BOARD OF AGRICULTURE.

VARIOUS REPORTS.

1892.

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REPORT

ON

Rust or Mildew on Wheat Plants.

1892.

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Rust or Mildew on Wheat Plants.

MEMORANDUM.

THE Board of Agriculture, having had repeatedly brought under their notice the extensive losses sustained by agriculturists from the presence of Rust or Mildew in wheat, have deemed it desirable to publish the following summary of the information collected in the summer of 1892 from various observers of the circumstances of this year's attack in different parts of England.

In order, at the same time, to place before wheat growers the conclusions of former investigations, and the results of the more recent researches into this matter abroad, and in order to recall attention to the leading features of the life history of this destructive and widely-prevalent fungus, Mr. Whitehead was requested to append to his report on the replies of the representative agriculturists, selected by him to give their experience in the past season, a series of more general notes on the points above indicated. He has also materially increased the usefulness of the report by the coloured illustrations supplied, exhibiting the various phases of the fungoid attacks now the subject of examination.

It is to be regretted that out of 144 agriculturists addressed by the Board in June last, with a request for co-operation by supplying the details of their experience, only thirty-seven have found themselves in a position to furnish precise replies—founded on their own observations—to the schedule of questions issued. The reports received, however, embrace the experience of gentlemen residing in as many as twenty-six different counties. In all but seven of these counties more or less disastrous attacks of rust were experienced in 1892. Few indications of novel explanations of the phenomena in question have been supplied by the reporters, although the connection between extensive attacks of mildew and sudden atmospheric changes and untimely frosts has again, as in all earlier inquiries, formed a prominent subject of comment.

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As pointed out in the following pages, the most notable of the earlier investigations throwing light on the character and consequences of Rust were those conducted by the Secretary of the old Board of Agriculture, Arthur Young, and published in 1805; by the President of that body, Sir John Sinclair, published in 1809; and, lastly, by Mr. W. C. Little, on behalf of the Royal Agricultural Society of England, in 1883.

Among the incidental questions which necessarily pass under review in connection with the development of the fungus known as "Puccinia graminis," is the part asserted to be played by the barberry as the host of a certain stage of the fungus. This matter was prominently noticed in Arthur Young's inquiry in the early years of the century. It had specific attention also called to it in Mr. Carruthers' note in the "Royal Agricultural Society's Journal," in 1882, when it was pointed out that the experiments of De Bary had proved that the *Æcidium* of the barberry and rust and mildew of wheat were only stages in the life of the same plant. This matter was specially urged on the Board by one of their earlier correspondents on this occasion as deserving further inquiry and observation. There is, however, but little corroborative evidence on this point furnished by the observers reporting in 1892, and the important extracts from the Australian reports herein given seem to indicate an increased probability that the barberry plant—despite what has been proved against it—may not be indispensable to the propagation of this fungoid attack.

It had been at one time hoped that the German and American investigations conducted in 1892 would have been completed in sufficient time to allow of the results being incorporated in this Report. But as these are not yet available it has been deemed inadvisable further to delay the issue of a statement which, it is hoped, may direct increased attention to a question of no little importance and interest, and which, on many of the points noticed, and particularly on that of the production of rust-resisting varieties of wheat, might usefully attract the careful examination of scientific observers.

REPORT

ON

RUST OR MILDEW ON WHEAT PLANTS.

In pursuance of a decision by the Board of Agriculture to make inquiry concerning rust or mildew on wheat plants, in the summer of 1892 the following schedule of questions was issued to certain agriculturists in different districts of the country, asking them to co-operate with the Board by giving their general experiences concerning mildew, as well as by recording facts derived from their observations in connection with it during that season.

Schedule of Questions.

I.

State (*a*) extent of farm; (*b*) area sown with wheat in 1892; (*c*) proportion of wheat crop attacked by mildew in 1892.

II.

Estimate of injury caused by mildew in 1892.

III.

Date of first appearance of the yellow, rusty (*Uredo*) form of the mildew, and stage and growth of wheat plants at the time of its appearance.

IV.

Date of first appearance of the black (*Teleutospore*) form of the mildew, and stage of growth of wheat plants at the time of its appearance.

V.

The nature, composition, and general characteristics of the soil of the affected wheat fields, noting especially, as far as possible, the relative mineral and organic constituents.

VI.

The cropping and manuring of the affected wheat fields during 1890 and 1891.

VII.

State (*a*) date of sowing; (*b*) variety of wheat sown; (*c*) nature of weather generally from sowing to harvest.

VIII.

State whether Barberry trees, or shrubs, *Berberis vulgaris*, or other varieties of *Berberis*, are growing near field affected by mildew.

IX.

Give opinion and experience as to the connection between the Barberry and wheat mildew.

X.

State experiences of former seasons when mildew has affected wheat plants.

XI.

State any other particulars bearing upon the question.

Extent of Injury.

Taking these questions *seriatim*, it appears from the answers received to No. I. that thirteen correspondents, in the counties of Bedford, Berks, Cambridge, Essex, Gloucester, Hants, Hereford, Lincoln, Norfolk, Northumberland, Somerset, and Warwick, reported that all, or nearly all, of their wheat was affected.

A similar number of observers, in the counties of Bedfordshire, Dorset, Essex, Hertford, Kent, Norfolk, Suffolk, Warwick, Wilts, and York, reported attacks of rust in varying percentages of their crops.

On nine farms in the counties of Essex, Monmouth, Northampton, Northumberland, Stafford, Surrey, and York, no attack of rust was observed.

Estimates of Loss from Mildew.

With regard to the amount of injury caused by the mildew, this is estimated, in the answers to Question No. II., at from nine bushels on a farm in Kent, to as high as sixteen bushels per acre upon land at Dillington, Somerset, as returned by Mr. Obed. Hosegood. Upon one farm in Norfolk, at West Barsham, the loss is set at from four to sixteen bushels per acre. Mr. Albert Pell puts the diminution in the yield of 120 acres in the Isle of Ely, on account of the mildew, at from 100 to 150 quarters. Mr. Palmer, of Revell's Hall, Hertford, estimates his loss at 150*l.* on seventy-five acres of wheat land. Mr. Martin, of Littleport, Ely, considers that his crop was decreased from two to four quarters per acre, adding that "it is the most serious and universal attack I have known for many years." Mr. Garne says of a farm at Great Rissington, Bourton-on-the-Water, Gloucestershire, that the loss on twenty acres of wheat and from mildew equalled 35 per cent. Mr. Murton Matson, of St. Osyth, Colchester, states that it is hard to tell the amount of loss, but certainly three sacks per acre. Mr. Charles Clarke, of Scopwick, Lincoln, who sowed 125 acres with

wheat, reckons that "mildew caused from one to two quarters less yield, which at present value would be 28*s.* and 56*s.* per acre." Besides the loss of weight of grain, the straw where mildewed was of indifferent quality. Thus Mr. Clare Sewell Read reports:—"On the twenty-five acres, all the thin-planted part of the field was badly blighted, and the straw very much discoloured and spoiled, but little apparent damage was done to the grain, which was a fair crop and a nice sample. Mr. Charles Howard, of Biddenham, Bedford, says, "the straw was more injured than the corn." Mr. Gearey, dating from King's Langley, Herts, remarks that the estimate of injury caused by mildew on his farm is "about 30*s.* per acre, including damage done to straw, the greater part of which is rendered black and is very rotten." Mr. Allsop, of Romsey, Hants, who sowed forty-two acres of wheat, puts the reduction of the yield at one-half, and states "that the straw is very black."

On the other hand, it was found by some reporters that though the mildew was present no actual loss was experienced. Mr. Glenny, of Barking, Essex, noticed that a portion of his wheat plants were mildewed, but records no damage. Mr. Philip Shepheard, of the Hall Farm, Hunningham, near Leamington, makes the following observations:—"I do not consider in my own case that very much damage has been done; the yield will not be affected probably beyond about two bushels to the acre. The warm sunny days we had in the middle of August came just in time to arrest what threatened to be a serious attack." Mr. Palmer, of Revell's Hall, Hertford, considers that the value of the straw upon a large portion of his wheat land was reduced by 10*s.* per load.

Date of Appearance of the Rusty (Uredo) Form.

Concerning the dates of the appearance of the yellow, or rusty (Uredo), form of the mildew, there is a great difference in point of time. In some cases it was noticed at the end of May. In others not until the end of July, and even as late as the first week of August. Mr. Clare Sewell Read remarks that after the heavy rains of the middle of July, accompanied by a sudden fall of temperature, some rough spots were observed under the ear, and then the yellow rust became general towards the end of the month. In Suffolk, Mr. Smith, of Rendlesham, perceived it just before the wheat came into ear. Mr. Gibb, of Lymington, Hants, first saw rust "about the 20th of June, when plants had been about a fortnight in ear, but the attack was not very severe until the 20th of July." Mr. Galpin, of Blandford, Dorset, did not notice any rust until after the severe frost of June 13 and 14. At Cardington, near Bedford, Messrs. Malden found rust "on June 10th; the ear was just bursting the sheath."

Date of Appearance of the Black (Teleutospore) Form.

The black form (Teleutospore) showed itself also at somewhat varying periods. The earliest note of it was made on the

19th of July, near Leamington, after ten days of very wet and cold weather and complete absence of sunshine. The beginning of August is the time most usually given, and just as the ripening process commenced. In Wiltshire, near Chippenham, Mr. Selman noticed it "in the second week in August, just as we commenced reaping, and it developed rapidly during the time the wheat was being cut." The first appearance of the black form of mildew in the neighbourhood of Ely, was on the 1st of August, according to Mr. Martin, of Littleport, who previously observed a large amount of yellow rust on the flag. Messrs. Malden, of Cardington, near Bedford, give the "3rd of August; grain commencing to harden, and straw turning," as the time the black form of mildew showed itself on their wheat. Mr. Clare Sewell Read noticed this form "just before the wheat was cut towards the end of August," and Mr. Palmer, of Revell's Hall, Hertford, states that the wheat was cut early on the 2nd of August, when it was still green, and before the black form of mildew had developed. The black form, the *Puccinia graminis* was extensively present upon straw forwarded some weeks later on. Mr. Alfred Smith, of Rendlesham, Suffolk, who has furnished much valuable information, gives the period of this appearing of the black form as "about a week or ten days before cutting. Began to cut August 4th Carter's Earliest of All; and the 13th August, other varieties. The first appearance was after a rainy day or two."

The Nature of the Soil, and the relative Mineral and Organic Constituents.

From the replies received it is apparent that the attributes of the soil did not affect materially the attack of the mildew. Light soils of a gravelly and sandy composition were as much affected as those of a heavy, clayey, and alluvial nature. To take a few typical instances where the injury done by mildew was great. The soil of Mr. Clarke's farm at Scopwick, Lincoln, is a "light heath, waterpit stone, and black soil, with gravel subsoil to the latter"; while that of Mr. Pell's "Australia" farm, in Cambridgeshire, is "black fen land; subsoil, gravel." Upon Mr. Hunt's holding in Colne, Lincolnshire, the soil is heavy land with a gault and clay subsoil. The land upon Mr. Ellis' farm at West Barsham, Norfolk, is "very varied, ranging from a gravelly, very light soil, to a strong clay, including, between the extremes, strong mixed soil resting on chalk, but there was little difference in the amount of blight, with the exception of the wheat following beans, where the attack was very serious." In the return furnished by Mr. Obed Hosegood, of Dillington Farm, Somerset, whose loss was from eight to ten bushels per acre, "the soil affected most generally is sandy, light soil." Mr. Kimber, of Abingdon, Berks, whose estimate of loss is from 15 to 20 per cent., states "the soil is chiefly of a sandy, friable nature, but in some of the

fields in which the underlying rock contains a considerable percentage of lime, the soil is of a sticky nature when wet. The percentage of organic matter is very low." Mr. Charles Howard's account of his land is "a light gravelly soil;" and the Messrs. Malden, also near Bedford, say, "The soil is all alluvial, and varies from light gravel to very heavy loam. The land is farmed fairly high, as it is used largely to grow market garden and special croppings. A slight deficiency in lime, owing to the land having been under arable cropping for a very considerable period, is the only feature worthy of notice. All the fields seemed to suffer but the more typical wheat land, the medium loams, perhaps, suffered most. The land is well drained, and there is nothing naturally prejudicial in the soil. In fact it holds a good reputation."

The seventy-five acres of wheat land belonging to Mr. Palmer, of Revell's Hall, Hertford, upon which the whole of the crop was affected, are categorized as under :—

15 acres, mostly gravelly.
18 „ gravel and light loam.
13 „ gravelly.
17 „ gravel and light loam.
15 „ light loam.

Upon a very heavy clay soil in Kent the attack was very slight, and only the red wheat was affected. The white wheat escaped.

At Hunningham, near Leamington, Mr. Shepheard, whose loss was equal to about two bushels per acre, reports that one of his affected fields is "a good mixed loam of medium, or light texture, overlying clay, with gravel under in places. Another is a marly clay. The relative organic and mineral constituents are such as are usually found in fairly fertile land. I am not aware of any particular preponderance or lack of any one constituent, but probably in the six-acre field the organic elements in the shape of nitrogen from the decay of the clover roots (the clover was a great full crop) would preponderate."

Previous Cropping and Manuring.

It is remarked by Mr. Shepheard, of Hunningham, that the wheat after clover was the most mildewed this season, a few pieces sown after beans and peas were not attacked nearly as much. Messrs. Malden write: "The cropping and manuring of previous years seem to have had very little influence upon the wheat mildew. It has been most impartial. Some of our wheat is on land which has received artificial manure within the last three years, and some has not. Some is after potatoes; other after clover; other after roots fed; other after peas; but there is nothing to choose between them."

In many cases the wheat was sown upon clover ley. On account of the wet autumn of 1891, it was very difficult to get some land in with wheat after turnips, beans, or peas.

Mr. Kimber, of Abingdon, found that his wheat after clover was the worst affected. He gives the following account : "The land is farmed on the four-course system, and grew clover in 1891, or else beans, or vetches fed off by sheep, and barley in 1890. The barley followed roots fed on the land by sheep. The beans in 1890 were manured with farmyard manure. Part of the clover had dung, and part had none. The wheat following the clover was most affected with mildew ; that after vetches next ; and the wheat after beans least affected."

Mr. Joseph Smith, of Hasketon, Suffolk, whose crop was considerably injured, sowed his wheat on a clover ley, well manured with farmyard manure, once mown, then fed with sheep having a liberal supply of cake. "If land is farmed high," Mr. Smith remarks, "with much decaying vegetable matter in the ground, then we may look for mildew, more or less severe, almost certain to develop itself if the plant is thin and backward."

Mr. Martin, of Littleport, Ely, states that "all land is affected more or less, whether sown with artificial manure, superphosphate, or farmyard manure. From observation, I am inclined to think that, as a rule, the mildew is most serious where wheat was sown after oats."

Mr. Hosegood, Somerset, found that wheat after mangels was the least rusted. After turnips fed off and got in after Christmas it was more rusted. But the worst generally was wheat after clover.

Mr. Pell says "all the crops on the fen lands are affected, quite irrespective of the cropping."

Nitrate of Soda.

But few records are given as to the influence of nitrate of soda, which is generally considered to be very conducive to the spread and injury of rust. Mr. Ellis, of West Barsham, holds that top-dressing a thin plant of wheat with nitrogenous manures nearly always intensifies, if it does not cause, mildew. Mr. Read, of Southam, Warwickshire, detected rust only in one acre out of fifty he had under wheat. This acre was in wheat after clover; and, as the plant rooted weak in spring, nitrate of soda had been applied of 1 cwt. per acre, and forced a heavy crop of straw. Taken as a whole, the evidence of the reporters tends to show that previous cropping and manuring have not an important influence upon mildew, though, on the other hand, it is believed that many farmers in Scotland hold that manuring, and especially with nitrate of soda, materially affects the attack of mildew.

Date of Sowing.

Owing to the unusually wet autumn, the dates of wheat-sowing vary considerably in the reports, ranging between the first week in October to the end of February. It is said, however, that there was no difference noted between wheats

sown early or late, as regards mildew. In one case the autumn-sown wheat was more affected than that got in during February; while exactly the reverse is chronicled in another instance. As will be seen later on in this Report, the Australian farmers find that early-sown wheat is always much less liable to mildew than that sown late.

Varieties of Wheat.

Upon the whole, it is shown that there is not much specific difference in the mildew-resisting powers of various kinds of wheat. Some reporters affirm that "Square-head" is less liable to mildew than other varieties. Mr. Middleton, of Marton, Yorkshire, remarks as follows: "there has been no mildew in my wheat this season. I attribute this in a great measure to the fact that I only sow the Square-head variety. I observe on several farms where I have been valuing the crops between the outgoing and incoming tenants that this variety has suffered much less than others, some being damaged fully one-half." On the other hand, Mr. Shepheard, of Hunningham, notes "that the Square-head variety of wheat is considered by many people to be particularly subject to mildew." Another reporter endorses this statement. "Rough chaff white" was in one instance much worse mildewed than other sorts. Mr. Kimber's experience is that the red wheats on his farm suffered most, and of these "Golden Drop" was the worst.

Mr. Rowland Wood, of Thrapston, makes this interesting note as to varieties: "Twice when I have had Reedy Red wheat and the old white Square-headed wheat, both have mildewed, when adjoining fields of Browick Red wheat, drilled the same time and the fields cultivated the same, have never blighted or mildewed. I have frequently tried to grow the white chaff Square-headed wheat, which has always blighted or mildewed, and I have never had the old Browick Red either blighted or mildewed. My land is woodland soil, and subsoil clay."

Upon Mr. Clarke's farm, at Scopwick, near Lincoln, Swallow's Red mildews as little as any variety. Mr. Clarke adds: "I have ten acres harvested this year from seed picked from the best ears, and it was only attacked slightly. I have thrashed it, and get four quarters per acre, and shall sow it this year all round."

"All red wheats," says Mr. Idiens, of Penkridge, "are less liable to mildew than white. I never knew a case of mildew on a variety known as the Old Red Lammas."

Most interesting records are furnished by Mr. Alfred Smith, of Rendlesham, upon this point. Mr. Smith sowed a field called Park Hill, in October 1892, with two varieties of wheat. "This field," he says, "in 1890 was cropped with peas, in 1891 with seeds, fed by sheep till July, when half of it was ploughed and sowed with mustard, which was fed off by sheep the latter part of October, the other part remaining seeds until October, when it was

mucked at the rate of sixteen carts per acre. The whole field was then ploughed the short way of the field, and drilled directly crossways of the plough. The half of the field next the road was drilled with 'Kinver' wheat, and was badly affected with mildew. The upper half was drilled with 'Windsor Forest,' and was free. Both varieties were drilled at the same time." It would seem from this that there is some resisting power in the Windsor Forest wheat, seeing that both varieties were subjected to the same treatment.

Samples of the grain and straw of Kinver and of Windsor Forest were sent most kindly by Mr. Smith, which bore out his statement. The straw and chaff of the former were much spotted with the black sori of *Puccinia graminis*, and the grains were shrivelled. But the Windsor Forest straw was bright and almost entirely free from sori, and the grain was plump and well-shaped, and as good a sample as could be seen in any season.

Mr. G. Watkins, of Gulpho Hall, Ipswich, experienced exactly the same result as Mr. Smith. Windsor Forest was perfectly healthy, whereas Square-head's Master, sowed alongside, and on the headlands round Windsor Forest, was badly blighted.

Weather.

