

THE RUSTS OF NOVA SCOTIA.—BY WILLIAM POLLOCK
FRASER, M. A., Macdonald College, P. Q.

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This paper embodies the results of field and microscopic studies of the rusts of Nova Scotia carried on during the years 1908 and 1909.* A few collections were made in 1906 and 1907, but careful and systematic study was begun in the summer of 1908 and has been continued since that time. The most of the collections were made near Pictou and in the surrounding districts, so that it might seem more appropriate to name the paper "The Rusts of Pictou County," but it was thought best to include all the collections made in the province, thus the more inclusive title is used.

Scarcely any attention has been given to this interesting group of fungi in Nova Scotia. The only references that have been found are in Dr. MacKay's "Fungi of Nova Scotia" and "First Supp. List." In these papers (Trans. N. S. Inst. of Science, 11:141. 1905; 12:124-126. 1908), the following species are listed: *Puccinia graminis*, *Gymnosporangium Juniperi*, *Gymnoconia interstitialis*, *Coleosporium Solidaginis*, *Melampsora Medusae*, *Puccinia acuminata*, *P. Taraxaci*, *P. sessilis* (?), *P. suaveolens*, *P. coronata*, *P. Menthae*, *P. Circaeae*, *P. Cicutae*, *P. Violae*, *P. Asteris*, *P. orbiculata*, *P. claytoniata*, *P. rubigo-vera*, *Uromyces Trifolii*, *U. caladii*, *Phragmidium subcorticium*, *Triphragmium clavellosum*, *Chrysomyxa Pirolae*, and the forms *Rostelia lacerata*, *Uredo Agrimoniae*, *Peridermium balsameum*, *Per. decolorans* and *Per. latinum*.

Of the species named in Dr. MacKay's list I now regard *Phragmidium subcorticium* as *Phragmidium americanum*, *Uredo Agrimoniae* is the uredinal stage of *Pucciniastrum*

* Revised to include collections and studies during 1910 and 1911.

Agrimoniae, *Puccinia coronata* is described in the following pages as *Puccinia Lolii* and *Puccinia rubigo-vera* as *Puccinia triticina*. *Peridermium decolorans* is the aecial stage of *Melampsoropsis ledicola* and *Peridermium elatinum* of *Melampsorella elatina*. The position of *Gymnosporangium Juniperi* and *Rostelia lacerata* is discussed under the genus *Gymnosporangium*.

In the present paper 92 species and 2 forms are described. A few of these have not been previously reported from North America.

In the general discussion and in some of the notes I am indebted to the literature of the rusts. A list of the works consulted will be found at the end of the paper.

INTRODUCTION.

The *Uredinales* (*Uredineae*) constitute a large group of fungi which are parasitic on flowering plants and ferns. Their structure consists of an inconspicuous mycelium in the tissues of the host plant and more or less conspicuous spores that usually break through the epidermis and appear as powdery masses or crusts. The vegetative mycelium is similar throughout the group, but the spores produced are unlike so that a study of the rusts is largely a study of the spore forms and their relation to each other and to the host plants. The mycelium eventually gives rise to the teliospores which are generally regarded as the last stage. Spores of five kinds are produced, though they are not all present in every species. Arthur has proposed new terms for these spores, which are used throughout this paper. The list below gives in order the term proposed by Arthur and the more commonly used term for each spore form:

- Basidiospore, sporidium.
- Pycniospore, spermatium.
- Aeciospore, aecidiospore.
- Urediniospore, uredospore.
- Teliospore, teleutospore.

These spores always follow each other in a definite order; that is, first pycniospores, then aeciospores, urediniospores, and lastly teliospores. One or more of the spore forms may be absent in certain genera or species, except the teliospores, but the spore succession is the same. The basidiospores are produced on a short promycelium developed directly from the teliospore and are thus always present. The largest number of rusts have all the spore forms present; the next largest is the series with all the forms suppressed except the teliospores; then the series with the urediniospores absent, and the smallest number is that in which the aeciospores are wanting. Not much attention has been given to the presence or absence of the pycniospores, for they seem to be present in a great majority of species, though wanting in a few.

Mycelium.

The vegetative mycelium of the rusts is very inconspicuous. It is much branched, colourless, septate and usually ramifies in the walls of the cells, sending haustoria into the cavities. It may be localized or it may permeate the whole plant, and in the latter case is often perennial. Thus the fungus may appear in the same plant year after year without spore infection. In *Puccinia obtegens*, the rust of the Canada thistle, the mycelium lives in the upper part of the rootstock during the winter and infects the young shoots in the spring. In the "Orange Rust of Raspberry" (*Gymnoconia interstitialis*) the aecial mycelium is perennial in the canes and thus lives from year to year.

Eriksson has advanced the theory that the mycelium may live in the cells of the host in the form of a plasma intimately mixed with the protoplasm of the host, and that under favourable conditions, as in the spring, this *mycoplasma* develops into the ordinary mycelium. This would account for the wintering of many rusts where the aecial hosts are not found and for the sudden outbursts that often occur in the cereal rusts.

The mycelium often produces abnormal growths. The most conspicuous in this region is the "witches' broom" of the balsam fir and the elongated and abnormally thickened stems of the bluberry due to the telial stage of *Calyptospora colum-naris*. Some species of the genus *Gymnosporangium* produce spherical galls on the cedar, but they do not seem to have been collected in Nova Scotia. In these cases the mycelium is per-ennial, but even localized mycelium may produce swellings and deformation especially in the stalks and midribs of the leaves. This is so in the case of the aecial stage of *Puccinia sambuci* which is common in the spring on *Sambucus canadensis*.

Pycniospores.

The pycniospores are produced in a pycnium (pycnidium, spermagonium) which is a small inconspicuous, punctiform body. It is usually flask-shaped averaging 100-150 μ in diameter, formed immediately beneath the epidermis, with the narrow neck protruding in order to discharge the spores into the air. Usually the opening is provided with a small tuft of hairs. Sometimes the pycnium is formed immediately beneath the cuticle and is then more or less hemispherical or conical. The pycnia are usually on the opposite side of the leaf from the spore-form accompanying them, but sometimes on the same side when usually they surround the accompany-ing form. Their position, arrangement, form, color and size are characters of some taxonomic value. Usually pycnia appear after infection by basidiospores without any regard to the kind of spore that is to follow: thus, though they usually precede the aecia, they may accompany the other spore forms when aecia are wanting.

The pycniospores are very small, oval or rounded bodies a few microns in length (about 5-8 μ). They are produced within the pycnium in short chains from converging hyphae and are held together by a viscid sugary secretion, which some-times attracts insects. As far as is known these spores have

no function nor any connection with the further development of the fungus. They may be made to grow and bud in a nutrient solution but nothing further has been obtained. It may be that they had some sexual function that has been lost, but there is not much evidence to support this view.

The pycnium is rarely absent in the life cycle, but it only occurs once, not being repeated with each generation. If the aecia repeat, spermatogonia only occur with the first generation. If the pycnium accompanies the uredinia it does not repeat. In the case of the teliospore it has not been established whether it accompanies each generation or not.

Aeciospores.

The mycelium, which results from the entrance of the germ tube of a basidiospore after it has produced a certain number of pycnia, soon develops aeciospores. Within the plant tissues hyphae collect together into a compact mass growing perpendicular to the surface of the host, and from the closely crowded hyphae the spores are cut off in basipetal succession so that they are produced in chains. At first sterile cells alternate with the spore cells, but these usually disappear by the time the spores are mature. The outer layer of hyphae usually becomes a wall or peridium, which surrounds the spore mass, and after the rupture of the epidermis usually becomes cylindrical or cupshaped. Sometimes the peridium is absent or it may be replaced by paraphyses as in the genus *Phragmidium*. The spore mass with its peridium or paraphyses is called an aecium or aecidium. The spores are at first polyhedral from mutual pressure, but they soon become free and are then usually globose or ellipsoid in shape. The wall is usually colorless (deep brown in the genus *Gymnosporangium*) with verrucose sculpturing. The roughened wall aids the spores in adhering to the host plant. The contents are chiefly orange-red or orange-yellow and in many cases soon become colourless. Eventually the aecia rupture the

epidermis, the peridium breaks open, sometimes in a characteristic way, and the spores escape. They are most effectively distributed by the wind.

Sometimes all unconnected aecia are placed in the form-genus *Aecidium*, but other form-genera are used, based on the presence or absence or form of the peridium. Thus, when the peridium is elongated and dehisces by longitudinal slits, the aecia are assigned to the form-genus *Roestelia*; when it is extended and ruptures irregularly, to *Peridermium*; when absent, to *Caeoma*; the other forms in which the peridium is usually cupshaped or cylindrical, to the form-genus *Aecidium*.

Aeciospores are provided with germ-pores, but they are usually visible only at germination. They germinate readily in water in a few hours. A germ tube is pushed out from one germ pore and the contents of the cell soon pass into the tube. On the host plant the tube enters through a breathing pore.

Botanists differ as to the length of time that aeciospores retain their germinating power. Plowright found they retained it only a few hours, Klebahn found they retained it for weeks, others found them uncertain.

The aecia that develop from the mycelium resulting from basidiospore infection are called "primary" aecia. When the complete series of spore-forms is present no further aecia are formed, but if the uredinia are wanting the aecia may repeat themselves for some time. That is, aeciospore infection may take place and produce aecia. These are called "secondary" aecia.

Urediniospores.

The urediniospores are produced in spore masses or cushions called uredinia, which usually rupture the epidermis and expose the spores as a dusty mass. They may develop from mycelia produced from the entrance of the germ tube of a basidiospore, an aeciospore or another urediniospore. Mycelial hyphae become crowded together in the host plant

at certain points; from this intertwined hyphal mass a number of branches are given off perpendicular to the surface of the host, and from each of these branches a urediniospore is produced. Sometimes paraphyses are present as in *Melampsora* and *Phragmidium*, and in a few genera a peridium is produced as in *Pucciniastrum* and *Melampsoridium*.

The urediniospores are usually produced singly on pedicels which soon fall away, but sometimes in chains, as in *Chrysomyxa* and *Coleosporium*. When arising in chains they resemble aeciospores, but the order of development will distinguish, the aeciospores always being produced first. The urediniospores are always unicellular, with verrucose or echinulate walls. They are never smooth, and are usually coloured brown. Two or more germ-pores (rarely one) are present which are usually evident. As the number is often definite, it sometimes forms a character of value in the determination of the species.

The urediniospores germinate readily in water, as in the case of the aeciospores. When mature and under favourable conditions on the host plant a germ tube is pushed out through one of the germ pores, which grows very rapidly, and the nucleus of the spore soon passes into it. When it reaches a breathing pore the tip swells into a vesicle, the appressorium, into which the protoplasm of the tube collects. A thin process passed down through the pore and swells into a vesicle in the respiratory cavity, the protoplasmic contents soon pass into the internal vesicle. Tubes or hyphae are soon formed from this vesicle which make their way among the cells. The development of the haustorium begins as a minute process from the hypha, which pierces the cell wall and at once swells up at its distal extremity into a minute head. Soon this grows out, often as an irregularly branched or variously shaped body. In many cases the growth is directed toward the nucleus and infection is complete. (Ward. Phil. Trans. Roy. Society, London, B., 196: 29-46. 1902).

The urediniospore is primarily a spore for the rapid distribution of the fungus so that it may repeat, that is the uredospores may infect the host plant. Often the first formed generation which appears in early spring and originates either from basidiospore infection, aeciospores, or from perennial mycelium, are called "primary" uredinia, and the second generation which develops from uredospore infection are called "secondary" uredinia. The primary uredinia are usually larger and more richly coloured, as in *Puccinia obtegens*.

In countries where the aecial host is absent and the urediniospore propagates the fungus, there is a tendency to abundant development of this stage, as in *Puccinia graminis* in Australia. This rust has lost the power to infect the barberry there and urediniospores are produced abundantly, almost to the exclusion of the teliospores.

Urediniospores retain their germinating power for some time. Bolley states that the uredospores of *P. graminis* in certain cases may survive the winter even in North Dakota, and thus carry the fungus over that period.

Amphisporos.

Another kind of urediniospore which has thickened walls and persistent or subpersistent pedicels is found in some species of gramineous rusts. The sori resemble telia and the spores have been mistaken by some observers for teliospores. They can be separated from the true teliospores by the presence of several germ-pores. They have been germinated in 1901 by Carleton and later by Arthur, and the germ tube of the urediniospore was the result. They have not been found in any species represented in Nova Scotia.

Arthur states that they belong to species having their main development in arid or semi-arid regions. They occur only in the United States and Mexico, except one species in India. Arthur (Bull. Torr. Bot. Club 32: 35. 1905) gives a list of five species which he found to possess amphisporos. All are from

the western United States and Mexico. The amphispore is evidently a uredospore which has developed the function of a teliospore.

Teliospores.

These are the last spores of the life cycle. It may possibly be that in some cases they are absent, but usually it is simply a case of not having been found. Teliospores are very varied in their forms and on this account have been used largely for purposes of classification. More stress is now laid on other characters.

They arise like the urediniospores in sori called telia or teleutosori, beneath the cuticle or the epidermis. They usually break through the epidermis at length, though they may remain covered. The sori may be pulverulent or compact and often dark in colour, though sometimes colourless or bright coloured. They may be borne on pedicels or sessile. In one genus (*Endophyllum*) not represented in North America the teliospores originate in chains and are surrounded by a peridium regarded as the test of the teliospore. The walls of the teliospores are usually much thickened and may be smooth or verrucose, but never echinulate. Sometimes finger-like projections are present at the apex, as in *Puccinia Loliæ*. The number of cells varies from one in *Uromyces* to several as in *Phragmidium*. The number of germ pores in a cell is usually one. In *Uromyces* it is always placed at the apex. In the genus *Phragmidium* and *Gymnosporangium* there are several in each cell.

The telia as in *P. "rubigo-vera"* is often divided into compartments by modified hyphae, which have been called paraphyses, but Arthur regards this as a stroma and not part of the sorus; he regards such sori as compound.

Some teliospores germinate at maturity on the host plant. But the teliospore is primarily a winter spore, whose purpose is to tide the plant over winter, and the majority will not

germinate unless exposed to the weather for some time. If kept inside during the winter germination does not follow even if placed under favourable conditions.

After exposure to the weather for some time, they usually germinate under favourable conditions, though germination is somewhat uncertain. A tube emerges from the germ pore and soon divides into four, each segment is called a basidium and produces on a sterigma a small, usually hyaline spore. These spores, called basidiospores (sporidia), when they reach a suitable host germinate, the germ tubes make their way through the epidermis and infection results.

When the teliospores germinate at once usually the other spore forms are suppressed. They are not lost, however, as they occasionally make their appearance. When the teliospores germinate at once the germ-tube of the basidiospore is said to enter at the breathing pore.

Mesospores.

In many rusts of the genus *Puccinia*, beside the usual two-celled spores large numbers of the single-celled spores are formed. These resemble the teliospores and function like them, the only difference being in form and the number of cells. They are called mesospores. They are common, especially in some species of the grass and sedge rusts. The presence of these one-celled spores seems to indicate a close relationship to the genus *Uromyces*. It is possible that the genus *Puccinia* developed from *Uromyces*.

Heteroecism.

Many rusts pass part of their life cycle on one plant and part on another, while in some species the whole life cycle is confined to one host plant. Those belonging to the former are called heteroecious species and the latter autoecious species. In heteroecious species one host plant bears the pycnia and aecia, the other the uredinia and telia. Usually the host plants

are not nearly related. Thus the species belonging to *Gymnosporangium* have their aecial stage on a tribe of the rose family while the telial stage is on conifers. The grass and sedge rusts usually have their telial stage on the *Compositae*, though there are many exceptions. All the grass and sedge rusts are heteroecious with one or two exceptions. Common autoecious rusts are those belonging to the genus *Phragmidium*; other species are *Puccinia Menthae*, *P. Violae*, *Uromyces Limonii* and *U. Polygoni*.

When different forms occur together on the same host plant they are often assumed to belong to the same species, but it is not always safe to do so, without the test of infection experiments.

In the largest number of heteroecious rusts the teliospores are formed at the close of the season or of the life of the host, and rest during the winter. The aecial host is infected in the spring, and the alternate host from the aeciospores. That is the case in *Puccinia graminis* and many other rusts. In other cases the telial mycelium hibernates, the teliospores are produced in the spring and germinate immediately, and the basidiospores infect the aecial host, as in *Chrysomyxa ledicola*. Again the telial mycelium may be actually perennial, the teliospores formed in the spring and germinating infect the aecial host, the aecial mycelium lasting only during the summer as in *Gymnosporangium*. There are other types in which the aecial mycelium hibernates, or the mycelium of both generations may be perennial.

The aecia of heteroecious rusts develop only from mycelium formed by basidiospore infection, the aecia do not repeat, nor can the basidiospores produce infection in the host plants in which the telia are produced. The mycelium that bears telia and uredinia arises only from infection by aeciospores or urediniospores. The rust, however, may be propagated by the urediniospores for some time, probably indefinitely. In Australia *P. graminis* has lost the power to infect the barberry

and, as far as known, aecia are never produced, yet it is very common.

The heteroecism of rusts was first suspected and established in the wheat rust, *P. graminis*. For years before botanists made the discovery, practical farmers suspected that the barberry was connected with the spread of wheat rust. In 1760 a law was passed in the State of Massachusetts for the destruction of barberry bushes. In 1816 Schoeler, a Danish schoolmaster, planted small barberry bushes in the middle of a field of rye and found that the rye around those bushes became rusted while not a rust spot could be found in the rest of the field. He also carried rusted barberry leaves into a field of rye, and rubbed them on the rye plants till he could see the "yellow dust" of the barberry leaves adhering to the plants. These plants were marked and were found to be the only ones in the whole field which became infected with rust. But botanists took no notice of these experiments or of farmers' observations, as they believed the barberry fungus and the rust on rye belonged to different genera. Tulasne showed that the uredinia and telia, which up to this time had been regarded as different genera, were connected. In 1861 De Bary pointed out that many of the rusts had urediniospores and teliospores and also that the latter gave rise to aeciospores, and conversely the aeciospores to urediniospores. In 1864 he sowed the teliospores of *Puccinia graminis* on barberry and produced aecia, and in 1865 he sowed aeciospores on rye and produced uredinia and telia, thus establishing the connection of the different forms. However, it was not till about 1880 that the heteroecism of the rusts was generally accepted. Since that time many botanists have carried on infection experiments, so that the number of heteroecious rusts now known amounts to over 150 species.

Much has been learned of the heteroecious rusts by infection experiments carried on by European and American botanists. In America Farlow and Thaxter for eleven years

(1880-1891) studied the genus *Gymnosporangium* in this way, and Arthur began culture work in 1899 and has carried it on to the present time.

The method used in culture experiments is usually as follows. Hosts or suspected hosts are grown from seed or transplanted into pots and kept in some suitable place. Teliospores that have been wintered are germinated in a moist chamber, and the basidiospores are then applied to the leaves of the plants, which are then kept under a bell jar for a few days. If successful the pycnia usually appear in 8 to 12 days. Infection by basidiospores is usually more marked than by aeciospores or urediniospores; a rich infection usually follows and is not likely to be confused with accidental infection. The writer has obtained the best results from first placing the leaves or parts bearing telia in a moist chamber till the teliospores had germinated, usually twelve or fifteen hours. These were then suspended above the suspected aecial hosts so that the basidiospores would fall on the leaves, the whole was then covered with a bell jar for a day or two.

The easiest and most successful way to obtain clues to the alternate hosts is to watch for the appearance of aecia in the spring and early summer. If they are found thickly covering the leaves or parts of a plant, usually search in the immediate vicinity will reveal plants bearing telia, and if the teliospores are or have germinated, it will be evidence that the aecia and telia are probably connected, especially if no other rust can be found near. These clues can be tested at once by cultures if viable material can be found; if not, the test can be made in the following season, when it may be easier to collect viable teliospores.

Association of Spore Forms.

As has already been stated, the spore forms appear in a definite order. Thus, when the cycle of development is complete, the germinating teliospores give rise to the basidiospores,

the mycelium produced by basidiospore infection develops pycnia followed by aecia, later the urediniospores appear, and finally the teliospores. Any of these forms may be omitted except the teliospores and basidiospores. The Roman numerals I, II, III, are used to represent, respectively, the aecia, uredinia and telia, and a cipher is used for the pycnia. The order of development and the suppression of the spore forms may be represented as follows:

Complete series, 0, I, II, III.

Uredinia wanting, 0, I, —, III.

Aecia wanting, 0, —, II, III.

Aecia and uredinia wanting, 0, —, —, III.

Not enough attention has been given to the presence or absence of the pycnia to be sure of the number of series, but it is probable that there is also the following series:

Pycnia and aecia wanting, —, —, II, III.

Pycnia, aecia and uredinia wanting, —, —, —, III.

Schroeter has proposed names for the different types of association of spore forms. Taking the genus *Puccinia* for example, and it may be used for other genera as well, the types would be as follows:

Eu-puccinia, complete series, 0, I, II, III.

Pucciniopsis, uredinia omitted, 0, I, —, III.

Brachy-puccinia, pycnia and aecia wanting, —, —, II, III.

Micro-puccinia, pycnia, aecia and uredinia wanting, —, —, —, III. (Teliospores germinating only after a period of rest).

Lepto-puccinia, pycnia, aecia and uredinia wanting, —, —, —, III. (Teliospores germinating immediately).

Duggar suggests terms applicable to all genera having similar spore forms, and at the same time expressing heteroecism and autoecism. He employs the word *uredo* as the common root in combination with the prefixes used by Schroeter. Thus a form that is eu-heteroecious will be termed

euheteruredo; a eu-autoecious, *euautouredo*; an opsis-heteroecious, *opsisheteruredo*, and the other combinations in a similar manner.

As the terminology of the spore structures in this paper is that proposed by Arthur, his definitions of the terms are quoted (Bot. Gaz. 39:221. 1905):

"The terms I have to propose apply to the sorus. By sorus is meant the structure which arises from a single fertile hyphal mass or hymenium, either with or without a peridium, now usually called spermagonium, aecidium, uredosorus, teleutosorus and kindred names. A simple sorus includes the peridium and all true paraphyses whether peripheral or discal.

"The new terms consist of four words, with their derivatives, one for each of the four stages of uredineal fungi. For the initial stage, usually designated by a cipher and called spermagonium, pycnidium, etc., I propose *pycnium*: derivatives pycnial, pycniospores, etc. For the sorus of the first spore-stage usually designated by the Roman numeral I, and called aecidium, roestelia, peridermium, etc., I propose *aecium*: derivatives aecial, aeciospore, etc. For the sorus of the second spore-stage, usually designated by the Roman numeral II, and called uredosorus, etc., I propose *uredinium* (uredo): derivatives uredinal, urediniospores or if preferred uredospore, etc. For the sorus of the third spore-stage, usually designated by the Roman numeral III, and called teleutosorus, I propose *telium*: derivatives telial, teliospores, etc."

Specilization.

Species have been based largely on morphological characters. Infection experiments have led to a new conception of species, based on the ability of the fungi to infect hosts. Thus it has been found that some rusts morphologically alike show differences in infecting power. On the other hand it has been found that rusts which show differences in the choice of

hosts are morphologically unlike, although the fact was not noticed until attention was called to it in this way.

By infection experiments it has been shown that *Puccinia coronata*, which was previously regarded as one rust, can be broken up into two species, one producing aecia on *Rhamnus frangula* and the other on *Rhamnus cathartica*. Again the latter, *Puccinia Lolii*, may be broken up into specialized forms based on their infecting power. This rust occurs both on oats (*Avena sativa*) and on grass, *Festuca elatior*; but spores from *Avena* will not infect *Festuca*, nor spores from *Festuca* infect *Avena*. In the same way the spores of *P. graminis* from oats will not infect rye nor the reverse, although the spores produced from the germinating teliospores of both will infect the barberry. The aecia produced on the barberry from the specialized form on rye will not infect oats nor the aecia from the form on oats infect rye. The forms remain true although no morphological differences exist. In some cases, however, the forms do not seem fixed and the aecial host acts as a bridge, the aeciospores from either form infecting both host plants. Different names are given to these forms: biological species, physiological species, sister species and specialized forms, are some of the terms used. If the aecial stage occurs on different plants, even if no morphological differences exist, the rusts are usually regarded as separate species; but if the aecia are produced on the same plant, and differences of infecting power exist, they are regarded as specialized forms or form species.

Sexuality.

Sapin-Trouffy showed that in the promycelium, sporidia and aecial mycelium to the base of the aecium, each cell contains but one nucleus, while in the aeciospores and the succeeding spores and mycelium each cell contains two. These fuse in the teliospore and he regards this fusion as a true sexual process.

