On the vegetative life of some Uredineae¹.

BY

JAKOB ERIKSSON, Ph.D.,

Professor at the Royal Agricultural Academy, Stockholm.

I. INTRODUCTORY REMARKS.

IN the middle of 1860 Anton De Bary succeeded in proving by experiments the power of some corn-rust Fungi to live in different forms on two or more distinct hosts, that is to say, their so-called Heteroecism.

At first, and for some time, there was no doubt that the question of the corn-rust had been solved through this discovery. The aecidium-forms on *Berberis*, *Rhamnus*, and *Anchusa* were considered to be indispensable generations of *Puccinia graminis*, *P. coronata*, and *P. rubigo-vera*. Then, this being the case, one must get rid of the corn-rust by rooting out from the neighbourhood of the cornfields as radically as possible the plants attacked by the aecidia. In several countries of Europe and America they have begun a war of eradication against the plants mentioned above, especially against the barberry bush.

It is true that many researches during the following decennia have confirmed the results of De Bary in essential points. Repeatedly it has been shown that aecidiospores of barberry, &c., if sown on the young leaves of corn, infect them and produce the uredo and then the puccinia on them. Conversely, the sporidia of the puccinia, if sown on the young leaves of barberry, &c., infect them and produce the spermogonia, and then the aecidia on them.

But at the same time it has become more and more manifest that the process of development of the corn-rust diseases cannot be quite as simple as it was considered at first.

¹ Read before the Botanical Section of the British Association, Cambridge, August 22, 1904.—Conf. J. Eriksson, *Sur l'appareil végétatif de la rouille jaune des céréales*, Compt. Rend., 1903, p. 578. *Über das vegetative Leben der Getreiderostpilze*, I, Kgl. Sv. Vet.-Ak. Handl., 1904, Bd. xxxvii, Nr. 6. *Nouvelles recherches sur l'appareil végétatif de certaines urédinées*, Compt. Rend., 1904, p. 85. *Über das vegetative Leben der Getreiderostpilze*, II–III, Kgl. Sv. Vet.-Ak. Handl., 1904, Bd. xxxviii, Nr. 3.

Now we know that we have to count with twelve instead of three species of corn-rust Fungi. *P. graminis* is divided into two species, *P. coronata* into two, and *P. rubigo-vera* into eight. Among these twelve species we find only four, *P. graminis* sens. strict., *P. coronifera*, *P. coronata*, and *P. dispersa*, which are heteroecious, and among these four species only the three first-mentioned have their teleutospores germinating in the spring after they are developed. The teleutospores of *P. dispersa* already germinate in the same autumn as they are developed.

Consequently we can explain the reappearing of the corn-rust in the following summer, in accordance with the principles of De Bary, only so far as concerns the three species with the teleutospores lasting the winter. In the case of *P. dispersa* that is impossible, because the aecidia on the *Anchusa*, like the *Anchusa* itself, end their lives before winter sets in.

Further, we must notice that *Berberis*, *Rhamnus*, and *Anchusa* do not at all occur so commonly as to explain the ubiquity of the corn-rust. In consequence it has become more difficult now than formerly to explain a rust-epidemic on our cornfields in a satisfactory manner.

Finally, I wish to observe that very numerous detailed studies executed in the open air during the last decennium, as well as many isolated cultures during the same time, have indicated the great probability of there existing an internal source of disease in the corn-plant itself, these internal germs being inherited from the parent plant.

In several works¹ I have submitted the hypothesis that the rust-fungus in the corn-varieties, extremely susceptible to rust, must live for a long time a latent symbiotic life in the cells of the plant itself—this symbiosis being called *mycoplasma*—and that only a short time before the eruption of the rust-pustules, when external conditions are favourable, it enters upon a visible state, assuming the form of a *mycelium*.

The mycoplasma hypothesis has been contested by many authors in several countries. However, through the criticisms presented I am not convinced of the error of the hypothesis. On the contrary I will now demonstrate some new investigations which appear to afford a good support to the theory already suggested.

Since the summer of 1902 I have been working at a cytological research on the vegetative life of the corn-rust Fungi. In this work I was effectively supported in the summer of 1902 and 1903 by Dr. George Tischler from Heidelberg.