In the reports received there is a general approximation with respect to the weather conditions. The autumn was very wet, so that the seed was got in late, and in very many cases went in badly. Here and there it could not be got in until February. After this there was a very dry time in most districts, which lasted more or less until the beginning of harvest. The temperature was below the average, according to all the correspondents. Beyond the fact that the difficulties of seeding, and the bad "season" caused a "thin plant," stated by several to be more liable to be attacked by mildew than a full and even plant, not much stress is laid upon the influence of unfavourable climatic conditions, with the exception of the remarkable frosts of June the 13th and 14th. According to many, the yellow, or rusty, form of the mildew showed itself soon after these frosts. This is corroborated by Mr. Duckham, the well-known agriculturist, who says, "I experienced a sharp frost in 1867 on the 28th of June. At that time my wheat was a grand crop. Yellow rust followed to a very serious extent." Mr. Duckham considers that wet weather also causes mildew, as he says that in 1879 and 1880, two very wet years, black mildew very seriously injured the crop; so much so, that the straw broke into short lengths when thrashed, and it was with difficulty he obtained any for thatching the ricks.

Barberry Trees.

Not much light is thrown upon the connection between barberry trees and mildew. They are said to be growing in the

neighbourhood of infected wheat-fields by some of the reporters, who, however, do not seem to attach much importance to their presence. Mr. Ellis, of West Barsham, reports that there are no barberry trees near, but their evil effects have been noted in the neighbouring district, but for several years the trees have not been permitted to grow. "My opinion," he says, "is that the mildew attacks are always rendered more virulent by the presence of the barberry. In a field of some forty acres a few years ago one hedge contained about seven barberry bushes, each of these most seriously affected a space in the form of an equilateral triangle; where the base was some forty yards wide with the bush midway, and the apex some 100 yards into the field, there the effect seemed to die away. The remainder of the field was quite free from blight." Mr. Kimber, of Fyfield Wick, has no barberry trees growing near his land, but he remarks that he had a farm for many years in the adjoining parish on which there were two light sandy fields—one lying on the east side and one on the west side of a garden shrubbery in which a barberry tree was growing. These fields when in wheat were often affected by mildew, and he noticed that the attack always began in a small spot in either field on the side adjoining the shrubbery, and gradually spread itself from those points.

Mr. Charles Howard has a barbery tree growing in his garden quite half a mile away from the wheat fields. He observes: "In my case it does not appear that the mildew could be caused by this single bush at such a distance. At the beginning of this century, Batchelor, in his book of Bedfordshire, gives the experience of several persons upon this point; but it appears that the wheat was only affected when grown in close proximity to the barberry bushes which were in the hedgerows."

Of infected wheat land, near Lymington, Hants, Mr. Gibb writes: "Barberry trees or shrubs are present in adjoining hedgerows, but are not very abundant. Wheat generally shows symptoms of attack at outsides, or near to hedges, first, indicating that uredospores are carried by the wind from hedges or other foul sources. Where barberry plants have been seen to be badly affected by æcidio-spores, if there is wheat near, an attack of mildew of greater or less severity, according to the season, has been seen to follow." One reporter, Mr. Galpin, of Blandford, who has given much practical information, remarks that his farm when he took it had been "beggared out, as they say." He states that there were several barberry bushes in the hedges. These he rooted out, and the farm, although naturally poor, is not nearly so liable to blight as it used to be. He adds: "With regard to the connection between barberry bushes and mildew I am not qualified to speak. but believing there to be some connection between the two, I thought it best to get rid of the barberries. I have noticed very little mildew in barberry bushes this year. My own opinion is that the best way to combat mildew in wheat is to farm high and sow early."

Messrs. Malden report that wild barberry, and many other species of *Berberis*, are very commonly found in the gardens,

as they are very popular shrubs. They are occasionally met with in the woods, hedges, and coverts in the neighbourhood. Messrs. Malden first noticed blight on the barberry this year about May 12th. On June 18th the cups were numerous, and in an advanced condition, and the microscope showed the spores being given off in large numbers.

Mr. Shepheard reports that there are no barberry trees near him. He has known instances in which a patch of mildew has spread across part of a field, apparently taking its rise from a barberry tree, and the attacked strip gradually narrowed as it got farther from the tree, but he has never farmed land where barberry trees have been in proximity.

Experiences of former Seasons.

Mr. Palmer, of Revell's Hall, Hertford, says, "We nearly always have had some mildew in this neighbourhood, and it is generally more prevalent in wet summers than in dry, but this is not always the case. There is not any doubt that wheat is best cut early when attacked by mildew, and it has always been my practice to cut it, if possible, before it has become black. There are two advantages in this: first, the straw is more valuable; second, the wheat is of better quality."

Mr. Stratton, of the Duffryn, Monmouth, reports that mildew generally attacks the wheat crops, especially when late sown. Crops grown on land in a high state of cultivation are more liable to it than any others; also on lands lying low and damp they are more often affected. Damp and sunless weather is very conducive to the development of mildew.

Mr. Clare Sewell Read has often had partial attacks of mildew, which generally followed heavy top-dressings or thin-planted wheats, especially from nitrate of soda, and frequently the grain has been greatly injured; but he never experienced such an attack of mildew which so damaged the straw, and *spared the grain*, as in the season of 1892.

On Ossemly Manor Farm, near Lymington, Mr. Gibb reports an attack in 1891, and writes: "Late-sown wheat was attacked, early-sown escaping. Where backward wheat is top-dressed with nitrate of soda, I have found it particularly liable to mildew; or wherever there be an excess of nitrogen in the soil, from whatever cause, when rain in June follows warm dry weather, an attack is almost certain. White wheats, particularly the long-strawed and delicate varieties, are more subject to attack than red. I have found the application of lime, where the soil is deficient in this property, very beneficial, either in the form of hot lime, gas lime, marl, chalk, or, latterly, basic slag. Superphosphate sown with wheat on the black peaty soils adjoining the New Forest will greatly lessen the chance of attack, and increase the yield of grain, and give stiffer and better straw, even when half the ordinary application of farmyard manure has been withheld."

"Mildew," Mr. Geary, of King's Langley, states, "has generally appeared in wet seasons, or when late frosts have been experienced. No blight in 1868, 1869, 1870, 1877, 1886, and 1887, except in the field near to the barberry tree."

The experience of Mr. Allsop, of East Wellow, Romsey, Hants, is that in seasons of mildew there is always a very bad yield of corn, a very bad sample, a very low price, and very poor weight per bushel. He says, "I am stacking my last field of wheat to-day, and it is the blackest straw, and the worst sample of corn, I have ever seen."

"Never experienced mildew, except there have been frosts; but people must rise early to know this," are the observations of Mr. Garne, of Bourton-on-the-Water, Gloucestershire.

Mr. Alfred J. Smith, of Rendlesham, has attributed mildew to game and rabbits keeping the plant backward during the spring, and consequently a very luxuriant growth later on, but he is not convinced of this.

Mr. C. Lee Campbell, of Glewstone Court, Ross, whose loss was heavy this year, states that his wheat crops were never seriously affected before.

Writing of his district in Bedfordshire, Mr. Charles Howard remarks: "It is thought that mildew has not affected the wheats so much since 1855."

"It has generally happened that the wheat has been mildewed when the summer has been dull and cloudy, with a lack of sunshine," writes Mr. Selman, of Chippenham.

Mr. Kimber's experience is that hitherto mildew has confined its attack at Fyfield Wick to single fields, or parts of fields, and the cause could generally be attributed to some special treatment which the fields had received; usually to an excessive dressing of nitrogenous manure. He adds: "This season it would appear that on our poor light soils the wheat plants suffered from weakness, and from some cause or other had not sufficient strength and vitality to resist the attack of the fungus."

"If a piece of wheat becomes laid about a month before ripening it has generally become affected by mildew," is the opinion of Mr. Albert Pell; and Mr. Joseph Martin, of Littleport, has always considered that the appearance of mildew is entirely owing to the weather, and this season has strongly confirmed his previous opinion.

Mr. Idiens, of Penkridge, Stafford, remarks that he has had a good deal of experience with mildew in former years, and is of opinion that it is sometimes caused by July frosts when the corn is in a milky stage, adding that such would be the case this year. He says "rough chaff wheat is the most liable, particularly if it is shown on a clover ley, and should it happen to be a *thin plant* in spring, and late in its spring growth, it is very certain to be blighted unless the summer is very dry."

The worst attack of mildew within the experience of Messrs. Malden, of Cardington, Bedford, was in 1879, when they weighed wheat only 49 lbs. the imperial bushel. They observe: "There is wheat in this country now no better; but, as it was

harvested in a dryer condition than in 1879, it weighs rather more; 1880 was nearly as bad as 1879. Every cold wet summer produces mildewed wheat. In fact, it is present and does damage every year, though, as a satisfactory yield is often obtained in spite of it, its evil effect is not noted. Between this and Luton, towards the left to Biggleswade, most of the plaiting straw used in the English straw plait manufacture is grown, and doubtless those who examined the straws carefully would say they never knew a season when all the straws were clean. There have been none of good quality for plaiting since 1887. The loss to the country must amount to an average of millions of pounds per annum. The disease is most prevalent in sunless years. Also in years like the present, when there are severe frosts in June. Stout straw wheats, such as Rivett's, generally suffer less than that of weaker varieties. Before 1887 Rivett and Hardcastle formed a mixture for which this parish was celebrated, but during the cold seasons after that period they could not be grown profitably; no sorts are profitable now. Square-head, Rivetts, and others had to be grown in their places. Latterly we have been able to grow the two former varieties with fair success, but this year all are a failure. No wheat in this parish has fetched 30*s.* per quarter (504 lbs.) this season. It would be most serviceable if it could be proved that the wheat mildew can only originate after it has passed through the barberry. As far as scientists have gone the point seems to be, can the uredo spores exist through the winter? If they cannot, the question lies in a nutshell."

Other Particulars on the Subject.

The answers under this head are somewhat diversified, and give a good deal of general information of a useful character. For instance, Mr. Ellis, of West Barsham, replies that top-dressing a thin plant with nitrogenous manure nearly always intensifies, if it does not induce, the blight; and, again, a thin plant is always more liable to blight than a full plant. Top-dressing in any case is, in his opinion, dangerous for wheat on starved land.

Mr. Idiens believes that rust and mildew are very frequently brought on through top-dressings of nitrate of soda and sulphate of ammonia on thin plants, and very rarely so if the plant be a thick one.

The opinion of Mr. Marsden, of Morley, Yorkshire, is, "that cold, wet weather in summer, and the absence of sunshine when the wheat is in bloom, is the chief cause of mildew, especially when the straw becomes lodged on the ground."

Another statement as to a thin plant of wheat being more often affected than a good, full plant is made by Mr. Selman, of Chippenham. "In a field," he writes, "of eleven acres, one-half of which was a good plant and free from mildew, the other half was this year affected badly, and on this part, although

sown the same day, the plant was thin, and this has been my experience on former occasions."

Mr. Clare Sewell Read remarks that late wheats, those thinly planted, and all those growing on peaty soils on low-lying lands, or where the field is surrounded with high hedgerows, and many trees, are more subject to mildew than early wheats with a full plant and growing upon high sound land. "Indeed," he adds, "it is only rarely that upon such soils, unless too heavily manured, that mildew does much damage in this part of Norfolk."

Mr. Primrose McConnell, of Ongar, Essex, believes that the attacks of mildew may be largely prevented by draining, liming, cutting down the hedges, and the use of mineral manures, so that a flaggy growth may not be induced, and by the growth of red wheat in preference to white.

Under this head, Mr. Chrisp, of Hawkhill, near Alnwick, writes: "I intended spraying all my wheat last spring by means of the Strawsonizer with hot lime and sulphur, two bushels of the former, and 4 lbs. of the latter to the acre, as a similar application worked wonders upon turnips the previous summer, but was prevented from carrying out my intention. This application, together with keeping the plant firm at the root by means of repeated rollings would conduce to its health and power of warding off disease."

Besides these communications in reply to the questions issued by the Board of Agriculture, others have been received complaining of the prevalence of mildew, notably in the Midland Counties and the Fen districts. These add to the conviction that the attack of mildew in 1892 was one of the most severe, if not the most severe that has ever been experienced in this country. They do not, however, throw any more light upon the cause of the disorder nor upon the conditions in which it appears, spreads, and devastates.

With regard to these conditions, the only definite consensus of opinion expressed in the answers to the Schedule of questions is that the low temperature in June caused the unprecedented attack. In some cases rust was noticed soon after the unusual frost of the morning of June 13th. In others the intensity of the attack is attributed to the general low temperature at the periods of the blossoming, and of the commencement of the hardening of the grains. No modes of cultivation seem to have made much difference. In respect of the influence of manures, some observers noted that mildew was worse when nitrate of soda had been used. It was also stated by several that wheat after clover ley was more severely affected than wheat after mangels and turnips. This evidence agrees remarkably with the opinion of Sir J. Lawes and Dr. Augustus Voelcker given *in extenso* later on, that mildew does far more harm to wheat on land having large available supplies of nitrogenous food. And, it must also be remembered, that an unusually large proportion of the wheat this year was put in after clover, as it was impossible to get it in on heavy soils after mangels and swedes.

There is nothing particularly new or striking in the evidence that has been obtained in the various answers to the Schedule of questions, and perhaps it could hardly be expected, as the subject involves close and continued observations, which busy men have not time to give. One or two points, however, stand out prominently, and require special comment. The first is that most of the reporters connect this severe attack of mildew with the changes of temperature, and particularly with the unusually severe white frosts in the spring and summer. And it is remarkable that in previous inquiries made with regard to mildew in this country by the Board of Agriculture in 1804, and by the Royal Agricultural Society in 1883, there is a similar agreement as to the connection between its attacks and abnormally cold weather. Another point is the apparent power to resist mildew in some varieties of wheat, as exemplified by Mr. A. Smith's experience above described. Mr. Smith's experience in this direction has been corroborated by the experience of Mr. Rowland with regard to the immunity from mildew of Red Browick.

PREVIOUS INVESTIGATIONS CONCERNING MILDEW.

It appears from agricultural literature that mildew has been common in this country for a long while. Hartlib, in his "Legacy of Husbandry." written in 1655, says, "Our husbandry is deficient in this, that we know not how to remedy the infirmities of our growing corn, especially smut and milde . which bring great calamities upon our country, the former in wet years, mildew in dry."

Jethro Tull, in his Horse-Hoeing Husbandry, published in 1731, speaks of mildew as causing "a year of blight, the like of which was never before heard of, and which I hope may never happen again."* It would seem that we do not know more "how to remedy this infirmity of our growing corn" than when Samuel Hartlib penned his Legacy. Though this has been for so long a persistent "infirmity," there have been only three inquiries of any importance concerning it. or at least inquiries of an official, or semi-official character. The first is that of Arthur Young, Secretary of the Board of Agriculture, made in 1805, and recorded in the Annals of Agriculture ;† the second was conducted by Sir J. Sinclair, in 1809,‡ also in connection with

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* *Horse-Hoeing Husbandry*, by Jethro Tull, p. 74.

† *Annals of Agriculture and other Useful Arts*, collected and published by Arthur Young, Esq., Secretary of the Board of Agriculture, vol. xliii., 1805.

‡ *Results of an Inquiry into the Nature and Causes of the Blight, the Rust, and the Mildew, which have particularly affected the Crops of Wheat on the Borders of England and Scotland*, by Sir J. Sinclair, Bart., M.P., 1809.

the Board of Agriculture; and the third by Mr. W. C. Little, in 1883, undertaken for the Royal Agricultural Society of England.* These inquiries were conducted pretty much upon the same lines, by means of a Schedule of questions forwarded to leading agriculturists in different parts of the country; and although in the first two the results are not particularly conclusive, except, perhaps, as to cold, changeable weather being, to a great extent, the cause of mildew, there are more definite conclusions stated by Mr. Little, which may be given here in his own clear words:—

1. "It would appear that seasons are the chief cause of mildew, and that sudden changes of temperature and rain, accompanied by close, still weather, are favourable to the spread of the disease.

2. That low-lying soils are most subject to this attack.

3. That high farming and too generous manuring, particularly with nitrogenous manure, promote mildew.

4. That early sowing is desirable on all land subject to mildew.

5. That a thin and gathering crop runs more risk of the disease than an evenly-planted crop."

Mr. Little also received most important communications from Sir J. Lawes and Dr. Augustus Voelcker, which are worthy of reproduction here, as they show that the effects of mildew depend materially upon the constituents of the soil. Thus, Sir John Lawes writes: "I consider that plants are liable to be attacked by fungi, parasites, insects, &c., in proportion as the soil is deficient in available mineral food. I happened to pass through the Fen district in the summer of 1881, and I particularly noticed the dreadful state of the wheat in that district; and as my own wheat, although not a good crop, had not suffered from mildew, I was anxious to know whether the season in that district possessed any special characters differing from my own. According to my view, fen-land wheat should be especially liable to mildew, as the balance of the soil-constituents is organic and not mineral. Ordinary arable land such as mine contains about 97 per cent. of mineral matter, and 3 per cent. of vegetable substances. Some of the fen land must have these proportions almost reversed. It is quite possible that when the climate favours mildew, it will prevail more or less, but the extent to which it will prevail, will greatly depend upon the relation between the mineral and organic matter in the soil, and I should be disposed to say that the greater the amount of available mineral matter, potash, lime, silica, phosphate at the disposal of the plant, the greater would be its power of resistance." †

* The Journal of the Royal Agricultural Society of England, vol. xix., 2nd ser.

† Mr. Little's Report, Journal of the Royal Agricultural Society, vol. xix., 2nd ser.

Dr. Augustus Voelcker, writing to Mr. Little in 1882, remarks, after having given the analysis of a soil upon which wheat was much mildewed: "This is a very instructive case, for it confirms the frequent observations I have made in various parts of England, that an excess of available nitrogenous food, be it nitrate of soda, ammonia, salts, or organic matters which are readily decomposed in the soil, appears to me to have a decided tendency to cause mildew in wheat." Dr. Voelcker goes on to show that wheat after a root-crop would be expected to be far less mildewed than wheat after clover, which leaves a large amount of nitrogenous food in the land.

These are valuable contributions to the theoretical knowledge of this subject, and are to some extent borne out by the various inquiries that have been made respecting it, but it requires careful experimentation and close observation to prove exactly what is the effect of nitrogenous manures upon mildew, as well as to demonstrate accurately what other conditions are favourable or unsuitable to its development and progress. Looking at the four sets of inquiries that have been made since 1805, and comparing them together, it is evident that the last does not throw much more light on the question than the first, and that if this question is to be solved satisfactorily it must be relegated to trained observers.

MILDEW IN FOREIGN COUNTRIES.

Mildew, or rust, as it is generally termed abroad, is exciting as much interest in other countries as in Great Britain. In the United States, mildew, or rust, is a frequent trouble to wheat-growers, occasionally causing much injury,* and is fitful and uncertain in its visitation. In the United States, as in England, and probably in all wheat-growing countries, there are other kinds of mildew, or rust, than that due to *Puccinia graminis*, which affect wheat crops, though they are not generally differentiated by agriculturists. For example, in Great Britain the fungus *Cladosporium herbarum* in some districts did as much harm as *Puccinia graminis* in 1892, and possibly in previous years. Rust is the common term employed in the United States for affections of this nature as distinguished, however, from smut, *Ustilago segetum*, and in Australasia rust is generally used to designate the effects of *Puccinia graminis* and other fungi of similar characteristics. In Germany the attack of *Puccinia graminis* is styled rust, *Getreide-rost*.

Great interest in the question of rust is being taken in the United States at this time. The Massachusetts Experiment

* In the Bulletin of the Agricultural Experiment Station of Indiana, U.S., it is stated that rust is often credited with damage equal to 50 per cent. of the normal crop, and it is estimated that the annual average loss from this cause represents a sum of 820,000*l*.