Blackman found that the aecial stroma formed beneath the epidermis consisted of small cells about three cells deep. The upper cells divide by walls parallel with the leaf surface. The upper cells thus formed are sterile. The lower cells formed by this division are fertile and have a large nucleus. Each cell elongates and soon two nuclei are seen in the cell, one of these having migrated into the fertile cell from the mycelial cell directly beneath or at the side of the base. A minute perforation is made in the wall and the nucleus migrates through. These nuclei divide side by side forming four nuclei, a wall separates the pair and the end cell forms the first spore. Conjugate division continues in such a way as to form a long row of cells each having two nuclei. Each cell does not at once form a spore but conjugate division of the nucleus takes place again, and a small cell is cut off from below, thus forming the spore and the intercalary cell. This migration and association of the nuclei is regarded as sexual fusion. This marks the beginning of the binucleated condition of the sporophyte generation. The unnucleated stage, on the other hand, from the basidiospores up to the base of the aecium, constitutes the gametophyte generation. Blackman regards the process as of the oosporic type—"a female cell is fertilized by the nucleus of an ordinary vegetative cell."

Blackman regards the sterile apical of the female gamete as homologous with the trichogyne of some other plants, and suggests that it once pushed its way through the epidermis, and functioned as a trichogyne fusing with the spermatia. He regards the spermatia as male cells that have lost their function, a simpler "internal" fertilization having replaced the former "external" fertilization.

Christman described a process of fertilization by the fusion of two cells, but the two cells he found to be approximately equal, so that the fusion is of the zygosporic type, the conjugation of two equal gametes.

Olive (*Annals of Botany*, 22: 331-360. 1908) confirms the work of Christman and Blackman and brings some of their apparently conflicting results into harmony, but on the whole confirming Christman's conclusion.

In general the nuclear life history of a species showing all the spore types is as follows: The mycelium which produces the pycnia and the aecia is uninucleate, as well as the pycniospores. There is a fusion of cells in the aecia and the aeciospores and the mycelium that produces the urediniospores, and these spores themselves are bi-nucleate. Fusion of the nuclei takes place in the teliospores, so that the basidiospores are uninucleate.

Spread of Rusts.

The question of how the rusts are spread and continued from season to season is an important one in the case of the grain rusts. *Puccinia graminis*, *P. Lolii* and other destructive grain rusts are heteroecious with hibernating teliospores, but as has often been shown the aecial host is not sufficiently distributed to explain the regular and general appearance of these rusts; in fact the general impression is that the barberry has little to do with the spread of the grain rusts. Where the winter is not too severe probably the rusts are continued from year to year by hibernating uredospores and mycelium. Carleton (*Bull. 16, Div. Phy. and Path. U. S. Dept. Agr.*, 1899) shows that several rusts winter over in the uredinial stage. Bolley states definitely that in some cases the uredospores may hibernate even in North Dakota and thus propagate the rust. Investigation tends to show that uredospores may winter and this favours the theory that spring infection comes from this source.

Another view is that the urediniospores are blown from more southern localities, where the winters are mild, and probably this has much to do with severe outbreaks. The large acreage of grains in all parts of the world and the known fact that in dust storms particles of dust are carried long

distances make this view probable. Klebahn placed wads of cotton batting in high exposed places and found thousands of rust spores in these traps. He concludes that this is the most probable method of rust distribution and accounts for the reappearance in northern latitudes. Ericksson claims that the grain seeds contain the rust in the form of "Mycoplasma," an intimate mixture of the protoplasm of the fungus with that of the host, and that under favourable conditions the mycoplasma separates and develops the normal mycelium of the rust. This would account for the reappearance of the rusts and the sudden outbreaks. He claims to have found the "corpuscles" or first visible signs of the "mycoplasma" separating from the normal cell protoplasm, but Ward has shown these to be haustoria. There is not sufficient evidence to support the theory, which has received much attention owing to the valuable work done by Eriksson in his study of the grain rusts.

Rust Enemies.

A parasitic fungus, *Darluca filum* Cast., is often present on the uredinia or telia. I have found it very common on all the rusts infecting *Juncus*, and also on many of the sedge and grass rusts. In some cases it was difficult to obtain teliospores owing to its attack. I have also found it very plentiful on the uredinia of *Coleosporium Solidaginis* and *Phragmidium Potentillae-canadensis*. This parasite can be recognized by the small, black pycnidia, which are filled with colourless, fusiform two-celled spores. The pycnidia are usually on the uredinia and occasionally on the telia and aecia. The parasite is doubtless an important factor in checking the spread of rusts.

Another parasite, a species of *Tuberculina*, was found attacking the aecial stage of *Gymnoconia interstitialis*, but it did not seem to be generally distributed.

The larvae of a species of *Cecidomyia* is very commonly present feeding on the aeciospores of many species. These

probably tend to reduce the fungus by devouring the spores, but they may aid in their distribution by spreading them as they crawl about.

Economic Aspects of the Rusts.

The rusts are true parasites and unable to live except in the tissues of their hosts. They attack many valuable trees and shrubs as well as field and garden crops, and, as they live at the expense of their hosts, often cause serious damage. They cannot be combatted with much success by spraying with the Bordeaux or other mixtures. Usually a knowledge of their life history will alone suggest some method of holding them in check.

Rusts of the Conifers: Many rusts of the genus *Coleosporium* and *Cronartium* have their aecial stages on some species of pine, but no rusts were found on the pine in Nova Scotia and none are likely to occur, unless the European currant rust (*Cronartium rubicola*) should be introduced. The aecial stage is found on the white pine (*Pinus strobus*) and is said to be very destructive in Europe. The uredinial and telial stages on currant bushes does not seem to be of much importance. An outbreak occurred at Geneva, N. Y., in 1906, and in 1909 pine seedlings which were imported from Germany and were distributed through the north eastern United States and Canada were found to be diseased. The only way to control the fungus would seem to be to destroy the wild species of *Ribes* in the neighbourhood of the pine forest areas.

The leaves of the balsam fir (*Abies balsamea*) are attacked by the aecial stage of the blueberry rust (*Calyptospora columnaris*) by *Peridermium balsameum* and by a *Caeoma*. The spores are formed on the under side of the leaves which turn yellowish. *Peridermium elatinum*, the aecial stage of *Melampsorella elatina*, forms the rather conspicuous witches' brooms on the same host. These may be removed in the spring

before the spores are shed and burned. However, little injury is done by these fungi and no measures of control are necessary.

Peridermium Peckii and *Caeoma Abietis-canadensis* Farl. occur on the leaves of the hemlock (*Tsuga canadensis*), but they are not very common nor of much importance. *Necium Farlowii*, which attacks the leaves and young twigs, is more injurious. The infected twigs soon curl up and die, but the fungus is rare and therefore of little importance.

The leaves of the spruces (*Picea*) are attacked by the aecial stages of the *Ledum* rusts (*Melampsoropsis ledicola*, *M. abietina*) and though sometimes they are very richly infected yet no serious injury seems to be done. The destruction of the *Ledum* plants in the neighbourhood of the spruces would probably be effective in controlling these rusts. The spruce cones are also attacked by the aecial stage of the *Pyrola* rust (*Melampsoropsis Pyrolae*).

The aecial stages of the willow and poplar rusts (*Melampsora Bigelowii*, *M. Medusae*) are found on the larch (*Larix laricina*) but they are rare and of no economic importance.

Rusts of Deciduous Trees: The leaves of the poplars and willows are attacked by the uredinial and telial stages of *Melampsora Medusae* and *M. Bigelowii* respectively, and those of the birches by *Melampsoridium Betulae*, but the injury is not serious and does not usually call for control. The burning of the infected leaves in the fall would probably be helpful in checking the rusts.

The aecial stage of some rust of the genus *Gymnosporangium* has been collected on the fruit of the wild plum (*Amelanchier*), and probably the alternate host is the low juniper. It is probably rare and of little importance. In the United States the aecial stages of some species of the genus *Gymnosporangium* attack the leaves of the cultivated apple, but these have not been reported from Nova Scotia.

Rusts of Shrubs: The rusts of the genus *Phragmidium* attack the wild roses freely and may attack the cultivated

species, but no injury to the latter plants has been reported from Nova Scotia. Control measures would be the destruction of the affected parts in the fall before the dispersal of the spores.

The "Orange Rust" of the raspberry and blackberry (*Gymnoconia interstitialis*) is a serious pest in some parts of the United States, attacking the cultivated species. As far as reported it is confined to wild species in Nova Scotia. The mycelium is perennial so that to combat this rust the diseased plants should be dug up and burned.

The aecial stage of a sedge rust sometimes occurs on the fruit of the cultivated gooseberry. This stage usually passes under the name of *Aecidium grossulariae*. It is probably not common enough to call for control measures, which would be the destruction of the sedges in the vicinity.

Rusts of the Cereals: A few collections of corn rust have been made, but it is not usually common enough to cause any serious injury and has not received much attention.

The black or stem rust (*Puccinia graminis*) attacks wheat, oats, barley, rye and many grasses. It has a world wide distribution and does immense damage to the grain crops.

It does not seem to be very common about Pictou, but in some parts of the province it is abundant and must cause much injury to the oat and wheat crop. It can be recognized by the black uncovered telia which are usually found on the stem, though they may occur on the leaves and sheaths.

The aecial stage is on the barberry, but this shrub is not common enough to explain its appearance year after year. It is probable that the barberry has little to do with the rust in Nova Scotia, and that the aecial stage is usually omitted. The uredospores live for some time and have been shown to survive the winter even in cold climates. Another theory is that the uredospores are carried from more southern countries, where they survive the winter, by the wind, and thus the spring

infection takes place. Many grasses are attacked by this rust, and some observers have thought that the mycelium may survive the winter in these grasses, and that infection of the grain crops may come from this source in the spring when uredospores are produced. However, artificial infection experiments indicate that few of the grass rusts will grow on wheat or other grains. The rusts on the various species have become adapted to their particular host and will not usually grow on other species.

Little can be done to combat this rust. Varieties that ripen early are not usually so badly affected, so early sowing and the sowing of early varieties would be advantageous. Some varieties are more susceptible than others and attention is now being given by plant breeders to the production of rust proof varieties. It is probable that much may yet be accomplished along this line. The barberry which is sometimes grown in hedges should be destroyed as it probably forms a bridging host between the various specialized forms on the grasses.

The crown rust of oats (*Puccinia Lolii*) is very common on the oat about Pictou and must do much injury to the crop. It is found only on the oat and can be easily distinguished from the stem rust, as the telia remain covered by the epidermis and occur only on the leaves and sheaths. The aecial stage is found on the buckthorn, an introduced tree or shrub which is rather common along some roadsides near Pictou. This may account for the prevalence of the rust as these trees showed a rather pronounced infection in the springs of 1909-10. No control measures are known, but the destruction of the aecial host.

The brown or covered rust of wheat, *Puccinia triticina*, is quite common about Pictou. The telia are usually formed on the lower side of the leaves. They are black in color and remain covered by the epidermis. This rust usually passes in America under the name *Puccinia rubigo-vera* or *P. rubigo-vero tritici*. Its systematic position is somewhat unsettled, and its aecial stage somewhat doubtful.

The timothy rust only began to attract attention in North America a few years ago. It seems to be rapidly increasing. Some regard it as identical with the stem rust of wheat, while others regard it as a distinct species with unknown aecia. In gross and microscope appearance it cannot be distinguished from the stem rust of wheat. It is quite common on the timothy about Pictou, especially on timothy about roadsides and fences that has not been cut at the harvest season. It seems to be increasing so rapidly that there is danger that it may become a pest, but the early maturing of the hay crop may prevent any serious damage.

Red Clover Rust: The uredinial and telial stages of clover rust (*Uromyces trifolii*) is common on the leaves of clover in the fields of Pictou. They appear as brownish powdery spots on the under surface of the leaves and on the stems. The aecial stage is unknown. It is said to do little damage to the early crop, but the attack on the second crop is more severe. Control is unnecessary, and no preventative measures are known.

Classification.

The classification of the rusts presents many difficulties owing to the variable number of forms and the heteroecism of many species. Besides, rusts that cannot be distinguished morphologically have become specialized or show physiological differences in the choice of their hosts, and botanists are not agreed as to the classification of these. Some regard them as separate species, while others would place them as simply physiological species or form species. The classification is likely to remain unsettled until they are more fully studied and their life histories and relations to their hosts more completely known.

The rusts are regarded by most botanists as belonging to the class *Basidiomycetes* on account of the germinating teliospore producing four basidia which either remain within the spore cell or are borne in the air on a short promycelium, each

basidium bearing a single spore. A few botanists regard the teliospore as an ascus in which the spore-wall is united with the ascus-wall, thus the rusts would belong to the class *Ascomycetes*.

The order *Uredinales* (*Uredinae* Tul.) to which the rusts belong is divided by Dietel into four families: *Melampsoraceae*, *Coleosporiaceae*, *Cronartiaceae* and *Pucciniaceae*. The separation is based on the character of the telia and the teliospores.

In the *Melampsoraceae* the teliospores stand side by side forming one-layered, flattened masses, which are separated with difficulty; or they may be scattered in the tissues of the host, then they are usually two- or four-celled; the genus *Uredinopsis* belongs to the latter group. The teliospores are always sessile.

In the *Coleosporiaceae* the teliospores are united into one- or two-layered, light-coloured, waxy crusts. They germinate without a promycelium, the spore cell soon divides into four basidia and each of these produces a large basidiospore about 20μ long. The teliospores are sessile except in a South American genus *Chrysospora*.

The *Cronartiaceae* have sessile teliospores which are formed in series and either separate from each other or remain united in filiform masses, as in *Cronartium*, or are formed in chains and compacted laterally forming cushion-shaped masses as in *Chrysomyxa*.

The *Pucciniaceae*, which contain the well known rusts, have stalked teliospores either fasciated or free, usually easily separable from the host plant, but sometimes, as in the genus *Gymnosporangium*, embedded in a gelatinous mass.

Arthur recognizes three families: *Coleosporiaceae*, *Uredinaceae* (the latter including Dietel's *Melampsoraceae* and *Cronartiaceae*), and *Aecidiaceae* corresponding to *Pucciniaceae*.

The following is a synopsis of the genera represented in north eastern North America. It is largely based on Dietel's *Uredinales* in *Die Natürlichen Pflanzenfamilien*.

MELAMPSORACEAE.

- I. Teliospores mostly 2- and 4-celled, in the latter case the walls in the form of a cross.
1. Teliospores singly in the parenchymatous tissue of the host.....*Uredinopsis*.
 2. Teliospores united in single layered crusts—
 - A. Teliospores formed outside the cells of host*Pucciniastrum*.
 - B. Teliospores within cells of host—
 - a. Life cycle with aecia and telia *Calypotospora*.
 - b. Life cycle with telia, on *Tsuga* *Necium*.
- II. Teliospores 1-celled, always united in small or large crusts.
1. Teliospores formed outside the cells of host—
 - a. Uredinia with paraphyses intermixed with spores. Aecia without a peridium ...
..... *Melampsora*.
 - b. Uredinia and aecia with peridium. No paraphyses *Melampsoridium*.
 2. Teliospores formed inside of cells of host—
 - a. Uredinia opening by a pore.....
..... *Melampsorella*.
 - b. Uredinia not opening by a pore, teliospores hyaline *Hyalopsora*.

COLEOSPORIACEAE.

1. Teliospores formed in a gelatinous swelling of sporophore, on *Pinus* *Gallowaya*.
2. Teliospores in flat crusts, uredinia in chains
..... *Coleosporium*.

CRONARTIACEAE.

1. Telia cushion shaped*Chrysomyxa*.
2. Telia thread-like or columnar*Cronartium*.

PUCCINIACEAE.

- I. Teliospores embedded in a gelatinous matrix, on
Coniferae *Gymnosporangium*.
- II. Teliospores not embedded in a gelatinous matrix, not
on *Coniferae*—
1. Teliospores one-celled *Uromyces*.
 2. Teliospores more than one-celled.
 - A. Teliospores two-celled—
 - a. Aecia without peridium
..... *Gymnoconia*.
 - b. Aecia with peridium.... *Puccinia*.
 - B. Teliospores more than two-celled—
 - a. Spore cells in a row—
 - (1) Teliospores colourless
..... *Kuehneola*.
 - (2) Teliospores coloured
..... *Phragmidium*.
 - b. Spore cells, three in the form of
a triad *Triphragmium*.

All the genera included in this synopsis are represented in Nova Scotia except *Gallowaya* and *Hyalospora*. The last one will probably yet be found.

Arthur has adopted a new system of classification of the rusts. His classification is based largely on the number of spore forms present. For example the genus *Puccinia* as now commonly known is replaced by four genera, *Dasyscypha* with teliospores, *Bullaria* with urediniospores and teliospores, *Allodus* with aeciospores and teliospores, and *Dicaeoma* with all spore forms. Yet the author of the system states that "it would be a wholly false impression to assume that this character of the suppression of the spore forms is the only one separating the genus from others of the group. It is the most prominent and most easily stated, but in the most cases will be found associated with other characters of accepted

value." He adds that his classification has to do fundamentally with the progressive evolution of the rusts and not with adaptations; thus the genus *Dasyscypha* includes species that have progressed in their evolution to the stage where aeciospores and urediniospores have been effectively suppressed from the life cycle. Such a classification demands a more intimate knowledge of the rusts and more insight into their life history than the old system which was based largely on the structure of the teliospores.

He also states that there are some short cuts that enable one to name his collections. "Thus, telia associated with pycnia may be safely assumed to belong to a genus in which aecia and uredinia are wanting, or at most so little developed as to be of no taxonomic importance. In like manner pycnia associated with uredinia, the so-called primary uredinia, may be assumed to indicate a genus in which aecia are wanting. If aecia show telia arising within or about them from the same mycelium, it may safely be assumed that no uredinia belong to the life cycle. Furthermore it rarely or never happens that teliospores of the *Uromyces-Puccinia* type, germinating immediately on maturity, belong to genera with other spore forms in the life cycle, excepting some largely tropical genera. Short cuts are also available in other directions. All gramineous and cyperaceous hosts bear rusts that may be assumed to possess all spore forms and are heteroecious. Only one exception is known at present."

In the following pages the species occurring in Nova Scotia are described. The classification is largely that of Dietel in "Die Natürlichen Pflanzenfamilien." While it might be better to follow Arthur's classification, as he has made the most extensive and thorough study of North American rusts, yet his work has not progressed far enough to make that possible in all cases, so for the present the classification that follows has been adopted.

A list of Nova Scotian genera follows with the number of species that have been found in each genus. The names used by Arthur in the North American Flora are enclosed in brackets where they differ from those in the classification adopted. *Melampsoropsis*, however, is used instead of *Chrysomyxa*, although Dietl adopts the latter term.

Nova Scotian Families and Genera.

Family.	Genus.	No. of Species
Coleosporiaceae.	Coleosporium	1
Melampsoraceae, (Urediniaceae).	Melampsora (Uredo)	3
	Pucciniastrum	6
	Melampsoridium	1
	Melampsorella	1
	Hyalopsora	0
	Calyptospora	1
	Necium	1
	Uredinopsis	5
Pucciniaceae, (Urediniaceae).	Melampsoropsis (<i>Chrysomyxa</i>)	5
	Cronartium	1
	Phragmidium { <i>Phragmidium</i> }	4
	{ Earlea }	
	Triphragmium	1
	Gymnoconia	1
	Kuehneola	1
	Gymnosporangium (<i>Aecidium</i>)	1
Pucciniaceae, (Aecidiaceae).	Uromyces { Pileolaria }	14
	{ Nigredo }	
	{ Uromycopsis }	
	{ Klebahnia }	
	{ Telospora }	
	Puccinia { <i>Tranzschella</i> }	45
	{ Polythelis }	
	{ Dicaeoma }	
	{ Allodus }	
	{ Bullaria }	
	{ Dasypora }	

The descriptions that follow are based on the collections of Nova Scotia material. It was necessary when certain forms were not collected or when the collections were scanty to make use of the systematic literature cited at the end of this paper. These cases are recorded in the notes that follow the description of the species.

An interesting feature of the work was the field study with the object of connecting aecial and telial stages and the culture experiments undertaken to test the clues thus obtained. As a result the life histories of a number of species previously unknown were worked out. These are noted under the descriptions of the species.

A 50% solution of lactic acid was used for the purpose of clearing the sections and swelling the spores to their normal shape and size. This is necessary in the case of the spores of the *Puccinia Hieracii* type, as the dried spores are much contracted and wrinkled. The spores or sections were placed on a slide and a drop of the lactic acid solution added. The slide was then heated over a spirit lamp and the liquid was brought to the boiling point or allowed to boil for a few seconds. This also brought out the germ pores more clearly.

The drawings are made with the aid of a camera lucida to a uniform magnification of 480 diameters, except in a few cases noted in the descriptions accompanying the drawings which are reduced to one-half the diameters in the photogravure process.

Gray's "New Manual of Botany" was used in determining the host plants.

The writer is deeply indebted to Dr. J. C. Arthur for valuable suggestions and for the determination of doubtful species. He is also indebted to John Macoun, Naturalist, Geol. Survey Dept. of Canada, for the prompt determination of a few doubtful host plants.

THE RUSTS OF NOVA SCOTIA.

Family I. COLEOSPORIACEAE.

Basidia internal, i. e. each original cell soon divides into four superimposed divisions (the basidia), each of these germinates by a single sterigma bearing a large basidiospore. Telia waxy. Teliospores compacted laterally into layers, sessile (in all North American species); walls weakly gelatinous.

This family is represented in North America by one genus, *Coleosporium*, or according to Arthur's classification by two genera, *Coleosporium* and *Gallowaya*, the life cycle of the latter having only telia. The family is represented in Nova Scotia by only one species, and no more are likely to occur as all the other species thus far reported in North America are of a more southern range. It is possible that *C. Campanulae* (Pers.) Lév., which has been collected in Vermont may yet be found to occur.

COLEOSPORIUM Lév.

Pyenia flattish, without ostiolar filaments. Aecia with large peridium. Aeciospores having colourless wall with dense deciduous tubercles. Uredinia without peridium. Urediniospores catenulate; wall colourless, verrucose, pores obscure. Telia waxy, usually roundish. Teliospores sessile, one-celled, (appearing four-celled owing to early division of contents); wall smooth, colourless, thickened and gelatinous at the apex.

Coleosporium Solidaginis (Schw.) Thuem.

0 & I. On *Pinus rigida* Mill. *Peridermium acicolum* Und. & Earle.

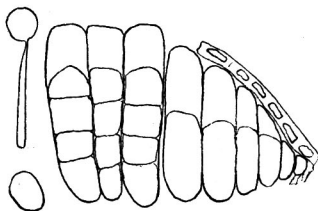
II. Uredinia mostly hypophyllous, sometimes caulicolous, scattered or sometimes gregarious, small, soon naked.

pulverulent, yellow or orange-yellow. ruptured epidermis rather inconspicuous. Urediniospores globose or ellipsoid, 16-22 by 19-35 μ ; wall rather thin, strongly verrucose; contents orange-yellow, slowly fading to colourless.

III. Telia hypophyllous, scattered or crowded and confluent, roundish or irregular, slightly elevated, small reddish-orange. Teliospores terete, 18-25 by 54-85 μ , round or obtuse at both ends, wall swelling above 30-40 μ ; contents orange-yellow; basidiospores globose or ellipsoid, about 12 by 18 μ , yellowish.

Uredinia and telia on *Solidago* and *Aster* species, Pictou, Truro, etc. The following hosts were determined: *Solidago bicolor* L., *S. rugosa* Mill., *S. canadensis* L., *Aster cordifolius* L., *A. umbellatus* Mill., *A. lateriflorus* (L.) Britton.

The uredinial and telial stages of this rust are very common on the various species of *Solidago* and *Aster* near Pictou, and probably throughout the Province. The aecial stage is found on *Pinus rigida* Mill. and in North America is known only from a small area from Massachusetts to southern New Jersey. (Arthur & Kern, Bull. Torr. Bot. Club, 33: 413. 1906).



1. Section of telium of *Coleosporium Solidaginis*.

Since the aecial stage (*Peridermium acicolum* Und. & Earle) appears to be limited to a small region along the Atlantic coast, and the other stages are common almost throughout the United States and Canada, the question arises how it passes the winter. Clinton carried out some experiments that would tend to show that the mycelium was not perennial in the rootstocks (Conn. Exper. Sta. Report 378, 1907). He believes that the mycelium of the fungus is carried over the winter in the basal rosettes of young leaves which may survive the winter.

Family 2. MELAMPSORACEAE.

Basidia external, i. e. germination with a typical promycelium with small spherical sporidia. Telia in more or less definite single layered crusts. Teliospores compacted laterally into layers, or rarely solitary within the tissues (Uredinopsis), sessile; wall usually firm, rarely with an outer gelatinous layer.

This family is represented in north-eastern North America by eight genera, and of these seven occur in Nova Scotia. The remaining genus *Hyalopsora*, which is confined to ferns, probably occurs, as *H. Aspidiotus* (Peck) Magn. on *Phegopteris Dryopteris* (L.) Fée has been reported from New Hampshire, and *H. Polypodii* on *Cystopteris fragilis* Bernh. from New York.

MELAMPSORA Cast.

