	Total number of diseased seedlings	Percentage of diseased seedlings
V. B	14 5	1931	11928	3	5.5	1.3	3198	27
V. C	30.0	1931	15000	3	7.6	1.2	3900	26
VIII	5.5	1932	35080	2	4.0	1.0	2141	6
Total	182.0	—	120210	—	—	—	20368	17

* A tsubo corresponds to 3.3 square meters.

In conclusion, the writer wishes to express his heartiest thanks for the kind direction of Professor SEIYA ITO.

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