Station sent out a circular of inquiries early in May 1892, to farmers, gardeners, and mycologists as to the condition in which rust is prevalent and destructive and as to its effects upon the crop. There were eight questions asked, and they are very similar to those at the head of this paper. The answers and the report thereon have not yet been received, but they cannot fail to be interesting, as the Massachusetts Experimental Station is one of the most important and most ably-conducted of these numerous American institutions.

A large number of experiments were made in 1892 by the Division of Vegetable Pathology of the United States Department of Agriculture upon wheat-rust; the results of these have unfortunately not yet been published. Experiments upon rust, or mildew, on wheat were also carried out in 1890 at the Agricultural College at Guelph, in Canada, and the following conclusions were arrived at :—

1st. Seasons are the chief cause of rust. Sudden changes of temperature and rain, accompanied by close sultry weather, are favourable to its increase.

2nd. Low-lying rich soils are most subject to its attacks.

3rd. An excessive use of manures rich in nitrogen encourages the disease.

4th. Late-sown grain-crops are the most liable to the attack.

5th. Thinly-sown wheat crops are most liable to rust.

An inquiry of this nature was also instituted by Professor Panton, Natural History Professor to the Ontario College of Agriculture, in which the results were identical with those arrived at from the Guelph experiments.

Australasia.

Rust has been present in some of the Australasian colonies for a long while, according to Sir J. Banks, who states that it was known in New South Wales in 1803;* but it appears to have increased lately, and has caused considerable excitement during the last few years. In 1890 a Conference of delegates from New South Wales, Victoria, Queensland, South Australia, and Tasmania was held at Melbourne to discuss the subject, and to consider what modes of prevention and remedies could be adopted. A similar Conference was held in 1891 at Sydney, and in 1892 delegates from the above colonies assembled at Adelaide. At the meeting at Sydney in 1891 the President, the Hon. Sydney Smith, Minister of Agriculture, in his address to the delegates said: "No one can deny the immense amount of damage caused by rust in special years, and the considerable mischief caused even in what may otherwise be called favourable years. When we learn that the loss in our greatest wheat-

* *A Short Account of the Cause of the Disease in Corn called by Farmers the Blight, the Mildew, and the Rust*, by Sir Joseph Banks, Bart., P.R.S.

growing colony has been estimated at 1,500,000*l.* for one year, and that the total loss to Australia is not far short of 2,000,000 *l.* sterling, it can easily be seen that the subject we have to discuss is one of national importance."

As a preliminary to these Conferences a circular of inquiries was sent to numerous farmers in each colony. Many replies were received, but, as was pointed out in 1892, by Dr. Cobb, a delegate from New South Wales, "The sending out of questions has been rather unproductive. If the Conference does nothing but propose a continuance of this plan of elucidating information from the farmers, any further meeting would be without practical result." It was stated by the President at this Conference that experiments were being regularly conducted at the Agricultural College in South Australia, thirty miles from Adelaide, and in various parts of the same colony, six experimental plots of 40 acres each had been established by the Government for the purpose of making experiments as to rust in different climatic conditions.

The conclusions of the Conference of 1892 may be shortly summarized. As they practically embody the results of the Conferences held in 1890 and 1891 it is unnecessary to go further. They are mainly, that the influences upon the development of rust of various kind of manurings, of treatment of the ground, treatment of seed, different times of reaping, of the variety of wheat grown, and so forth, were put to the test of experiments extending over two years, and found to be unimportant as compared with the time of sowing, and, especially with the variety of wheat grown. Manuring and treatment of the soil, methods of cultivation, time of reaping, etc., have an influence upon the development of rust, but that influence is trifling compared with the influence of the variety of wheat grown and the time of sowing. It was clearly shown that there are several varieties of wheat, which, except under very unusual circumstances, are never seriously attacked by rust. And it was also shown that in many districts early sown wheats of a kind liable to rust generally escape damage by rust while the same wheats sown late suffer seriously.

In view of these facts, the Conference directed attention mainly to encouraging the growth of varieties less liable to be attacked by rust, and also to early sowing. To this end it was found desirable to find out precisely what are the characteristics of those wheats which are less liable to be attacked by rust, and a step has been taken in this direction. In the first place, the following classes were made in which to place the various wheats :—

First Class.—Rust-proof wheats, by which are meant wheats which will not permit the mycelium of rust to enter into their tissues.

Second Class.—Rust-resisting wheats, by which are meant wheats which in localities suited to their growth and under normal conditions, resist at all seasons of the year either

the entrance of the rust mycelium into their tissues, or its subsequent growth and outburst. Of this class many examples are known.

Third Class.—Rust-liable wheats, by which are meant wheats which, under the usual conditions of growth, offer no resistance to rust. Australian wheats now mostly belong to this class.

Fourth Class.—Rust-escaping wheats, that is to say, wheats which, like the third class, are rust-liable, but which if sown at the proper time, ripen so early as to be ready for harvest before the rust of an ordinary season can prevent a paying crop.

Of these two classes the most important are the second and fourth. The characteristics of the second class, namely, the rust-resistant wheats, have been found by a thorough and close examination of 12 varieties to be as follows :—The possession of a thick or tough skin, so tough that though the mycelium may enter the plant by means of the open stomata, yet it cannot break through the skin in order to mature and shed its spores, so that its further development is prevented. And, secondly, the presence of waxy exudation on the surface of the plants similar to the bloom of fruit; this waxy covering, when present about the mouth of the stomata, prevents the rust mycelium from entering. Wheat-plants possessing tough skins, and especially if possessing toughness of the skin in conjunction with the waxy bloom, may be grown under all conditions suitable to their normal growth without suffering seriously from rust. On the other hand, rust-liable wheats, which are characterized by the possession of a thin and tender skin, and often by the absence of waxy bloom, can be grown successfully during a rusty year only in one way, namely, by sowing at such time as the plant shall be for only a short time subject to the attacks of the rust-fungus.

The principal measures recommended by the experts and farmers assembled in conference in Australia for dealing with rust are the growth of suitable varieties of wheat, and for this they advised that an organized system should be established for the maintenance or improvement of the qualities of the best existing varieties, and for the production and distribution of new and improved varieties. For this a definite scheme of an Intercolonial character was arranged to be established, by means of which farmers, it is hoped, may have distributed among them, as occasion may require, rust-resistant and rust-escaping wheats suited to their districts, whose qualities have been proved by stringent tests.

It was stated that at the Agricultural Show held in Adelaide in June 1892 two very fine and complete collections of rust-resistant wheat were exhibited, and prizes awarded.

No absolutely rust-proof variety of wheat has yet been discovered; but experiments have proved that by importing varieties, and carefully selecting and crossing them within the

colonies certain kinds have been found to escape to a considerable extent the ravages of rust, and the last Conference recommended that the work of selecting and crossing imported wheat should be continued; and for this it was resolved to recommend the Governments to establish a central station in each colony for testing new wheats imported, and producing new varieties, and distributing them among the farmers.

Germany.

The German Agricultural Society, Deutsche Landwirtschafts-Gesellschaft, issued a list of questions upon the prevalence of rust throughout Germany in 1891. There were no less than 400 replies from all parts of the country.

From these it was shown that East Prussia and the Rhine Provinces had suffered the least from rust. Posen and Silesia had suffered considerably more, as well as the Middle States to Hanover and Oldenburg, and through Hesse and Nassau to Würtemburg and Baden. Thus in Prussia 83 per cent. of the wheat-land was rust-free; and 80 per cent. in Westphalia and the Rhine Provinces, while in Posen, the Middle German States, and Würtemberg, the per-centage of rust-free wheat-land ranged from 42·4 to 50 per cent.

With respect to the loss sustained in Germany from rust on wheat plants in 1891, it was reported by 143 agriculturists, having 19,855 acres of wheat-land, that their average loss amounted to over five bushels per acre.

In answer to the question regarding the effect of manures upon rust, the general reply was that where nitrate of soda had been applied as a top dressing (kopfdüngung) the rust was worst. Phosphatic manures, on the contrary, exercised a good influence against rust.

But little information is gained from the replies to the question as to varieties which resisted rust better than others. Winter wheat, Noë Weizen, was found to be more rust-resistant than spring wheat, and among the most resistant varieties Square-head, or Sheriff's Square-head wheat stood prominent.

The German Agricultural Society continued this inquiry in 1892, but the results have not yet been published.

India.

Rust is very destructive in India. At least it is certain, according to the statement of the late Mr. A. Barclay, F.S.A., that this disease exists in the Punjab, North-Western Provinces and Oudh, the Central Provinces, and Berar. Mr. Barclay estimates the annual average loss to the wheat-growers of this area at nearly 3,000,000 rupees, adding that if rust prevails in the other parts of wheat-growing India, as he believes it does

prevail, the total annual loss would equal 4,000,000 rupees.* Mr. Barclay, in a communication to the "Transactions of the Agricultural and Horticultural Times of India," quotes Captain Herman, who reported that he had seen, so long back as 1827, "rich sheets of uninterrupted wheat cultivation for twenty miles by ten in the valley of Narbadda, so entirely destroyed by this disease that the people would not go to the cost of gathering one field in four."

Japan.

Mr. Barclay also quotes the Director of the Agricultural Experiment Station of Indiana, lately in the service of the Government of Japan, who states that in the northern parts of that country, where the Government has made strenuous and costly exertions to supplant rice-culture by wheat-growing, the latter crop is frequently ruined, and on the average damaged to the extent of 20 per cent. by rust.

THE CAUSE OF MILDEW OR RUST.

Mildew on wheat-plants has been known in Great Britain for over 300 years, according to the records. Probably, however, it has been present upon them since the first cultivation of wheat. That it is a very ancient affection is proved by frequent references to it, and deprecatory remarks concerning its baneful influences in old Greek and Latin writings. The first published account of it, ascribing it to fungoid origin was, it is believed, given by an Italian, Fontana, in 1767.† Persoon gave a more correct and elaborate description of the fungus in 1797, and named it *Puccinia*, after Puccini, a Florentine professor.‡ The first highly-magnified figures of it were made by Bauer in 1805. These admirable coloured figures were drawn to illustrate the account of the mildew written by Sir Joseph Banks, President of the Royal Society, and published as a separate essay, which was published also in the "Annals of Agriculture," by Arthur Young.§ Sir Joseph Banks had a very good idea of the cause of mildew, or "the blight" in wheat, and of the action of fungus upon it by its spores "germinating and pushing their minute roots, no doubt, though these have not yet been traced, into the cellular texture beyond the bark where they draw their nourishment, by intercepting the sap that was intended by nature for the nutriment of the grain." Sir Joseph Banks also considered it "more than probable that the parasitic fungus of the barberry and that of wheat are one and the same species, and that the seed is

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* *Rust and Mildew in India*, by the late A. Barclay, M.B., F.L.S.—Journal of Botany, British and Foreign, vol. 30, January, 1892.

† *Crittogamia agraria*, pel Dr. Comes.

‡ *Synopsis Methodica Fungorum.* Gottingen, 1797.

§ Annals of Agriculture, vol. xliii.

transferred from the barberry to the corn."* Professor Henslow was the next authority upon this subject, who confirmed Sir Joseph Banks' conclusions, and first propounded the theory, afterwards confirmed by Tulasne, that the yellowish rust which appears in summer, and the black mildew which comes later, are identical. Professor Henslow also gave much credence to the connection between the barberry and the wheat mildew, but did not much advance the knowledge of this part of the subject beyond Sir Joseph Banks' "possible" connection.† But little was added to the information as to mildew until 1865, when De Bary published the results of experiments practically demonstrating that an Æcidium,‡ or a stage of a fungus known as *Æcidium berberidis*, found on the barberry tree, is the origin of the wheat mildew, or, in other words, the first stage in the life of the mildew.§ This explained the mystery. All attempts to produce the early stage of the mildew, called "rust," upon wheat plants by means of the black spores, or teleutospores, had utterly failed, and De Bary proved that wheat plants can be affected by the Æcidiospores, or spores direct from the barberry tree, and that the teleutospores germinate upon and infect the barberry. De Bary's discovery was not accepted at once, but now it is generally recognised as the solution of the difficult question as to the first cause of wheat mildew.

There is, however, a disposition to believe that the Æcidium may have another host plant, at least in other climates, and in some circumstances; this will be dealt with later on.

The Life History of the Fungus.

The wheat mildew, *Puccinia graminis*, belongs to the group of fungi, termed Uredineæ, which, as De Bary points out, are all parasites on livng plants.‖ Some of the species of this group go through the various stages of their existence upon our host plants, being styled autœcious. Others are heterœcious, and pass from one host to a different host in their various stages of development. *Puccinia graminis* is a typical instance of this, as in its Æcidium form it lives upon varieties of Berberis; and only upon corn plants and grasses, first, in its uredospore, and then in its teleutospore condition.

Those who have carefully noticed barberry bushes in the

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* *A Short Account of the Cause of the Diseases in Corn, called by farmers the Blight, the Mildew, and the Rust*, by Sir Joseph Banks, Bart. P.R.S.

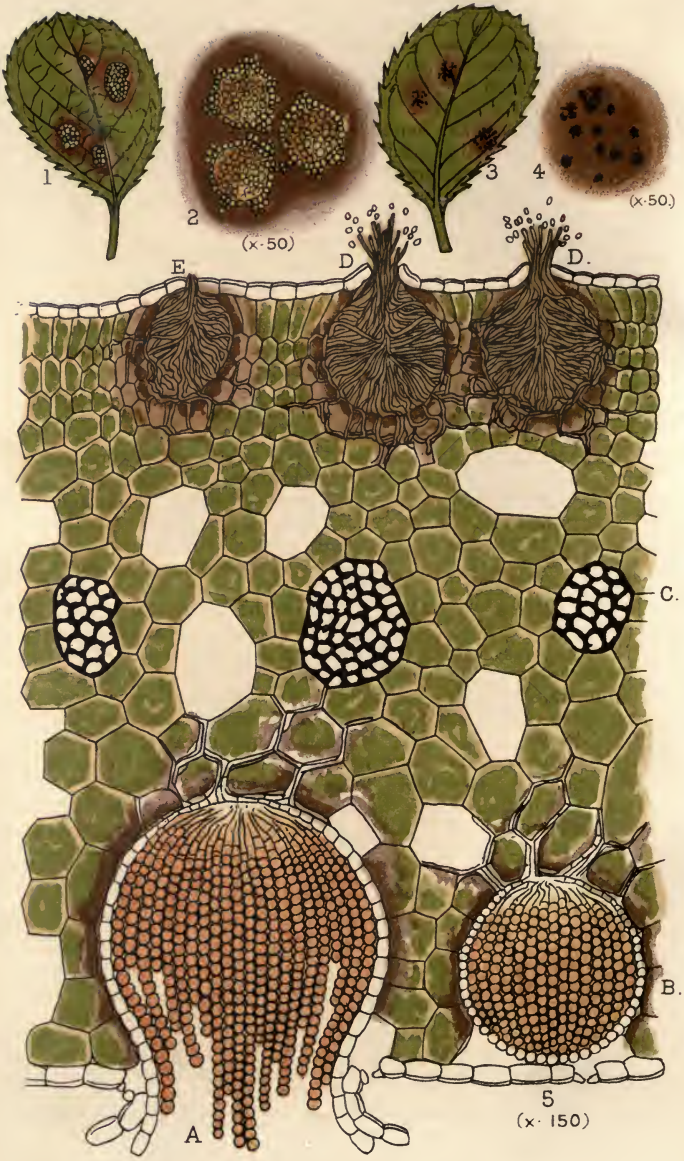
† *On the Diseases of Wheat*, by Professor Henslow, M.A. Journal of the Royal Agricultural Society of England, vol. ii., p. 1, 1841.

‡ Literally, a small house. De Bary explains it as "in the Uredineæ, a cup-shaped envelope and a hymenium occupying the bottom of the cup, from the basidium of which spores, æcidiospores, are serially and successively abjointed."

§ *Neue Untersuchungen über Uredineen.* De Bary, Monatsbericht der Berlin Akademie, 1865.

‖ *Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria*, by A. De Bary.

Barberry Blight.



Æcidium Berberidis Pers.

spring have frequently seen yellow spots upon their leaves (Pl. I., Fig. 1), where threads of mycelium can be seen thickly running through their parenchyma. In these spots there are two kinds of fructification. The one consists of numerous spore-like bodies detached from hyphæ, or branches, from the mycelium formed in urn or flask-shaped receptacles upon the upper side of the leaf (Pl. I., Figs. 1 and 2). It has not yet been discovered what functions these spermogonia perform.* The other fructification occurs on the underside of the barberry leaf, appearing, first, as groups of tiny dots (Pl. I., Figs. 3 and 4). These are surrounded with mycelial threads, and when ripe they burst through the epidermis, or skin, of the leaf, forming cups or bell-shaped cavities (Pl. I., Fig. 5, A. & B). In the bottom of the Æcidium cup there is a hymenium or collection of "mother spore cells," from whose hyphæ spores are being continually given off. They are not quite round,† and are inconceivably numerous, so that thousands may be disseminated far and wide by the wind from one spot, or Æcidium cluster. Mr. Marshall Ward, writing of another species of the Uredineæ, the *Hemileia vastatrix*, the pest of Ceylon coffee planters, estimated that upon one "disease spot upon a leaf of a coffee plant there were 150,000 spores present." There were 127 "disease" spots upon one pair of leaves, so that the number of spores upon one plant might be beyond calculation.‡

In Plate I., at Figure 5, is shown a transverse section through a barberry leaf infected with *Æcidium berberidis*, displaying the Æcidia in two forms at the lower part, (A. & B.) and the spermogonia on the upper part, (E. & D. D.), with intercellular spaces invaded, (C.)

Mr. Carruthers, in a concise report upon the wheat mildew, says, "the quantity of spores produced on a barberry leaf is enormous."§

These spores, known as Æcidiospores, germinate readily upon the leaves of the wheat and oat plant, and many grasses, as enumerated by Mr. Plowright.‖ De Bary first germinated these spores upon wheat plants, and his experiment has been repeated by others. Mr. Marshall Ward observes, "These Æcidiospores will germinate readily in water on the leaves of wheat, and their germ tubes enter the stomata, and develop a mycelium which gives rise to the uredospores, and eventually to the teleutospores of *Puccinia graminis*."¶

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* Mr. Worthington Smith says, "these spermogonia are supposed to be little grains belonging to a male organism roughly answering to the pollen of flowering plants."—*Diseases of Field and Garden Crops*, by Worthington G. Smith.

† Sachs says, "Originally of a polyhedral form in consequence of pressure from opposite sides, they afterwards become rounded." *A Text-book of Botany*, by Julius Sachs.

‡ *Report on the Coffee Disease*, by H. Marshall Ward, Esq., 1881.

§ *The Wheat Mildew*, by W. Carruthers, F.R.S., Journal of the Royal Agricultural Society of England, vol. xviii., 2nd Series.

‖ The Gardeners' Chronicle, August 1882.

¶ *Illustrations of the Structures and Life History of Puccinia Graminis, the Fungus causing the Rust of Wheat*, by Marshall Ward, M.A., F.R.S., F.L.S. Annals of Botany, vol. ii., 1888–9.

The Æcidiospores are formed from the latter part of April up to as late as July; the appearance of a plant infected by them is described by Fig. 1, Pl. II. When the spores fall upon the leaf of a corn or grass plant they germinate in from seven to ten days if moisture is present. The filaments of the germinating spores enter the stomata, and form the mycelium developed in the tissues of the leaves. Uredospores are formed in longitudinal red blotches, or sori, upon the leaves and stems of the host plant, as shown by Fig. 2, Pl. II., and in this stage the fungus is usually denominated *Uredo linearis*. One of these pustules considerably magnified is given in Fig. 3, Pl. II. A vertical section of a sorus, more highly magnified (Fig. 4, Pl. II.), shows under the broken upturned epidermis of the leaf the branching hyphæ with spores. These spores are soon disengaged and disseminated by the wind, or other agencies, and germinate in favourable circumstances in a few hours upon wheat, oats, rye, and some grasses. Their shape and appearance are indicated by Fig. 5, Pl. II., very highly magnified, and on either side of the spores are shown germ tubes put forth from them in the process of germination. There may be several generations of this uredo form of the fungus during the season.