Pycnia conoidal or hemispheric without ostiolar filaments, hymenium flattish. Aecia without peridium or paraphyses. Uredinia without peridium. Urediniospores borne singly on pedicels; wall colourless, verrucose; capitate paraphyses intermixed with the spores. Telia indehiscent in waxy layers or crusts. Teliospores one-celled, closely compacted into a single layer, prismatic or ellipsoid; wall smooth, coloured.

Both heteroecious and autoecious species belong to this genus, the former only have been found in Nova Scotia. *Melampsora lini* (Pers.) Tul. is an autoecious species which is destructive to flax in the United States.

Melampsora Bigelowii Thuem.

Uredo Bigelowii (Thuem.) Arth.

0. Pycnia chiefly epiphyllous, scattered, minute, punctiform, pale yellow, inconspicuous.

I. Aecia chiefly hypophyllous, scattered or somewhat gregarious, on whitish areas occupying part of the leaf, small, round or mostly oblong, pale yellow fading to colourless, soon

naked, pulverulent, ruptured epidermis evident. Aeciospores mostly globoid, about 18-24 μ ; wall colourless, thick, minutely verrucose.

II. Uredinia hypophyllous, on conspicuous yellow spots, usually gregarious, round, oval or irregular .3-.6mm. across, sometimes confluent, ruptured epidermis inconspicuous, soon naked, somewhat pulverulent. Urediniospores globoid or ellipsoid, 15-19 by 18-27 μ , wall colourless, thick, evenly verrucose, pores scattered; paraphyses mixed with the spores, capitate, smooth, 50-80 μ long, heads 19-24 μ broad, wall thick, 3-5.5 μ .

III. Telia amphigenous, sometimes mostly hypophyllous, scattered, often abundant and occupying most of the leaf surface, roundish or irregular, often confluent, sometimes elevated, orange-yellow, becoming yellowish or purplish-brown, subepidermal, teliospores prismatic, sometimes oblong, 12-15 by 33-44 μ , rounded at both ends or truncate; wall cinnamon-brown, smooth, uniformly thin or sometimes thickened above.

Pycnia and aecia on *Larix laricina* (DuRoi) Koch, Pictou.

Uredinia and telia on *Salix rostrata* Richards, and other *Salix* species, Pictou, Truro, Oakfield.

Collections of aecia on *Larix laricina* were made on June 24, 1910, and during the following week. The aecia were found to be widely distributed in the vicinity of Pictou, so that almost every tree of *Larix* examined showed at least a few infected leaves. In June, 1912, aecia were found to be very abundant in one region near Pictou, the young *Larix* trees appearing yellow at a considerable distance. It was impossible to determine whether the aecia belonged to this species or to *M. Medusae* as there is no morphological differences. It seems probable, however, that these collection belong to this species as cultures by the writer showed that the poplar rust in this region has aecia on *Tsuga canadensis*.

Melampsora Medusae Thuem.

0. Pycnia amphigenous, mostly hypophyllous.

I. Aecia hypophyllous, often on the young twigs causing deformation, elongate or rounded, ruptured epidermis inconspicuous, pale yellow fading to white. Aeciospores globoid, about 16-20 μ ; wall colourless, thick, minutely verrucose.

II. Uredinia amphigenous or mostly hypophyllous, often on yellowish spots, scattered, roundish, very small, soon naked, somewhat pulverulent, orange-yellow, fading to pale yellow. Urediniospores ellipsoid or obovate-ellipsoid, 16-17 by 22-27 μ , wall colourless, rather thick, sparsely but rather strongly verrucose; paraphyses numerous, capitate, thick walled, intermixed with the spores. (Urediniospores often flattened laterally with flattened sides smooth).

III. Telia amphigenous, usually only hypophyllous, scattered or confluent, irregularly roundish, small, slightly elevated, reddish-brown, becoming dark chocolate-brown, subepidermal. Teliospores prismatic, 10-16 by 27-46 μ ; wall smooth, light brown, uniformly thin.

Pycnia and aecia on leaves and cones of *Tsuga canadensis* (L.) Carr., Pictou, Truro.

Uredinia and telia on *Populus grandidentata* Michx., Pictou, New Glasgow, Truro; *P. tremuloides* Michx., Pictou.

The writer has shown by cultures that this species has in this region its aecia on *Tsuga-candensis*. (See Mycologia 4: 188.



2. Surface view of part of telium of *Melampsora Medusae*. Side view.

1912). The aecial stage is *Caeoma Abietis-canadensis* Farl., which is rather common on its host. Arthur has shown by cultures that the aecial stage also occurs on *Larix* (Jour. Mycol. 10:

13. 1904; 11: 52. 1905; 12: 13. 1906). It is probable that there are two races of the same species, that in the east having aecia on *Tsuga* and in the west on *Larix*.

The telial stage is rather common on the large-toothed aspen about Pictou. It is rather rare on the more common poplar, (*Populus tremuloides* Michx.). The uredinial stage is not conspicuous but leaves, when the telial stage appears in the fall, soon turn black and are then quite conspicuous.

Melampsora arctica Rostr.

Uredo Rostrupiana Arth.

0. Pycnia amphigenous, chiefly hypophyllous, punctiform, inconspicuous, honey-yellow.

I. Aecia hypophyllous, arranged in two rows, roundish, oval or oblong, pale orange-yellow, fading to colourless, soon naked, pulverulent, ruptured epidermis evident, .2-.3 by .3-.7 mm. Aeciospores globoid, about 16-21 μ in diameter; wall thick, colourless, verrucose, contents pale yellow.

II. Uredinia chiefly hypophyllous, scattered, round, very small, orange-yellow fading to pale yellow, somewhat pulverulent, ruptured epidermis inconspicuous. Urediniospores ellipsoid or obovate, small, 14-16 by 16-20 μ ; wall colourless, thin, uniformly and closely verrucose; paraphyses mixed with the spores, smooth, about 50 μ long with heads about 22 μ broad, wall thickened above.

III. Telia mostly hypophyllous, rounded or irregular, scattered or often confluent, slightly elevated, reddish brown, becoming dull brown, subepidermal. Teliospores prismatic or oblong, 8-10 by 22-32 μ ; wall smooth, pale brown, thin.

Pycnia and aecia on *Abies balsamea* (L.) Mill., Pictou.

Uredinia and telia on *Salix discolor* Muhl., and *S. rostrata* Richards, Pictou.

This rust can be distinguished from *M. Bigelowii* by the small and thin walled urediniospores. It is common in the vicinity of Pictou. Cultures by the writer during the spring of 1912 showed that the aecial stage is on *Abies balsamea*. (See Mycologia 4: 187. 1912).

MELAMSORIDIUM Kieb.

Uredinia with a firm peridium dehiscing by a central pore, cells of the orifice sharp pointed. Urediniospores borne singly on pedicels. Telia indehiscent, forming evident layers beneath the epidermis. Teliospores oblong or prismatic, one-celled.

The genus includes three species on *Betulaceae*. Arthur in the North American Flora reports from North America only the species described below.

Melampsoridium betulinum (Pers.) Kieb.

Melampsoridium Betulae (Schum.) Arth.

0 & I. On *Larix decidua* Mill. (Europe). Not yet collected in North America.

II. Uredinia hypophyllous, on small yellow spots, scattered, small, round, reddish-yellow, at length pulverulent; peridium hemispherical, firm, opening by a central pore, cells polygonal, with pointed cells at the orifice, points 10-14 μ long. Urediniospores elongate-elliptical or elongate-obovate, 10-16 by 25-40 μ ; wall colourless, thin, strongly and sparsely echinulate except smooth apex.

III. Telia hypophyllous, small, often thickly covering the surface of the leaf, at first waxy yellow, becoming brown and finally blackish, indehiscent. Teliospores prismatic in a palisade like layer beneath the epidermis, 7-16 by 30-50 μ , somewhat rounded at each end; wall nearly colourless, thin, slightly thicker at the apex, smooth.

Uredinia and telia on *Betula populifolia* Marsh, *B. lutea* Michx., Pictou.

The uredinial stage of this species was common on *Betula populifolia* about Pictou during the fall of 1909. It is conspicuous as the leaves are thickly covered with small yellow spots and usually a number of leaves near together are infected.

It was less common during the fall of 1910, only one collection being made. The telial stage was not found although collections were made at various intervals during the fall and early winter. The aecial stage, *Peridermium Laricis* (Kleb.) Arth. & Kern, has not been collected in North America.

MELAMPSORELLA Schroet.

Aecia with peridium. Aeciospores with verrucose walls. Uredinia with peridium. Telia effused, indehiscent. Teliospores within the epidermal cells, one-celled; wall smooth, colourless.

But one species of this genus is found in North America. Some of the species which Dietel places in this genus are assigned to *Hyalopsora* by Arthur.

Melampsorella Cerastii (Pers.) Schroet.

Melampsorella elatina (Alb. & Schw.) Arth.

0. Pycnia epiphyllous, few, scattered, punctiform, inconspicuous.

I. Aecia from a perennial mycelium forming witches' brooms; hypophyllous, in two rows, dropping out of leaf at maturity, mostly irregularly oblong or roundish, rather large; peridium colourless, soon falling away and exposing spores. Aeciospores sub-globoid or ellipsoid, 15-22 by 19-27 μ ; wall colourless, thin, closely verrucose.

II. Uredinia amphigenous, scattered or grouped, small, round, .1-4 mm. across, orange-red when fresh, pale yellow when dry; peridium hemispherical, dehiscent by a small central orifice. Urediniospores ellipsoid or obovoid, 12-18 by 16-30 μ ; walls pale yellow, rather thin, sparsely echinulate.

III. Telia hypophyllous, on whitish or pale reddish spots. Teliospores within the epidermal cells, one-celled, short-cylindrical or polygonal, 13-20 μ broad; wall colourless, smooth, thin.

Aecia on *Abies balsamea* (L.) Mill., Pictou, July 10, 1909. Uredinia and telia on *Stellaria* and *Cerastium* (Europe and United States).

The aecial stage, *Peridermium elatinum* (A. & S.) Kunze & Schmidt, is common and widely distributed. It produces the conspicuous witches' brooms so common on the balsam fir.

Klebahn and Fischer have proved by numerous cultures the connection of the aecial stage on *Abies* and the stages on *Alsine*, *Stellaria* and *Cerastium*. The uredinial and telial forms are very inconspicuous, but they have been collected a few times in North America, mostly in the western United States.

PUCCINIASTRUM Oth.

Uredinia barely protruding through the epidermis; peridium present, opening by a central pore. Urediniospores borne singly on pedicels with colourless walls, pores not evident.

Telia forming layers in the epidermal cells or immediately beneath the epidermis. Teliospores oblong or prismatic, two to four-celled by vertical or oblique walls in two planes.

Nine species of this genus are found in North America. Six are here described from Nova Scotia. Another species, *P. sparsum* (Winter) Ed. Fisch., may occur on *Arctostaphylos alpina* (L.) Spreng., as it has been collected in Quebec.

Pucciniastrum pustulatum (Pers.) Diet.

0. Pycnia hypophyllous, abundant, inconspicuous.

1. Aecia hypophyllous, mostly in two rows, cylindrical, about 1 mm. high. Aeciospores ovoid or irregularly globoid, 10-20 by 16-22 μ ; wall colourless, finely verrucose, rather thick, contents orange-yellow.

II. Uredinia hypophyllous and fruticolous, scattered or in small groups, not discolouring the leaf, small, bullate, round, dehiscence by a central pore, orange fading to pale yellow, long covered by the arched epidermis; peridium hemispherical, delicate, cells cuboidal, wall smooth. Urediniospores obovate

or oval, sometimes globose, 11-16 by 15-24 μ ; wall colourless, thin, finely echinulate; contents orange-yellow when fresh.

III. Telia hypophyllous, indehiscent, flat, small, scattered or often gregarious and confluent, reddish-brown, becoming blackish-brown. Teliospores usually in one layer, oblong or angular by pressure, about 18-30 μ high by 16-27 μ wide; walls pale brown, smooth, thin, thicker at the apex.

Pycnia and aecia on *Abies balsamea* (L.) Mill., Pictou, June, 1911.

Uredinia and telia on *Epilobium angustifolium* L., *E. Hornmanni* Reichenb., Pictou; *E. adenocaulon* Haussk., Truro.

Arthur gives the measurement of the teliospores as 10-14 by 17-35 μ . This species is very common on its hosts especially on *Epilobium angustifolium*. The leaves become discoloured when the telia are well formed, and usually soon die.

The life history of this species in North America was worked out by the writer. (*Mycologia* 4: 176. 1912). It had been previously established in Europe, the aecia occurring there on *Ribes pectinata* DC. The aecia of this rust have not yet been recognized elsewhere in North America.

Pucciniastrum arcticum (Lagerh.) Tranz.

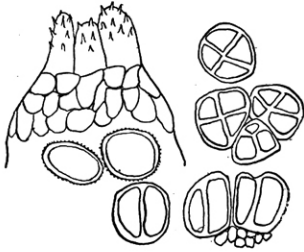
0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, usually thickly scattered over extended areas, round, small, orange-yellow, fading to pale yellow, dehiscent by a central pore, somewhat pulverulent; peridium firm, ostiolar cells coarsely echinulate above. Urediniospores obovate or ellipsoid, 13-15 by 16-25 μ ; wall colourless, thin, distinctly echinulate with low points.

III. Telia hypophyllous, brownish, small, flat, inconspicuous. Teliospores intercellular, globoid or cuboid, about 19-24 μ in diameter; wall smooth, light brown.

On *Rubus triflorus* Richards, Truro, Pictou; *Rubus idaeus* Var. *aculeatissimus*, (*Rubus strigosus* Michx.), Pictou, New Glasgow.

The uredinial stage is very common on the raspberry. It is not conspicuous, but can be easily recognized by examining



3. Partial section of aecidium of *Pucciniastrum arcticum*. Surface and side view of teliospores.

the under side of the leaf. The telial stage is difficult to distinguish, but late collections of leaves affected by the uredinal form usually show abundant telia, when sectioned and examined with the microscope.

Arthur in the "North American Flora" reports this species only from Alaska on *Rubus stellatus*. Farlow (Rhodora 10:

13. 1908) mentions a specimen of typical *P. arcticum* on *Rubus triflorus* from Grand Manan, N. B. He also describes a *Pucciniastrum* found on *Rubus neglectus* and *Rubus strigosus* in the north-eastern United States, and regards it as a variety of *P. arcticum* differing from the type in the markedly conical shape of the peridium and prominent spines. To distinguish it he gives it the name *P. arcticum* (Lagerh.) Tranz., Var. *americanum* Farlow. If this separation holds good the collection on *Rubus triflorus* belongs to the species and that on *Rubus idaeus* Var. *aculeatissimus* to the variety.

***Pucciniastrum Myrtilli* (Schum.) Arth.**

Pucciniastrum Vacciniorum Diet.

0 & I. Pyenia and aecia on *Tsuga canadensis*.

II. Uredinia hypophyllous, scattered or somewhat gregarious, small, bullate, round, long covered by the overarching epidermis; peridium hemispherical, cells small, cuboidal. Urediniospores obovate or ellipsoid, 13-16 by 16-24 μ ; wall colourless, minutely and sparingly echinulate; contents orange-yellow.

III. Telia chiefly epiphyllous. Teliospores in the epidermal cells, ellipsoid or globoid, 18-23 by 20-30 μ ; wall smooth, thin.

On *Vaccinium Pennsylvanicum* Lam., Pictou, Oct. 4, 1910.

Arthur in the "North American Flora" describes the telia as hypophyllous, and the teliospores as oblong or columnar and 7-10 by 14-17 μ . There is a marked difference in the position of the telia and the size and shape of the teliospores of my collections from this description. The uredinia agree with Arthur's description.

The rust is inconspicuous and, though only a few collections were made, it will probably be found to be common.

The aecial stage of this rust is doubtless the *Peridermium* so common on *Tsuga canadensis* which has been confused with *Peridermium Peckii*. Clinton (Report Conn. Agric. Exper. Station for 1909-1910, page 719) has connected this rust with *Peridermium Peckii*, but it is probable his aecia are the most common form which have been confused with the true *Peckii*. The aecia, which doubtless belong to this species, were found to be very common at Truro, Oakfield and Pictou, and the field evidence was very strong that they were connected with this rust. Collections sent to Dr. Arthur were regarded as distinct from *Per. Peckii*.

Pucciniastrum Pyrolae (Pers.) Diet.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, on small reddish spots, small, scattered or grouped, inammillose, yellowish-red, dehiscent by a central pore, long covered by the overarching epidermis; peridium hemispherical, cells elongated vertically below, ostiolar cells large, echinulate. Uredinospores oblong or ellipsoid, 13-16 by 24-35 μ ; wall colourless, rather thick, minutely and sparsely echinulate; contents orange-yellow when fresh.

III. Telia hypophyllous, adjoining uredinia, inconspicuous, subepidermal, an even layer of laterally flattened cells. Teliospores oblong or columnar, 10-12 by 24-28 μ ; wall uniformly thin, colourless.

On *Pyrola elliptica* Nutt., Pictou, Oct. 4, 1910.

Only the uredinial stage was collected. The species does not seem to be common.

***Pucciniastrum minimum* (Schw.) Arthur.**

0. *Pycnia* hypophyllous, rarely epiphyllous, numerous, scattered, inconspicuous.

I. *Aecia* hypophyllous in two rows, occupying part or usually all of the leaf, cylindrical, small, about .5-1 mm. high; peridium colorless, dehiscing at the apex, cells joined loosely, slender. Aeciospores broadly ellipsoid, 13-17 by 19-27 μ ; wall colourless, rather thin, finely and evenly verrucose.

II. Uredinia hypophyllous, small, scattered or chiefly grouped on indefinite discoloured areas, mammillose, pale yellow, dehiscent by a central pore, finally pulverulent, long covered by the overarching epidermis; peridium hemispherical, cells small, cuboidal. Urediniospores ellipsoid or obovate-oblong, 15-18 by 19-27 μ ; wall colourless, thin, finely and sparsely echinulate.

III. Telia amphigenous, chiefly epiphyllous. Teliospores in the epidermal cells, ellipsoid or globoid, 16-24 by 19-35 μ ; wall uniformly thin, pale yellowish, smooth.

Pycnia and *aecia* on the leaves and cones of *Tsuga canadensis* (L.) Carr., Pictou, July, 1911.

Uredinia and telia on *Rhodora canadense* (L.) BSP., Pictou.

This species was found to be rather common near Pictou on *Rhodora canadense*. The aecial stage was shown by cultures of the writer to occur on the leaves and cones of *Tsuga canadensis* (see *Mycologia* 4:184. 1912). This stage was determined as *Peridermium Peckii* by Dr. Arthur. The *aecia* were much lighter in colour than the much more common *aecia* on *Tsuga canadensis* which has usually passed as *Peridermium Peckii*. The more common form doubtless belongs to *Pucciniastrum Myrtilli*.

***Pucciniastrum Agrimoniae* (Schw.) Tranz.**

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, thickly scattered over definite or extended yellowish areas, bullate, round, small, orange-yellow, dehiscent by a central pore; peridium rather delicate, hemispherical, cells small, cuboid. Urediniospores broadly obovate or globose, 12-16 by 15-23 μ ; wall hyaline, rather thin, finely echinulate; contents orange-yellow, fading to pale yellow.

III. Telia hypophyllous, forming scattered, irregular patches, indehiscent. Teliospores intercellular, beneath the epidermal cells, oblong or somewhat cylindrical, 18-30 by 19-32 μ ; wall smooth, brownish-yellow; contents colourless.

On *Agrimonia gryposepala* Wallr., New Glasgow, Truro.

This species was collected only near New Glasgow, but there was a rich development on the plants infected. The telia can be easily recognized when the leaves have been killed by the frost as small dark brown patches on the under side of the leaves. They are late of being formed and only in late collections will telia be found. Search was made on the neighbouring conifers in the spring for the aecial stage, but without success. Nothing whatever is known of it, but as *Pucciniastrum pustulatum* has aecia on *Abies* in Europe, this species may have like aecial hosts.

UREDINOPSIS Magn.

Cycle of development not understood; telia and two other spore forms known, called aecia and uredinia.

Aecia small, bullate, roundish, indehiscent. Peridium depressed globose, delicate. Aeciospores borne singly on pedicels, obovate to globose, angular or polyhedral; wall colourless, medium thick, minutely verrucose.

Uredinia bullate, roundish, usually larger than aecia, dehiscent by central rupture, spores ejected in a long white filament; peridium delicate. Urediniospores borne singly on

pedicels, fusiform, acute or beaked above, narrowed below; wall colourless, thin, smooth except two opposite longitudinal thickened ridges bearing single rows of minute projections, not always evident when wet.

Teliospores globose, one to four-celled or more, usually with intersecting septa; wall smooth, colourless, thin.

This genus is found only on ferns. The species can usually be recognized in the field by the yellow areas, on the lower side of which the minute uredinia can be made out with a lens. Often the small white filiform columns of urediniospores can be seen, where they have emerged.

The teliospores can be studied best by sectioning the leaf, or if a small piece of the discoloured area be boiled for a few seconds in lactic acid the spores can then be made out with the aid of the microscope. Viewed from above they appear circular with the walls (if four-celled) appearing as two diameters at right angles. Viewed from the side they usually appear two-celled.

Dietel in "Engler and Prantl" regards the form, which Arthur places for convenience as an aeciospore, rather as a stalked teliospore, but its true position is not known.

Arthur in the "North American Flora" describes seven species, of these five are here described from Nova Scotia. The other two have been reported only from the Pacific coast.

From careful field study the writer believes that the fern rusts belonging to this genus are heteroecious, the aecidial stages in some species being found on *Abies balsamea*. This matter is discussed further under *Peridermium balsameum*.

Uredinopsis Osmundae Magn.

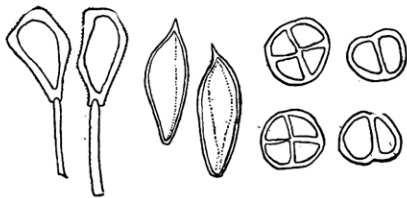
I. *Aecia* unknown.

II. *Uredinia* hypophyllous, on yellowish spots, usually bounded by veins, small, roundish, dehiscing by central opening, spores exuded in a white filiform column. Urediniospores oval or fusiform, sometimes clavate, 10-19 by 31-52 μ , acute or

acuminate above, with a straight or bent beak, usually $8-15\mu$, sometimes obsolete, narrowed below and truncate; wall colourless, thin, smooth except for two longitudinal lines of delicate cilia.

III. Teliospores crowded in and beneath epidermal cells, globoid, ellipsoid or somewhat irregular, about $20-27\mu$ broad by $18-32\mu$ high, usually four-celled, sometimes two to many-celled; wall colourless, thin, smooth.

On *Osmunda cinnamomea* L., *O. Claytoniana* L., Pictou, Truro, Folleigh Lake, Oakfield; *O. regalis* L., Oakfield.



Uredinopsis Osmundae. Two aeciospores. Two uredinospores. Teliospores, surface view, cross section.

This species is very common and widely distributed on *Osmunda cinnamomea* and *O. Claytoniana*. It is usually conspicuous from the sharply defined yellow areas between the veins. Collections in August and

September show abundant development of both the uredinia and telia.

***Uredinopsis mirabilis* (Peck) Magn.**

I. Aecia hypophyllous, scattered or somewhat gregarious, roundish, small; peridium strongly developed. Aeciospores angularly obovate or polyhedral, $15-20$ by $24-36\mu$; wall colourless, medium thick, minutely verrucose.

II. Uredinia hypophyllous, scattered on discoloured areas, usually bounded by the veins, roundish, small, soon dehiscent by an apical rupture; peridium delicate. Uredinospores fusiform, ovate-fusiform or clavate, $12-17$ by $27-55\mu$, acuminate above tapering into a beak $3-14\mu$ long, wall colourless, thin, smooth except two lines of closely set minute spines.

III. Teliospores thickly scattered in the mesophyll of the leaf, globose or often broader than wide, usually about $22-32\mu$

broad by $19-25\mu$ high, 2-4 celled; wall colourless, thin, smooth.

On *Onoclea sensibilis* L., Pictou, Truro, Folleigh Lake.

This species is abundant and usually shows a rich development of the uredinial stage on its host. The aecia are not common on my collections. Specimens of July 30 show abundant uredinia but no teliospores. August and September collections have well developed teliospores.

Uredinopsis Struthiopteridis Stoerm.

I. Aecia hypophyllous, scattered, roundish, bullate, pale yellow, peridium well developed. Aeciospores oblong or ovate, somewhat angular, $16-20$ by $24-35\mu$; wall colourless, thick, especially at the angles, minutely verrucose; pedicels hyaline, usually shorter than spore.

II. Uredinia hypophyllous, scattered on yellowish or discoloured areas, roundish, pale yellow, dehiscent by an apical rupture; peridium delicate. Urediniospores mostly fusiform, $13-17$ by $30-40\mu$, acute or acuminate, with a beak $3-8\mu$ long; wall colourless, thin, smooth, with two longitudinal serrated ridges.