Material of leaves, straws and ears of several corn-varieties, collected in several seasons and in varying stages of development, was fixed for the

¹ J. Eriksson, *Vie latente et plasmatique de certaines urédinées*, Compt. Rend., 1897, p. 475. *Der heutige Stand der Getreiderostfrage*, Ber. d. Deutsch. Bot. Ges., Bd. xv, 1897. *Sur l'origine et la propagation de la rouille des céréales par la semence*, Ann. d. Sc. Nat., Bot., sér. 8, t. 14-15, 1901-2. *The Researches of Professor H. Marshall Ward on the Brown Rust on the Bromus and the Mycoplasma Hypothesis*, Ark. f. Botanik, Stockholm, 1903, s. 139.

most part in Flemming's Fluid, but sometimes in Hermann's Fluid, in Absolute Alcohol, in Corney's Fluid or in Merkel's. The washing, the hardening and the paraffin-embedding were done in the usual way. The staining took place mostly with Flemming's Saffranin-gentian-violet-orange, but now and then with Heidenhain's Iron-alun-haematoxylin or with Fuchsin-methyl-green.

II. PERENNIAL MYCELIUM. DOES IT EXIST IN THE WINTERING CORN-PLANT?

The first pressing question which had to be solved was whether there exists in the wintering corn-plant (Winter Rye, Winter Wheat) a mycelium surviving from the late autumn of the one year until summer of the following year, at which time the new rust-pustules are breaking out.

To explain this I fixed and embedded species of the leaf of three Wheat-varieties (Horsford's Pearl, Michigan Bronze, Squarehead), and one Rye-variety (Pirna Rye) in the year 1902 on October 6, 14, and 27, and in the year 1903 from the same plots on April 28, May 28, June 5, 11, and 18, and lastly on July 4. From October 6, 1902 until June 18, 1903 there was no trace of rust-pustules to be discovered on the plots. On July 4 we saw solitary spots of yellow rust-pustules (*Uredo glumarum*), breaking out on the wheat-leaves (Horsford's Pearl), but the small pieces for embedding were taken as far away from these pustules as possible, on those parts of the leaves which looked wholly sound. The Rye leaves were clean also on July 4.

From the embedded pieces of leaves very numerous series of sections were cut and examined. On this examination we have seen in none of the sections—and the research involved the examination of thousands of such—the least trace of mycelium either in the wheat or in the rye-leaves, not even in the wheat-sections (Horsford's Pearl) of July 4, which were taken far from the pustules.

From this examination we can conclude, I think, with a great degree of certainty, that the outbreak of *Uredo glumarum* on the wheat-leaves in the first days of July, and of *Uredo dispersa* one week later, could not be explained from a *perennial mycelium in the corn-plant itself*. Such a mycelium *was not at all to be found there*.

I ought to observe that the period of the biennial corn-plant's life, in which no mycelium is to be discovered, must be very varying in different years. For the season 1902–3 this period lasted from the sprouting in the beginning of October until the beginning of the following July, that is to say for nine months. In other seasons, when external conditions are favourable for the development of the Fungus, we can already see proleptic outbreaks of rust-pustules at the end of October or in November, and the

principal outbreak in the new year can take place in the beginning of June or even earlier, in the course of May. Thus in the past season 1903 I have seen on November 2 pustules of *Uredo glumarum* abundantly in several wheat-plots on the experimental-field, and new pustules were already breaking out in great abundance in the first days of May. In such a season the period lacking mycelium in the wheat-plant's life must be short, two or three weeks in October after the sprouting, and in the new year, two or three months, March-May, in the early spring.

III. THE INTRACELLULAR MYCOPASM-LIFE OF THE FUNGUS.

The results of the researches carried out have, however, by no means been only negative. In all embeddings of varieties especially susceptible to the disease we find *some cells more or less filled up with a particular dense plasmatic substance*, at first commonly fine-grained, later more retiform and vacuolar. In the younger stages—*the resting-stage of the mycoplasm*—the cell-nuclei seem to be of normal size, but later they swell to twice their normal size and lose to a certain degree their normal fibrillar structure. Gradually they also lose their normal form and appear as if eroded on the surface. At last they usually disappear as organized bodies, vacuoles frequently appearing as well as some small bodies, which take the saffranin stain. Now the mycoplasm enters into its *ripening-stage*.