After a time a change occurs in the colour of the spores that are produced. The spores become dark brown, and finally black. The sori also turn to black brown, and the spores then are termed teleutospores, or the final spores. This change happens as the host plants ripen, and is caused by the process of maturing. And it is at this stage that the fungus does the most mischief, or it may even be said its chief mischief, as the host plants require all their starch for forming seed at this period.* If there is much moisture at this time favouring the development of the fungus, it frequently happens that the straw is thickly covered with the black pustules, and the grains of corn are shrivelled because of the abstraction of the starch necessary to make them perfect. As a rule, the first stage, or the uredo stage, with its reddish yellow spores, is not particularly harmful to corn plants, unless the season is exceptionally favourable for its development.

The peculiarly shaped black pustules, or sori, of the teleutospore stage, on the straw of corn plants, are delineated in Figs, 6 (natural size) and slightly magnified at 7, Pl. II., and are shown considerably magnified in Fig 8, Pl. II. If a section of infected straw is examined it is found that the tissues of the cells have been completely broken down by the action of the mycelium of the fungus, and the teleutospores can be seen upon their hyphæ (Fig. 9, Pl. II.). These teleutospores are quite different in shape from the uredo spores, being shaped like a club, and dark brown or blackish, in colour.† They are divided in the middle by a wall or partition, so that they form two cells. (Fig. 10, Pl. II.)

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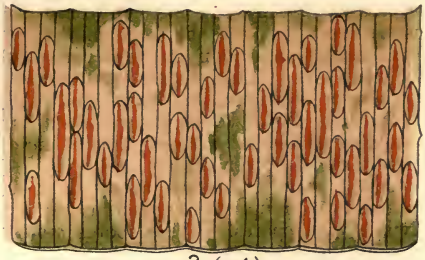
* As is well known, parasitic fungi cannot form starch like other plants which have chlorophyll, and must get this food from the host plants.

† Uredo spores and teleuto spores can sometimes be found together, coming from the same mycelium, or centre.

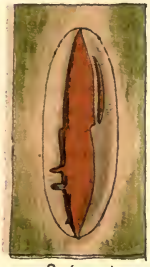
Summer Rust & Mildew of Corn.

1.

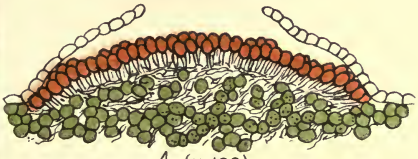


2 (x·4)

5
(x·700)



3 (x·20)

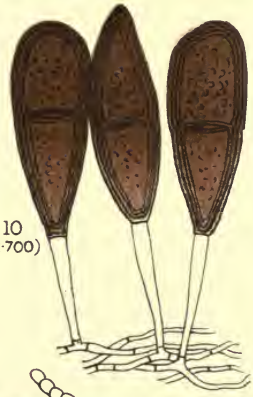


4 (x·100)

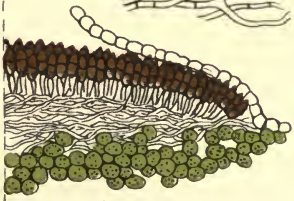
6.

7 (x·4)

8 (x·20)



10
(x·700)



9 (x·100)

Puccinia Graminis Pers.

Teleutospores are practically the rest, or resting, spores of *Puccinia graminis*, in which form the fungus is carried through the winter. They do not germinate at once, at least naturally, and go through the winter on the infected straw, or grasses. It is not known whether they "rest" on the ground, or in other places where they may have been carried by the wind and other agencies.

De Bary says: "Teleutospores of *Puccinia graminis* which have lasted during the winter germinate with great readiness in the spring which succeeds their period of ripeness; more slowly and more infrequently during the following summer months, and I was unable to procure their germination after August, or in the spring of the second year."*

Marshall Ward, on the other hand, gives a figure of four teleutospores germinating, of which he says, "the one to the top, and that to the right hand had been kept for three years in my laboratory."†

The teleutospores are, at all events, upon the straw, upon the stubble, and upon numerous grasses;‡ but in this form they will not germinate upon corn and grass plants. So far as is known, the *Puccinia graminis* can only be reproduced, and its life history completed, in this country at least, by means of the barberry, upon whose leaves the teleutospores germinate, by putting forth from their cells germ-tubes, like hyphæ, forming the promycelia producing sporida, which penetrate the epidermis of the barberry leaves, and, like the potato fungus, *Phytophthora infestans*, establish mycelia in the parenchyma.§

In due course the æcidium form, *Æcidium berberidis*, is evolved from these mycelial centres, and the æcidiospores are distributed over the land in the same manner as the spores of the fungus which attack the potato plant, and those of other destructive fungi.

The Æcidiospores germinate and produce uredospores upon wheat, oats, and rye plants, and many grasses. Oat plants, fortunately, are not materially injured in this country, but in other countries, as Germany, Russia, Sweden, Norway, with others, both oat and rye plants are as much affected as wheat plants. The injury caused to oats and rye is similar to that caused to wheat; the straw is blackened and deteriorated in value, and the grains are shrivelled, small, and deficient in starch.

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* *Comparative Morphology of the Fungi, Mycetozoa, and Bacteria*, by A. De Bary, 1884.

† *Illustration of the Structure and Life History of Puccinia Graminis, the Fungus causing the Rust of Wheat*, by H. Marshall Ward, M.A., F.R.S., F.L.S. Annals of Botany, vol. ii.

‡ Mr. Plowright gives a list of thirty-two grasses which are hosts of *Puccinia Graminis*. Among these are rye grass, couch grass, and other common grasses in fields, meadows, aod hedgerows.

§ De Bary says that "If the tube receive sufficient nourishment it developes directly in many cases into a mycelium or thallus, like that of the parent, and it is therefore the primordium of the mycelium." Op. cit.

The Berberis and Mildew.

In the history that has been given of this remarkable fungus and its many forms, it has been endeavoured to avoid minute details and elaboration, and merely to place before those principally and vitally interested the most salient and practical points. The least clear and definite among these is in respect of the intermediate host of the fungus, which is alleged to be the Berberis; and the Berberis alone. The careful investigations of De Bary failed to discover any other means of continuity. Many skilled mycologists have made experiments in this direction without any new discovery. Mr. Plowright has especially devoted himself to this study, and though once light seemed to be showing, obscurity still prevails.

This Berberis connection has been long known. Sagacious British farmers a great while ago suspected barberry trees of blasting their wheat. It formed the subject of one of Arthur Young's questions in the wheat mildew circular alluded to before.* Sir Joseph Banks speaks of the possible connection between the barberry and mildew. Sir John Sinclair also mentions cases where the presence of "barberry bushes" caused mildew in the neighbourhood. †

In France the pernicious influences of the barberry is fully recognised. As recently as April 1891 an order was issued by the Prefect of the Department of Eure-et-Loire, based upon the law of 1888 empowering local authorities to decree the destruction of insects and fungi injurious to agriculture, compelling landowners, tenants, and métayers, to root out and utterly destroy the barberry (l'épine vinette) upon their farms and lands before the 10th of July 1891, and in woods and forests to a distance of 32 yards from their outsides, seeing that the barberry is a veritable scourge of cereals, on which it develops black rust (rouille noire).

Then there is the old barberry law of Massachusetts, America, enacted by the Governor, Council, and House of Representatives,‡ which provided that. in order "to prevent damage to English grain from barberry bushes" all such bushes should be destroyed.

It should be understood that the *æcidium* of *Puccinia graminis* has been found upon several species of Berberis. Mr. Plowright gives a list of eight of these, including one of the pinnate species known as Mahonia, which are so frequently found in ornamental woods and shrubberies.§ It has also been produced upon *Mahonia aquifolium*, which is so largely used

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* *Annals of Agriculture*, by Arthur Young, Esq., F.R.S., vol. xliii., 1808.

† *Result of an Inquiry into the Nature and Cause of the Blight, the Rust, and the Mildew*, by Sir J. Sinclair, Bart, M.P.

‡ Province Laws of Massachusetts, 1736–1761, p. 152. Anno Regni Regis Georgii II., Vicesimo Octavo, Cap. X. (Issued January 13, 1755).

§ *Wheat Mildew and its connection with the Barberry.* Gardeners' Chronicle, August 1882.

for planting in game covers, and it may be inferred that other species of Berberis, and of other genera of the Berberidaceæ, are also hosts of the fungus.

The weak point in the conclusions arrived at by scientists as to the Barberry being the sole host of the æcidium form of *Puccinia graminis* is the fact that in countries where the Berberidaceæ are not indigenous, mildew on corn-plants is more abundant and destructive than in Europe. In parts of America, for instance, these shrubs are not known. In the Australasian Colonies, where mildew is fearfully prevalent, they do not occur. In India the barberry is common in the Northern Provinces, but "throughout the plains of India there is no species of barberry, and it is necessary to assume that the wheat plants were attacked by the æcidiospores of the barberry which had been wafted to them from enormous distances. The spores are, however, exceedingly minute, and it is quite possible they may be carried by the winds to such immense distances." *

The Australasian mycologists are endeavouring to discover the host of the æcidium, which stage has never yet been seen in Australasia.† Dr. Cobb, the pathologist to the New South Wales Department of Agriculture, states this, and at the Conference of Australasian delegates at Sydney in 1891, he said that "it was not true that the barberry stage was necessary for rust to go annually through the barberry. The mistake had been made in Australia in assuming this. The facts in a cold country would probably warrant the assertion, but here, inasmuch as they could find red rust existing all the year round, it followed that it was not necessary at all."

Mr. D. MacAlpine, of the Victoria (Australia) Department of Agriculture, holds that as the barberry is not indigenous to Australia, and cannot play the host to the promycelial spores, either the red spores can prolong their germinating power in the genial climate, and carry on the life of the fungus from year to year, or there is an unknown plant on which the promycelial spores germinate. Mr. Pearson, another authority, says, some botanists hold that the promycelial spores, which are produced during warm spring weather, and are wafted about in countless numbers not long before the rust begins to show itself on the wheat, alight on the young wheat plants, and if the atmospheric conditions are favourable germinate thereon, entering the wheat tissues through the stomata, and give rise to the red or uredo stage." ‡

Plant pathologists in Australia are endeavouring to discover another host than the barberry for the *Puccinia graminis*, or to

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* *Rust and Mildew in India*, by the late A. Barclay, M.B., F.L.S. The Journal of Botany, vol. xxx., 1892.

† *Contributions to an Economic Knowledge of the Australian Rusts* (*Uredineæ*), by N. A. Cobb, Agricultural Gazette of New South Wales, January, 1892.

‡ *Appendix to Report of Conferences on Rust in Victoria*, 1890, by Mr. A. W. Pearson.

determine that the teleutospores can germinate upon corn plants and grasses, and whether the climatic conditions which differ totally from those of other rust-affected countries shorten the chain of stages in the life of the fungus believed to be necessary in Europe.

Attention is also being directed to this question by mycologists in all parts of the world since the Australasian Rust Conferences have made fully public the extraordinary prevalence of rust in hot, arid regions, and of its persistence without the barberry.

Predisposition.

A certain predisposition of the host plant of parasitic fungi, or of many of them, is generally recognised. In some cases an unhealthy state of a plant may make it liable to receive injury, and this unhealthy state may be caused by its environment, such as influences of weather. situation, soil, cultivation, nitrogenous manurings, changes of temperature, excess, or lack, of water, and by conditions causing chemical changes in the cellular system of the plant. De Bary says, "The physiological reason for these predispositions cannot in most cases be exactly stated; but it may be said in general terms to lie in the material composition of the host, and therefore to be indirectly dependent on the nature of the food. In the case of the Pythieæ, for example, it is easy to see that the host displays degrees of susceptibility or power of resistance in presence of the parasite proportioned to the amount of water which it contains."*

Mr. Marshall Ward also deals ably with this subject, and shows that the host plants of fungi are more or less predisposed to receive injury according to the limits of their health.† After describing certain chemical and structural changes produced by weather and other influences, Mr. Marshall Ward concludes that "under certain circumstances the parenchymatous tissues of the living plant may be in a peculiarly tender, watery condition where the cell walls are thinner and softer, the protoplasm is more permeable and less resistant, and the cell sap contains a larger proportion of organic acids, glucose and soluble nitrogenous materials than usual. When the external conditions become more favourable—the temperature higher, the air drier, and the sunlight more powerful—increased transpiration and respiration lead to more normal metabolic activity, for which energetic assimilation provides the materials. Of course, all kinds of combinations are possible in detail, but when dull, cold, wet weather prevails for some time, after a period of bright,

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* De Bary. *Op. cit.*

† Sorauer also holds that predisposition depends upon the limit of health"—Breite der Gesundheit,"—in his work, *Die Schäden der einheimischen Kulturpflanzen*, 1888.

A.

Nursery Wheat from healthy plants.

B.

Nursery Wheat from rust-infected plants.

hot, and dry weather, we are apt to have herbaceous plants in such a condition as that described."*

This would seem to explain why in some seasons the epidemic of wheat mildew is prevalent, and in some seasons absent, and is confirmed in a most practical manner by the statements of many of the agriculturists who answered the questions contained in the Schedule, as to the coincidence of the attack with the abnormal white frosts and the frequent and great changes of temperature during the last summer.

Moisture is necessary for the germination of the spores. It has been considered that the moisture from the transpiration of the plants is sufficient for their germination, at all events if it is abnormal, or increased by unhealthy conditions. The entrance of the germ-tube into the stomata of the wheat-leaf is easily accomplished in normal circumstances, and is rendered easier if the stomata are relaxed by influences unfavourable to the health of the plant. Then, having gained an entrance, it would appear to be dependent upon the nature of the food within its reach in the cells of the wheat-plant, as to whether it forms mycelium and continues its actively destructive work in transporting the products of assimilation from the host to itself, as Sachs puts it.†

This is the usual action of what are known as "obligate" parasites, or those which the host plant serves directly to support, and it is the action of the wheat mildew fungus, at least, in its stages upon corn and grasses. In its other, or æcidium, stage this action is modified, as the fungus appears then to lose some of its obligate characteristics.

This entire dependence of the fungus upon the wheat plant naturally tends to injure it in proportion to the quantity of the parasite upon it, if there is a continuance of conditions favourable to the one and unfavourable to the host. The direct injury is generally to the straw, which it blackens, disintegrates, and spoils for every purpose but that of rough litter.

Then in bad attacks the number of grains are lessened in the ears. There are empty awns, and some of the grains are much shrivelled, having lost weight, shape, quality, and colour. In less severe attacks there is a percentage of grains more or less shrivelled and distorted, which serves to spoil the appearance of the sample. This is illustrated by Plate III., showing wheat from a field infested by the fungus last season, though not very badly. In this sample there were about 70 per cent. of grains plump and well-shaped, as seen in Fig. A., and the rest more or less shrivelled and deformed, as given in Fig. B. It will be understood in this case, as in most cases of attacks of mildew, that there was an unusual quantity of "tail" wheat, and it was necessary to "run down" the wheat more frequently and closely than usual

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* Croonian Lecture, *On some Relations between Host and Parasite in certain Epidemic Diseases of Plants*, by H. Marshall Ward, F.R.S. Proceedings of the Royal Society, 1890.

† *A Text-book on Botany*, by Julius Sachs.

Modes of Prevention.

Knowing that the Berberis is the host of the fungus, it seems obvious enough that it is most desirable to banish all its species from gardens, woods, and shrubberies. But this must be done with one accord, and even then there may not be perfect immunity from mildew, as the spores may be wafted from other countries, where men refuse to sacrifice ornamental shrubs without sufficient proof of their baneful influences, as they may hold. The potato disease was brought by the wind to this country in 1845, according to the statements of many observers. It has been shown how far the spores of the *Puccinia graminis* are carried in India, and those of the *Hemileia vastatrix* in Ceylon, and if moths can be conveyed in the air from foreign countries, the tiny spores of fungi may be thus brought from immense distances. The legislators of the State of Massachusetts evidently saw that it was useless for individuals to destroy the Berberis in their State, at their will and pleasure, and, therefore, by their famous barberry law, cited above, made its destruction compulsory.

Burning the straw of infected corn plants has been recommended by experts in this country, who affirm that even if the straw were heated in mixens, the spores would preserve their vitality. But burning straw would be an expensive process. In a season like the last, it would hardly be an exaggeration to say that a fourth of the straw produced was infected more or less with mildew. The stubble also on infected fields sown with clover, or seeds, may be a dangerous source of infection, as well as the stems of the numerous grasses which this fungus attacks.

Burning infected straw is strongly recommended in Australasia, America and Canada. At the Conferences of Australasian delegates before alluded to, it was resolved that as the *locus* of the spores of the rust fungus is chiefly the straw of the infected crop, it is advised that, where practicable, all infected straw, tailings, or stubble, and all grasses immediately adjoining thereto be carefully burned ; and that where infected straw must necessarily be used as food or litter for stock, all the manure thereof be well rotted and applied to land about to carry a non-cereal crop. Straw, as a rule, in Australasia is practically a waste product, and no loss is incurred in burning it, but in Great Britain it would be impracticable to endeavour to stamp out infection in this way.

Preventive Spraying.

Corn plants upon land subject to mildew, whose composition and constituents are of the character described above by Sir John Lawes, as containing large quantities of organic matter, might be advantageously sprayed with compositions of sulphate of copper and lime, or sulphate of iron, and other compounds similar to those employed in treating vines, potato, and other plants for fungoid attacks. These should be applied as a preventive treatment, in the spring, before the wheat plants are

high. The later this spraying is done the better it would be, in order that as much as possible of the plant growth may be treated with the composition. For putting this on, the best machine seems to be the Strawsonizer, which distributes liquids finely and evenly, and takes a good breadth at once.

It is considered that the best composition is sulphate of copper, in the proportion of fifteen pounds of sulphate of copper and five pounds of lime to 100 gallons of water. A small quantity of molasses or treacle added to this, say two or three pounds to 100 gallons of the compound, tends to make the composition adhere to the leaves of the plants, and is highly recommended by foreign experimentalists. The composition should be put on so that, as far as possible, every part of the leaves should be covered with fine spray.

If rust seriously attacks wheat plants later on when the plants are high, it might be expedient to spray them even at the risk of trampling down and injuring them to some extent. This spraying would be a remedial measure obviously. It has been adopted in Australia, and in answer to inquiries as to this, Mr. McClean, the Under Secretary for Agriculture of Queensland, was good enough to state that from experiments made with the sulphate of copper and lime composition, there was every reason to believe that if "rust cannot entirely be destroyed, it can be held in check sufficiently long to secure a good crop." Mr. McClean further said, in reply to a remark as to the difficulty of spraying as a remedial measure when the plants were high, that at the time the last dressing was given to the experimental plots in Queensland, the plants were fully three feet high, and yet comparatively little damage was done. 'Even if damage were done,' Mr. McClean concludes, "would it not be better to save four-fifths of the crop than to lose the whole from the rust?"

With regard to these particular experiments, they were not altogether satisfactory on account of the impossibility of proper supervision, as the experimental plots were 150 and 180 miles respectively distant from the offices of the Queensland Agricultural Department at Brisbane.

In selecting the sites for these rust experiments, spots said to be "the rustiest in Queensland" were taken. The spraying was made at different stages in the life of the plant, the last being made after the ear had formed and the grain was in the "dough" stage.