III. Teliospores in the mesophyll, abundant, globose, usually broader than high, $20-27\mu$ broad by $14-22\mu$ high, 2-4 celled wall colourless or slightly yellowish, thin, smooth.

On *Onoclea Struthiopteridis* (L.) Hoffmn., New Glasgow, Folleigh Lake.

Collections at Folleigh Lake on August 31, show all the stages well developed. The aeciospores in my collections are distinctly though finely verrucose even when wet.

Uredinopsis Atkinsonii Magn.

I. Aecia hypophyllous, on pale spots, small; peridium strongly developed. Aeciospores oval or obovate, angular, $12-20$ by $25-43\mu$, sometimes acute; wall colourless, rather thick, closely and minutely rugose, appearing smooth when wet.

II. Uredinia hypophyllous, scattered on discoloured areas, roundish, very small, opening by a central aperture, the spores oozing out in a small column. Urediniospores ovoid or fusiform, 10-15 by 27-45 μ , acute with apex prolonged into a slender beak, 5-16 μ long; walls colourless, thin, smooth except two longitudinal lines of very minute papillae, only visible when dry.

III. Teliospores numerous, in the mesophyll of the leaf, aggregated in the areas occupied by the uredinia, globoid, 15-25 by 22-30 μ , 2-4 celled, wall thin, colourless.

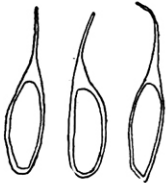
On *Aspidium Thelypteris* (L.) Sw., Pictou, Oakfield; *Asplenium Filix-femina* (L.) Bernh, Pictou.

This rust did not seem very common but was collected in several places near Pictou, the first collection being on September 11, 1909. My collections show abundant uredinia and telia but few aecia. It has been reported from Massachusetts but that seems to be the nearest station. It is probably, however, not rare.

Uredinopsis Phegopteridis Arth.

I. Aecia unknown.

II. Uredinia hypophyllous, scattered on discoloured areas bounded by the veins, roundish, small, brownish-yellow. Urediniospores ovoid or fusiform, 10-16 by 27-58 μ ; acute or acuminate, prolonged into a long and slender beak, 12-32 μ long; wall colourless, thin, smooth except two longitudinal lines of minute papillae.



5. Urediniospores of
Uredinopsis
Phegopteridis.

III. Teliospores scattered in the mesophyll, 2-4 celled, chiefly globoid, 16-25 μ in diameter; wall colourless, thin, smooth. On *Phegopteris Dryopteris* (L.) Fée, Pictou, September, 1910:

The long slender beak of this species is characteristic. It does not seem to be common. Arthur in the "North American Flora" records it only from Wisconsin.

CALYPTOSPORA Kühn.

Pycnia rarely seen. Aecia cylindrical, dehiscent at the apex. Peridium colourless. Aeciospores ellipsoid; wall colourless; contents orange. Telia forming continuous layers of considerable extent, indehiscent. Teliospores 4-celled by a vertical septa, formed in the epidermal cells.

Only one species is known. The telial stage of it is common in North America and Europe.

Calyptospora columnaris (Alb. & Schw.) Kühn.

Calyptospora Geoppertinana Kühn.

0. Not formed.

I. Aecia hypophyllous, in two rows, irregular rows on yellowish areas occupying the whole or part of the leaf, cylindrical, slender, about 1 mm. in length, dehiscent at apex; peridium colourless, finely lacerate, cells mostly elongate. Aeciospores broadly ellipsoid or ellipsoid, 12-18 by 18-25 μ ; wall colourless, thin, closely and distinctly verrucose; contents orange, fading to pale yellow or colourless.

II. Not formed.

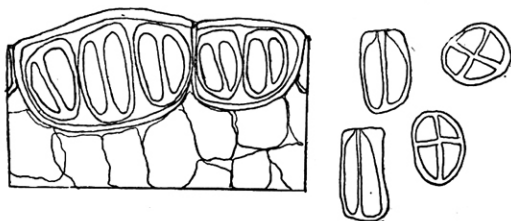
III. Telia caulicolous, forming a continuous layer around the stem, stems much thickened and often elongated, surface smooth shining reddish-brown, becoming dull. Teliospores in the epidermal cells, closely pressed together, usually 4-celled, oblong or somewhat ellipsoid, 12-20 by 22-40 μ ; wall pale yellowish-brown, smooth, thin, somewhat thickened at the apex.

Aecia on *Abies balsamea* (L.) Mill., Pictou, July 14, 1909.

Telia on *Vaccinium pennsylvanicum* Lam., Pictou, Truro.

The telial stage of this rust is very common about Pictou on *Vaccinium pennsylvanicum*; it was not found on *V. canadense*.

The aecial stage has never been collected elsewhere in North America. It is probably common but has been overlooked.



6. Section of telia of *Calyptospora columnaris*.
Teliospores in longitudinal and cross section.

The first collection was on July 14, 1909, and it was found to occur rather sparingly over a considerable area during that summer. In 1910

collections were made first on June 21 and the aecia soon became common, and in some shaded places were abundant and rather conspicuous on young trees. It was found rather common at the Park, Truro, and also at Oakfield, and doubtless is common throughout the province.

Using material from Pictou, Arthur (*Mycologia* 2: 231. 1910) sowed the teliospores of this rust on *Abies Fraseri* and the aecial stage developed. European investigators had previously established their connection. (For cultures by the writer see *Mycol.* 4: 177. 1912).

The aecial stage can be easily recognized as the spores are orange in colour and pycnia are absent, and no other *Peridermium* on *Abies balsamea* has these characters. No pycnia are formed, which is rare in the case of heteroecious rusts.

NECIUM Arth.

Cycle of development includes telia and possibly pycnia. Telia indehiscent, forming continuous layers, more or less distinguishable as compound sori. Teliospores oblong or prismatic, apparently one-celled; wall smooth, slightly coloured.

The description of the genus is based on Arthur's description in the "North American Flora."

***Necium Farlowii* Arth.**

0, I & II. Wanting.

III. Telia amphigenous, mostly hypophyllous, also common on the young twigs and cones, forming compound raised sori on the leaves on the twigs and cones, usually a more or less continuous layer, reddish, waxy. Teliospores in the enlarged epidermal cells closely appressed, oblong or cylindrical, 7-16 by 35-90 μ ; wall pale brown, uniformly thin. Basidiospores spherical, 8-11 μ in diameter, reddish yellow.

On *Tsuga canadensis* (L.) Carr., Pictou.

The life history of this species was worked out by the writer (see *Mycologia* 4:182. 1912). The telia that were present on the twigs were found germinating on June 14, and well developed telia were collected on July 5.

The rust was locally abundant in the vicinity of Pictou during the seasons of 1910-11 and did considerable injury to the hemlocks. It was not found elsewhere in the province. It is inconspicuous when occurring on the leaves, but on the twigs it is quite conspicuous as they become swollen and much curved and soon bare of leaves. The affected cones in the early stages of infection are yellow in colour, later they become dark coloured.

Family 3. CRONARTIACEAE.

Similar to *Melampsoraceae* but the telia in columnar, filiform, wart-like, lens-shaped or cushion-like masses.

MELAMPSOROPSIS (Schroet.) Arth.

Aecia with well developed peridium. Aeciospores with colourless walls, closely verrucose with deciduous tubercles. Uredinia with delicate, evanescent peridium, sometimes wanting. Urediniospores formed in chains like aeciospores. Telia erumpent, naked, waxy becoming velvety. Teliospores in simple or branched cell-rows.

Five species are here reported from Nova Scotia. *M. Empetri* Schroet on *Empetrum nigrum* L. has been collected in New Hampshire and Quebec so that it may be expected to occur here.

Melampsoropsis Pyrolae (DC) Arth.

Chrysomyxa Pirolae (DC.) Rostr.

0. Pycnia episquamous, numerous, flat, forming continuous layers, not or slightly elevating the surface, producing yellowish areas on the scales.

I. Aecia chiefly episquamous, forming bullate swellings, irregularly round, large, crowded and often confluent, finally rupturing the epidermis, very pulverulent; peridium somewhat convex, soon falling away, cells coarsely tuberculate, resembling the spores. Aeciospores broadly elliptical or obovoid, variable in size, 19-30 by 24-45 μ ; wall colourless, thick, covered with large, crowded, deciduous tubercles.

II. Uredinia hypophyllous, small, circular, about 1 mm. in diameter, evenly and thickly distributed, usually occupying the whole under surface of the leaf; peridium delicate, walls smooth, colourless, thin. Urediniospores elliptical or obovate, often somewhat angular, 17-22 by 22-30 μ ; wall colourless, distinctly verrucose; contents reddish-orange.

III. Telia hypophyllous, evenly and closely scattered, Truro; *P. elliptica* Nutt., Pictou.

The uredinial and telial stages of this rust are very common near Pictou. In 1910 the uredinia were mature by May 7 and the telia germinating by May 20.

The life history of this species was established by the writer by cultures in the spring of 1911. (See *Mycologia* 4: 183. 1912). The aecial stage on the cones of *Picea* was common near Pictou in the season of 1910. It was rather rare the following year. The infected cones are quite conspicuous.

Melampsoropsis abietina (Alb. & Schw.) Arth.*Chrysomyxa Ledi* De Bary.

0. Pycnia amphigenous, numerous, scattered, yellow, becoming reddish-brown, punctiform.

I. Aecia hypophyllous, on discoloured areas occupying part or all of a leaf, somewhat in rows, flattened laterally, low, dehiscent at apex; peridium colourless, lacerate, cells abutted. Aeciospores chiefly ellipsoid, 16-22 by 19-30 μ ; wall colourless, thick, densely and somewhat coarsely tuberculate, tubercles deciduous; contents orange-red.

II. Uredinia hypophyllous, on yellow spots, scattered or grouped, small, yellowish-red or brownish-yellow, roundish, about 130 μ in diameter; peridium delicate. Urediniospores elliptical or subglobose, 13-20 by 18-33 μ ; wall colourless; closely and rather finely verrucose, tubercles deciduous; contents orange fading to colourless.

III. Telia hypophyllous, scattered or chiefly grouped on discoloured areas, small, .1-.3 mm., reddish at first. Teliospores oblong or cuboid, 11-19 by 16-30 μ , in a series 70-90 μ ; wall colourless, thin, smooth; contents orange-red, fading to colourless.

Pycnia and aecia on *Picea rubra* (DuRoi) Dietr., Pictou.

Uredinia and telia on *Ledum groenlandicum* Oeder, Pictou.

The teliospores of this species were germinating freely in the summer of 1910 by the second week of June, the first collection being on June 10. Aecia were mature by the 17th of July.

The aecial stage of this rust, *Peridermium abietinum* (A. & S.) Arth., has not been recognized elsewhere in North America, though it was known in Europe on *Picea excelsa* (Lam.) Link. Cultures were made by the writer in 1910 and aecia were produced on *Picea rubra* from a sowing of the

germinating teliospores. (*Mycologia* 3:69. 1911). Field collections were also made near the rusted *Ledum* that seemed without doubt to be connected. These were sent to Dr. Arthur and were determined by him as *Peridermium abietinum*. All stages are very common in the neighbourhood of Pictou.

Melampsoropsis ledicola (Peck) Arth.

Chrysomyxa ledicola Lagerh.

0. Pycnia amphigenous, numerous, arranged in rows, prominent, punctiform, honey-yellow, becoming dark reddish-brown.

I. Aecia hypophyllous, in two rows on yellowish areas, occupying a part or all of the leaf, much compressed laterally, erumpent from elongated openings, low, dehiscent at apex, soon falling away; peridium colourless, margin lacerate. Aeciospores broadly ellipsoid or globoid, 20-35 by 20-50 μ ; wall colourless, thick, densely and rather coarsely verrucose; contents orange-red fading to colourless.

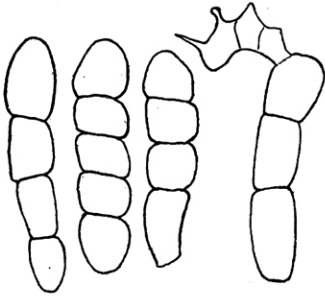
II. Uredinia epiphyllous, on reddish-brown spots, roundish or oblong-polygonal, early dehiscing, ruptured epidermis evident; peridium delicate. Urediniospores chiefly elliptical or globoid, 20-32 by 30-45 μ ; wall thick, colourless, verrucose with close set, deciduous tubercles; contents orange-red.

III. Telia epiphyllous, chiefly grouped on discoloured areas, irregular or roundish, small about .2-.5 mm. in diameter, ruptured epidermis evident. Teliospores oblong or cuboid, 16-22 by 18-33 μ ; wall colourless, thin, smooth, in a series 65-100 μ long; contents orange-red when fresh.

Pycnia and aecia on *Picea canadensis* (Mill.) BSP., *P. rubra* (DuRoi) Dietr., *P. mariana* (Mill.) BSP., Pictou, Truro.

Uredinia and telia on *Ledum groenlandicum* Oeder, Pictou, Truro.

The connection of the aecial stage, *Peridermium decolorans* Peck, and the telial form on *Ledum*, was shown by cultures in 1910 by the writer. (See *Mycologia* 3:70. 1911). The germinating teliospores of the rust on *Ledum* were sown on *Picea canadensis* and abundant pycnia and aecia developed.



7. Teliospores of *Melampsoropsis ledicola*, one germinating.

The aecial stage is very abundant about Pictou and doubtless throughout the province. The aecia begin to mature about the first of July. The telial stage is also common. The teliospores begin to germinate about the first of June, and when germinating are quite conspicuous. The uredinia were rare, only one collection being made.

The urediniospores and especially the teliospores are much larger than the measurements given in the "North American Flora" by Arthur.

***Melampsoropsis Cassandrae* (Peck & Clinton) Arth.**

Chrysomyxa Cassandrae Tranz.

0. Pycnia amphigenous, numerous, scattered, conspicuous, punctiform, honey-yellow, becoming blackish-brown.

I. Aecia chiefly hypophyllous, in two irregular rows on yellowish spots occupying part or all of the leaf, flattened laterally, .5-1.5 mm. long, .5-.8 mm. high, dehiscent at the apex; peridium colourless, rather delicate, cells slightly overlapping. Aeciospores broadly ellipsoid or globoid, 17-24 by 24-33 μ ; wall colourless, medium thick, moderately and densely verrucose.

II. Uredinia hypophyllous in small groups; peridium inconspicuous, delicate. Urediniospores catenulate, elliptical,

16-19 by 21-30 μ ; wall colourless, thin, closely and prominently verrucose with deciduous tubercules; contents orange.

III. Telia hypophyllous, rather small, ruptured epidermis conspicuous, 130-500 μ across, pale orange, inconspicuous. Teliospores oblong, 16-19 by 16-33 μ , in a series 60-100 μ long; wall uniformly thin, colourless, smooth, contents orange-red.

Pycnia and aecia on *Picea mariana* (Mill.) BSP., Pictou.

Uredinia and telia on *Chamaedaphne calyculata* (L.) Muench., Pictou.

The teliospores of this rust were germinating by June 13, and aecia were mature by July 17. The telial stage is fairly conspicuous when germinating, but rather inconspicuous before germination.

Cultures by the writer (*Mycologia* 3:68, 69. 1911) and field observations showed that *Peridermium consimile* Arth. and Kern, is the aecial stage. Clinton (Report Conn. Agr. Exper. Sta., pt. 6:386. 1907) described infection experiments that led to the same conclusion.

Melampsoropsis Chiogenis (Dietel) Arthur.

Chrysomyxa Chiogenis Deitel.

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous, scattered, roundish or irregular, flat, honey-yellow; peridium delicate, walls thin, smooth. Urediniospores catenulate, oblong to linear oblong, 14-21 by 22-40 μ ; wall colourless, coarsely verrucose with somewhat deciduous tubercules, medium thick; contents orange-yellow when fresh.

III. Telia hypophyllous, loosely scattered, round, small, orange-yellow fading to pale yellow, soon naked, ruptured epidermis noticeable; teliospores broadly oblong or squarish, 7-10 by 13-16 μ in a series 30-80 μ long; wall colourless, smooth, thin.

On *Chiogenis hispidula* (L.) T. & G., Pictou, Truro.

The description is based on that of Arthur in the "North American Flora." The collections contained only uredinia, but probably telia developed later. The species seems to be rather local in its distribution.

CRONARTIUM Fries.

Cycle of development includes pycnia, aecia and telia, heteroecious.

Pycnia broad and flat.

Aecia with membranous peridium, rupturing at the sides. Aeciospores coarsely verrucose with deciduous tubercles.

Uredinia with peridium. Urediniospores borne singly on pedicels, pores obscure.

Telia erumpent, the catenulate teliospores adhering to form a long cylindrical or filiform column, horny when dry. Teliospores one-celled.

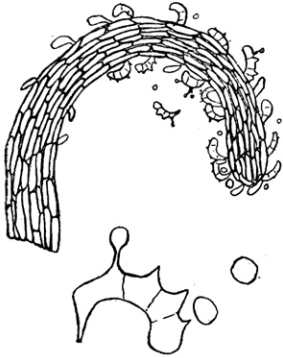
Cronartium Comptoniae Arth.

0 & I. On *Pinus rigida* Mill., *P. virginiana* Mill., *P. sylvestris* L. (Not collected in Nova Scotia).

II. Uredinia hypophyllous, scattered or gregarious, small, round, dehiscent by a central opening, pulverulent; peridium with polygonal cells, larger at the top with very thick walls. Urediniospores oval or obovate, 13-21 by 30-60 μ ; wall colourless, thick, sparsely and finely echinulate.

III. Telia columns hypophyllous, filiform, about 55-135 μ thick and 1-1 $\frac{1}{2}$ mm. long. Teliospores fusiform-oblong, 13-17 by 30-60 μ ; wall colourless, smooth, thin.

Uredinia and telia on *Myrica Gale* L., Pictou, August 25, 1910.



Telial column of *Cronartium basidium* with basidiospores

that this species is identical with the European *Cronartium asclepiadeum* Fr.

This species was found only at Cole's Pond, near Pictou. A few of the teliospores were germinating when collected. It was rather abundantly developed in a limited area.

Clinton (Report Conn. Agric. Exper. Sta. Pt. 6:380. 1907) sowed the spores of *Peridermium pyriforme* Peck on *Myrica asplenifolia* and the uredinia of this rust appeared. He thinks it probable

Family 4. PUCCINIACEAE.

Basidia external, i. e. germinating by a typical promycelium. Telia usually erumpent, firm or pulverulent. Teliospores fascicled or free, pedicelled; wall firm or with outer gelatinous layer, overlaid by the cuticle.

The great majority of rusts belong to this family. The teliospores may be one-celled as in *Uromyces* or two-celled as in *Puccinia* or several celled as in *Phragmidium*.

UROMYCES Link.

Nigredo Roussel.

Pycnia immersed in the tissue of the host, globose or subglobose with projecting neck. Aecia with evident peridium, finally cup-shaped. Aeciospores without distinct germ-pores. Urediniospores formed singly on distinct pedicels with several germ-pores, echinulate or verrucose. Teliospores unicellular, formed singly on distinct pedicels with a single apical germ-pore. Basidiospores inequilateral, nearly reniform.

The one-celled teliospore with a single apical germ-pore separates this genus from *Puccinia*. They are alike in other respects. Though the teliospores and urediniospores are both one-celled in *Uromyces* they may be easily distinguished, as the urediniospores are always echinulate or verrucose with several germ-pores, while the teliospores are usually smooth (sometimes verrucose) with only one apical germ-pore. The wall of the teliospore is, also, usually thicker.

Arthur divides this genus chiefly into four as follows:

Life cycle with all the spore forms. Nigredo.

Life cycle with pycnia, aecia and telia. . . . Uromycopsis.

Life cycle with pycnia, uredinia and telia. Klebahnia.

Life cycle with pycnia and telia. Telospora.

The genus is a very large one embracing over 500 species.

Uromyces Scirpi Burr.

Nigredo Scirpi (Cast.) Arth.

0. Pycnia amphigenous, numerous, scattered, inconspicuous.

I. Aecia amphigenous, gregarious, on discoloured spots, short cylindrical; peridium pale yellowish, the margin lacerate, recurved. Aeciospores globoid or broadly ellipsoid, 16-21 by 18-24 μ ; wall colourless, thin, minutely verrucose.

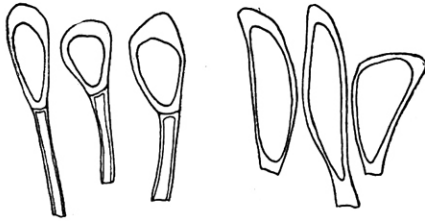
II. Uredinia amphigenous, elongate, remaining covered for some time by the epidermis. Urediniospores mostly ellipsoid, 16-23 by 22-40 μ ; wall light brown, sparingly echinulate, pores 3 or 4, equatorial.

III. Telia amphigenous, oblong or linear, long covered by epidermis, compact, brownish-black. Teliospores fusoid or clavate ellipsoid, 17-22 by 33-46 μ , rounded at the apex, sometimes conical; wall light brown, thickened at the apex to 8 μ ; pedicel firm, hyaline, or light brown, equalling or longer than the spore.

Pycnia and aecia on *Cicuta maculata* L. Not collected in Nova Scotia, but obtained from cultures by the writer. (See *Mycologia* 4:178. 1912).

Uredinia and telia on *Scirpus campestris* Var. *paludosus* (A. Nelson). Fernald, *S. validus* Vahl., Pictou.

Arthur has shown by cultures that aecial stage is on *Cicuta maculata* (Arthur, *Jour. Mycol.* 13:199. 1907). European



Teliospores of *Uromyces Scirpi*.

investigators have shown that this species produces aecia on a number of different hosts. Arthur in the "North American Flora" lists collections of aecia on *Cicuta bulbifera* L.,

Oenanthe californica S. Wats., *Sium cicutaefolium* Schrank, and *Glaux maritima* L. as belonging to this species as well as the aecia on *Cicuta maculata*.

The description is from the collection on *Scirpus campestris* Var. *paludosus*. The uredinia and urediniospores are similar on *Scirpus validus* except that the uredinia remain covered in the latter. The telia on *Scirpus validus* are placed immediately beneath the stomata embedded in the tissues; they are small, numerous, and do not break through the epidermis. The teliospores are sometimes as long as 70μ and somewhat irregular in shape, probably due to the pressure of the strong epidermis. The pedicel is very short or obsolete.

Uromyces perigynius Halsted.

Uromyces Solidagini-Caricis Arth.

Nigredo perigynia (Halsted) Arth.

0. Pycnia epiphyllous, sometimes amphigenous, grouped on yellow spots, honey-yellow.

I. *Aecia* hypophyllous, often circinate; peridium pale, low, cylindrical, margin revolute, lacerate. *Aeciospores* globose, about 15-16 μ ; wall colourless.

II. *Uredinia* hypophyllous, small, oval, up to $\frac{1}{2}$ mm. in length, ruptured epidermis evident, ferruginous, pulverulent. *Urediniospores* oval or obovate, 13-18 by 19-25 μ ; wall medium thick, pale brown, finely echinulate, two equatorial germ pores.

III. *Telia* hypophyllous, oblong or linear, pulvinate, firm, soon naked, dark chestnut-brown or black. *Teliospores* obovate, rounded or obtuse above, narrowed below, 14-22 by 24-35 μ ; wall smooth, thin, light brown, much thickened at the apex, 6-12 μ ; pedicel slender, tinted, as long as the spore or longer.

Aecia on *Solidago bicolor* L. and other species of *Solidago*, Pictou and vicinity.

Telia and *uredinia* on *Carex deflexa* Hornem., *C. flava* L., *C. intumescens* Rudge, *C. novae-angliae* Schwein., *C. tribuloides* Wahlenb. and Var. *reducta* Bailey, *C. scoparia* Schkuhr., Pictou and surrounding districts.

This species also has *aecia* on *Aster*. (See Arthur, *Mycologia* 4:21. 1912).

The writer by cultures (*Mycologia* 4:181. 1912) showed that this rust has *aecia* on *Solidago* species. Arthur had previously established this connection.

It seems probable that there is only one species of *Uromyces* rust on the sedges in this vicinity, that is, all belong to this species. It is very common on *Carex scoparia*.

Uromyces Poae Rab.

Nigredo Poae (Rab.) Arth.

0. *Pyrenia* amphigenous, mostly crowded on spots bearing *aecia*. honey-yellow.

I. Aecia mostly hypophyllous, also epiphyllous and petiolicolous, crowded in small groups on discoloured often depressed areas, low, small; peridium lacerate. Aeciospores yellow, becoming colourless, subglobose or polygonal, 16-24 μ ; wall colourless, finely verrucose.

II. Uredinia hypophyllous, linear, long covered by the epidermis, 1 mm. or less in length. Urediniospores globose or elliptical, 16-29 by 19-24 μ ; wall pale brown, rather thin, finely echinulate.

III. Telia hypophyllous, small, black or dark brown, mostly oval or linear, long covered by the epidermis. Teliospores variable in form, obovate, broadly clavate or oval, 16-23 by 23-33 μ ; wall brown, smooth, scarcely thickened at the apex; pedicel brown, much shorter than the spore, persistent.