From this time the Fungus must be considered as a true parasite, beginning to dissolve the cell-nucleus. Simultaneously one sees in the mycoplasmic reticulum small spherical bodies, which take the saffranin stain. These bodies are surrounded by hyaline areas and are believed to be the nucleoli of *the nuclei of the mycoplasm*, the hyaline area surrounding each nucleolus being the body of the nucleus. The spherical bodies are very variable in size.

IV. THE INTERCELLULAR MYCELIUM-LIFE OF THE FUNGUS.

Now the plasmodium is ready to force itself out of the host-cell, in order to develop an intercellular mycelium. On its forcing itself out no dissolution of the cell-wall, either total or partial, takes place. It seems to be the case that the plasmodium effuses through the subtile pores that must be supposed to exist in the cell-wall, that is to say in the same way as the plasmodesms between the cells.

At this stage of development we often find places in the preparations, where wholly *corresponding portions of plasma are to be found inside and outside the cell-wall*. The connexion between the two plasma-portions is only broken off in consequence of the plasmolysis of the cell-contents.

The inner and outer plasma-portions otherwise show quite the same structure, and react in the same way towards staining agents.

When expelled from the cell the nucleoli of the plasmodium are dissolved and their contents are transported into the outer plasma-portions. One often finds distinct threads growing from the larger nucleoli towards the cell-wall. In this case we have before us a body very like a young haustorium, as that is generally described and represented. But there is a great difference, in that we have before us here a growth that must be considered as coming from within. I will name it an *Endohaustorium*. The contents of the former nucleolus gradually get exhausted, and then only the outer light halo remains as a wide vesicle still connected with the outer mycelium and transporting nourishment to this from the cell-residues.

In company with these round-headed bodies we find now and then some elongated ones, otherwise of the same structure. Probably they also must be considered as endohaustoria.

It sometimes happens that the production of mycoplast-nucleoli is very reduced or quite absent, and nevertheless the plasmodium is forcing itself out. This is probably due to an accidental weakness of the mycoplast.

At first one observes no distinct nucleoli in the intercellular *Protomycelium*, only various small grains of plasma, which take the violet colour more deeply than the other parts of the plasma. These grains are to be considered as a preliminary stage of nucleoli.

Very quickly, however, a new stage begins, in which are formed large distinct nucleoli, surrounded by a light halo.

Hitherto there were no partition-walls in the intercellular fungus-body, but later on such walls are formed, simultaneously with the dissolving of the nucleoli.

After this we get a true *mycelium*, and finally a tissue of threads winding round the remaining leaf-cells, that is to say a *pseudoparenchyma*. Gradually the tissue of the host-plant is consumed by the Fungus. The chlorophyll-corpuscles are agglomerated into an irregular lump, and at last all the remaining parts of the cells are devoured by the Fungus.

Now the Fungus is ready to produce spore-pustules. This seems to be initiated by a new appearance of large nucleoli in the pseudoparenchyma. The spore-forming threads grow outwards and the spores are produced.

With the production of spores a new period, the fructificative period, of the fungus-life is introduced, the vegetative period being ended.

So far the investigation has as yet been followed up only to the stage of development of the corn-plant, where its tender germ is sprouting out of the earth. The question, where the plasmodia in the leaves of the corn-plants have come from, must be left for further investigation.

Eriksson, Jakob. 1905. "On the vegetative life of some Uredineae." *Annals of botany* 19, 55–59. <https://doi.org/10.1093/oxfordjournals.aob.a088992>.

View This Item Online: <https://www.biodiversitylibrary.org/item/233541>

DOI: <https://doi.org/10.1093/oxfordjournals.aob.a088992>

Permalink: <https://www.biodiversitylibrary.org/partpdf/318784>

Holding Institution

Smithsonian Libraries

Sponsored by

Biodiversity Heritage Library

Copyright & Reuse

Copyright Status: Not in copyright. The BHL knows of no copyright restrictions on this item.

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.