Professor Lowrie, of South Australia, speaking of spraying when the corn plants are high, says, "Of course we had the machine going, and the horse treading through the growing crop. That will work some mischief, but it will be comparatively small, half a bushel to the acre, probably, which is very little compared with the immense loss we have from rust."

Experiments were made in 1890–1 at Childers, Gippsland, Victoria, with sulphate of iron, at the rate of 6 lbs. to 100 gallons of water. A plot was sprayed six times during its

growth, with the result that the crops upon the plot were much more free from rust than those untreated.

A further experiment performed by Mr. Whelan in Gippsland, confirms this. In his report, he says: "In addition to preventing rust, a weak solution of ferrous sulphate will cure the rust. I marked a rust-infected wheat plant and syringed it with a solution of ferrous sulphate (one oz. to a gallon of water), with the result that all the rust had disappeared in twenty-four hours; nor was the plant again attacked for fourteen days."

It appears that this treatment keeps off rust for fourteen days; the period during which rust may be considered to jeopardize the yield of grain is probably not more than one month to six weeks, so that if during this period the crop were to be sprayed three times with a dilute solution of sulphate of iron, say 6 lbs. to the acre, at intervals of a fortnight, it is anticipated that it would effectually save the crop. At this rate, the cost of material would be trifling, from 8*d.* to 1*s.* per acre, and the cost of application from 2*d.* to 3*d.* per acre, or 1*s.* 6*d.* at the outside. It would not need to be applied every year, but only during rusty years.

Dr. Cobb, of New South Wales, at the Rust Conference held in Sydney in June 1891, remarked "with regard to curative measures, the fact of the Strawsonizer being good or not, was only a question of time. I have settled beyond doubt that we are able to recommend a solution to be used with the Strawsonizer which will kill the spores of rust. Wheat has a bloom upon it which prevents anything but the finest spray from having an effect upon it. This may be a good thing, because the rust will wet more readily, and if we can wet the rust without wetting the wheat, it will be all the better." Dr. Cobb, it appeared, had not tried sulphate of iron, but sulphate of copper, and he advised that molasses, or treacle, should be mixed with it.

In 1892, at the Rust Conference held in Adelaide, Dr. Cobb showed a figure of a piece of a wheat leaf that had been sprayed with ammonia-carbonate of copper; that is, carbonate of copper dissolved in dilute ammonia. He said: "After a plant has been sprayed with this solution, the diluted ammonia evaporates and leaves the carbonate of copper in the shape of an exceedingly fine powder. Consequently, when we examine the surface of the sprayed plant with a microscope, we instantly notice this deposit distributed in patches. It is clear that by spraying the wheat leaf we have dotted it with tiny patches of poison. As long as the patches of poison remain, they constitute a protection against the infection that occurs by means of the spores falling upon the sprayed leaf. Even should a spore fall on a portion of the leaf where there is no poison, growth may be prevented." In the figure alluded to, spores are shown where germination had been checked because their germ tubes had run against and absorbed some of the poison. Dr. Cobb continued

as follows:—"At the last Conference, I was, perhaps, as little sanguine as any member with regard to spraying; nevertheless, now I am perhaps the most sanguine. Next year I shall carry out experiments on a large scale if I have the opportunity, but I shall not be disappointed if the results are not all I expect. I believe that sulphate of iron is far the best of the fungicides I have tried."

Experiments were made with spraying at four different stations in Victoria, in 1891–92. From these it is learned that the spraying did apparently kill the rust with which it came in contact, but the rust re-appeared, and in the end when the yields came to be weighed the advantage of spraying did not become apparent. As regards quantities, it was found that twelve pounds of sulphate of iron to 100 gallons of water, put on at the rate of thirty gallons per acre, formed the best dressing. There seemed no advantage in putting on more than thirty gallons to the acre, even on the heavy crops that were treated, which were very dense and about 5 ft. 6 in. high.

It is stated that although the final outcome of these experiments was not a success, it must not be considered that they were failures; they were not failures, they resulted in partial success and the reports received at first were highly encouraging. The reason why the experiments resulted in only a partial success is attributed to the leaf and stem surface not having been all covered. Where the fungicide fell the spores did not germinate. If the whole surface were covered the fungus would find no place to enter.

The Strawsonizer seemed to be more satisfactory in the early stages of the corn crops, but not where they were high and heavy, and complaints were made that the pipes got easily clogged. A sprayer has been fashioned to be worked by steam, which, from its results is said to be the sprayer of the future, not only for field crops but also for orchards. This steam sprayer has, it is said, an important advantage over the horse and hand sprayer, namely, that it requires less water to cover a given area by means of it.

Mr. Pearson, who conducted the above experiments, in answer to questions during a discussion, said: "no value could be placed on the yields, as they were exceedingly variable. I think the best test that can be quoted is with regard to the plots sprayed with the Bordeaux mixture. One was sprayed with the sprayer directed above the crop, and the other with the sprayer directed within the crop; the latter was the most effective. The spraying from within gave a yield of thirty-one bushels; while where the sprayer was directed above, this yield was twenty-five and a half bushels. These two cases may be taken as a tolerably fair index. If we had succeded in a thorough spraying I have not the least doubt that thirty-one bushels would have been increased to forty bushels."

On the other hand, experiments with spraying in Queensland, conducted by Professor Shelton, failed to show any beneficial results. Bordeaux mixture (bouillie bordelaise) and sulphate of

iron solution were used. Mr. Shelton makes the following practical remarks, "So far as work in the wheat field is concerned, this subject presents enormous difficulties, among which may be mentioned the enormous extent of the fields, the enormous mass of verdure (often four feet or five feet deep) which marks the wheat growth, and the difficulty in getting machinery over and through this dense vegetable growth without doing great damage to the growing crop."

In their Report, the Conference of 1892 encourage the continuance of experiments, especially in the direction of spraying. "The statements," they say, "made at the Sydney Conference of 1891, concerning the fatal effect of various fungicides on the germination of the rust spores have been confirmed during the past season, but the difficulties attending the application of fungicides to wheat crops have not been wholly overcome, although progress has been made in this direction, and through the action of the Conference an important addition has been made to the machinery for applying sprays cheaply and on an extensive scale."

During the last season a series of experiments, having in view the prevention of rust in corn crops, were undertaken by the United States Department of Agriculture, through the agency of the Division of Vegetable Pathology, in Maryland and Kansas.* There were no less than 700 plots of wheat, oats, rice, and other grains under treatment. This work was to some extent preliminary, and the commencement of a series of careful investigations. It involved tests of soil, seed, manurings, together with spraying trials at varying dates, and with various fungicides. This will be published in the volume of Reports issued by the United States Department of Agriculture for 1892.

The extremely successful result of an experiment of spraying wheat in France to prevent rust is reported in the "Journal d'Agriculture Pratique" of the 26th January 1893. This was conducted by M. Léon Noirot, cultivator, at Veuxhaules Côte d'Or, France, upon white wheat, blé blanc du pays, sown on the 8th of November 1891, and sprayed on the 28th of May 1892. The plot was 80 perches in size. Of this 40 perches were sprayed and 40 perches not sprayed. The solution used for spraying consisted of 4 lbs. 4 ozs. of sulphate of copper and 6 lbs. 6 ozs. of sulphate of soda, dissolved in 17½ pints of water. M. Noirot states that the 40 perches that were sprayed yielded 8 bushels of wheat, weighing 64 lbs. per bushel, while the 40 perches not sprayed gave only 5½ bushels, weighing only 58 lbs. per bushel. Upon the sprayed part of the plot the straw was perfectly white; but upon the unsprayed part it was rusty and all black. Samples of the wheat and straw from both the sprayed and unsprayed parts of this experimental plot can be seen at the Exposition du Palais de l'Industrie, Paris.

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* *See* Report of the Secretary of Agriculture, United States Department of Agriculture, Washington, December 1892.

Rust Resistant Varieties.

Jethro Tull* remarks that "the white cone wheat, which hath its straw like a rush full of pith, is less subject to blight than Lammas wheat, which ripens a week later." There does not appear to be any special allusion to the rust-resisting powers of varieties of wheat in the replies to the inquiry instituted by the Board of Agriculture in 1804. Neither is there much information afforded in the answers to the questions sent by the Royal Agricultural Society in 1883, except that Rivett, Lenny's White, Browick Stand-up, and Red Chaff White, were less affected than other varieties, such as Scholey's Square Head, Golden Drop, Nursery, etc.†

It is somewhat remarkable that though Scholey's Square-head is shown to be liable to mildew by the Royal Agricultural Society's Report, it was found to resist it better than any other variety in 1891, in Germany, where it is largely cultivated, having superseded all German varieties. M. Georges Ville says of the Square-head variety, "Two circumstances explain the favour—without parallel, I believe, in the history of wheat—which attaches to the Square-head. In the first place the resistance of the straw to laying, and to the action of parasitic fungi, especially rust; these qualities are inseparable. Everyone knows the close relation which exists between the appearance of a parasite and the texture of its host. The straw, which is bent under the weight of the ear, is formed of a yielding succulent tissue, which opposes but a slight obstacle to the penetration of the mycelium of the parasite. The Square-head, born under the humid sky of Britain, possesses in the utmost degree the faculty of consolidating its mechanical system under the influence of the more variable climate of the Continent."‡

Most valuable researches have been made in Australia by Dr. Cobb as to the causes of certain varieties of wheat being less liable to rust than others. Dr. Cobb made a series of observations on the number and size of the stomata, or breathing pores, because it was imagined that the structure of the stomata must have an important bearing on the entrance of the promycelium of rust. He found that the number of the stomata upon the leaves of wheat varied from thirty-eight to seventy-five per square millimetre. In general the stomata were smaller and more numerous, while on nearly all leaves the number of stomata was fewer by abour 10 per cent. on the lower surface than the upper. Nevertheless the smallest stomata were observed to be large enough to admit the entrance of the promycelial thread of rust. Dr. Cobb saw enough to convince him that rust had entered freely through the smallest stomata observed. As many as fifty spores per square millimetre were noticed on the upper surface of the leaves, and about twenty-five per square millimetre on the lower surface.

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* *Horse-Hoeing Husbandry*, by Jethro Tull, 17.
† *Report on Wheat Mildew*, by W. C. Little, R.A.S.E. Journal, vol. xix., sec. ser.
‡ *The Perplexed Farmer*, by Georges Ville.

It is shown, however, that the thickness of the cuticle of wheat leaves affects their liability to rust. Out of several experiments one may be selected, made upon an eminently rust-resistant variety, Ward's Prolific, and an eminently rust-liable wheat, Zimmerman. It was found that the cell walls of the cuticle of the latter (Zimmerman), were less than half as thick as those of the rust-resistant kind, Ward's Prolific. This seemed to be a very general rule. Twelve varieties of wheat were examined in this way, and Dr. Cobb arrived at the conclusion that the structure of the leaf cuticle in a variety of wheat has a most important influence in determining its liability to rust.

The rationale of this is, according to Dr. Cobb, as follows: "First, the cuticle might be so constructed as to prevent the entrance of rust; secondly, it might be so constructed that although it permitted the rust to enter it would not allow it to get out again; in other words, to fructify so as to disseminate spores. A thick tough cuticle would doubtless enable a wheat to act in this second way, and we have no longer any doubt that many rust-resistant wheats are such, because of a tough cuticle acting in this manner."

Not only had these rust-resistant wheats a thick cuticle, but the leaves were tougher than the rust-liable sorts, as was shown by the results of an elaborate series of experiments made to test their relative tensile strength. This toughness further tended to prevent the fungus from sending out spores from within to form, in short, what are known as teleutospores. Dr. Cobb concludes: "From these experiments it will be seen that the wheats which we had selected as most rust-liable, namely, Zimmerman, Steinweder, and King's Jubilee, have a low tensile strength, while the resistant sorts have the highest tensile strength."

Dr. Cobb made an interesting observation on an hitherto unknown function of the waxy covering, so characteristic of certain wheats, especially when they are young. "This wax, or bloom," he says, "is intended to protect the plant from the injurious effect of water. We discovered, however, that it had no small influence in keeping out the promycelium of rust. This waxy bloom, when it occurs in abundance on the sheaths of wheat almost completely covers the surface of the cuticle, being interrupted only at the stomata. When one examines such a sheath under the microscope, it is some little time before the stomata are seen, so perfectly are they hidden; their position is indicated only by a very narrow crack in the wax, a crack *so narrow that the promycelial threads fail to enter it.* We made this observation repeatedly on a wheat known as Blé carré de Sicile rouge, a particularly glaucous wheat, especially when young. We took sheaths of this wheat and germinated on them large numbers of the spores of *Puccinia graminis*, but we failed after a long search to find a single promycelial thread that had gained an entrance. These observations explain in a remarkably clear manner why the sheath and straw of glaucous wheats often remain quite free

from rust, although the flag may be quite rusty. The flag, especially the upper surface, is usually less glaucous than the sheath. It is noticeable that the resistant wheats, as a rule (there are marked exceptions), are wheats possessing a glaucous character."

The principal conclusion arrived at by the Australasian Conference of 1892 was that manuring and treatment of the soil, methods of cultivation, times of reaping, &c., have an influence on the development of rust; but that influence is, generally speaking, trifling as compared with the influence of the variety of wheat grown and the time of sowing. There are several varieties of wheat which, except under very unusual circumstances, are never seriously attacked by rust, and it was recommended that the sorts of wheat should be grown which local experiences have shown to be rust-resisting or rust-escaping.*

Experiments will be made in Queensland, Victoria, New South Wales, and South Australia in the coming season to discover wheats that are rust resistant in various localities.

The freedom from rust of the variety known as "Windsor Forest," instanced by Mr. Smith, of Rendlesham, and by Mr. Watkins, of Gulpho Hall, Ipswich, corroborate the experience of the Australian experts. It will be remembered that this wheat was grown under the same conditions in the same field with wheats of other varieties which were badly rusted. In one case, the rusted variety, Kinver, was actually sown on the headlands of the part of the field devoted to the rust-free Windsor Forest. Examination with the microscope showed certain slight differences in the arrangement of the cells and in the numbers and arrangement of the stomata.† The straw, however, when received, was ripe and hard, and therefore would not probably show distinctions like those found by Dr. Cobb in the green stalks of the varieties he examined. It is desirable that experiments should be made in Great Britain to prove whether there are varieties of wheats that are rust resistant and less liable to be attacked than others.

Another great point insisted upon at these Conferences in Australia was that of early sowing, as the general reports of wheat growers in different parts of the four Colonies that were represented, showed that early sown wheat was always the least damaged, and in many cases escaped injury altogether by rust. The reason of this is without doubt that early sown wheats get established before adverse weather comes, and are, therefore, stronger, healthier, and better able to resist the attacks of fungi. It will be noticed that several of those who filled up the

* The Hon. John D. Macansh, of Queensland, stated at the last Conference that the Canning Downs rust-proof wheat came originally from India, and had been grown by him for eight consecutive years, and the grains had never been damaged in the slightest degree by rust. It had been grown in the same field, a furrow only dividing them, with wheat that was worthless from rust.

† The report of an experienced microscopist upon samples of Kinver and Windsor Forest straw was that in the former the vascular bundles were rather wider apart than in the straw of Windsor Forest and the stomata more abundant.

Schedule of questions of the Board of Agriculture in 1892 stated that early sown wheats escaped rust more than those which were put in late. It would seem far more important to get wheat in early in Great Britain, where climate is so much colder, and the winter far more severe than in Australasia.

SPRING-RUST AND MILDEW ("Puccinia rubigo vera").

There is much confusion, and most naturally, among cultivators in all countries where cereals are grown, concerning the two kinds of rusts which attack these crops, especially wheat and oats. It will be useful, therefore, having fully described the summer-rust and mildew, *Uredo linearis*, and its forms of *Puccinia graminis* and *Æcidium berberidis*, to give a detailed account also of the spring-rust, *Uredo rubigo vera*, and its mildew forms of *Puccinia rubigo vera*.

The differences between these two rusts and mildews are sharp and clear, and when once noted they will be easily remembered. In the first place, the spring-rust (*Uredo rubigo vera*) often appears as early as March, much earlier than the the summer-rust (*Uredo linearis*). The colour of the spring-rust is more yellow and not so red, or orange-coloured, as that of summer-rust. Its sori, or blotches, upon the blades are not quite so large nor so long, being more round in shape, as will be seen by figures 1, 2, and 3 of Plate IV.* By comparing the figures of a spring rust sorus, and a section of a sorus highly magnified, and of the spore germinating (Figs. 4 and 5, Plate IV.) with those shown on Plate II. (Figs. 4 and 5) illustrating *Puccina graminis*, in its uredo stage, a marked distinction will be noticed.

The sori, of *Puccinia rubigo vera* (Fig. 3, Plate IV), are full of spores of a yellow colour, somewhat oval in shape. These spores are constantly discharged in immense quantities upon the plants near them, and carried by the wind in all directions upon corn plants and grasses. They germinate upon suitable hosts by putting forth germ tubes (Fig. 5, Plate IV.). These enter the stomata of the leaves and form new sori, so that there is a continual succession of these uredo spores until autumn approaches, and the corn plants begin to ripen. A change then takes place; the reddish-yellow spots become dark-coloured (Figs. 6 and 7, Plate IV.), just as in the case of *Puccinia graminis*, and the uredo form is gradually merged into the Puccinia or teleutospore form. The sori of the teleutospores are considerably smaller than those of *Puccinia graminis*, and of a rather lighter colour (Figs. 8 and 9, Plate IV.). The spores from these sori are also smaller and rather differently shaped, and enveloped in coverings, paraphyses (Fig. 10, Plate IV.). In these states they are actively injurious to the corn plants. Though it

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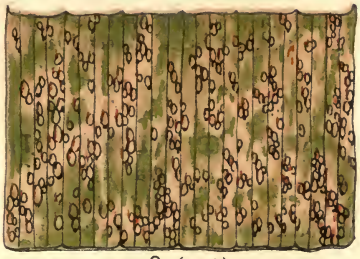
* The figures of this Plate, as well as those of Plates I. and II., were drawn by Mr. Worthington G. Smith.

Spring Rust & Mildew of Corn.

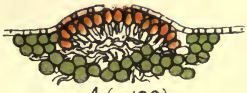
1.



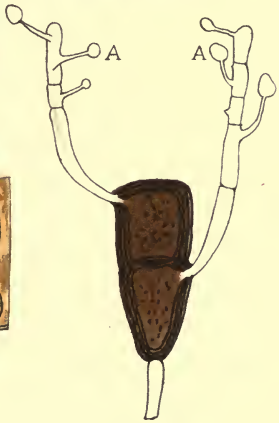
2 (x·4)

5 (x·700)

3 (x·20)



4 (x·100)



10 (x·700)

6.

7 (x·4)

8 (x·20)

9 (x·100)

Puccinia Rubigo-Vera D.C.

nas been said that the injury caused by spring rust and mildew is inconsiderable, this is by no means borne out by facts. Corn plants badly infected by it have been carefully watched, and have been found to yield poor crops of more or less shrivelled grains. In some cases where wheat has been much covered with the blotches of the fungus, the plant appeared to be quite checked in its growth.