Pycnia and aecia on *Ranunculus repens* L., Pictou, May 25, 1910.

Uredinia and telia on *Poa trivialis* L., Pictou, July 17, 1910.

This is an European species of which neither aecial nor telial stage has been previously reported from North America. It was collected in only one place. The aecia were collected in the spring, and in July the other stages were found to be common on *Poa* that grew near.

Uromyces Peckianus Farl.

Nigredo Peckiana (Farl.) Arth.

0. Pycnia amphigenous, usually in small groups surrounded by the aecia.

I. Aecia amphigenous, on rounded spots, circinating, bright orange, long cylindrical, lacerate. Aeciospores angular globose or ellipsoid, about 16-22 μ ; wall nearly colourless, medium thick, contents orange, fading to pale yellow.

II. Uredinia epiphyllous, scattered or in lines, oblong or linear, ochraceous-brown, pulverulent, surrounded by the ruptured epidermis. Urediniospores mostly globose, 19-24 μ ; wall yellowish-brown, thick, about 2 $\frac{1}{2}$ μ , finely and densely verrucose.

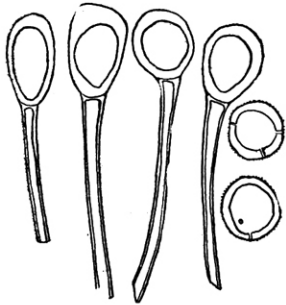
III. Telia mostly epiphyllous, sometimes hypophyllous, scattered, often confluent, abundant, rounded oblong or linear, often 1 cm. or more in length, pulvinate, dark brown or black. Teliospores globose, subglobose, obovate or elliptical, 13-22 by 19-40 μ ; wall dark brown, smooth, thickened at the apex; pedicel hyaline, much longer than spore; a few two-celled spores present.

Pycnia and aecia on *Atriplex patula* L., *A. patula* Var. *hastata* (L.) Gray, Pictou, May 21, 1910. (*Chenopodium album* L., shown by cultures, not collected).

Uredinia and telia on *Distichlis spicata* (L.) Greene.

The life history of this rust was made out by the writer by cultures during the spring of 1910 (Mycologia 3: 72-74, 1911).

Sowings of the teliospores were successful on *Chenopodium album* and *Atriplex patula* Var. *hastata*. Collections of aecia were made on *Salicornia europea* L. and *Suedia maritima* which probably also belong to this rust. They were collected beside the rusted *Distichlis* and were morphologically similar to the aecia on *Atriplex*.



Uromyces Peckianus. Four teliospores, two urediniospores.

Infection experiments by Arthur (Jour. Mycol. 1:234, 1909) showed that *Puccinia subnitens* Dict. on *Distichlis spicata* has aecia on *Chenopodium*, *Atriplex* and other plants. The aecia of both rusts are similar and cannot be separated easily. These facts suggest the possibility that the rusts were once identical

and that the *Puccinia* has in course of time developed from the *Uromyces*. The urediniospores are also alike and a few mesospores are present in the *Uromyces*, which would tend to strengthen the supposition.

Uromyces Spartinae Farl.

Uromyces acuminatus Arth.

Nigredo Polemonii (Peck.) Arth.

0. Pycnia chiefly epiphyllous, gregarious, in small groups, not conspicuous, punctiform, honey-yellow, becoming brownish.

I. Aecia chiefly hypophyllous, gregarious, more or less crowded in groups on slightly discoloured spots, cupulate or cylindrical, margin lacerate, slightly recurved. Aeciospores subglobose, 15-24 by 18-27 μ ; wall colourless, rather thin, evenly and finely verrucose.

II. Uredinia epiphyllous, intercostal, linear, soon naked, ruptured epidermis evident, yellowish-brown, not inconspicuous. Urediniospores globose or broadly elliptical, large, 22-32 μ in diameter, a few 25 by 35 μ ; wall thick when immature, becoming thinner, yellowish, rather sparsely echinulate, pores large, scattered.

III. Telia similar to the uredinia but blackish-brown and more conspicuous; teliospores obovate or oblong-clavate, 15-22 by 22-42 μ ; wall dark brown, apex darker and thickened, 6-10 μ , usually rounded or acuminate above, base narrowed; pedicel slightly coloured, firm, usually longer than the spore, often twice its length.

Pycnia and aecia on *Arenaria lateriflora* L., *Spergularia canadensis* (Pers.) Don., Pictou.

Uredinia and telia on *Spartina patens* (Ait.) Muhl., *S. glabra* Var. *alternifolia* (Loisel) Merr., *S. Michauxiana* Hitchc., Pictou.

This species is composed of distinct races. In this vicinity the form on *S. patens* infects *Spergularia*, that on *S. Michauxiana* and *S. glabra alterniflora* infects *Arenaria*. This has been shown by cultures of the writer. (*Mycologia* 4:186. 1912). In the interior of North America the form on *S. Michauxiana* infects *Polemonium* and another form on the same host infects *Steironema*. This has been shown by cultural experiments by Arthur (*Jour. Mycol.* 12:24. 1906).

Uromyces Silphii (Syd.) Arth.

Uromyces Junci-tenuis Syd.

Nigredo Silphii (Desmaz.) Arth.

0. Pycnia chiefly epiphyllous, in small groups, golden-brown.

I. Aecia amphigenous, in groups 4-10 mm. across, crowded about the pycnia on discoloured spots; peridium colourless, margin recurved, lacerate. Aeciospores angularly globoid, small, 13-18 μ ; wall colourless, thin, minutely verrucose.

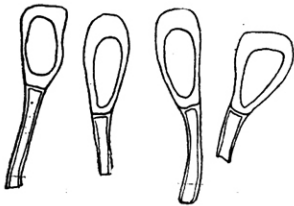
II. Uredinia amphigenous, scattered, roundish or somewhat elongated, small, tardily naked, dark cinnamon-brown, ruptured epidermis not conspicuous. Urediniospores broadly ellipsoid or sometimes obovate, 13-19 by 15-23 μ ; wall golden yellow, sparsely and bluntly echinulate, pores 5 or 6, scattered.

III. Telia amphigenous, scattered, roundish or somewhat elongated, small, tardily naked, firm, somewhat pulvinate, blackish-brown, ruptured epidermis noticeable. Teliospores angularly obovate, rounded, truncate or occasionally pointed above, usually narrowed below, 12-19 by 26-35 μ ; wall chestnut-brown, much thickened above, 7-10 μ , smooth; pedicel light-chestnut brown, one to one and a half times the length of the spore.

Aecia on *Silphium integrifolium* Mich., *S. teribinthinaceum* Jacq., *S. perfoliatum* L., *S. laciniatum* L. (Not collected in N. S.)

Uredinia and telia on *Juncus tenuis* Wild., Pictou and vicinity.

The collections of this rust were so badly parasitized that the description is largely based on Arthur's original description (Jour. Mycol. 13: 202 1907). The aecial hosts are not found in Nova Scotia. The rust is common.



Teliospores of *Uromyces Silphii*.

The rust has generally passed as *Uromyces Junci* (Desm.) Tul. Arthur (l. c.) showed by cultures that the aecial stage is on *Silphium* and separated the rust. The European *Uromyces Junci* has its aecia on *Pulicaria dysinterica*. A rust not morphologically distinct is found in western North America and has passed under the name of *Uromyces Junci* though no cultures have been made to determine its aecial stage.

Uromyces effusus Arth.

Uromyces Junci-effusi Syd.

Nigredo Junci-effusi (Syd.) Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, scattered, oblong or linear, tardily naked, dark cinnamon-brown, ruptured epidermis evident. Urediniospores broadly ellipsoid or oval, 14-19 by 18-26 μ ; wall light yellow, sparingly and bluntly echinulate. pores 4, equatorial.

III. Telia amphigenous, numerous, scattered or collected in groups about stem, oblong or linear, sometimes confluent, ruptured epidermis conspicuous. Teliospores obovate or oval,

12-17 by 20-30 μ , rounded, obtuse or acute at apex, mostly narrowed below; wall light chestnut-brown, thickened at apex, 5-10 μ , smooth; pedicel yellowish, persistent, about the length of the spore.

On *Juncus filiformis* L., Pictou.

Nothing is known of the aecial stage of this rust. It was found in only one place, and, though careful watch was kept for two seasons in the neighbourhood, no aecia appeared except those that have already been connected.

This collection adds a new host, as all previous collections were on *Juncus effusus* L.

This species is found throughout the eastern United States on *Juncus effusus* L. It has passed under the name *U. Junci* (Desm.) Tul., but Arthur (Jour. Myc. 13: 192. 1907) shows that it is morphologically distinct, especially as the urediniospores are echinulate and four-pored instead of verrucose and two-pored, as in *U. Junci*. He gives the following key to separate the three common species of *Uromyces* on *Juncus*:

Urediniospores verrucose, pores 2, equatorial—*U. Junci* (Desm.) Tul.

Urediniospores echinulate, pores 4, equatorial—*U. effusus* Arth.

Urediniospores echinulate, pores 5-6, scattered—*U. Silphii* (Syd.) Arth.

Uromyces Polygoni (Pers.) Fuck.

Nigredo Polygoni (Pers.) Arth.

0. Pycnia yellow to honey-colour, in small groups.

I. Aecia mostly hypophyllous, crowded in roundish groups, peridium rather low, with broad, whitish, torn edges. Aeciospores subglobose, 16-18 μ , pale yellow to orange, verrucose.

II. *Uredinia* amphigenous, mostly hypophyllous, rounded or oval, pulverulent, surrounded by the ruptured epidermis. Urediniospores ellipsoid or obovate, 16-20 by 21-27 μ ; wall yellowish, very finely and densely echinulate. pores 2, lateral.

III. *Telia* scattered, roundish on leaves, abundant and elongated on the stem, pulvinate, blackish. *Teliospores* globose or subglobose, 19-24 by 24-38 μ , rounded or pointed above, wall chestnut-brown, apex thickened up to 7 μ , smooth; pedicels tinted, persistent, firm, long, usually much longer than the spore.

On *Polygonum aviculare* L., Pictou, Truro.

This is a cosmopolitan species, and is probably common. The collections were made in the fall, so no aecia were present. The teliospores are not formed till late summer.

Uromyces Arisaemae Cke.

Uromyces Caladii Farl.

Nigredo Caladii (Schw.) Arth.

0. *Pycnia* hypophyllous, scattered.

I. *Aecia* hypophyllous or petiolicolous, scattered, abundant, low, margin erose. *Aeciospores* subglobose or ellipsoid, often angular, 18-24 by 22-25 μ , verrucose.

II. *Uredinia* amphigenous, scattered, rounded or oblong, often covered by the epidermis, frequently confluent. *Urediniospores* pear-shaped, base truncate, 15-21 by 25-32 μ , conspicuously echinulate.

III. *Telia* amphigenous, mostly epiphyllous, abundant, scattered, rounded or oblong, long covered by the conspicuous epidermis, sometimes confluent, somewhat pulverulent, brown. *Teliospores* oval, subglobose or ovate, 19-27 by 27-40 μ ; wall light yellowish-brown, uniform in thickness, with a small, hyaline, apical papilla, (sometimes more than one), pedicel hyaline, fragile, deciduous, about the length of the spore.

On *Arisaema triphyllum* (L.) Schott., Pictou, Truro.

This species is doubtless common. Collections made throughout the summer show no uredinia and only a few urediniospores mixed with the teliospores.

Uromyces Limonii (DC.) Lév.

Nigredo Limonii (DC.) Arth.

0. Pycnia amphigenous mostly hypophyllous, accompanying the aecia, numerous, brown.

I. Aecia amphigenous, in circular groups on brown or reddish spots, peridium short, cylindrical, margin whitish, lacerate. Aeciospores angular-globose or ellipsoid, 18-26 by 21-32 μ , yellowish, finely verrucose.

II. Uredinia amphigenous, scattered, mostly rounded on the leaves, oblong on the stem, long covered by the epidermis, at length naked, pulverulent, cinnamon-coloured. Urediniospores globose, subglobose or ovate, 20-28 by 22-32 μ , yellowish-brown, densely verrucose, 2-3 pores.

III. Telia amphigenous, scattered or in circular groups, mostly rounded on the leaves, oblong on the stem, long covered by the epidermis, at length naked, surrounded by the ruptured epidermis, pulvinate, brownish-black or black. Teliospores subglobose, mostly clavate or oblong, sometimes angled and irregular, 19-27 by 27-44 μ , apex rounded or conical, base narrowed; wall brown, thickened at apex up to 8 μ , smooth; pedicel persistent, tinted, usually longer than spore.

On *Limonium carolinianum* (Walt.) Britton, Pictou, September, 1909.

The collections on this plant showed an abundant development of aecia and telia, but no uredinia. The first collection of mature aecia was on June 10, 1910.

Uromyces Fabae (Pers.) De Bary.*Nigredo Fabae* (Pers.) Arth.

0. Pycnia hypophyllous, scattered among the aecia.

I. Aecia hypophyllous, on yellow spots, solitary or in rounded or elongated groups; peridium short, cup-shaped, margin incised, revolute, whitish. Aeciospores angular globose or ellipsoid, 12-14 μ in diameter, yellowish, finely and densely verrucose.

II. Uredinia amphigenous, mostly scattered, circular on the leaves, elongated on the stem, small, pulverulent, light brown, surrounded by the ruptured epidermis. Urediniospores mostly ellipsoid or ovate, 18-21 by 23-30 μ ; wall yellowish, becoming light brown, sparingly echinulate, usually 3 sometimes 4 pores.

III. Telia amphigenous, rounded on the leaves, elongate and more abundant on the stem, pulvinate, dark brown to blackish-brown. Teliospores obovate, clavate or subglobose, 17-24 by 22-43 μ , rounded or conical, sometimes truncate above; wall brown, thickened at apex up to 10 μ , smooth; pedicel persistent, thickened, coloured, equalling or longer than spore.

On *Vicia cracca* L., Pictou.

This species is found on several genera of the *Leguminosae*. It was collected on only one species, and seemed to be common on that host. On some host plants aecia are abundantly produced, on others they do not seem to occur. It may be that *Vicia cracca* belongs to the latter class as no aecia were found.

Uromyces Trifolii (Hedw. F.) Lév.*Nigredo fallens* (Desmaz.) Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia hypophyllous or petiolicolous, mostly scattered, small, sometimes confluent, pulverulent, soon naked, surrounded by the ruptured epidermis, light brown. Urediniospores globose, subglobose or ellipsoid, 22-27 by 23-30 μ ; wall about 2 μ thick, yellowish-brown, sparingly echinulate, pores 5-7.

III. Telia mostly caulicolous, oblong or rounded, sometimes confluent, covered for some time by the epidermis, at length naked, pulverulent, dark brown. Teliospores globose, subglobose, elliptical or oblong, 19-24 by 22-32 μ , rounded at the apex, with a small apical papilla at the germ-pore; wall bright brown, smooth (sometimes very finely verrucose); pedicel hyaline, slender, deciduous, about the length of the spore.

On *Trifolium pratense* L., Pictou.

The uredinal stage of this rust is very common on clover, and must cause a considerable amount of injury. No aecial stage is known.

Uromyces Trifolii-repentis Liro.

Nigredo Trifolii (Hedw. F.) Arth.

0. Pycnia chiefly epiphyllous, in small groups or spread over larger areas, not conspicuous.

I. Aecia amphigenous, in roundish groups, or on the veins and petioles in elongate groups, short cupulate; peridium white erect, or slightly recurved, finely erose. Aeciospores broadly ellipsoid or somewhat angular, 15-17 by 16-21 μ ; wall light yellow or nearly colourless, thin, finely verrucose.

II. Uredinia similar to *U. Trifolii*, but there are 3 or 4 equatorial germ pores, instead of 4-6 scattered ones.

III. Telia similar to those of *U. Trifolii*.

On *T. hybridum* L., Pictou.

This species differs from the more common rust on red clover by the presence of aecia on the same host as the uredinia and telia, also by the different number of germ pores in the urediniospores. It is also found on *Trifolium repens* L.

The aecial stage was not collected. The description given is based on that in the "North American Flora."

Uromyces Hyperici-frondosi (Schw.) Arth.

Nigredo Hyperici-frondosi (Schw.) Arth.

Uromyces Hyperici Curt.

0. Pycnia mostly hypophyllous, accompanying the aecia, subepidermal, somewhat globose, about 140μ in diameter, becoming blackish.

I. Aecia hypophyllous and caulicolous, on orbicular yellow or purple spots 2-4 mm. in diameter, in small rounded groups on leaves, larger groups on the stem and leaf veins, cup-shaped, margin revolute, incised. Aeciospores angularly globose, $16-22\mu$ in diameter, finely verrucose.

II. Uredinia hypophyllous, scattered, sparingly developed, small, rounded, yellowish-brown. Urediniospores globose, subglobose or ellipsoid, 15-20 by $18-27\mu$; wall light brown, finely echinulate.

III. Telia hypophyllous or caulicolous, sometimes on purplish spots, small and rounded on leaves, larger and elongated and in groups on the stem, sometimes confluent, pulvinate, blackish-brown or black. Teliospores subglobose ovate or oblong, mostly ovate, 16-19 by $19-33\mu$, apex mostly rounded; wall pale brown or dark brown, thickened at the apex up to 9μ ,

smooth; pedicel hyaline or coloured above, equalling or exceeding spore, fragile.

On *Hypericum virginicum* L., Pictou; *H. canadense* L., Pictou; *H. ellipticum* Hook., Pictou, Folley Lake.

This species is very common on the genus *Hypericum* in the vicinity of Pictou. The teliospores on *H. ellipticum* show a much less thickened apex than on the other host plants.

PHRAGMIDIUM Link.

Aecia of the caeoma type without peridium, but surrounded by a dense crown of paraphyses. Aeciospores with numerous germ-pores, scattered; wall colourless. Uredinia also surrounded by paraphyses. Urediniospores singly not in chains, with numerous germ-pores. Teliospores three or more celled in a vertical row (rarely two celled), usually several germ-pores in each cell.

This genus occurs only on the rose family. Dietel (Hedwigia 44:344. 1905) records 46 species, of these 17 are found in North America and four are here reported from Nova Scotia. Arthur has added a new species from the western United States. (Torreya 9:24. 1909).

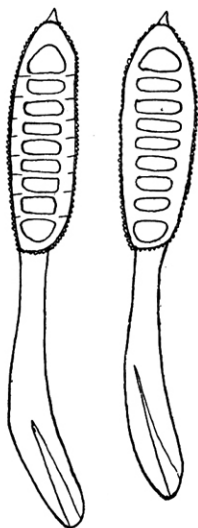
Phragmidium americanum Diet.

0, I & II. Pycnia, aecia and telia not collected. All are formed.

III. Telia hypophyllous, on reddish-brown, small, irregular spots, mostly scattered, small, black, readily detachable. Teliospores oblong, 46-86 by 24-26 μ , obtuse at the apex with colourless apiculus, mostly 7-10 celled; wall dark brown or almost black, verrucose; pedicel longer than the spore, hyaline, swelling in water at base.

On *Rosa* species, Pictou, New Glasgow.

This species was for some time confused with *Phr. subcorticium* (Schrnk) Wint. (*Phr. mucronatum* Lk.). Peck first called attention to a variation in the number of cells. He states that "American specimens generally have the spores more opaque and with two or more septa than the typical form. This variant form might be called Var. *americanum*." (N. Y. State Mus. Rep. 28: 86). Dietel raised the variety to specific rank under the name of *Phr. americanum*.



Teliospores of *Phragmidium americanum*.
9:27. 1909).

According to Arthur *Phr. americanum* inhabits the north-eastern region of North America along the Atlantic coast from Maryland northward and north of the great lakes, chiefly on *Rosa blanda*, *R. lucida*, *R. Sayi* and certain cultivated varieties derived from these (Torreya

It seems to be common on the roses in this vicinity. Collections of another stage of the rust were made but they were lost in drying. The collection reported in Dr. MacKay's Fungi of N. S. (Trans. N. S. Inst. of Science 12: 124) as *Phr. subcorticium* belongs here.

Phragmidium imitans Arth.

Phragmidium gracile Arth.

0. Pycnia not observed.

I. Aecia rounded, small, scattered, epiphyllous, soon naked, yellowish. Aeciospores rounded, oblong, elliptical or oval, 16-24 by 12-29 μ ; wall unequally thickened, echinulate; paraphyses slender, long, clavate, hyaline, incurved.

II. Uredinia hypophyllous, scattered, small, rounded. Urediniospores elliptical or obovate, 12-16 by 20-24 μ ; wall rather thick, colourless, echinulate; paraphyses slender, clavate, thin-walled, hyaline, about 13-22 by 55-80 μ , incurved.

III. Telia hypophyllous, scattered, or somewhat grouped, small. Teliospores cylindrical, dark brown, 5-10 celled, rounded above with a hyaline apiculus 5-10 μ , 26-31 by 75-127 μ , verrucose; pedicel hyaline, tinted above, equal to or longer than the spore.

On *Rubus idaeus* Var. *aculaetissimus* (C. A. Mey) Regel & Tiling, Oakfield, August 13, 1910.

The description of the aecia is based on that given by Saccardo.

Phragmidium imitans is a common species throughout northern North America. However, it does not seem to be common in Nova Scotia as only one collection was made.

Phragmidium Potentillae-canadensis Diet.

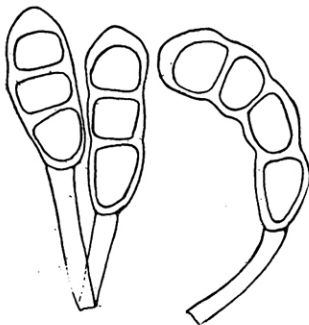
Kuehneola obtusa (Strauss) Arth.

0. Pycnia epiphyllous in small crowded groups.

II. Uredinia hypophyllous, on reddish spots, orange-red, roundish, scattered or gregarious, pulverulent, surrounded by clavate paraphyses. Urediniospores globose, elliptical or ovate, 13-18 by 16-22 μ , echinulate.

III. Telia hypophyllous, small, orbicular, scattered, brown, pulverulent, soon naked. Teliospores oblong, 21-24 by

46-85 μ , sometimes curved, mostly 3-4 septate, somewhat constricted at the septum, usually obtuse at the apex, (wall of lower cell often hyaline), smooth; pedicel even, colourless, usually about the length of the spore.



Teliospores of *Phragmidium Potentillae-canadensis*.

On *Potentilla canadensis* L., Pictou, New Glasgow.

A very common rust. The uredinia and telia are usually parasitized by *Darlucula filum*.

Arthur in the "North American Flora" places this species in the genus *Kuehneola* on account of the absence of the aecia.

Phragmidium speciosum Fr.

Earlia speciosa (Fr.) Arth.

0. Pycnia mostly hypophyllous, in groups opposite aecia.

I. Aecia hypophyllous, petiolicolous or caulicolous, sometimes epiphyllous, often developing on the fruit, solitary or in irregular groups, small or occupying considerable areas, up to 1 cm. long on the stem, orange; paraphyses mostly oblong or clavate, usually 8-15 by 40-50 μ . Aeciospores globose, subglobose or ellipsoid, 20-25 by 22-35 μ ; wall pale yellowish, verrucose, contents orange.

II. Uredinia wanting.

III. Telia caulicolous or especially fruiticolous, producing swellings on stem and pedicels, large, sometimes 2 x 1 cm. compact, black. Teliospores cylindrical, sometimes somewhat ellipsoid, 29-33 by 60-115 μ , usually rounded below, slightly narrowed above, cells 3-9, apex with sub-hyaline papilla; wall brown to black, about 4 μ thick; pedicel hyaline or tinted above, very long, 8-10 times the length of the spore or longer, not swelling in water.

On *Rosa* (species not determined), Pictou.

This rust is very common on the wild roses about Pictou. It attacks especially the pedicels and the fruit, the affected fruit remaining green and not changing to the normal red colour.

It occurs upon any and all species of roses and is widely distributed in the United States and Canada. Arthur places this species in the genus *Earlia*, as it differs from the true members of the genus *Phragmidium* in the gelatinous pedicels of the teliospores, the large compact telia on the stems and the absence of uredinia.

KUEHNEOLA Magnus.

Like *Phragmidium* but teleutospores colourless, germ-pore under cross wall, and spores germinating when mature.

Kuehneola albida Magn.

Kuehneola Uredinis (Link) Arthur.

0. Pyenia epiphyllous, in small crowded groups on reddened spots.

I. Aecia wanting.

II. Uredinia mostly hypophyllous, pulverulent, orange-yellow; paraphyses wanting. Urediniospores usually ellipsoid, about 15-20 by 20-27 μ ; wall colourless, moderately thin, closely verrucose-echinulate.

III. Telia hypophyllous, scattered, irregularly roundish, early naked, pulvinate, velvety, yellowish or pure white, ruptured epidermis inconspicuous. Teliospores cylindrical or cylindrical clavate, 18-24 by 85-110 μ , irregularly flattened or coronate above, narrowed below, 5-13 celled, usually 5-6 celled, each cell about 20 by 25 μ , trapezodial and articulated to the cell above by a projection containing the pore; wall colourless, thin, the apical thicker above, the other cells thickened above uniformly or only at the lateral projections, smooth or slightly roughened at apex; pedicel colourless, terete, very short, often seemingly wanting.

On *Rubus hispidus* L., Pictou.

The description is based on that of Arthur in the "North American Flora." The rust does not seem to be common as it was collected only in one place but occurred there quite abundantly on its host.

TRIPHAGMIUM Link.

Teliospores of three cells united in the form of a triangle, a basal cell supporting two others alongside of each other.

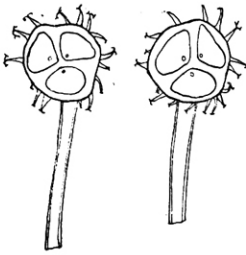
Triphragmium clavellosum Berk.

Nyssopsora clavellosa (Berk) Arthur.

0. Pycnia unknown, possibly not formed.

I & II. Aecia and telia wanting.

III. Telia epiphyllous, rarely on stems, on circular yellowish spots about 4 mm. in diameter which may become purplish, crowded, often circinate, sometimes confluent, small, mostly circular, about .3-.4 mm. in diameter, sometimes elongate, surrounded by the ruptured epidermis, pulverulent, black. Teliospores



Teliospores of *Triphragmium clavellosum*.

three-celled, somewhat triangular or truncate-obovate, about 27-33 μ ; wall dark brown, with bent spines up to 11 μ , tips forking and recurved; pedicel hyaline, exceeding the spore.

On *Aralia nudicaulis* L., Pictou,

New Glasgow.

The large black groups of telia, which are sometimes very abundant on the upper surface of the leaves make this a very conspicuous rust.

GYMNOSPORANGIUM Hedw. F.

Aecia with well developed peridium dehiscing by longitudinal slits. Teliospores two-celled (rarely 3-5-celled), embedded in a gelatinous matrix, germ-pores usually more than one in a cell and lateral. Uredinia unknown.

The telial stage of the species of this genus as far as is known infest the *Cupresseae*, the majority of the species occurring on *Juniperus*. The aecial stage occurs on the tribe *Pomeae* of the family *Rosaceae*. The only exception to this is *Gymnosporangium externum* Arth. & Kern, in which the aecial stage is found on *Gillenia stipulaceae* (*Mycologia* 1:253. 1909).

The name *Roestelia* has been applied to the aecial stage of the *Gymnosporangium* rusts. Usually the peridium dehisces by longitudinal slits, and thus soon becomes fimbriate and revolute. Some species have their aecial stage on the apple and often cause serious damage. No uredinial stage is known. This is remarkable as all other heteroecious rusts possess all the spore forms.

The genus is characterized by the teliospores having long hyaline pedicels which swell in moisture and form a jelly-like matrix in which the spores are embedded. This yellowish, jelly-like material is often very conspicuous during wet weather in spring and early summer. The telial mycelium is perennial, the teliospores being produced in spring and germinating immediately. The aecial stage develops slowly but dies during the summer. In many species the perennial mycelium produces distortions on the branches which are sometimes globular in shape. This has given the fungus the name of the "Cedar Apple Fungus."

GYMNOSPORANGIUM Sp.

A roestelia on the fruit of *Amelanchier* was collected at Walton, Lunenburg Co., by Miss Clara A. Corkum. (I am indebted to Prof. H. W. Smith of Truro for the specimens). It is doubtless the aecial stage of one of the species of *Gymnosporangium*, probably either *G. clavariaeforme* (Jacq.) D. C. or *G. germinale* (Schw.) Kern (*G. clavipes* C. & P.). Both of these species may have their aecial stage on the fruit of *Amelanchier* and the telial stage on *Juniperus nana* Willd.

MacKay (Trans. N. S. Inst. Science 11:141, 1904) records *Roestelia lacerata* on the authority of Dr. John Somers and Prof. G. Lawson. This is the aecial stage of *G. clavariaeforme*. It is widely distributed in North America.

MacKay also records on the authority of Prof. G. Lawson *G. juniperi* Link. from Halifax Co., but gives no host. It may be, as the *Roestelia* and *Gymnosporangium* were collected at

the same place, that they were forms of the same species. The connection of the different forms was not well known, nor the nomenclature settled at the time of Prof. Lawson's collection. It may be that both collections belong to *G. clavariaeforme*.

GYMNOCONIA Lagerh.

Aecidia without peridium or enveloping paraphyses, dehiscing irregularly. Teliospores two-celled.

Only one species is known. It is found in North America and Europe.

***Gymnoconia interstitialis* (Schlect.) Lagerh.**

0. *Pyenia* epiphyllous.

I. *Aecia* hypophyllous, occupying the whole surface of the leaf, large, irregular; peridium absent, epidermis rupturing irregularly, bright orange at first, appearing waxy. Aeciospores subglobose, elliptical or oblong, 15-27 by 25-40 μ ; wall thin, finely verrucose; contents orange, fading to colourless.

II. *Uredinia* wanting.

III. *Telia* hypophyllous, scattered, on irregular or brownish areas, very small, pulverulent, blackish-brown. Teliospores variable, often irregular, upper cell usually triangular, lower quadrangular or irregular; wall rather thin, uniform with papillae at germ-pores, smooth, chestnut-brown; pedicel hyaline, very slender, short, deciduous.

On *Rubus glandicaulis* Blanchard, Pictou, Truro.

This fungus is common on the species of blackberry named above. It was not collected on the more common large blackberry which has passed under the name of *Rubus villosus*. One collection of the aecial stage was parasitized by a species of *Tuberculina*.



Teliospores of *Gymnoconia interstitialis*.

In the United States this rust attacks the cultivated raspberries and blackberries and is known as the "orange rust." It does not seem to be troublesome in Nova Scotia.

The mycelium is perennial and thus the fungus can be successfully combatted only by destroying the infected plants.

PUCCINIA Pers.

Pyenia mostly subepidermal, sub-globose or flask-shaped, honey-coloured. Pycniospores very minute, globose or ellipsoid, hyaline.

Aecia mostly with well developed peridium, at first globose and closed, at length open, usually cup-shaped or cylindrical. Aeciospores arising in serial order, soon free, globose, sub-globose or angular, hyaline, yellow or orange.

Uredina generally small, sometimes paraphysate. Uredinospores formed singly, usually with two or more germ pores, rarely one.

Telia variable in size, flattened or pulvinate, sometimes paraphysate. Teliospores free, on pedicels, two-celled (sometimes with one-celled spores mixed, rarely three-celled), one germ-pore in each cell. Basidiospores ovoid or reniform, mostly hyaline.

The genus *Puccinia* is a very large one. Species belonging to this genus can usually be recognized by the two-celled teliospores. All the rusts that have been reported from Nova Scotia with two-celled teliospores belong to this genus except *Gymnoconia interstitialis*, the orange rust of the blackberry and raspberry.

Sydow in his monograph describes 1231 species. He includes the genera *Uropyxis* and *Diorchidium* as subgenera.

Arthur breaks up the genus into several genera, largely on the basis of the number of spore-forms present. *Tranzschelia* and *Polythelis* are separated because the teliospores are borne at the apex of a common stalk, and on other grounds. The majority of the species now included under *Puccinia* he places in the following four genera, which are separated by the spore-forms present as follows:

- Life cycle with all the spore-forms.....Dicaeoma.
 Life cycle with pycnia, aecia and telia.....Allodus.
 Life cycle with pycnia, uredinia and telia.....Bullaria.
 Life cycle with pycnia and telia.....Dasyspora.

Puccinia Hieracii (Schum.) Mart.

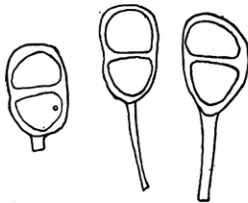
0. Pycnia not observed.
 I. Aecia probably not formed.

II. Uredinia amphigenous, mostly epiphyllous, scattered, punctiform, soon naked, pulverulent. Urediniospores globose, subglobose or ellipsoid, 16-24 by 22-27 μ ; wall yellowish-brown, echinulate, pores 2.

III. Telia similar to the uredinia but elliptical to oblong on the stem and darker brown in colour. Teliospores ellipsoid or ovate-ellipsoid, 18-22 by 22-35 μ , rounded at both ends, not or slightly constricted at the septum; wall brown, equally thickened, finely verrucose; pedicel delicate, hyaline, deciduous, mostly short but sometimes exceeding the spore.

On *Hieracium scabrum* Michx., Pictou; *H. canadense* Michx., Macdonald's Barren, C. B. (Collected by C. B. Robinson).

Formerly a number of species on *Compositae* which show little morphological differences were included under *P.*



Teliospores of *Puccinia Hieracii*.

Hieracii. Jacky by cultures showed that infection from teliospores on *Hieracium* was confined to plants of this genus. This was also shown to hold for some other genera of the *Compositae*, that is teliospores from one genus of host plants could not infect a different genus. As a result

of Jacky's work the rusts on the different genera of the *Compositae* are regarded as distinct.

The rust is not conspicuous but will doubtless be found to be common and generally distributed.

***Puccinia Cichorii* (DC.) Bell.**

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous and caulicolous, scattered, minute, chiefly round, pulverulent, cinnamon. Urediniospores globose or subglobose, 22-27 μ in diameter; wall light brown, echinulate.

III. Telia mostly caulicolous, oval, blackish-brown. Teliospores ellipsoid or ovate-ellipsoid, slightly or not constricted at the septum, 21-28 by 30-46 μ , rounded at the apex and base; wall uniform, smooth, brown; pedicel hyaline, delicate, deciduous.

On *Cichorium Intybus* L., Durham, August 16, 1910.

This species does not seem to be common, as only one collection was made.

***Puccinia obtogens* (L.) Tul.**

Puccinia suaveolens Lk.

0. Pycnia hycophyllous, at length covering the whole surface of the leaf

I. Aecia not formed.

II. Uredinia hypophyllous, at length amphigenous, scattered on upper, crowded on lower surface of leaf, pulverulent, dark brown. Urediniospores globose or subglobose, 25-30 μ ; wall light brown, echinulate, pores three.

III. Telia similar to the uredinia. Teliospores ellipsoid or ovate-ellipsoid, 18-22 by 32-35 μ , rounded at both ends or base, slightly narrowed, not or slightly constricted at the septum; wall uniform, brown, slightly verrucose; pedicel slender, hyaline, deciduous, short.

On *Cirsium arvense* (L.) Scop., Pictou, Truro.

The rust on the Canada thistle is common and widely distributed. The life history of the fungus has been worked out by Rostrup. The mycelium hibernates in the upper part of the rootstock and thus the spring shoots are infected, the mycelium invading the plant. The first generation consists mostly of pycnia and uredinia, the second comes from urediniospore infection and the mycelium is localized. Urediniospores are freely produced but no pycnia.

The germ pore of the upper cell is placed at the apex; that of the lower cell is often some distance below the septum.

***Puccinia variabilis* Grev.**

0. Pycnia not observed.

I. Aecia amphigenous, mostly hypophyllous, usually on small yellow or purple spots, solitary or in scattered small groups; peridium low, margin lacerate. Aeciospores subglobose or ovate, 18-22 by 22-27 μ ; contents orange, fading to colourless, verrucose.

II. Uredinia amphigenous, on small yellow or purple spots, scattered, small, soon naked, brown. Urediniospores globose, subglobose or ovoid, 18-20 by 20-27 μ ; wall brown, echinulate, pores 2.

III. Telia similar to the uredinia but dark brown. Teliospores ellipsoid or oblong-ellipsoid, 19-22 by 30-38 μ , rounded at both ends, slightly or not constricted at the septum; wall thin, uniform, finely verrucose, dark brown; pedicel hyaline, slender, deciduous.

On *Taraxacum officinale* Weber, Pictou, French River.

According to Plowright two rusts are found on *Taraxacum* in Europe, *P. Taraxaci* with only the uredinial and telial stages and *P. variabilis* possessing an aecial stage as well. I have found the present species so closely associated with aecia

that there seems to be little doubt but that they are connected. Other collections on *Taraxacum* show no aecia. I have placed there under *P. Taraxaci* and the former are assigned here to *P. variabilis*, yet it seems probable that they belong to the same species. The aecia may only be produced under favourable conditions.

The germ-pore of the basal cell of the teliospore is usually placed low, not far from the pedicel; that of the upper cell is in the usual position near the apex.

The aecial stage of a sedge rust also occurs on *Taraxacum*, but has the aecia collected in large clusters, not scattered as in *P. variabilis*.

Puccinia Taraxaci (Rabent.) Plowr.

0. Pycnia not observed.

I. Aecia regarded as not formed.

II. Uredinia amphigenous, scattered, small, rounded, or oblong, pulverulent, brown. Urediniospores globose, subglobose or ovoid, 20-22 by 23-30 μ , brown, echinulate.

III. Telia similar to the uredinia but blackish brown. Teliospores ellipsoid or ovate-ellipsoid, 19-22 by 25-35 μ , rounded at both ends, little or not constricted at the septum; wall uniform, thin, finely verrucose, brown; pedicel hyaline, short.

On *Taraxacum officinale* Weber, Pictou.

This species differs from *P. variabilis* in the absence of the aecial stage. The germ pores of the urediniospores are two in number and are placed toward the apex.

Puccinia orbiculata Peck.

0. Pycnia amphigenous, few, in small groups on spots with the aecia.

I. *Aecia* hypophyllous and petiolicolous in groups on pale yellowish spots 1-3 mm. in diameter, hemispherical; peridium poorly developed. Aeciospores globose or ellipsoid, 17-20 by 20-30 μ ; wall pale yellowish, medium thick, densely and finely verrucose.

II. *Uredinia* amphigenous, on yellow or purple spots, seat erod, small punctiform, pulverulent, cinnamon. Urediniospores globose or subglobose, 22-27 μ ; wall yellow, finely echinulate.

III. *Telia* similar to the *uredinia* but dark brown. Teliospores ellipsoid, rounded at the base and apex, slightly constricted at the septum, 24-30 by 33-54 μ ; wall uniformly thin, finely but distinctly verrucose; pedicel hyaline, short, deciduous.

On *Prenanthes altissima* L., New Glasgow, Folleigh Lake.

This species occurs rather sparingly on its host, but is probably generally distributed.

***Puccinia Onopordi* Syd.**

0. *Pycnia* not observed.

I. *Aecia* unknown, probably not formed.

II. *Uredinia* amphigenous, mostly epiphyllous, usually on pale yellowish spots, small, scattered, pulverulent, soon naked, surrounded by the ruptured epidermis, light brown. Urediniospores globose or subglobose or ellipsoid, about 27-39 μ in diameter, or 24-30 by 27-35 μ ; wall brown, distinctly but sparsely echinulate with fine points.

III. *Telia* amphigenous, scattered on leaves, crowded and abundant on the stem, small and rounded on leaves, soon naked, mostly oblong on the stem and covered for some time by the epidermis, at length naked, pulverulent, dark brown. Teliospores variable in shape, often ellipsoid or oblong, 22-27 by 38-54 μ ; mostly rounded above, often narrowed toward the base, not or slightly constricted at the septum; wall uniform

except a low papilla where the germ pore emerges, finely punctate; pedicel hyaline, deciduous, shorter than spore.

On *Onopordon Acanthium* L., Pictou, New Glasgow, French River.

Sydow in his Monograph describes two new species of rusts on *Onopordon*, *Puccinia Onopordi* from Syria and *Puccinia Acanthi* from Germany, the latter differing from the former in having smaller teliospores. My collections have even larger teliospores than *P. Onopordi* and are therefore placed under that species.

***Puccinia Bardanae* Cda.**

0 & I. Pycnia and aecia unknown, possibly wanting.

II. Uredinia amphigenous, scattered, rounded, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, echinulate, light brown, 26-30 by 22-27 μ .

III. Telia amphigenous mostly hypophyllous, scattered, small, rounded pulverulent, blackish. Teliospores ellipsoid, apex not thickened, slightly constricted at the septum; wall dark brown, finely verrucose, 22-27 by 30-42 μ ; pedicel hyaline, short.

On leaves of *Arctium Lappa* L., Pictou.

This species does not seem to have been previously reported from North America. It was collected in only one place in the town of Pictou.

***Puccinia Leontodontis* Jacky.**

0. Pycnia not observed.

I. Aecia probably not formed.

II. Uredinia amphigenous, scattered, not confluent, small, punctiform, light brown. Urediniospores globose, subglobose or ellipsoid, 22-27 by 27-33 μ , light brown, echinulate, germ-pores 2, in upper part of cell.

III. Telia similar to the uredinia but dark brown, variable, slightly ellipsoid, 20-30 by 27-41 μ , rounded at both ends, slightly or not constricted at the septum; wall uniform, finely verrucose, chestnut-brown; pedicel, hyaline, short, deciduous.



Teliospores of *Puccinia Leontodontis*.

On *Leontodon autumnalis* L., Pictou.

This species is found in Europe, but it does not seem to have been previously reported in North America. It is common in the vicinity of Pictou.

***Puccinia Solidaginis* Peck.**

0. Pycnia not observed.

I & II. Aecia and uredinia probably not formed.

III. Telia amphigenous, mostly hypophyllous on yellowish or purple spots, very small, mostly in groups, compact, brownish-black. Teliospores oblong or sub-clavate, 15-22 by 33-65 μ , rounded above or acute, narrowed at the base, constricted at the septum; wall light brown, much thickened at the apex, up to 8 μ , smooth; pedicel hyaline, persistent, about equalling the spore.

On *Solidago nemoralis* Ait. (?), Westwille, Sylvester; *Solidago puberula* Nutt., Pictou, August 24, 1910.

***Puccinia bicolor* E. & E.**

0. Pycnia not observed.

I. Aecia probably not formed.

II. Uredinia not observed. Urediniospores mixed with the teliospores, mostly ovate, 16-18 by 27-35 μ , pale yellowish, sparingly echinulate with rather large points.

III. Telia amphigenous, but mostly hypophyllous, small, thickly scattered over the under surface of the leaves, occupying all or part of a leaf, orbicular, rather compact, straw-yellow, becoming ochraceous. Teliospores oblong ellipsoid or clavate, rounded above or somewhat acute, usually narrowed toward the base, distinctly constricted at the septum, 13-20 by 28-45 μ ; wall hyaline or pale yellowish, smooth, thickened at the apex, 8 μ or less; pedicel hyaline, firm, usually equally the spore or longer.

On *Hieracium scabrum* Michx., Pictou.

This species is probably distinct from *Puccinia bicolor*, but it is placed here for the present.

The telia develop early. They are evident by May 1 as small yellowish dots, and by the last week of May the teliospores are germinating, and continue developing till the last of June. Uredinia were present on some of the infected plants, but they seem to belong to *Puccinia Hieracii*. The infected leaves become elongated and yellowish in color, so that the rust is quite conspicuous.

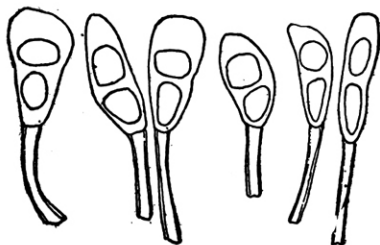
***Puccinia Asteris* Duby.**

0. Pycnia not observed.

I & II. Aecia and uredinia not formed.

III. Telia mostly hypophyllous, on orbicular or irregular spots coloured yellow, brown or purple, mostly crowded, compact, brownish-black, surrounded by the ruptured epidermis. Teliospores clavate, 16-22 by 30-60 μ , rounded or pointed above, narrowed toward the base, upper cell broadened, slightly constricted at the septum, wall dark brown, much thickened at apex, up to 12 μ , smooth; pedicel nearly hyaline, rather broad, usually shorter than spore, sometimes longer.

On *Aster macrophyllus* L., Westville, Truro; *A. acuminatus* Michx., Folleigh Lake; *A. lateriflorus* (L.) Britton, Pictou.



Teliospores of *Puccinia Asteris*.

The teliospores on *Aster acuminatus* are slenderer than on *Aster macrophyllus*. The groups of telia are not so crowded nor so abundant on the former.

P. Asteris occurs on a number of asters. Morphological differences exist but they are not constant, so separation cannot be made on these grounds. Cultures alone can show whether more than one species are included.

***Puccinia Cicutae* Lasch.**

0. Pycnia not observed.

I. Aecia on the nerves of the leaves more frequently on the petioles and stems, causing deformation, peridium poorly developed, not cup-shaped, breaking through the epidermis and rupturing irregularly. Aeciospores globose, sub-globose or ellipsoid, 15-22 by 20-27 μ , subhyaline, finely punctate.

II. Uredinia amphigenous, mostly hypophyllous, small, scattered, circular, pulverulent, light brown. Urediniospores ovoid or ellipsoid, 20-24 by 20-30 μ ; wall pale brown, echinulate, pores 3.

III. Telia similar to the uredinia but larger and darker. Teliospores ellipsoid or oblong, 20-30 by 30-41 μ , rounded at both ends, slightly constricted at the septum; wall much roughened, sometimes almost smooth, not thickened at the apex, brown; pedicel hyaline, slender, deciduous, up to 30 μ , sometimes placed laterally on basal cell.

On *Cicuta maculata* L., Pictou, Piedmont.

This species is very common on its host in the districts near Pictou.

Sydow states that the aecial stage is rarely collected, the only collections being in Finland, Siberia and once in Germany. As this stage is conspicuous and not likely to be overlooked, he regards the aecia as not necessary for the fungus and only developed under favourable conditions.

A collection of the aecia was made near Pictou on July 3, 1909, in a shaded position. There was such a rich development that in some cases the host plants were killed.

***Puccinia Thalictri* Chev.**

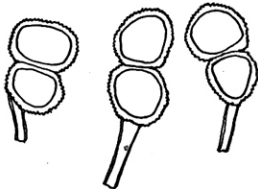
Polythelis Thalictri (Chev.) Arthur.

0. Pycnia hypophyllous, few, scattered among the telia.
I & II. Aecia and uredinia not formed.

III. Telia hypophyllous, scattered, never confluent, circular, 2-5 mm. across, soon naked, pulverulent, dark chestnut-brown, surrounded by the ruptured epidermis. Teliospores ellipsoid or oblong ovate, sometimes very irregular, much constricted at the septum, the cells separating easily, 15-30 by 22-52 μ ; walls dark brown, uniformly thickened, very coarsely and evenly verrucose; pedicel delicate, hyaline, about the length of the spore, deciduous.

On *Thalictrum polygonum* Var. *hebecarpum* Fernald, Truro, September 3, 1908; September 1, 1909; August 9, 1910.

Arthur places this species in the genus *Polythelis* on the basis of the teliospores forming heads by being attached by short pedicels to a common stalk, which is short and inconspicuous.



Teliospores of *Puccinia Thalictri*.

It seems to be rare, as it was found on only a few plants on the banks of the Salmon River near Truro, although search was made for it in other places. The fungus appears on the same plants each year and is for that reason regarded as perennial.

Puccinia Circaeae Pers.

0. Pycnia not observed.

I & II. Aecia and uredinia not formed.

III. Telia hypophyllous, on definite yellowish-brown or purple spots, about 2-3 mm. in diameter, small and crowded, pulvinate, at first yellowish, at length dark brown. Teliospores fusiform or oblong, 10-14 by 25-40 μ , usually conical above and narrowed toward the base, slightly constricted at the septum; wall yellowish or light brown, much thickened at the apex, up to 8 μ , smooth; pedicel hyaline, usually longer than the spore.

On leaves of *Circaea alpina* L., *C. lutetiana* L., Pictou.

Owing to the yellow or purple spots on the leaves, this rust is conspicuous. It is common in the districts about Pictou.

The telia formed late in the season differ from the earlier in being large and more elongated. The teliospores are similar in form, but the earlier are lighter in colour and germinate at once. The later are darker and germinate after wintering. Telia are formed also on the stem but my collections do not show this.

Puccinia Iridis (DC.) Wallr.

Uromyces Iridis DC.

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous, scattered, rounded or linear, long covered by the epidermis, at length naked, pulverulent, rusty-brown. Urediniospores globose, sub-globose, ellipsoid or ovate, 20-27 by 24-35 μ ; wall thick, yellowish-brown, echinulate.

III. Telia hypophyllous, scattered, linear, sometimes confluent, soon naked, black. Teliospores clavate or oblong, 14-22 by 30-52 μ , rounded acuminate or truncate above, usually narrowed below, slightly constricted at the septum; wall light fuscous, darker and much thickened at the apex, up to 14 μ , smooth; pedicel brownish, persistent, shorter than the spore.

On *Iris versicolor* L., Pictou.

The telial stage was not found although careful search was made for it in late autumn and early winter.

Sydow states that in some places only the urediniospores have been found, in other places teliospores and urediniospores may occur together, while in other places the teliospores are found only very late in the season.

***Puccinia mesomegala* B. & C.**

0. Pycnia not observed.

I & II. Pycnia and aecia probably not formed.