With respect to the hibernation of this fungus, *Puccinia rubigo vera*, there is some doubt. De Bary has proved that the teleutospores will germinate readily, and form Æcidia upon some species of the *Boraginaceæ*, as *Borago officinalis*, common borage, *Anchusa officinalis*, common alkanet, and other species in the autumn, in this respect differing from those of *Puccinia graminis*, which will not germinate until the spring. De Bary first proved this, and termed this form *Æcidium asperifolii*. He also found that the spores from this Æcidium form germinate upon grasses and corn plants in the same way as the spores from *Æcidium berberidis*.* But De Bary shows that the spring rust is reproduced year after year in frightful quantities by the uredo spores only. These produce also millions of teleutospores which germinate, but without result, because the sporidæ seldom meet with the conditions necessary for developing æcidia. These certainly are developed if the conditions are favourable; but the instance shows that the species can multiply abundantly without the interposition of æcidia.†

The fungus causing spring rust and mildew is continued through the winter in the uredo form upon grasses and self-sown corn plants, and probably upon winter wheat and winter barley. Frank, confirming De Bary's statement as to the fungus passing the winter in the uredo form upon self-sown corn plants and grasses, says that it is most desirable to eradicate wild grasses from the neighbourhood of corn fields, and especially *Bromus mollis*, soft brome grass. He also advises that all weeds of species of *Boragineæ* should be rooted up. ‡

Puccinia rubigo vera is most common in India. Mr. Barclay remarks that "*P. rubigo* appears to be the most prevalent rust in the Simla region."§ The natives of India recognise the distinction between *Puccinia rubigo vera* and *Puccinia graminis*. They call the first "Rolli," and the other "Rolla."

In America *Puccinia rubigo vera* is also quite common, according to Mr. Galloway, Chief of the Section of Vegetable Pathology of the United States Department of Agriculture.

In Australasia it is extraordinarily abundant. At the Rust Conference in New South Wales, before alluded to, Dr. Cobb

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* Monatsbericht der Akademie der Wissenschaften, zu Berlin, 1866.

† *Comparative Morphology and Biology of the Fungi; Mycetozoa and Bacteria*, by A. De Bary 1884.

‡ *Die Krankheiten der Pflanzen.* Von Dr. A. B. Frank.

§ *Rust and Mildew in India.* By the late A. Barclay, M.B., F.L.S.

said, "as far as the experiments of last season (1890) went there could not be the least doubt that nearly all the damage was caused by spring rust, *Puccinia rubigo vera*." Dr. Cobb further said, "during the past two years it has been proved that *Puccinia rubigo vera* exists in the uredo stage all the year round in Australia, either on self-sown wheats, oats, barley, &c., or on certain grasses," and further on he remarks, "there can be no excuse for permitting rust to pass the winter on cereals, self-sown through careless farming, or on weeds."

BOARD OF AGRICULTURE.

REPORT

ON

INSECTS AND FUNGI INJURIOUS TO CROPS.

1892.

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1893.

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Report upon Injurious Insects and Fungi.

1892.

MEMORANDUM.

The following report, with detailed notices of various insects and fungi noted in 1892 as attacking the crops of the farm, the orchard, or the garden, has been prepared by Mr. Charles Whitehead, F.L.S., in his capacity of Technical Adviser to the Intelligence Branch of the Board of Agriculture. The reports upon injurious insects and fungi which have been hitherto issued by this Department have contained block illustrations only; but, with the object of facilitating the identification of insect and other pests, it has been deemed desirable on this occasion to illustrate the descriptions given by means of carefully coloured plates. The plates now included have been reproduced from sketches placed at the disposal of the Board by Mr. Whitehead, and it is believed they will materially enhance the usefulness of the report.

The circumstances of the year under review necessitated the issue of only three leaflets dealing with insect attacks. These were respectively the Apple Blossom Weevil, the Raspberry Moth, and the Mangel Wurzel Fly, the last named infection being probably the most widespread of the pests of the season of 1892. Accounts of the life history of each of these insects, and of eleven others, are now given, together with such suggestions as experience has shown can be offered for the prevention or mitigation of the attacks complained of.

The two cases of fungoid attacks, which are reported on, form subjects of special interest. The notice of the *Plasmodiophora brassicæ* or Club Root suggests that there is room for further research into the strange conditions of this plague, the recognition of which nevertheless dates back more than a hundred years.

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The last of the series of plates in this volume gives a graphic illustration of the appearances presented by the so called Black Mould in corn *Cladosporium herbarum*). The serious harm caused by this fungus both to Wheat and Barley plants rendered it desirable that attention should be directed to this attack, and that the distinction between this pest and the ordinary Wheat Rust or Mildew (*Puccinia graminis*) pointed out. A special inquiry has been conducted this year into various circumstances attending the prevalence of Rust in Wheat, and it is intended to issue as a separate volume the information collected on this point from various observers in this country, giving at the same time some notice of the results, so far as they can be obtained, of the recent researches which have been in progress in other countries.

Board of Agriculture,
December 1892.

GENERAL REPORT

UPON

INSECTS AND FUNGI INJURIOUS TO CROPS IN 1892.

INSECTS.

During 1892 there was not any very serious attack of a particular insect like that, for instance, of the Diamond-back Moth upon the turnip crop in 1891, and of the Winter moth upon apple trees and other fruit trees in 1889 and 1890. Still there has been considerable harm done to certain crops in some localities; such as in parts of Cambridgeshire to mustard by the mustard beetle, *Phædon betulæ*, whose ravages are most difficult to check. The raspberry moth, *Lampronia rubiella*, which formed the subject of a leaflet issued in May last, again caused much mischief to raspberry canes in Kent, Surrey, Gloucestershire, and Worcestershire, as well as the currant moth, *Incurvaria capitella*, to red currant bushes in several places. The red spider, *Tetranychus telarius*, was most troublesome to gooseberry bushes in the spring in plantations and gardens throughout the country. In some cases the leaves dropped off the bushes, in others they turned yellow, and the fruit was small in consequence. Later on these pests materially injured damson, plum, and peach trees. In the last few years red spiders have increased enormously and have attacked various crops. Their work of destruction is frequently attributed to influences of weather, or of soil, or to natural decay, as they are so small that they can hardly be distinguished without a pocket lens; but when the leaves of trees and plants become rusty in the summer they should be closely inspected for red spiders, and treated in the manner prescribed in this report.

Apple producers complained much of the quantities of Apple blossom weevils, *Anthonomus pomorum*, on the apple trees in the early spring. It was therefore thought desirable by the Board of Agriculture to publish a leaflet giving particulars of successful methods of combating this insect adopted in France, which has been reproduced in this report. The Codlin Moth, (*Carpocapsa pomonana*) was unusually plentiful in some districts, as is evidenced by the state of many stored apples.

The appearance of the Diamond-back Moth in 1892, was first reported on the sixth of June, by that close observer Mr. Norman Berwick, of St. Andrews, Scotland. Two or three other later reports came from England and Scotland, but these spoke only of a few moths having been seen, and here and there a few caterpillars were noticed. But, as anticipated, the deluges of rain in August 1891 pretty well stamped out this insect, and the showery and inclement character of the spring of 1892 prevented the few survivors from doing mischief this year. The Hessian fly has, happily, also been nearly ousted from this country by the inclement summer weather of late years. Only three accounts of slight attacks came to hand, whose results were of the most trifling consequence. It seems to be established that this much-dreaded insect will not be able to affect British corn crops in any material degree, except, perhaps, in cycles of hot and dry summers.

There has been a remarkable and fortunate cessation of the plague of Winter moths, *Cheimatobia brumata*, whose caterpillars have in some previous seasons cleared the apple trees and other fruit trees of leaves and blossoms in orchards, plantations, and gardens throughout the country. This cessation is without doubt due to the measures that have been taken against them, in the shape of banding the trees to prevent the ascent of the female moth, and syringing infested trees with unpleasant and poisonous washes; also, to some extent, to the heavy, cold rains which have proved fatal to other species of Lepidoptera. Fruit growers should not relax any precautions against the Winter moth, and be careful to syringe their trees if only a few caterpillars are found upon them in the springtime.

Pea Weevils, *Sitones lineatus*, were unusually destructive to pea crops in a few localities.

Byturus tomentosus, the Raspberry beetle, literally swarmed in many fruit plantations and gardens.

Probably, the most general visitation was that of the Mangel fly, *Anthomyia betæ*. In very many parts of England and Scotland it was exceptional to find a field of mangel wurzel plants free from it. In many fields a plant could hardly be found without the unmistakable evidence of the maggots of the fly within the tissues of its leaves. Early in June complaints began to be made from Sussex, Kent, and other counties. Where the plants had been manured properly and were kept well horse-hoed they grew away from the attack; they were aided in this by the heavy showers that fell in the latter part of June which were not congenial to the maggots; but even in these cases the yield of roots was clearly lessened. Upon land indifferently manured and cultivated, the crop was decreased somewhat considerably.

A leaflet was issued in June by the Board of Agriculture, describing this insect, and reccommending remedies and modes of prevention against it.

An uncommon infestation of the pods of rape was communicated by Mr. W. C. Little, of Stag's Holt, March, who forwarded several rape pods on the 11th of June, containing very small white maggots with yellow streaks on their bodies, which soon pupated. On the 29th of June, tiny gnats came forth, proving to be *Cecidomyia brassicæ* (Winnertz). Schiner says of this that its larvæ are found in the seed pods of several species of brassicæ.

Very great injury was sustained by oat plants from the minute larvæ of the Frit fly, *Oscinis Frit.* Much of the work of this insect, it is believed, was wrongly attributed to the lateness of the sowing on account of the wet spring. The backward state of the plants, and their slow growth, however, favoured the action of this fly, and enabled it to increase and multiply in an unprecedented ratio.

Among aphides the chief workers of mischief were the Corn, Turnip, and Hop aphides. The first was very prevalent in most parts of Great Britain, and reduced the quantity and deteriorated the quality of wheat in a most unusual degree. Though the Turnip aphis did comparatively small harm, the Hop aphis was present in the hop grounds of Kent, Sussex, Surrey and Hants almost throughout the season in great numbers, and the hop crop, as a rule, was only saved by persistent costly washings of the plants with quassia and soft soap solutions. These aphides have been regular annual visitors in the hop plantations for several years in succession, and "washing" the plants has become a part of the ordinary routine of hop production. The Hop aphis appeared two years since in the hop yards of Washington Territory, Oregon, California, and other noted hop-producing districts in the extreme west of the United States, much to the dismay of American hop producers.

Among less important injuries to crops during the year, those caused to ripening hops by a maggot in the stem of the cones may be cited. From observation it seems that the plants upon poor, dry, and high spots as well as the outsides of hop grounds, are most subject to this infestation. Upon examination it is found on picking a hop with indications of premature ripening, that the stem is tunnelled and occupied by very small white maggots, the cause of the evil. As late as the first week in October, cones that were left upon young hop plants were found with white maggots within their stems, which tends to show that there is more than one brood of this insect. These maggots when placed upon earth in a box quickly buried themselves in it, and it is hoped that perfect insects may come from these and be identified in the spring.

The Currant Mite, *Phytoptus ribis* is causing great injury to black currant bushes, which becomes more serious each year. A new species of *Phytoptus* has been discovered in the buds of raspberry canes. This has been termed *Phytoptus rubi.*

Beech trees in some places suffered from the onslaughts of the large caterpillars of the "Buff tip" moth, *Pygœra bucephala.* Copper-leaf beeches were especially chosen by them, and their leafage was stripped before the offenders were discovered. Some small trees were much injured by these caterpillars.

FUNGI.

Among the injuries to crops in the past year by fungi, those caused to wheat by rust and mildew were most conspicuous. In consequence of the extensive prevalence of these disorders a circular with a schedule of questions was issued by the Board of Agriculture in the summer to agriculturists in the chief corn-growing districts inviting a statement their experiences upon the subject. As a full report on rust and mildew, embodying the information thus received, will be forthcoming in the beginning of 1893, it is not necessary to deal now with this subject.

In addition to the very extensive attack of mildew, caused by this fungus, *Puccinia graminis,* the wheat plants in many districts suffered from the action of another fungus upon their straw, chaff, and corn, which had evidently hindered the full and perfect development of the grain. This fungus was identified as *Cladosporium herbarum,* a spore-bearing form of *Sphæria herbarum,* and is described at length in this report. Barley plants were also infested by this fungus in some localities, which it appears had not been previously noticed as affecting barley.

Cases of clover, both of Red Clover, *Trifolium pratense* and *Trifolium incarnatum,* affected by the fungus *Polythrincium trifolii* (*Kunze*) were reported late in November. As a remedy it was recommended to apply 40 or 50 lbs. of powdered sulphur with a sulphurator on the first fine day: the effect of this has not yet been reported.

The destructive hop fungus, *Podosphaera castagnei,* has done comparatively little harm to this year's hop crop, and the potato fungus, *Phytophthora infestans,* on which further experiments have been made this season with *Bouillie bordelaise,* was happily far less dangerous than usual.

Plasmodiophora brassicœ, the curious slime fungus, having some of the characteristics of low animal organisms, was extremely destructive to turnips of all kinds during the summer and autumn, causing the distortions and malformations upon their roots known as Club-root, Club-foot, Finger-and-toe, and Anbury in this country; Vingerziekt in Belgium, Kohl-hernie in Germany, Botch in Australia, and Maladie digitoire in France. An account of this fungus is given in this report, together with recommendations for the prevention of the evil.

Apple branches and twigs were received from various quarters showing abnormal conditions due in some cases manifestly to the fungus belonging to the group *Ascomycetes,* termed

Nectria ditissima. These conditions were those of the affection commonly known as "canker," displayed by the dying away of the ends of leading shoots, as well as of branches and twigs, from wounds or fissures in the rind extending deeply into the woody tissue. The vermilion perithecia of the fungus *Nectria ditissima* were clearly seen in some of these fissures, evidently showing the fungoid nature of the attack. But in others there were no traces of the fungus, though the symptoms were precisely the same. Canker is attributed by Hartig and some other botanists to this fungus, *Nectria ditissima.* Fruit growers and gardeners generally consider it to be due to the action of frost when the trees are full of sap, or to other weather influences, also to the land being too wet or too dry. It is, however, believed that *Nectria ditissima* is the main cause of canker proper, and as a remedy syringing the trees with solutions of sulphate of copper in the form of Bouillie bordelaise, as used for the potato disease, has been recommended, especially for young trees. This should of course be done in the winter.

Besides the communications received concerning the insects and fungi mentioned above, many others have been made with reference to minor attacks, all of which have received immediate attention, and suggestions have been made as to remedying or preventing mischief as far as possible. The interest taken by cultivators of all kinds in injurious insects and fungi, and the desire for information regarding them and the methods of dealing with them increase year by year.

The Currant Moth.—(*Incurvaria capitella*).

(Plate I. Fig. 1.)

This is a comparatively new pest in red currant plantations in this country, and it appears that it is not particularly troublesome in other countries, though it is mentioned by Kaltenberg as one of the insects attacking currant bushes.

The caterpillars attack the buds in the early spring, living upon them and preventing them from developing leaves and blossoms. Later on, the second generation of caterpillars feed upon the inside of the ripening currants and do some injury in this way.

About the tenth of April specimens of infested currant buds were first sent from fruit plantations in Gloucestershire, Kent, and Worcestershire. They were fastened together by a kind of web. The little caterpillars were found within the buds, feeding upon their contents. Afterwards several complaints were made from various places of similar attacks.

Life History.

Some of the caterpillars in currant buds sent during April were placed in breeding cages. The first moth appeared on the 15th of May. Observation showed that the pupal state continued from 9 to 11 days. The term of caterpillar existence could not be accurately noted as the buds naturally withered and the food supply was cut off.

The moth (Fig. 1 *a* and *b*) has a wing expanse of from 7½ to 8 lines, or close upon three-fourths of an inch. Its body is three lines in length, or the fourth of an inch. The fore wings are brown with a slight purple tinge. Mr. Stainton says :—" A pale yellow fasciaform spot lies on the inner margin before the middle, and beyond the middle are two large pale yellow opposite spots." The head is dark yellow. The antennæ are dark and the legs yellowish.

Its mode of oviposition is remarkable. This was first noticed by Dr. Chapman, and was confirmed afterwards by my own observations. The moth selects a currant, and with the help of a long ovipositor places eggs in it close to the seeds within their pulpy surroundings. I did not see more than two eggs placed in the same currant. The eggs are ovoid and almost colourlesss, with a small knot at one end. The moth is provided with a very long apparatus for this process, almost half as long as its body. Dr. Chapman terms it a double " instrument, dorsal and ventral, each with two long rods for working it." The caterpilar (Fig. I.d.) is hatched in five or six days and feeds for a while upon the pulp of the fruit, and leaves by a small opening which it makes in the currant, and gets under the bark or, more properly,

Fig. 1.

The Currant Moth. (Incurvaria capitella.)

a. Moth. nat. size. b & c. Moth: magnified. d. Larva: nat. size & magnified.

e. Pupa: nat. size & magnified.

Fig. 2.

The Y Moth. (Plusia gamma.)

a. Moth: nat. size. *b. Larva: nat. size.*

the skin, of the stem below the buds. Dr. Chapman has carried this point farther, as he found the caterpillar "in firm little cocoons under the scales of the buds for next year clearly in a hibernating condition." And, as seen just when they had left the currant, and as seen later on by Dr. Chapman in their cocoons, these caterpillars had not arrived at their full growth, as they were only about the eighth of an inch in length, whereas in the spring, as found in the currant buds, they are nearly double this length when full grown.

In its early stages the caterpillar is reddish. After feeding in the currant buds it becomes green with a tinge of yellow. It has a black head and blackish marks on the second segment, and an orange-coloured mark between the seventh and ninth segments. The prolegs are black. The figure of the caterpillar (Fig. 1. *d*) represents it when near pupation.

The pupa is of a greenish colour with a brown shade.

Methods of prevention and Remedies.

Picking off the infested buds has been practised in some plantations, but this is obviously a tedious and costly process, and can hardly be recommended upon a large scale. Where infestation is considerable and the bushes have been seriously injured by the caterpillars it would be well to cut the bushes hard in order to remove the infested branches as much as possible. Or, the bushes, after they have been well pruned, might be brushed over with soft soap and paraffin, or syringed just before the buds burst forth, with a mixture of soft soap and paraffin, or a strong solution of quassia with soft soap. All cuttings should be burnt at once, and not left on the ground.

The Y. Moth.—(*Plusia Gamma.*)

(Plate I. Fig. 2.)

In some seasons the large prettily-marked caterpillars of this moth appear in great numbers and clear off whole fields of clover —chiefly the second cuts. They also devour peas, rape, turnips, and cabbage. According to Taschenberg and Ritzema Bos, they attack sugar-beet plants in France and Germany, and Nördlinger says that in France in 1735 they ruined the crops of peas, beans, hemp, flax, and vegetables in wide-spreading districts. In 1828, in parts of East Prussia, many fields of beans, peas, flax, cabbage, and potatoes, were stripped of all but the stalks of the plants. Most serious damage has been caused to sugar-beet in more recent seasons in Saxony and other parts of Germany. In the summer of 1879 there was a great invasion of this insect in the whole of Western Europe, and much harm was caused to many crops.

In 1881 these caterpillars were abundant in several parts of Kent, and appeared again though in somewhat diminished numbers in 1892. Complaints of much injury done by caterpillars to clover were received on July 8th 1892, from the neighbourhood of Rochester, Kent. Again, on the 13th of July, another correspondent wrote, "I send you some caterpillars. This pest has eaten a piece of second-cut clover, near Gravesend, 40 acres in extent, till there is hardly a green leaf to be seen. I notice they eat turnips, lettuces, thistles, when what appears to be their natural food is finished, but they seem to favour thistles, though I have found them eating potatoes. They have now almost disappeared, having been eaten by rooks, starlings, and other birds."

Another observer, writing on the 11th of July, from North Kent, said: "When the clovers were cut, the fields were swarming with caterpillars, which have eaten up the undergrowth so completely that the fields are perfectly brown, and it is very doubtful whether we shall get any second cut at all. They have also invaded the cottage gardens adjoining." Upon the 18th of July a note was received from the same observer to the effect that "the caterpillars have apparently left the clover fields, or have been destroyed by the rooks and starlings. I am afraid the cottage gardens, where the birds cannot get at them so well, have suffered a good deal."