III. Telia amphigenous, arranged in rows on pallid, circular or oval spots, about 5-8 mm. in diameter, spots sometimes coalescing, distinct, oval or circular, 150-320 by 150-450 μ ; ruptured epidermis conspicuous, ferruginous, pulverulent. Teliospores oval or oblong, rounded or pointed above, rounded or narrowed at the base, not or little constricted at the septum, 13-24 by 27-41 μ ; wall uniformly thin, light brown, sometimes with a small hyaline papilla at the apex and the side of the lower cell at the opening of the germ pore; pedicel hyaline, delicate, deciduous, equalling or shorter than the spore.

On *Clintonia borealis* (Ait.) Raf., Pictou, June 15, 1910.

Puccinia mesomegala was collected only in one place near Pictou. It is probably not common, as it is rather conspicuous.

***Puccinia acuminata* Peck.**

Puccinia porphyrogenita Curt.

0. Pycnia not observed.

I & II. Aecia and uredinia probably not formed.

III. Telia hypophyllous, on brown or purplish often depressed spots, scattered, 1-3 mm. in diameter, surrounded by the ruptured epidermis, compact, black. Teliospores clavate.

oblong-clavate or oblong, 16-22 by 45-60 μ , constricted at the septum, apex rounded or acuminate; wall dark brown, much thickened at the apex, 18 μ or less, smooth; pedicel tinted, persistent, shorter than or equalling the spore.

On *Cornus canadensis* L., Pictou and Truro, (Prof. C. L. Moore.

***Puccinia Acetosae* (Schum.) Koern.**

Puccinia Rumicis Lasch.

0. Pycnia not observed.

I. Aecia not known, probably not formed.

II. Uredinia amphigenous, mostly hypophyllous, scattered, small, rounded, pulverulent ferruginous. Urediniospores globose, ellipsoid or pyriform, 20-24 by 22-28 μ , somewhat spiny, brownish.

III. Telia similar to the uredinia but oblong on the stem and dark brown. Teliospores ovoid, ellipsoid, oblong or sub-clavate, 19-26 by 30-46 μ , rounded at both ends or slightly narrowed below, somewhat constricted at the septum; wall uniform, finely verrucose, chestnut-brown; pedicel hyaline slender, deciduous, up to 35 μ long.

On *Rumex Acetosella* L., Pictou.

This rust was collected in one place near Pictou and this collection showed only a scanty development of urediniospores. Though search was made during the summer it was not found elsewhere. The rust is not conspicuous and may have been overlooked.

***Puccinia Menthae* Pers.**

0. Pycnia in small groups, honey-coloured, conspicuous.

1. Aecia hypophyllous, on yellowish spots, sometimes purple, circinate. Aeciospores sub-globose or polygonal 16-25 μ , verrucose, pale yellow.

II. *Uredinia* hypophyllous, small, on pale spots, roundish, surrounded by the ruptured epidermis, pulverulent, cinnamon-brown. Urediniospores sub-globose, ellipsoid or obovate, 18-22 by 22-27 μ ; wall thin or thick, echinulate, pores 2 or 3, equatorial.

III. *Telia* hypophyllous or caulicolous, scattered or aggregated, sometimes confluent, linear or oblong on the stem, rounded on the leaves, pulverulent, blackish-brown. Teliospores ellipsoid or sub-globose, 22-27 by 27-35 μ , rounded at both ends, a small hyaline papilla at apex, little or not constricted at the septum; wall chestnut-brown, smooth; pedicel slender, hyaline, usually much longer than the spore.

On *Mentha arvensis* Var. *canadensis* (L.) Briquet, Pictou, Piedmont.

Burril separated the American rust on the mints as Var. *americana* on the grounds that the teliospores are more strongly verrucose and more globose in shape. The collections from this vicinity agree more nearly with the European form, the teliospores being smooth.

The aecia are much less common than the other forms. A collection from Loch Broom, near Pictou, showed an abundant development of this stage, but the peridium had not opened when the collection was made. The infected plants grew in a shaded position.

The species is worldwide in its distribution, occurring on a large number of mints. It may be that several species are included in this one.

***Puccinia Glaucis* Arthur.**

0. *Pycnia* not seen, probably obsolete.

III. *Telia* amphigenous, solitary or sometimes confluent in groups, 1.5-2 mm. across, roundish, 0.5-1 mm. in diameter, soon naked, pulvinate, compact, dark brown, becoming grey by germination of the spores, ruptured epidermis inconspicuous.

Teliospores lanceolate-oblong, 13-16 by 43-50 μ , obtuse at both ends, slightly constricted at the septum; wall smooth, golden brown, rather thin, 1-1.5 μ , obtusely thickened at the apex, 6-9 μ ; pedicel light yellow, slender, one-half to once length of spore.

On *Glaux maritima* L., Halifax.

I have not seen this species. The description is from the original one in the Bulletin of the Torrey Botanical Club, vol. 37, page 571, 1910.

***Puccinia claytoniata* (Schw.) Syd.**

Puccinia Maria-Wilsoni Clinton.

0. Pycnia scattered among the aecia, orange.

I. Aecia hypophyllous, often petiolicolous or caulicolous, rarely epiphyllous, regularly scattered, often in crowded groups, occupying the whole surface of the leaf, low, rather wide, orange, margin subrevolute, laciniate. Aeciospores angular, sub-globose, 15-18 μ , finely verrucose, orange.

II. Uredinia not observed.

III. Telia hypophyllous, often petiolicolous or caulicolous, rarely epiphyllous, irregularly scattered, small, rounded, surrounded by the ruptured epidermis, pulverulent, rufous brown. Teliospores irregular, usually ellipsoid or ellipsoid-oblong, rounded at both ends, 18-27 by 30-52 μ ; wall brown with a small lighter papilla at the apex, verrucose, not or little constricted at the septum.

On *Claytonia*, Three Brooks, Scotch Hill.

Specimens of *Claytonia* collected by Miss Isabella McCabe at Three Brooks showed a rich development of the aecial stage, especially on the stems and petioles, which were much deformed by the fungus.

Puccinia Violae (Schum.) DC.

0. Pycnia mostly epiphyllous, honey-yellow.

I. Aecia amphigenous, often deforming the petioles and leaves, in irregular clusters, low, margin recurved, lacerate. Aeciospores mostly sub-globose, 16-21 by 21-26 μ , mostly 20-21 μ in diameter, orange-yellow, fading to colourless, finely verrucose.

II. Uredinia hypophyllous or petiolicolous, scattered, small, rounded or elongate on the petiole, soon naked, pulverulent, cinnamon-brown. Urediniospores globose, sub-globose or ellipsoid, 18-22 by 20-28 μ , dark brown, echinulate.

III. Telia hypophyllous or petiolicolous, often on yellowish spots, aggregated or scattered, small, rounded elongate on the petiole, pulverulent, dark brown or black. Teliospores ellipsoid or oblong-ellipsoid, 20-27 by 30-38 μ , rounded at both ends, base sometimes narrowed, slightly or not constricted at the septum; wall chestnut-brown, somewhat thickened at the apex with a lighter papilla, usually smooth; pedicel deciduous.

On *Viola cucullata* Ait. and other *Viola* species, Pictou, French River.

The violet rust is very common in this vicinity.

Arthur and Holway (Minn. Bot. Studies 11, Part 5:631-641, 1901) in a paper on the violet rusts of North America state that this rust is common in its three forms, aecia, telia and uredinia, throughout North America on nearly all the indigenous species of the genus *Viola*.

Puccinia Polygoni-amphibii Pers.

Puccinia Amphibii Fuck.

P. Polygoni Alb. and Schw.

0 & I. On *Geranium maculatum* L.

II. Uredinia amphigenous, mostly hypophyllous, scattered or in circular groups, rounded, soon naked, pulverulent, yellow-

ish-brown. Urediniospores globose, ellipsoid or ovoid, 17-22 by 22-33 μ ; wall yellowish-brown, echinulate.

III. Telia hypophyllous, scattered or often arranged in circular groups, abundant, at length covering the under surface of the leaf, confluent, rounded on leaves, elongate on stem, remaining covered by the epidermis, blackish-brown. Teliospores clavate or oblong, 17-22 by 35-65 μ , rounded, truncate or pointed above, mostly narrowed toward the base, slightly constricted at the septum, sometimes no constriction; wall dark brown, thickened at apex, about 7 μ , smooth; pedicel hyaline or slightly coloured, usually shorter than the spore.

On *Polygonum amphibium* L., Pictou.

This rust was only found in one place at Cole's Pond near Pictou. It has a world wide distribution on *Polygonum* species. On some hosts the telia remain covered by the epidermis, in others they are soon naked.

Tranzschel was the first to show by cultures that the aecia on the wild geranium belonged to this rust. Arthur (Jour. Myc. 11:59. 1905) sowed the spores of *Aecidium sanguinolentum* Lindl. from *Geranium maculatum* on *Polygonum emersum* (Michx.) Britton and produced the uredinia and telia of this rust. In the following year he sowed the teliospores from *Polygonum emersum* on *Geranium maculatum* and the aecia developed.

I have not found the aecial stage, nor even the host plant, in this vicinity.

***Puccinia punctata* Link.**

Puccinia Galii Schw.

P. asperula Fuck.

0. Pycnia collected in small groups, honey-coloured.

I. *Aecia* hypophyllous, rarely caulicolous, on circular yellow spots, short cylindrical, margin recurved, whitish. Aeciospores globose or sub-globose, 17-22 μ , orange-yellow, smooth.

II. *Uredinia* amphigenous, small, rounded or irregularly scattered, chestnut-brown. Unrediniospores globose, sub-globose or ellipsoid, 19-24 by 19-30 μ ; wall light brown, strongly echinulate.

III. *Telia* amphigenous, rounded on leaves, oblong or linear on stem, blackish, compact. Teliospores oblong or clavate, sometimes ellipsoid, 18-24 by 27-57 μ , truncate or rounded above, sometimes conical, narrowed at base, slightly constricted at the septum; wall brown, much thickened at apex, smooth; pedicel coloured, persistent, thickened, usually shorter than the spore.

On *Galium asprellum* Michx., New Glasgow.

A collection on July 22 showed the aecia past their prime and uredinia beginning to appear; another on August 26 showed telia developed on the leaves and stem. This rust was only found in one place so that it does not appear to be common.

***Puccinia graminis* Pers.**

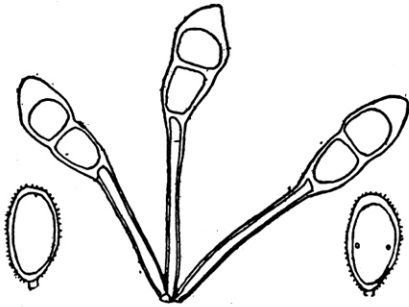
Puccinia poculiformis (Jacq.) Wettst.

0. Pycnia in small groups, honey-yellow.

I. *Aecia* hypophyllous, usually in small groups on discoloured spots, cylindrical, margin white, erect, more or less incised. Aeciospores angular-globose, orange-yellow, becoming pale yellow, 14-16 μ ; wall thin, smooth.

II. *Uredinia* amphigenous, often on culms and sheaths, scattered or grouped, oblong or linear, soon naked, pulverulent, ferruginous, surrounded by the ruptured epidermis. Urediniospores elliptic-oblong or obovate, 14-22 by 19-38 μ , brownish-yellow, becoming yellowish, echinulate, pores usually four, equatorial.

III. Telia amphigenous, mostly on culms, sheaths and inflorescence, oblong or linear, often confluent, black, soon naked, surrounded by the ruptured epidermis, pulvinate. Teliospores oblong-clavate, oblong-fusiform, narrowly obovate or sometimes ellipsoid, 16-22 by 22-68 μ ; apex rounded, obtuse or conical, base narrowed, sometimes rounded, usually somewhat constricted at the septum; wall chestnut-brown, apex darker, thickened 8-10 μ , smooth; pedicel coloured, firm, usually as long as the spore, sometimes short.



Teliospores of *Puccinia graminis*.

Aecia on *Berberis vulgaris* L. (cultivated), Truro.

Uredinia and telia on *Agropyron vulgare* L., *A. repens* Beauv., *Avena sativa* L., *Agrostis alba* L., Pictou, Truro; *Hordeum jubatum* L., Pictou; *Secale cereale*, Truro.

Puccinia graminis is found on a large number of grasses. By infection experiments Ericksson showed that it consists of a number of specialized forms, all having their aecia on the barberry, but nevertheless not capable of infecting one another. As a result of experiments so far conducted, the following forms have been indicated:

1. *Secalis*, on Rye (*Secale cereale*) and other hosts.
2. *Avenae*, on Oats (*Avena sativa*).
3. *Airae*, on *Airia*.
4. *Agrostidis*, on *Agrostis*.
5. *Poae*, on *Poa*.
6. *Tritici*, on Wheat (*Triticum vulgare*).

Arthur (Mycol. 2:227. 1910) states that, though in the uredinial stage this rust shows racial strains that inhibit the ready transfer from one species of host to another, yet in the aecial stage racial strains play no part, and the barberry acts as a bridging host between each and every other gramineous host.

***Puccinia phlei-pratensis* Erikss. and Henn.**

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, on the stem linear and breaking through the epidermis by a lateral fissure, on the leaves scattered, small and oblong, pulverulent, yellowish-brown. Urediniospores ellipsoid, oblong-ellipsoid or obovate, 16-21 by 24-32 μ ; wall dull yellow, echinulate.

III. Telia similar to the uredinia but blackish-brown, mostly on the stem. Teliospores mostly elongate, 16-20 by 35-48 μ , rounded or somewhat acute above, narrowed toward the base, slightly constricted at the septum; wall chestnut-brown, thickened at the apex, usually 5-8 μ , smooth; pedicel persistent, strongly tinted, thickened, usually longer than the spore.

On *Phleum pratense* L., Pictou.

In 1894 Ericksson and Henning separated the timothy rust as a distinct species, on the ground that it does not form its aecial stage on the barberry. Previously it was considered as identical with *Puccinia graminis*, from which it cannot be separated on morphological grounds. Kern (Torreya 9:3, 1909) points out that in Ericksson and Henning's original report, out of nine trials to infect the barberry with teliospores of the timothy rust one was successful and eight were failures. He thinks that more weight ought to be given to the one positive result than to all the failures, and concludes that the timothy rust may be considered a race or physiological species

of *Puccinia graminis*. Arthur (Mycologia 1:231. 1909) reports several unsuccessful trials to infect the barberry with this rust, nevertheless he expresses his agreement with Kern's conclusions.

This rust has only recently attracted attention in North America. It seems to be rapidly increasing. I have found it rather common on timothy growing by the roadsides and in shaded places in fields. Here both the uredinial and telial stages are developed, the latter appearing late in the fall. The uredinial stage was common on the after-grass in hay-fields about Pictou. It may yet do a considerable amount of injury to the hay crop, but probably will not be sufficiently developed before the hay is harvested to do serious damage.

***Puccinia Lolii* Neils.**

Puccinia coronifera Kleb.

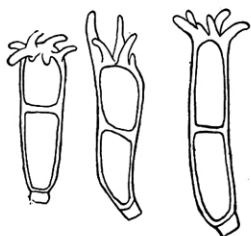
0 & I. Pycnia amphigenous, usually in small groups, sometimes abundant, on the spots bearing aecia, honey-coloured.

I. Aecia hypophyllous or peticolous, on yellowish or yellowish-purple spots, causing distortion of the petioles, cylindrical, rather low, margin whitish, lacerate, revolute. Aeciospores irregular, globose, about $19-25\mu$; wall colourless, finely verrucose; contents orange.

II. Uredinia amphigenous, oval or linear, pulverulent, orange. Urediniospores globose, sub-globose or ovate, $16-24$ by $20-30\mu$; wall orange, echinulate, pores 3 or 4, sometimes a few colourless, capitate paraphyses present.

III. Telia hypophyllous, oblong or linear, often confluent and crowded, long covered or remaining covered by the epidermis, black. Teliospores elongated clavate, $16-22$ by $33-70\mu$, tapering toward the base, apex truncate with irregular, blunt, curved processes, variable in size and shape, not or

slightly constricted at the septum; wall yellowish-brown or brown, thickened at the apex, smooth; pedicel short, thickened, coloured, persistent.



Teliospores of *Puccinia Lolii*.

Pycnia and aecia on *Rhamnus cathartica* L., Pictou.

Uredinia and telia on *Avena sativa* L., Pictou, Truro.

This rust is very common on the cultivated oat. It is found chiefly on the leaves. It is much more common in this vicinity than *Puccinia graminis*.

Both are often found occurring on the same plant, *P. Lolii* on the leaves, and *P. graminis* chiefly on the stems and sheaths.

Culture experiments have shown the following form species:

1. *Avenae* on *Avena sativa*.
2. *Alopecuri* on *Alopecurus pratensis*.
3. *Festucæ* on *Festuca elatior*.
4. *Lolii* on *Lolium perenne*.
5. *Glyceriæ* on *Glyceria aquatica*.
6. *Holci* on *Holcus lanatus* and *H. mollis*.

***Puccinia coronata* Cda.**

Puccinia Rhamni (Pers.) Wettst.

0 & I. Pycnia and aecia on *Rhamnus alnifolia*. (Not collected).

II. Uredinia hypophyllous, scattered or arranged in lines, sometimes confluent, small, more or less oblong, pulverulent, orange. Urediniospores globose, sub-globose or ovate, 16-24 by 20-30 μ , echinulate, yellow, pores 3 or 4, paraphyses present.

III. Telia hypophyllous or caulicolous, scattered, sometimes in long lines on the stem, sometimes confluent, oblong or linear, covered for a long time by the epidermis, at length

naked, black. Teliospores oblong or clavate, 16-22 by 38-68 μ , apex with projections, erect or inclined, often crown-like, base narrowed; wall thin, thickened somewhat at apex, brown, darker at apex; pedicel short, thickened, sometimes absent.

On *Calamagrostis canadensis* (Michx.) Beauv., Pictou.

The aecia of this species is on *Rhamnus alnifolia* L'Her.

Puccinia coronata Corda was the name formerly given to the species occurring on oats (*Avena sativa*) and other grasses, with teliospores provided with a crown of processes and called the crown rust. Klebahn, by culture experiments, found that teliospores from some of these grasses produced aecia only on *Rhamnus frangula*, while teliospores from others produced aecia only on *Rhamnus cathartica*. This showed that two species were included under *P. coronata*. Klebahn gave the name *P. coronifera* to the rust producing aecia on *Rhamnus cathartica* and the original name was retained for the rust producing its aecia on *Rhamnus frangula*. Later, on the basis of priority, the name *P. Lolii* Neils has replaced Klebahn's *P. coronifera*.

Ericksson has shown that this species, *P. coronata* Corda, as limited by Klebahn, consists of several biological forms:

1. *Calamagrostidis*.
2. *Phalaridis*.
3. *Agrostidis*.
4. *Agropyri*.
5. *Holci*.
6. *Epigaei*.

Arthur sowed teliosporic material, part of the Pictou collections, on *Rhamnus frangula* with abundant infection. (See Arthur Mycologia 4:18. 1912).

***Puccinia Maydis* Béreng.**

Puccinia Sorghi Schw.

Puccinia Zeae Rabh.

0 & I. Pycnia and aecia on *Oxalis corniculata* L. (Not collected in Nova Scotia).

II. Uredinia amphigenous, scattered or aggregated, elliptical or oblong, long covered by the epidermis, ruptured epidermis prominent, yellowish-brown. Urediniospores globose, sub-globose or elliptical, 24-28 by 27-33 μ , wall yellowish-brown, finely and sparingly echinulate, pores 4, scattered.

III. Telia amphigenous, scattered or somewhat gregarious, linear or oblong, long covered by the epidermis, at length naked, compact, black. Teliospores oblong, ellipsoid or obovate, 16-24 by 27-41 μ , rounded or obtuse, rarely somewhat acute, base rounded or slightly narrowed, slightly constricted at the septum; wall golden-brown, moderately thickened at apex, about 2½ μ , smooth; pedicel tinted, thickened, persistent, usually about the length of the spore or somewhat longer.

On *Zea mays* L., Lower Mount Thom.

In 1904 Arthur (Jour. Myc. 11:65. 1905) sowed aeciospores from *Oxalis corniculata* L. on young corn plants and produced the uredinia and telia of this rust. In the following year (Jour. Myc. 12:17. 1906) he sowed the teliospores from the corn on *Oxalis corniculata* L. and aecia followed. Kellerman (Jour. Myc. 12:10. 1906) confirmed the last result, producing aecia on *Oxalis corniculata* by sowing the teliospores from corn.

The specimens in my herbarium were collected by Prof. C. L. Moore.

***Puccinia triticina* Erikss.**

Puccinia Rubigo-vera (DC.) Winter.

Puccinia Rubigo-vera Var. *Triticici*.

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, scattered, oblong, small, ferruginous. Urediniospores globose or sub-globose, 20-27 μ , sparingly echinulate, yellow.

III. Telia hypophyllous (or culmicolous), scattered, oblong, covered by the epidermis, black. Telia oblong-clavate



or clavate, 15-20 by 35-48 μ , apex rounded, truncate or sometimes obliquely pointed, slightly constricted at the septum, base narrowed; wall thin, brown, slightly thickened at the apex; pedicel short, coloured; paraphyses brown, numerous.

Teliospores of *Puccinia triticina*.

On *Agropyron vulgare*, Pictou.

This rust on wheat, which can be easily separated from *P. graminis* by its covered telia, was found to be rather common in this vicinity. It may not be identical with the European species, but, until culture experiments have been tried, may be placed here provisionally.

Formerly the rusts on wheat and other grasses, which are characterized by the presence of paraphyses among the teliospores, and the telia remaining covered for a long time by the epidermis, were regarded as one species, *Puccinia Rubigo-vera* (D. C.) Winter. Eriksson and Henning in 1896 divided this species into two on the grounds of differences in the uredinia, *P. glumarum* with bright orange uredinia arranged more or less in rows, and *P. dispersa* Erikss. with chocolate-brown uredinia more or less scattered over the leaves.

Infection experiments have shown the following specialized forms in *P. glumarum*:

1. *Triticum*.
2. *Hordeum*.
3. *Elymus*.
4. *Agropyrum*.
5. *Secalis*.

From *Puccinia dispersa* Erikss. a number of biological species have been separated by infection experiments, so that

the former *P. dispersa* Erikss. now consists of the following species:

P. dispersa Erikss. on rye (*Secale cereale*). Aecia on *Anchusa* species.

P. triticina Erikss. on wheat (*Triticum*). Aecia unknown.

P. bromina Erikss. on brome grass (*Bromus*). Aecia on *Symphytum officinale* and *Pulmonaria montana*.

P. agropyrina Erikss. on coach grass (*Agropyron repens*). Aecia unknown.

P. holcina Erikss. on *Holcus* species. Aecia unknown.

P. Triseti Erikss. on *Trisetum flavescens*. Aecia unknown.

***Puccinia agropyrina* Erikss.**

0 & I. Pycnia and aecia unknown.

II. Uredinia mostly epiphyllous, scattered, small or medium sized, oval or oblong, rusty yellow. Urediniospores globose or sub-globose, 20-27 μ , finely echinulate; wall pale yellow; contents yellow.

III. Telia mostly hypophyllous, often on the sheaths, scattered or sometimes aggregated, oblong, covered by the epidermis, black. Teliospores oblong or oblong-clavate, 14-21 by 40-54 μ , rounded or obtuse at apex, narrowed toward base, not or slightly constricted at the septum, smooth, brownish; pedicel short, coloured; paraphyses present.

On *Agropyron repens* L., Pictou.

This rust is very common on its host near Pictou, especially on the after-grass in hay-fields. Both the uredinial and telial stages were found abundantly in late fall.

This species may not be identical with the European rust on *Agropyron repens*, but it is placed here provisionally, or until infection experiments decide its position. It may be *P. obliterata* Arth., which has aecia on *Thalictrum* and *Aquilegia*. (Arthur, Mycologia 1:250. 1909; 2:225. 1910).

***Puccinia perplexans* f. *lowri*.**

0. Pycnia not described.

I. Aecia hypophyllous or petiolicolous, on rounded yellow spots, in elongate or rounded groups, cup-shaped or cylindrical, margin white, incised. Aeciospores angular-globose, finely verrucose, orange, 18-27 μ in diameter.

II. Uredinia chiefly epiphyllous, scattered, chiefly oblong or linear, yellowish brown. Urediniospores sub-globose or ovate, 16-20 by 19-27 μ ; wall rather thick, pale yellowish, echinulate.

III. Telia chiefly hypophyllous, scattered, small, oblong or linear, about 1-1 $\frac{1}{2}$ mm. long, covered by the epidermis, blackish. Teliospores mostly oblong-clavate or clavate, apex rounded, truncate, rounded or obliquely conical, somewhat thickened at the apex, slightly constricted at the septum, 16-24 by 36-60 μ ; wall brown, darker above, smooth, thickened somewhat at the apex; pedicel very short.

Pycnia and aecia on *Ranunculus acris* L., Pictou, June, 1911.