Upon carefully examining these caterpillars it was found that they had the appearance of *Plusia gamma* caterpillars, but some were darker in colour than these usually are. There were great differences, however, in their colour.

Not being quite clear as to whether they were *Plusia gamma* caterpillars, at Mr. Stainton's suggestion Mr. G. P. Porritt was asked to give his valuable opinion. Mr. Porritt at first had some doubts upon the subject, but after having received some moths from myself bred from the caterpillars, he came to the conclusion that they were *Plusia gamma* caterpillars notwithstanding somewhat essential differences.

The moths bred in confinement from the caterpillars sent from Rochester were undoubtedly *Plusia gamma*, though very small, This was due in all probability to their unnatural surroundings. In fact, only a small proportion of the caterpillars sent to me assumed the cocoon stage, and not all of the cocoons produced moths.

Mr. Porritt, in a communication to the *Entomologists' Monthly Magazine* for September 1892, on this subject says: "On August 4th Mr. Whitehead sent me two moths he had just bred from some of the larvæ, and on the 6th he forwarded another; while in the meantime I also had bred a good specimen, the only one which emerged from my larvæ. All the moths were exceedingly small, less than half the size of a number of ordinary gamma, which I netted for comparison on the Lancashire coast, where the species was flying in thousands towards the end of August. But apart from size and the tone of colour I could find nothing to distinguish them from *Plusia gamma*."

Description and Life History.

The Y moth is about three-quarters of an inch long with a wing expanse of from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. The head and thorax are brown, with a purple tinge, and the fore wings are silvery gray, with brownish markings. Upon each wing there is a silvery mark placed obliquely, resembling the Greek letter γ or an English Y. Its hind wings are grayish brown with dark margins. (Fig. 2 *a*.)

The ordinary caterpillar is light green, with pale yellow or whitish lines down its back, and a darker yellow streak along the side, with somewhat sparse hairs upon the body. (Fig. 2 *b*.) It has only twelve feet, and moves with a modified "loop." The caterpillar spins its cocoon under the leaves of plants and changes to a black chrysalis. There are successions of broods. The moths may be seen flying about from June till October, and hibernation is passed in the moth stage and in the chrysalis form, as well as in the larval state, as small caterpillars have been found in the winter.

Methods of prevention and Remedies.

When the caterpillars are noticed on clover, rolling with a heavy roller has been found beneficial. This can only be done in the early stages of the growth of the plants, after the first crop has

been carried. The caterpillars being green it is difficult to detect them, therefore careful observation is requisite from May to ascertain whether caterpillars are present in the clover crops. If they are present in formidable numbers the clover should be cut as soon as possible to prevent the chrysalids from turning into moths. A correspondent wrote that he believed the attack upon one large clover field was stopped by this means, the chrysalids being taken up with the hay and killed by the heat of the rick.

Lime, and lime and soot mixed, applied in damp weather have been found to be most unpleasant to the caterpillars. Where they are present on turnips and other plants in drills they may be dislodged by bunches of furze, birch, or green broom fastened on each side of a horse hoe. This should be immediately followed by another horse hoe to bury them, or kill them.

These caterpillars are very fond of thistles and nettles. Several correspondents remarked that they appeared to like the thistles in clover fields just as well as the clover. These weeds should be kept down, as they serve as food for the caterpillars before the clovers and other cultivated plants are ready.

In Germany they push long troughs of lath and sacking upon two light wheels through the young clover, flax, and beet, before the plants are too high, to catch the caterpillars.

Many correspondents wrote of the inestimable value of rooks, starlings, and other birds in clearing off these caterpillars, during the late attack. Rooks and starlings seem to be particularly fond of them, as they are smooth.

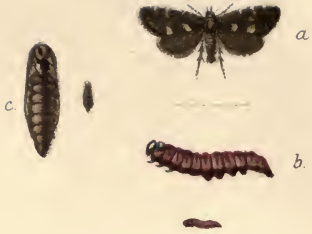

Fig. 1

Raspberry Moth. (Lampronia rubiella.)

a. Moth: line showing nat. size. b. Larva: nat. size & magnified.
c. Pupa: nat. size & magnified.

Fig. 2.

Cabbage Fly. (Anthomyia brassicæ.)

a. Fly: lines showing nat. size. b. Larva: nat. size & magnified.
c. Pupa: nat. size & magnified.

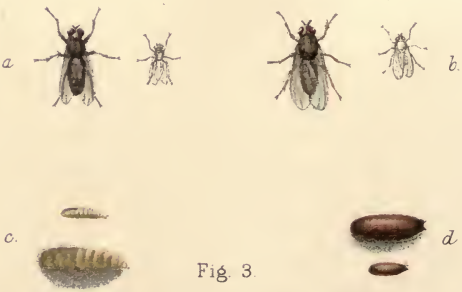

Fig. 3

Mangel Fly. (Anthomyia betæ.)

a. Male. nat. size & magnified. b. Female: nat. size & magnified.
c. Larva: nat. size & magnified. d. Pupa: nat. size & magnified.

The Raspberry Moth. (*Lampronia rubiella*).

(Plate II. Fig. 1.)

The small red caterpillars of this moth have been most destructive to raspberry canes in the last five seasons. The culture of raspberries has increased enormously during the past 10 years, as they have proved to be a profitable crop, and the canes come quickly into bearing. In 1891 very great loss was caused by these caterpillars, and in the past season in some districts the crop was almost a failure in consequence of their attacks. In 1891, upon several large fruit farms in Kent, nearly half of the buds of the raspberry canes were destroyed, and in 1892 the injury caused by the caterpillars was even worse in some localities. The attack of the previous season appeared also to have affected the health and vigour of the stock, as the new shoots were weak and small, and produced but little fruit. Many of the two years' shoots also were bare of leaves.

Upon close examination of canes infested with this caterpillar it was seen that the soft juicy whorls at the base of the buds had been eaten away so that foliage and blossoms could not be put forth. In some cases almost every bud contained a caterpillar, or had been destroyed by one which had left it and gone to another bud.

Life History.

The Raspberry Moth (*Lampronia rubiella*) belongs to the family *Tineidæ* of the group *Tineina*. It is a very pretty little moth, of a light brown colour—"shining brown," Mr. Stainton terms it—having a series of spots, as of burnished gold upon its fore wings.* The hinder wings are rather lighter coloured with pale fringes. It is barely half an inch across the wings and its body is not quite the fourth of an inch in length. (Fig. 1 *a*.) The moths may be seen towards the end of May and the beginning of June flying round the raspberry canes, and laying eggs upon their flowers. As to this process Dr. Chapman says: "the moth selects a fully open flower, and without any prolonged examination insinuates her terminal segment in the angle formed at the base of the stamens outside, between them and the calyx, seating herself on the stamens. The spear with which the ovipositor is armed pierces the substance of the receptacle in this angle, and the egg is placed in the substance of the receptacle at a depth from the surface about equal to its own diameter." The egg is

* Delta, in the Entomological Magazine, describes this moth as *Maculis insignis et auro.*

somewhat round. In about five days the caterpillar comes from the egg and works its way into the raised white receptacle upon which the fruit, or, more correctly, the collection of little fruits comprising the raspberry, is formed The caterpillar does not injure the fruit, nor does it feed at all at this time. Mr. Stainton says that it hibernates without feeding, and no traces of feeding could be found either in the fruit or the receptacle in which it is ensconced. It soon leaves the receptacle through a hole which it makes at its base, and goes down into the ground where it remains in larval form in a small cocoon during the winter. Upon the approach of spring it crawls up the canes and gets into a bud and feeds on it, remaining in this condition about 15 days, when it scoops out a hole at the base of the bud, and turns therein to a chrysalis. This last state continues from 12 to 14 days.

From observations noted this year it seems that a caterpillar is not satisfied with one bud, but feeds upon one and moves on to another when it has exhausted it, or finds it not pleasant to its taste.

The caterpillar is the fourth of an inch long, in colour reddish, or pinky red, varying in individuals, but becoming a pronounced red later on. (Fig. 1 *b.*) It has a black head, black marks on the segment next the head, three pairs of black feet on the thoracic segments, four pairs of fore legs, and a pair of anal feet. The chrysalis is exactly a quarter of an inch long and tapers somewhat unusually at its lower end (Fig. 1 *c.*)

Methods of prevention and Remedies.

The caterpillars pass the winter in the earth and rubbish around and among the stocks of the raspberry canes, staying there from about Midsummer until some time in March, early or late according to the season. After an attack it would be well to dig the earth deeply round and between the stocks with a digging fork, or spud, or to hoe around the stocks deeply with a three-pronged hoe, to destroy some, and bury some so that they could not get out of the ground. Soot and lime, mixed in the proportion of one bushel of lime to three bushels of soot, might advantageously be dug or hoed into the ground, or lime ashes might be used where these are procurable.

Raspberry canes in field culture are pruned very closely, so that there are but a few canes, or stems, from each stock. It would not be difficult, therefore, to put a little thick soft soap, mixed with carbolic acid or paraffin oil, or other offensive sticky stuff, upon the lower part of each cane with a large paint brush. This would, it is thought, prevent the caterpillars from crawling up. They are so small that the least obstruction of a sticky and disagreeable nature would stay their progress. Cartgrease with a little tar in it would keep them best.

Cutting off and burning infested canes would be the means of preventing further mischief. It would not injure next year's crop, as plenty of shoots are always thrown up from the stocks to take the place of those cut away. A badly infested cane would probably die if allowed to remain on the stock, so that nothing would be lost by cutting it away while the caterpillars are in its buds.

The Cabbage Fly. (*Anthomyia brassicæ.*)

(Plate II., Fig. 2.)

Complaints of injury to cabbages, broccoli, cauliflowers and other species of brassicæ were sent in during the last summer. Some of these came from market gardeners in Bedfordshire, Essex, Lancashire, and Surrey, who spoke of considerable mischief having been caused by whitish maggots in the roots of the plants which prevented them from forming heads and hearts properly. One correspondent styled this an extraordinary attack on the cabbage plants throughout the locality. In other cases farmers reported that the Drumhead varieties of cabbage were much injured. Swedes also were affected to some extent. It was said that there was a dirty white grub of a cylindrical shape in the roots, and that the plants thus infested turned yellow and flagged, or in some cases died. This is by no means a new pest. Curtis described it and spoke of losses occasioned by it in certain years. French, German, and American entomologists write of it as quite common in parts of France, Germany, and America.

Description and Life History.

The fly is rather larger than a house fly, and the female differs rather materially from the male, as is the case in most of the *Anthomyidæ*. Unfortunately females only came from the larvæ sent, so that a figure of a male from life cannot be given here.

The female is of a light grey colour with sparse hairs on the body, and legs also grey. Its head is clear grey and the eyes very wide apart with a red coloured space between them, having black hairs upon it. It has translucent wings, slightly yellow at their bases. The male is ash-grey, covered with black hairs. Its thorax is dark grey having three longitudinal black stripes. The abdomen is lighter in colour with a rather narrower black stripe down it, and three transverse black lines, so that eight black spots, or patches, are formed. The wings and legs closely resemble those of the female.

These flies may be seen throughout the summer. In the spring the females begin to place eggs upon the roots, as deeply below the junction of the leaves and roots as they can reach. Larvæ come forth in about 10 days and make their way at once through the cuticle of the roots, and scrape out passages within them, living upon their juices and thereby checking their growth. Besides, they cause decay in the roots, and young plants soon succumb to this attack.

The larva is dirty white in colour without hairs, cylindrical cut square at the tail end, with a pointed head furnished with two hooks, and is rather more than the third of an inch long. (Fig. 2 *b*.)

It continues from 24 to28 days in a larval state, and changes to a chestnut coloured pupa in the ground, and sometimes in the holes of the roots. This is about the fourth of an inch long, barrel shaped, with two thick projections at its lower extremity. (Fig. 2 *c*.) Pupation continues in the summer season for about 16 days. There are continuous broods from spring to autumn.

Methods of Prevention and Remedies.

Ammoniacal liquor, which may be had as refuse from gas works at a low price, has been found to be remedial in some instances. It must be mixed with water at the rate of from 2 to 2½ parts of water to one of the liquor, and poured carefully round the plants so as to get at the roots.

Ordinary lime water has also been found useful, but the difficulty obviously is to get these solutions to the roots.

Nitrate of soda, soot, and guano put on close round the plants have also been found valuable, as if they fail to act remedially they at least stimulate the plant's growth and help it along out of the way of the larvæ.

Badly infested plants should be pulled up and burnt at once, and the soil from which they are taken well limed or gas-limed and dug very deeply. In America strong brine is used occasionally to destroy the larvæ in the ground.

Before plants are put in they should be dipped in solutions of soft soap and quassia, composed of 7 lbs. of soft soap, 12 lbs. of quassia, to 100 gallons of water; or of 7 lbs. of soft soap and 6 to 7 quarts of carbolic acid.

Hellebore powder has been used for this with some success in the United States, mixed at the rate of a quarter of a pound to 10 quarts of water.

In the United States, according to Professor Lintner, it is dangerous to use fresh farmyard manure for cabbage ground.

If possible it would be well to avoid taking successive crops of plants of the cabbage tribe on infested land, at least until it has been deeply dug two spits deep, and limed or gas-limed.

The Mangel Wurzel Fly.—(*Anthomyia betæ.*—Curtis.)

(Plate II., Fig. 3.)

Many notes were received in the first week of June from various parts of the country, of much harm caused to mangel wurzel plants by the larvæ, or maggots, of this fly, and the agricultural journals from time to time during the summer recorded accounts of the injury occasioned by them. In some cases the plants were killed by the action of the maggots upon the leaves. In others their growth was retarded and the crop was consequently diminished.

A field of mangels, ten acres in extent, was inspected on the 8th of June, and it was found that 65 per cent. at least of the plants had eggs and maggots of the fly upon them. Some of the leaves were brown, and it seemed as if the greater part of them would be destroyed. Upon examination from 5 to 15 maggots were discovered in many of the leaves, whose surfaces were blotched, or blistered. They were within the tissues of the leaves, in which they had made long mines, or passages, and upon which they were feeding, exhausting their juices and extracting the chlorophyll, or green colouring. There were also quantities of eggs upon a great number of the leaves, from which maggots were being constantly hatched. As the land was full of manure, and nitrate of soda was added soon after the presence of the insects was discovered, the plants grew away from them evenually and yielded a good crop of roots, but their traces were plainly visible throughout the summer, and the crop was reduced. Fine growing showers also helped the plants considerably. If the land had been poor and the weather dry, it is believed that the plants could not have got over the attack.

This is not by any means a new mangel wurzel pest. Curtis describes the male, and mentions this insect as affecting the crop in 1847.* The first serious mischief resulting from this fly was in 1876. Again in 1880 much harm was done by it. Also in 1889 there were complaints of serious losses from its action in many counties.

Description and Life History.

The fly belongs to the family *Muscidæ*. It is about the size of a common house fly which it resembles in appearance. In colour it is grey of a somewhat ashy shade. The legs of the

* Journal of the Royal Agricultural Society of England, Vol, viii., 1 ser., p. 413.

male are black, with parts slightly tawny. Those of the female are testaceous. In the male the body is long and narrow with longitudinal spots on the back, and the eyes nearly meet; while the body of the female is much broader, the spots or lines, on the back are indistinct, and the eyes are far apart, with a white border around them (Fig 3 *a.*). The flies appear first in March. There are several broods of flies during the spring and summer, the number depending upon the weather and the state of the plants. Eggs, white, oval, with pretty markings which can be seen with a good pocket lens, rather more than half a millimetre in length, are laid in groups of from two to seven on the under surfaces of the leaves. As many as forty eggs were found on one leaf in July last. Larvæ, or maggots, come from the eggs in about eight days, and immediately bore into the leaf, getting out of sight as quickly as possible. The maggot (Fig 3 *c.*) is about the third of an inch in length, without feet, yellowish white, but with green colour in the intestinal canal showing plainly through the skin after it is a few days old. It is cut square at the tail end, but its head is sharply pointed, being furnished, as Westwood describes it, "with a corneous instrument in the shape of S, "which moves round a small fixed point, enabling them to scrape "up the soft parenchyma of the leaf." If the maggot is watched under a strong glass its head will be seen to move with a rapid circular motion, scooping out the leaf tissues, and feeding with wonderful voracity. It took a full-sized maggot just five minutes to bury itself completely in a fresh leaf upon which it was placed. For about 28 days the larva feeds, and then pupates either in the ground or upon the leaves. Many pupæ were found on the leaves in July and August last. The pupa is of a reddish colour, and about the fourth of an inch long (Fig. 3 *d*). From pupæ I kept in a glass case flies came in 11 days, but they did not lay eggs in confinement, though fresh leaves were constantly supplied.

Methods of Prevention and Remedies.

Syringing the plants with solutions of soft soap and quassia directly the first signs of the attack are visible, makes the leaves unpleasant for the maggots, and prevents them from getting in to the tissues, just as syringing hop plants with this mixture either prevents the winged aphis from remaining on the leaves and depositing her young, or the young aphides from feeding on them. From five to six pounds of soft soap and the extract of nine to ten pounds of quassia should be used to 100 gallons of water and put on well under the leaves by means of a "Knapsack" machine, or a Strawsonizer.

Carbolic acid, or paraffin, may be used with soft soap instead of quassia, in the proportion of three to four quarts to 100 gallons of water. This mixture should be prepared with very hot water and kept well stirred It should be understood that the soft soap is mainly useful in fixing the unpleasant materials upon the leaves.

It is desirable to keep the land well moved between the plants, and to push their growth on quickly with nitrate of soda. It is in the earlier stages of growth that the maggots do most harm.

The land should be deeply ploughed after a crop of mangels that have been infested, and a corn crop taken so that the soil may not be ploughed again until after the succeeding summer. All leaves and decayed leaves should be spread on the land and ploughed in, or raked together after the roots are tapped and burnt or buried deeply.

Curtis remarks of this insect that parasites no doubt keep it under,* and that we may trust to them for assistance. This is the fact, as four Ichneumon flies came from the 20 pupæ in my glass case.

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* Farm Insects, by J. Curtis, page 397.

Frit Fly. (Oscinis frit.)

a. Larva. nat size & magnified x 6. b. Pupa: nat. size & magnified x 6
c. Fly: nat size & magnified x 6. d. Oat: infested.

The Frit Fly. (*Oscinis frit.**)

(Plate III.)

Though this fly has been known in this country for many years, it had not caused much injury until 1888, or, at least serious injury had not been traced to it. Curtis describes it in "Farm Insects," evidently, under the name *Oscinis vastator*, and as injuring wheat plants. He does not speak of it as attacking oat plants. In 1888 the Frit Fly was most destructive to oat plants in many parts of England, and since then it has been more or less troublesome. This year, very great harm has been done to the oat crop by its action, which was materially helped by the weather. During the last few years it has not been noticed to have injured wheat or barley plants in this country, though Schiner says it attacks barley plants, and gives *Musca hordei* as one of its synonyms.† In Sweden also it is most destructive to barley, and chiefly, as it appears, from the larvæ living upon the grains of barley before they harden.

The spring of 1892 was very backward, and where farmers missed the few opportunities of getting in oats that were afforded them in February and the first part of March, this crop was sown unusually late. Indeed, many of the oats were "cuckoo" oats, and as is well known to practical men, late sown oats never grow away rapidly, but linger, and are apt to "die away in May." This gave opportunities to the larvæ of the Frit Fly to feed fully upon the soft part of the plant, in the bulb or crown, just above the ground, and the insects increased and multiplied enormously, and followed the plants throughout their stages. Larvæ were found in the bulbs, then in the nascent ears, and lastly on the grains themselves. Some large fields of oats were closely watched throughout the spring and summer, and this progress of the mischief was clearly traced. By many the sickly appearance of the oat plants and their slow growth were attributed to the late sowing and the dryness of the early part of the summer, whereas the larvæ were really the cause. In most instances there was no suspicion of the real origin of their unhealthy state, as the larvæ are so minute that they would not be noticed by unobservant persons.