Uredinia and telia on *Alopecurus pratensis* L., Pictou.

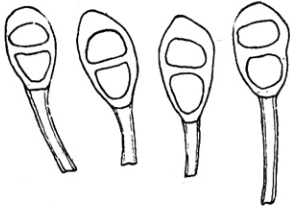
This species does not seem to have been previously collected in North America. Cultures by the writer confirmed what had already been established by European investigators, that the aecia are produced on *Ranunculus acris* L. (See Mycologia 4:179. 1912).

***Puccinia anthoxanthi* Fuck.**

0 & I. Pycnia and aecia unknown.

II. Uredinia amphigenous, mostly epiphyllous, on indefinite yellow spots, scattered or aggregated, elliptical or linear, soon naked, small, yellowish-ferruginous, capitate paraphyses present. Urediniospores mostly ovate or obovate, 18-22 by 23-33 μ , finely echinulate, yellowish.

III. Telia amphigenous, scattered, small oblong or linear, soon naked, blackish-brown. Teliospores elliptical, sub-clavate or oblong, 18-22 by 25-40 μ , apex mostly rounded, base rounded or narrowed; wall chestnut-brown, thickened at apex, smooth; pedicel persistent, coloured, usually shorter than spore.



Teliospores of *Puccinia anthoxanthi*

On *Anthoxanthum oderatum* L., Pictou.

Sydow does not report this species from North America, nor has it been reported as far as I am aware. It was found in only one place near Pictou in 1909 and 1910.

Puccinia tomipara Trel.

0. Pycnia epiphyllous, in small groups, honey-yellow, punctiform.

I. Aecia hypophyllous, in orbicular groups, crowded; peridium somewhat low, margin slightly revolute, erose. Aeciospores globose, 20-25 μ ; wall thin, colourless, verrucose.

II. Uredinia epiphyllous, scattered, rounded or oblong, small cinnamon. Urediniospores globose or sub-globose, 22-27 μ , echinulate, yellowish-brown.

III. Telia epiphyllous, mostly oblong, remaining covered by the epidermis, compact, black. Teliospores oblong or oblong-clavate, 16-24 by 35-54 μ , mostly truncate at the apex, sometimes rounded or acute, narrowed below, not constricted at the septum; wall chestnut-brown, somewhat thickened at the apex, smooth; pedicel very short.

Aecia on *Clematis virginiana* L., New Glasgow, July 6, 1909.

Telia on *Bromus ciliatus* L., Truro, Sept., 1908, 1909.

The collections do not show uredinia. They probably had disappeared before the collections were made.

The connection of the aecial stage was shown by cultures in 1904 by Arthur. (Jour. Myc. 11:62. 1905). He confirmed these results by later cultures.

Puccinia perminuta Arth.

0 & I. Pycnia and aecia unknown.

II. Uredinia not collected.

III. Telia mostly hypophyllous, rounded, oval or chiefly linear, dark brown, remaining covered by the epidermis. Teliospores variable, usually oblong, truncate or rounded at the apex, sometimes narrowed toward the base, 10-16 by 30-50 μ ; wall brown, rather thin except at the apex, there much thickened, 10 μ or less; pedicel very short.

On *Agrostis alba* L., Pictou, August, 1910.

Only telia were present in the collections of this rust, and no description of the uredinia is at hand. The determination was made by F. D. Kern.

Puccinia obscura Schroet.

0 & I. Pycnia and aecia on *Bellis perennis* L. (Europe).

II. Uredinia amphigenous, mostly hypophyllous, on irregular yellowish spots, scattered or irregularly distributed, elliptical or oblong, covered for some time by the epidermis, at length naked, pulverulent, yellowish-brown. Urediniospores subglobose, ellipsoid or obovate, 20-25 by 27-35 μ ; wall rather thick, brown, strongly but sparingly echinulate.

III. Telia similar to the uredinia but more compact. Teliospores oblong or clavate, 16-20 by 30-48 μ , rounded above, sometimes rather acute, base narrowed, constricted at the septum, cells separating easily; wall pale yellowish-brown, somewhat thickened at the apex, about 3-5 μ , smooth; pedicel mostly hyaline, usually shorter than the spore.

On *Luzula campestris* Var. *multiflora* (Ehrk.) Celak., New Glasgow; *L. saltuensis* Fernald, New Glasgow, French River, Truro.

The uredospores appear in early spring, so that it is very probable that the mycelium is perennial, as the leaves of the host remain green during the winter.

Plowright worked out the life history of this rust showing that the aecial stage is on *Bellis perennis*. No cultures have been made to establish the identity of the American and European rusts.

***Puccinia cinerea* Arth.**

0 & I. Pycnia and aecia on *Ranunculus cymbalaria* Pursh.

II. Uredinia mostly caulicolous, sometimes on the leaves, linear, 1 mm. or less, ferruginous, pulverulent, ruptured epidermis evident. Urediniospores oval or obovate, 18-23 by 27-33 μ ; wall colourless, medium thick, very finely echinulate; contents orange-yellow.

III. Telia amphigenous and caulicolous, linear, remaining covered by the epidermis, blackish. Teliospores clavate, oval, or oblong, rounded, truncate or narrowed at the apex, chiefly narrowed at the base, slightly or not constricted at the septum, 16-23 by 32-50 μ ; wall yellowish-brown or dark brown, slightly thickened at the apex, smooth; pedicel short, tinted, persistent.

Pycnia and aecia on *Ranunculus cymbalaria* Pursh., Pictou.

Uredinia and telia on *Puccinellia maritima* (Huds.) Parl., Pictou, September, 1910.

Arthur (Mycologia 1:246. 1909) by infection experiments showed that *Puccinia cinerea* has its aecial stage on *Ranunculus cymbalaria*.

Puccinia Sambuci Arth.

0. Pycnia amphigenous, mostly epiphyllous, in small groups on the aecia bearing spots, honey-yellow.

I. Aecia hypophyllous, on rounded yellow, often bullate spots, in circular groups of different sizes, irregular shaped on the nerves, margin recurved, incised. Aeciospores angular-globose, about 16-19 μ , finely verrucose, yellowish.

II. Uredinia hypophyllous, rounded, elliptical or linear, surrounded by the ruptured epidermis, pulverulent, cinnamon. Urediniospores sub-globose or obovate, about 22 μ in diameter, echinulate, yellowish-brown.

III. Telia hypophyllous, rounded or oblong, scattered or gregarious and confluent, surrounded by the ruptured epidermis, pulvinate, blackish-brown. Teliospores oblong-clavate, 18-24 by 38-52 μ , rounded or obtuse above, narrowed below, constricted at the septum; wall light brown, much thickened above, 5-10 μ , smooth; pedicel persistent, hyaline, usually shorter than spore.

Pycnia and aecia on *Sambucus canadensis* L., Pictou.

Uredinia and telia on *Carex lurida* Wahlenb., Pictou.

The aecial stage was common on its host near Pictou. Only one collection of the rust on *Carex lurida* was made. It differs somewhat from Sydow's description. The teliospores are smaller and the pedicels shorter, but it is placed here provisionally. It may be that some other common *Carex* rusts belong to this species

Puccinia Opizii Bubak.

0. Pycnia numerous, on the spots with the aecia, dark honey-yellow.

I. Aecia hypophyllous or culmicolous on purplish or reddish circular spots surrounded by a more or less extensive yellowish zone, spots $\frac{1}{2}$ to 1 $\frac{1}{2}$ cm. in diameter, in groups occupy-

ing the whole of the spot, cup-shaped or short cylindrical, low, margin white, revolute, lacerate. Aeciospores globose, sub-globose or ellipsoid, about $16-18\mu$ in diameter, verrucose, orange.

II. Uredinia hypophyllous, in small yellowish spots, scattered, minute, ovate or oblong, at first covered by the epidermis, at length naked, pulverulent, brown. Urediniospores globose, sub-globose or ellipsoid, $17-22$ by $18-33\mu$, remotely echinulate, brown, pores two.

III. Telia hypophyllous or culmicolous, scattered or aggregated, small, ovate or oblong, long covered by the epidermis, pulvinate, black. Teliospores clavate or oblong-clavate, $13-24$ by $35-60\mu$, apex rounded, truncate or long conical, base narrowed, slightly constricted at the septum; wall yellowish-brown, much thickened and darker at apex, smooth; pedicel hyaline, persistent, equalling the spore.

Pycnia and aecia on *Lactuca spicata* (Lam.) Hitchc. and Var. *integrifolia* (Grey) Britton; *L. canadensis* L., Pictou.

Uredinia and telia on *Carex muricata* L., (Europe). (Not collected in Nova Scotia).

Arthur (Jour. Myc. 13:194. 1907) produced what he regards as the aecia of this rust on *Lactuca* from the teliospores of an undetermined *Carex*. Bubak had previously worked out the connection for the European rust by cultures. The aecia are so characteristic that there is little doubt that they belong to this species, and that the telial form on *Carex* will yet be found.

Puccinia Caricis-Asteris Arth.

0. Pycnia epiphyllous, in small groups on the spots that bear the aecia.

I. Aecia hypophyllous, usually grouped on yellowish spots, cup-shaped or cylindrical, low, margin revolute, lacerate. Aeciospores angular globose, about $13-16\mu$; wall colourless, finely verrucose; contents yellow.

II. Uredinia hypophyllous, oblong. Urediniospores ovate, echinulate, 14-17 by 17-22 μ ; wall thin, brownish.

III. Telia hypophyllous, oblong or linear, soon naked, surrounded by the ruptured epidermis, dark brown or blackish. Teliospores oblong or oblong-clavate, apex mostly rounded, much thickened, 16-21 by 37-60 μ ; pedicel tinted, shorter than or equalling the spore.

Puccinia and aecia on *Aster acuminatus* Michx. and other *Aster* species, Pictou.

Uredinia and telia on *Carex trisperma* Dewy, and probably on other *Carex* species, Pictou.

The writer established by cultures that the *Puccinia* on *Carex trisperma* has aecia on *Aster acuminatus*. It is probable that a number of other collections on *Carices* belong to this species. That on *Carex canescens* Var. *disjuncta* Fernald is probably included here.

Puccinia Caricis-Solidaginis Arthur.

0 & I. On *Solidago graminifolia* (L.) Salisb. and other species of *Solidago*, Pictou.

II. & III. Uredinia and telia on *Carex scoparia* Schk. and *C. stipata* Muhl., Pictou.

There does not seem to be any marked morphological differences between the forms of this species and *Puccinia Caricis-Asteris* so that a description is not given.

Cultures by the writer established the connection of the above forms for this region. (See *Mycologia* 4:181. 1912). It is probable that other collections of *Puccinia* on sedges in this vicinity belong to this species.

Puccinia caricina DC.

On *Carex Deweyana* Schwein., *C. paupercula* Michx., *C. stellulata* Good., *C. stellulata* Var. *cephalantha* (Bailey)

Fernald, *C. tenetta* Schkuhr., *C. canescens* Var. *disjuncta*, Pictou.

These rusts are placed under this species provisionally until their position is determined by cultures. Some of them may belong to *Puccinia Caricis-Solidaginis* Arth. which has aecia on *Solidago* species; probably some belong to *P. Caricis-Asteris* Arth., while others may have their aecia on *Ribes*. Culture work is necessary before many of the rusts so common on the sedges can be assigned to their proper species.

***Puccinia angustata* Peck.**

0. Pycnia epiphyllous, in small groups on the spots bearing aecia.

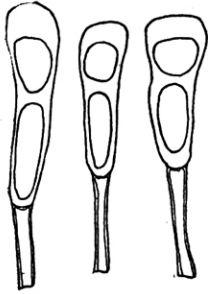
I. Aecia hypophyllous or caulicolous, on yellow, brown or brownish-purple orbicular spots, in small dense groups on the spots, in irregular, larger groups on the stem and petioles, cylindrical, cup-shaped, margin recurved, incised, white. Aeciospores globose or angular-globose, 16-20 μ , verrucose, pale yellowish.

II. Uredinia hypophyllous, often on yellowish areas, mostly arranged in lines, oblong or linear, long covered by the epidermis, pulverulent, light brown. Urediniospores subglobose, ellipsoid or obovate, 18-22 by 26-31 μ , wall strongly but sparingly echinulate, yellowish-brown.

III. Telia similar to the uredinia but black and rather compact. Teliospores clavate or fusoid-clavate, 16-22 by 43-73 μ , apex truncate, rounded or acuminate, base narrowed, slightly constricted at the middle; wall pale brown, much thickened, up to 14 μ , and darker at apex, smooth; pedicel light brown, thickened, persistent, usually a little shorter than spore.

Aecia on *Lycopus americanus* L., *L. uniflorus* Michx., Pictou.

Uredinia and telia on *Scirpus cyperinus* (L.) Kunth., *S. rubrotinctus* Fernald, Pictou.



Teliospores of *Puccinia angustata*.

The aecial stage on *Lycopus* and the uredinial and telial on *Scirpus* are very common and usually found closely associated. The aecia appear in the early part of July. Arthur worked out the connection between the stages in 1899 (*Bot. Gaz.* 29:273. 1900) and has confirmed his results several times. (*Jour. Myc.* 8:53. 1902; 11:58. 1905; 13:196. 1907; 14:14. 1908; *Mycologia* 1:234. 1909).

It may be that the collections on *Scirpus rubrotinctus* represent a distinct species.

***Puccinia albiperidia* Arth.**

0. Pyenia amphigenous, small, pale orange.

I. Aecia hypophyllous, small, in somewhat circular clusters, substratum scarcely thickened; peridia white, low, margin incised, reflexed. Aeciospores pale yellow when fresh, sub-globose, 15-20 μ in diameter; wall thin, smooth.

II. Uredinia hypophyllous, small, round or oblong, soon naked. Urediniospores oblong, small, echinulate.

III. Telia hypophyllous, globose or oblong, pulvinate, dark brown. Teliospores oblong-cuneate, apex rounded or obtuse, thickened at apex, slightly or not constricted at the septum, 17-24 by 31-45 μ ; pedicel slender, coloured, as long as the spore or longer.

Aecia on *Ribes oxycanthoides* L., *R. prostratum* L'Her., Pictou.

Uredinia and telia on *Carex crinita* Lam., *C. intumescens* Rudge, *C. pallescens* L., *C. debilis* Vr. *Rudgei* Bailey, *C. arctata* Boott., Pictou.

The limits of this species are not known at present. It may be that more than one species is represented in the collections assigned here. Possibly some of them belong to *Puccinia Grossulariae* (Schum.) Arth.

The collections on the *Carex* species assigned here were shown by the cultures of the writer to have their aecial stages on *Ribes*. (See Mycologia 4:180. 1912). Probably several other collections on *Carex* species also belong to this rust. But cultures are necessary before the relation of many of the rusts on the genus *Carex* can be ascertained.

Puccinia Eleocharis Arth.

0. Pyenia epiphyllous.

I. Aecia hypophyllous, grouped on yellow spots 3-4 mm. in diameter, cylindrical, cup-shaped, low, margin revolute, lacerate. Aeciospores mostly angular-globose or sub-globose, about 14-18 μ , hyaline, verrucose.

II. Urediniospores mixed with the teliospores, irregularly globose or ovoid, finely and sparsely echinulate, yellowish.

III. Telia scattered or subgregarious, sometimes confluent, small, rounded, remaining covered for a long time by the epidermis which at length ruptures, sometimes black. Teliospores oblong, rounded or obliquely subtruncate, 16-21 by 45-54 μ , apex moderately thickened, not or slightly constricted at the septum; base rounded or often somewhat narrowed, smooth, dark brown; pedicel thickened, very short.

Pyenia and aecia on *Eupatorium perfoliatum* L., Pictou.

Uredinia and telia on *Eleocharis intermedia* (Muhl.) Schultes, *E. palustris* (L.) R. & S. (not collected).

The aecial stage was found in only one place near Pictou. The telial stage on *Eleocharis* was not collected, but as the host plants are common and as the rust has been collected in Maine, it probably occurs in Nova Scotia. As the rust is inconspicuous it may easily be overlooked.

THE RUSTS OF NOVA SCOTIA.—FRASER.

Arthur (Jour. Myc. 12:23. 1906) by cultures showed the connection of the aecia on *Eupatorium* and has confirmed this result by recent cultures. (Jour. Myc. 13:193. 1907; Mycologia 1:233. 1909).

Form Genera.

These are imperfect forms, which occur in only one stage and cannot be assigned to their proper genera till the complete life cycle is known. It is convenient to assign them to form genera till their true position is determined. The forms included here are *Uredo*, *Caeoma*, *Aecidium*, *Peridermium* and *Roestelia*.

Uredo.

Uredo forms are uredinia that have not been connected with their telial form. They have the characteristics of the uredinial stages of the *Pucciniaceae*. It is possible that some possess perennial mycelium so that they can dispense with teliospores, or that the urediniospores may carry the fungus over the winter. I have not collected any of them in Nova Scotia.

Aecidium

Peridium present, usually cup-shaped, spores in chains. Forms placed here are simply the aecial stages of unconnected rusts. The form genus *Peridermium* is sometimes included.

Aecidium Compositarum Var. **Solidaginis.**

0. Pycnia amphigenous, in small groups on the spots that bear the aecia, inconspicuous.

I. Aecia chiefly hypophyllous, on yellow spots or areas, cylindrical or cup-shaped, low, margin lacerate. Aeciospores angular-globose or ellipsoid, about 15-19 μ ; wall colourless, finely verrucose; contents yellowish, becoming colourless.

On *Solidago canadensis* L., *S. rugosa* Mill., Pictou.

These collections are probably the aecial stage of *Puccinia Caricis-Solidaginis* Arth., as field observations indicated that they belonged to a *Puccinia* on *Carex*.

Aecia were also collected on *Solidago latifolia* L., which differed from the more common aecia on *Solidago* being in very small groups or solitary and pale or whitish. They probably belong to a distinct species.

Peridermium.

All aecial forms inhabiting the *Pinaceae* and *Gnetaceae* and possessing peridia are usually included under this form genus. They are probably the aecial stages of rusts belonging to the families *Melampsoraceae* and *Cronartiaceae*. All *Peridermia* that have been connected with telial forms belong to these families except a few leaf inhabiting species on *Pinus* which belong to the genus *Coleosporium*.

I have collected ten species in the vicinity of Pictou. They are tabulated below and their connexions with telial genera where known:

Peridermium decolorans Peck.—*Melampsoropsis ledicola* (Peck) Arth.

Per. consimile Arth. & Kern.—*Mel. Cassandrae* (Peck & Clinton) Arth.

Per. abietinum (A. & S.) Thuem.—*Mel. abietina* (A. & S.) Arth.

Per. columnare (A. & S.) Kunze & Schm.—*Calyptospora columnaris* (A. & S.) Kuehn.

Per. elatinum (A. & S.) Kunze & Schm.—*Melampsorella elatina* (A. & S.) Arth.

Per. conorum-Piceae (Rees) Arth. & Kern.—*Melampsoropsis Pyrolae* (DC.) Arth.

Per. Peckii Thuem.—*Pucciniastrum minimum* (Schw.) Arth.

Peridermium (on *Tsuga*).—*Puccinistrum Myrtilli* (Schum.) Arth.

The connexion of the following form has not yet been established:

Per. balsameum Peck.

Two other species may occur in Nova Scotia, *Per. coloradense* (Diet.) Arth. & Kern, and *Per. Laricis* (Kleb.) Arth. & Kern. The former has been collected in Maine. It forms witches' brooms on *Picea* and is conspicuous. The latter has not been collected in North America, but as the telial form on *Betula* [*Melampsorium Betulae* (Schum.) Arth.] is rather common, it will doubtless be found also.

***Peridermium balsameum* Peck.**

0. Pycnia hypophyllous, few, scattered, honey-yellow, small.

I. Aecia hypophyllous, in two irregular rows on yellowish areas occupying all or part of the leaf, white, mostly cylindrical, small, opening at apex; peridium colourless, margin erose or somewhat lacerate. Aeciospores ellipsoid or globoid, 15-22 by 19-27 μ , wall thin, densely verrucose; contents colourless.

On *Abies balsamea* (L.) Mill., Pictou, July 15, 1909; Scotsburn, August, 17, 1909; Folley Lake, August 31, 1919.

This species is characterized by its white spores, no other *Peridermium* in Eastern North America shows this character. It may be identical with the European *Aecidium pseudocolumnare* Kuhn, which also has white spores, (See note Arthur & Kern, Bull. Torr. Bot. Club 33:436. 1906).

From field study the writer is convinced that *Peridermium balsameum* is the aecial stage of some species of the genus *Uredinopsis*. Probably several species are confused under this *Peridermium*.

Caeoma.

Aecia without peridia of which the telial forms are not known are classed here. I have collected three of these forms in Nova Scotia, *Caeoma nitens* on the raspberry, the aecidial stage of *Gymnoconia interstitialis*, a *Caeoma* on *Abies balsamea*, which I have shown to be the aecial stage of *Melampsora arctica*, and *Caeoma Abietis-canadensis* Farl., which I have connected with *Melampsora Medusae*.

Roestelia.

The name *Roestelia* has been applied to the aecial stage of the *Gymnosporangium* rusts. The peridium is well developed and dehisces by longitudinal slits, and thus soon becomes fimbriate and revolute. The Nova Scotia collections are discussed under the genus *Gymnosporangium*.

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NOTE.

Since this paper was revised the writer by culture experiments during the early summer of 1912 established the life history of several of the fern rusts of the genus *Uredinopsis*. These experiments have shown that *Uredinopsis Osmundae* Magn., *U. Struthiopteridis* Stormer, *U. Phegopteridis* Arthur,

U. mirabilis (Peck) Arthur, and *U. Atkinsonii* Magn., have their aecial stages on *Abies balsamea* (L.) Mill. The aecia are the white spored forms that have passed as *Peridermium balsameum* Peck.

The question arises whether these are distinct species with like aecia or only one species that has been regarded as distinct on account of minor differences. The experiments as far as they went tended to show that the species established are good or at least are races of the same species.

The following European species has also been recognized since the paper was revised. It adds a new species to the American flora. The determination was made by Dr. J. C. Arthur.

***Puccinia karelica* Tranz.**

0. I. Pycnia and aecia in *Trientalis americana* (Pers.) Pursh. Pictou, June 20, 1912.

II & III. Uredinia and telia in *Carex paupercula* Michx., Pictou, Folleigh Lake.

NOTE.

The following additional species were collected after the preceding paper was in type.

Hyalopsora

Cycle of development not understood; telia and two other spore forms known, called aecia and uredinia; aecia and uredinia sub-epidermal, telia within the epidermal cells.

***Hyalopsora Aspidiotus* (Peck) Magn.**

I. Aecia amphigenous, rounded, small, yellow, tardily dehiscent. Aeciospores ellipsoid or polyhedral, large, 30-40 by 40-50 μ ; wall thick 2.5-3.5 μ , colorless, verrucose.

II. Uredinia amphigenous, irregularly scattered, round, small, golden-yellow, somewhat pulverulent; peridium delicate.

Urediniospores ellipsoid or oval, 19-24 by 29-35 μ ; wall colourless, medium thick, minutely verrucose.

III. Teliospores in the epidermal cells, globose, often irregular 25 by 21-35 μ ; usually four-celled; wall thin, 1 μ , colorless, smooth.

On *Phegopteris Dryopteris* (L.) Fee., Pictou, New Glasgow, July, 1912.

The spores appeared so early in spring that it does not seem probable that they are preceded by aecia on another host, so the writer is inclined to regard this species as autoecious.

The description of the genus and species is based on that of Arthur in the *North American Flora* as all the spore forms were not present on my collections.

Puccinia Osmorrhizae (Peck) Cooke and Peck.

O. & I. Not present on Nova Scotia collections.

II. Uredinia amphigenous, scattered, rather small, pulverulent, cinnamon. Urediniospores mostly ovate, yellowish, about 25 by 28 μ ; wall echinulate, thick.

III. Telia blackish, elongate on the stem and pedicels. Teliospores ellipsoid, rounded at both ends, slightly constricted at the septum, 21-27 by 28-35 μ ; wall rather thin, slightly or not at all thickened at the apex, reticulate; pedicel delicate, hyaline, deciduous, shorter than the spore.

On *Osmorrhiza Claytoni* (Michx.) Clarke., New Glasgow, July, 1912.

OMISSION FROM PAGE 364.

The third paragraph from the bottom of the page has only the first and last line of the author's paragraph which should read as follows:

III. Telia hypophyllous, evenly and closely scattered, occupying all or part of the under surface of the leaf, small, round, .2-.45 mm. across, waxy, at first yellowish-red, afterward dull-red; Teliospores ellipsoid, 12-15 by 12-19 μ ; wall colorless smooth, thin; basidiopores 7-8 μ in diameter.

Pycnia and aecia on the cones of *Picea mariana* (Mill.) BSP., *P. canadensis* (Mill.) BSP., Pictou, July, 1910, 1911.

Uredinia and telia on *Pyrola americana* Sweet, Pictou, Truro; *P. elliptica* Nutt., Pictou.

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