Many of the plants attacked by this insect did not form any panicles, but were stunted and abortive, and for the most part exactly like the plant shown at *d.*, Plate III. Upon examination it was seen that the bulb, or centre, had been riddled by the larvæ. A proportion formed grain, but the panicles remained enveloped in the sheaths, the plants not having strength, apparently, to force them out. Traces of the action of the larvæ were noticed all up the stems, and pupæ were found among the panicles still in their sheaths. In many cases where the plants

* It is so named because "frit" is used in Sweden, where the fly is very destructive, to designate thin "tail" corn.

† *Fauna Austriaca. Die Fliegen.* Von. J. Rudolph Schiner.

were fully developed, larvæ were feeding upon the ripening grains, and later on, when the oats were fit to carry, there were quantities of pupæ imbedded in the grains.

Larvæ of the Frit Fly have also been found in the late autumn upon winter oats and rye, so that the insect is at its work of mischief during the greater part of the year. As late as the end of November in self-sown oats in fields that were badly infested this summer they were seen to be abundantly present.

Description and Life History.

The fly is very small (Plate III. *c*). It is shiny black with black legs, and the feet, or tarsi, are yellowish to brownish yellow. The wings are translucent, with brown shades. Taschenberg says that the eggs are reddish, and laid singly on the underside of the leaf. The larva (Plate III. *a*) is first noticed in the bulb, or crown, upon whose juices it feeds. It is yellowish white, not quite the eighth of an inch long, and without legs. Its head is furnished with formidable hooks, and its tail end with two spiracles. The pupa is reddish brown, somewhat shining, having at its extremity two curious knobs. (Plate III. *b*.) It seems, from the fact that larvæ were found in the spring in the bulbs, in the joints in the summer, in the oat grains later on, and in young winter oats and rye plants in the autumn, that there is a constant succession of broods depending upon the state of the food plants and the weather. Many pupæ are carried into the ricks, and may be taken into the yards and fields in the oat straw, and in the cleanings from the threshing machines. Some of the pupæ fall to the ground, and either remain there during the winter or change to flies, which lay eggs on winter oat and rye plants.

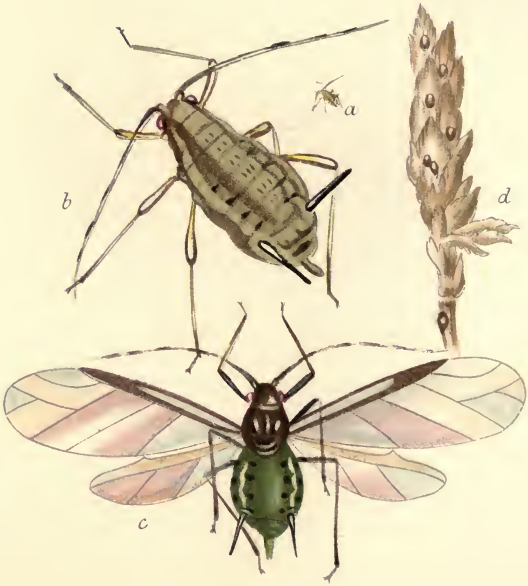
Methods of Prevention and Remedies.

No direct remedy can be devised for this attack. The larvæ cannot be reached by liquid or powder applications. When it is noticed that oat plants turn red in their early stages, and have a stunted appearance, they should be manured with nitrate of soda or sulphate of ammonia, to force them along rapidly. This should be done in dry seasons especially, when oat plants are usually inclined to stand still in May even when there is no attack of insects.

To prevent this attack it would be desirable to plough infested oat stubbles soon and deeply after harvest, and not to sow winter oats and rye near infested fields. When threshing oats from infested fields it would be desirable to burn the chaff, cavings, and cleanings.

Parasitic Flies.

Parasitic flies of two distinct species came from pupæ of the Frit Fly placed in a glass-capped case. Five of these came from 20 pupæ.



The Grain Aphis

(Siphonophora granaria.)

a. Apterous viviparous female, nat. size.

b. d.º d.º d.º magnified.

c. Winged viviparous female, magnified.

d. Part of an ear of wheat studded with aphides which have been struck by an Ephedrus.

The Grain Aphis. (*Siphonophora Granaria.**)

(Plate IV.)

There has rarely, if ever, been a more general and severe attack of this aphis than in the last season. Complaints came from all quarters, and wheat ears were sent in swarming with aphides in all stages. In going through the country in August their presence could be plainly seen by the colour of the wheat. Rust and mildew were very prevalent also, but in some fields there was a peculiar appearance, principally due to aphides. It was found, upon examination of the ears of wheat infested with aphides, that many of the grains were shrivelled, and not fully developed; also, that in a great number of the ears there were no grains in the chaff near their bases. Some growers assessed the injury at from 5 to 15 per cent., others, at from 15 to 20 per cent. It was, however, most difficult to make correct estimates of the loss from this cause; but it is obvious that the continuous suckings of quantities of aphides round the forming grain, and until just before it ripened, must have materially affected its quantity, weight, and quality.

From inquiries made as to cultivation and previous cropping, it appeared that no circumstances of this kind affected the attack. Wheat plants on all kinds of soil and in every description of situation alike suffered. Nor does it seem that the weather influences had much to do with the number and persistency of the aphides. The season was not very wet and not very dry. In former attacks it had been considered that dry weather and east wind caused, or at least, intensified them. Professor Riley, of the United States Department of Agriculture writing of a kindred insect, "The Grain Louse, *Aphis avenæ*," says: "That it may always be expected in a tolerably wet year that was preceded by a dry one." It might be "said that 1892 was a tolerably wet year," but 1891 was certainly not dry.

It was observed that plants near the outsides of wheat fields were attacked worse than those some distance in, and that small enclosed fields were worse than large extents of wheat land. Some reports showed that foul land was worse than land free from weeds, also that wheat after clover ley was the most injured.

Description and Life History.

The wingless female (Plate IV. *a* and *b*), which brings forth living aphides is greenish or brownish green. The colour varies very much between green and brown, so that it would sometimes

* Mr. Bowdler Buckton, F.R.S., has courteously allowed Plates IV. and V. to be copied from his valuable work—*A Monograph of British Aphides.*

almost appear that some belonged to a different species. It has a short rostrum, or beak, red eyes, blackish legs, and long brown cornicles.

The winged egg-laying female is not developed until late in the season, or when the food supply fails. It is not known where the eggs are placed, but probably upon grasses in the neighbourhood of the infested wheat fields. Although this insect cannot fly far, or strongly, *proprio motu*, it may be carried long distances by the wind. There seems to be no doubt that, as in the case of many other aphides, the viviparous larvæ hibernate and bring forth broods of larvæ directly the weather is favourable. American entomologists have found the larvæ of the *Aphis avenæ*, a closely allied insect, at the roots of wheat plants during the winter. But, as Mr. Buckton says, "Up to the present time no satisfactory answer has been given as to what becomes of the Wheat aphis in the winter months, neither do we know where the female deposits her eggs." It is suggested that it places them in the autumn upon grasses as cocksfoot, couch grass, the Poas, *Holcus lanatus*, *Bromus mollis*, and others, specified by Kaltenbach as being infested by this insect.

In the early stages of the wheat plant the aphis is found near the stems of the growing plants, from which it sucks up the sap. At this time the numbers are few, and the harm caused is comparatively small, but when the ear appears, its sweet juices cause the aphides to increase with marvellous rapidity after the manner of their kind. In many of the infested wheat fields the ears were literally swarming with aphides in all stages, and it seemed almost impossible that they could produce grain of the slightest value.

Methods of Prevention and Remedies.

When the wheat ears are out, and that is the time when the presence of the aphides is generally first discovered, it is obviously too late to adopt any remedies. Where observation in the winter, or spring, has shown that aphides are present upon the blades of the wheat plants, dressings of soot, lime, soot and lime mixed, or guano, might check their progress. If there are quantities of the insects present it might answer to dress the plants with a soft soap and quassia mixture, of 5 or 6 lbs. of soft soap, and the extract of 7 or 8 lbs. of quassia, to 100 gallons of water, put on with a Strawsonizer. Harrowing and rolling with a ring roller before the wheat plant was too high would interfere materially with the aphides. Feeding off with sheep would be remedial, where the state of the plants and the condition and nature of the land allowed this to be done.

After an attack of aphides the wheat stubble should be scarified or cultivated, and the rubbish burnt, or the land should at once be deeply ploughed. If the succeeding crop is to be tares, trifolium, potatoes, turnips, or mangels, thorough cleaning and destruction of couch and other grasses would be sufficient. A

succeeding white straw crop should be avoided after a bad attack.

Care should be taken to keep fields clear of couch grass and other grasses, and to clear away grassy outsides as much as possible.

Parasites.

Upon wheat ears infested with aphides observers would have noticed many brown bodies, evidently of dead larvæ (Plate IV. *d*). These are larvæ in which parasitic flies have laid their eggs, and the maggots from these eggs have fed upon the contents of their bodies. From infested wheat ears placed under glass several flies, of two distinct species, came from these brown bodies, and soon commenced to search actively for living larva in which to place eggs.

One of these flies was *Aphidius avenæ*. This parasite comes from the lower part of the body of its victim. It is a pretty insect with black, shiny body, long antennæ, and bright wings, whose expanse is just a quarter of an inch, and the body about the eighth of an inch; altogether much larger than the *Aphis granaria*. Curtis, in *Farm Insects*, describes the process of egg deposition in the body of the aphis larva, as witnessed by Mr. Halliday. "This is done by bending her body under her breast, and by lengthening her tail, the ovipositor is conducted under the aphis, and an egg is instantly inserted in the body under the tail. She then searches for another victim, passing by those that have been inoculated."† This description is most accurate, as the process was noticed several times in the last season, as well as the mode of egg-laying of the other species of parasite fly alluded to above, which, however, was not present in such numbers as *Aphidius avenæ*.

This other fly corresponds exactly with that called by Curtis *Ephedrus plagiator*. It is smaller than *Aphidius avenæ*. Its antennæ are more curved and much shorter. Its body has an ochreous tinge, and is pointed at the end, and its legs are yellowish; those of *Aphidius avenæ* being blacker. The eggs of this fly were inserted in the backs of the aphides.

At least 25 per cent. of the aphides on the ears, taken indiscriminately, were infested by one or other of these parasites, and there appeared to be a continuous birth of flies, which at once laid eggs in the aphides near them. The winged aphides were avoided; only the viviparous larvæ were chosen. From the experiences of this season it is clear that this action of these parasitic flies must decrease the number of aphides in a very important degree.

Not many lady-birds, *Coccinellidæ*, whose larvæ are wholesale devourers of aphides, were noticed in infested wheat-fields, but

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* *A Monograph of British Aphides*, by J. Bowdler Buckton, F.R.S.
† *Farm Insects*, by J. Curtis, p. 292.

there were considerable numbers of curiously-shaped larvæ of two distinct species of Syrphus found actively at work in the ears. These are the larvæ of large, handsome flies, more than half an inch long, with a wing expanse of slightly over an inch, with bands of yellow on their bodies, known respectively as *Syrphus balteatus* and *Syrphus pyrastri*. The latter fly is rather larger than the former and of somewhat stouter build.

One of the larvæ, that of *Syrphus pyrastri*, which eventually changed to a brownish cocoon, shaped like a soda-water bottle, and after 15 days to a wasp-like fly, was of a greenish colour, three-fourths of an inch long, with its body tapering to a point at its mouth end, which, as Mr. Walker says, "is armed with a trident, or "three points, on which they transfix their prey, and then raise "it in the air, and devour it."* This curious flourish in the air was always made when fresh aphides were seized. Though without eyes, the larva seemed to know instinctively the propinquity of aphides, and made, from time to time, sweeping movements with the head and nearly all the body in every direction. Three of these in a glass-topped box were supplied with aphides daily for 8 days. They were insatiable; the quantity of aphides whose contents they sucked up was extraordinary. One would have cleared a wheat ear in a few minutes. No species of aphis that could be procured was rejected by them.

These larvæ are frequently found upon aphis-infested hop plants and rose trees. They should be protected as carefully as ladybirds are in hop growing districts. A hop grower sent a larva of *Syrphus pyrastri*, suggesting that it was another of the numerous enemies of the hop plant.

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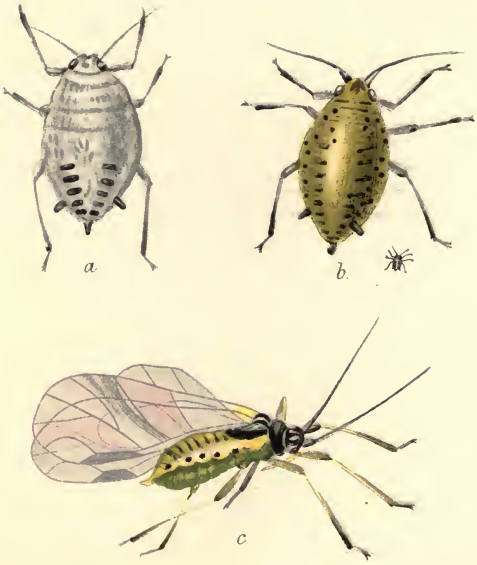
* "This peculiar action was invariable." *Insecta Brittanica*, by Francis Walker, F.L.S.



The Turnip Aphis.

(Aphis brassicæ)

a. Wingless viviparous female, covered with a mealy coat.

b. Wingless viviparous female, nat. size & magnified.

c. Winged viviparous female, seen in profile.

The Turnip Aphis. (*Aphis brassicæ.*)

(Plate V.)

Injury to a considerable extent was caused to turnip and swede plants during last summer by the turnip aphis. Cabbages of all kinds were also attacked in some places. Several specimens of infested plants of turnips and cabbages were sent for the identification of their affection. Cattle cabbages suffered somewhat seriously from these aphides, which penetrated even to their innermost leaves; and cauliflowers also were damaged, and their appearance spoilt for market.

The aphides congregate on the under surface of the leaves of swedes and turnips, where they increase with wonderful rapidity, and suck up the juices of the plants with their beaks, or rostra. Added to which, their filth and "honey dew" fall on the lower leaves, stopping up their stomata, and hindering respiration. After a short time the larvæ change colour. The growth of the roots is stayed, the stalks, or shanks, of the plants are elongated unnaturally, and finally the crop is ruined, or the weight of roots is materially lessened, and the leafage made unfit for food.

As a rule, these aphides are not seen on turnips and cabbages very early in the season as other aphides, those of the hop, lime, rose, for example. At least, they have not been noticed until the plants have attained a fair size. The first generations are bred on cruciferous weeds, as charlock, wild mustard, penny cress and others; and winged viviparous females fly from these, or are borne by the wind, to cultivated plants. Mr. Buckton says: "This species feeds on a variety of plants, such as *Raphanus sativus, Capsella bursa pastoris, Sinapis arvensis,* and the garden cabbage, *Brassica oleracea,* both the upper and under sides of the foliage of which last plant it often crowds with such numbers that the leaves become hidden by the living mass. Indeed, sometimes, weight for weight, there is more animal than vegetable substance present. The leaves then become putrid, offensive in odour, and quite disgusting to the eye."*

Description and Life History.

The winged viviparous female (Plate V. *c*) has a black head and thorax, with a green or yellowish-green abdomen, and very dark yellow legs. The antennæ are brown; the legs dark brown. The cornicles are also brown. The wings are rather short, with dark stigmata. Upon settling down on plants whose food supply is

* *A Monograph of British Aphides,* by G. Bowdler Buckton, F.R.S., vol. 2, p. 34.

grateful to them, these females produce larvæ, or "lice," which, after the manner of aphides, bring forth many generations like themselves.

These wingless viviparous females (Plate V. *a* and *b*) have oval bodies, and are covered with a whitish, powdery substance after they are a few days old, which hides their natural green colour. When first born they are yellow, shining, and have no powdery material upon them. In course of time egg-laying females are evolved. It is not known where the eggs are placed, but probably upon cruciferous weeds in hedgerows, clover leys, and other places. And, as in the case of other species of aphis, at the end of the season, or when the supplies of food fail, or become unsuitable, winged egg-laying females are generated which fly, or are wafted through the air, to plants suitable for their purpose.

It is certain that continuity of existence is not preserved upon the turnip and cabbage crops, except perhaps upon autumn planted cabbages, as they are consumed or carried away, and the ground is ploughed up at once to be sown with corn. Therefore, it must be assumed that the eggs are put by migratory females upon wild cruciferous plants. And, without doubt, some of the wingless viviparous females may be left upon wild cruciferæ, and hibernate at their roots. No amount of cold appears to affect them, as they have been seen upon plants and producing young in February after the coldest weather.

Methods of Prevention and Remedies.

It has been proved, without the least doubt, that solutions of quassia and soft soap, if applied in due time and properly, soon clear away hop aphides, whose habits resemble those of the turnip aphides. The soft soap causes the bitter principle of the quassia to stick to the leaves and make them unpalatable; while the aphides themselves are most unpleasantly affected by the wash which adheres to them.

From 7 to 8 lbs. of soft soap and the extract of from 8 to 9 lbs. of quassia chips are the best proportions for 100 gallons of water, and are those of which "hop wash" is ordinarily composed.

For this aphis two or three, or even four, quarts of carbolic acid, or paraffin oil, may be used, instead of quassia, upon swedes and turnips.

These washes may be put on with large garden engines having strong pumps and two lengths of indiarubber hose, with spray jets somewhat curved that they may be got under the leaves, for distribution. Hop-washing engines, which are stronger, would also be useful for washing turnips and cabbages. Both these and the garden engines must be set on high wheels in order to go over the rows of plants. Narrow, long-bodied engines might be constructed to go between the drills.

The wash may also be put on by the Strawsonizer, as adapted to throw the liquid up under the turnip leaves. On small

holdings the Éclair, or other similar Knapsack machines, may be used.

In the case of large cabbages, among which it would be difficult to move a machine, Knapsack machines would be more convenient. It would be necessary to apply the wash all over these plants.

Powdered applications have not been found so efficacious as washes, and rather, perhaps, that it has been difficult to throw them up under the turnip leaves, where the aphides congregate. But the Strawsonizer, as was proved in the Diamond-back moth experiments carried out by the Board of Agriculture in 1891, has been arranged so as to thoroughly cover every particle of the under surfaces with dry substances. Soot and lime, mixed in the proportion of one part of lime to three of soot form the best remedy of this nature. Very small quantities can be put on by the adapted Strawsonizer, and such were found sufficient to rout the caterpillars of the Diamond-back moth, as they were blown up with great force.

It is clear that the main attack of these aphides comes from cruciferous weeds, which retain the eggs during the winter, or harbour the wingless viviparous females and furnish them with food in the early spring, nourishing them until the cultivated plants are ready for them. Therefore, charlock, penny cress, the wild radish, shepherd's purse, and other cruciferous weeds, should be kept from fields and their outsides as much as possible. Charlock and other weeds of this order are frequently found in clover leys. They are dangerous sources of mischief, and should be brushed off close in the autumn. It must be remembered that a few females can blight whole districts. Réaumur has calculated that one aphis can be the progenetrix of 5,904,900,000 aphides during its life.

There are several enemies of the *Aphis brassicæ*, which, in some seasons, greatly diminish its numbers. Among these are Lady-birds, *Coccinellæ*, whose black larvæ, known as "niggers" in the hop districts, clear them off by wholesale. The voracious larvæ of at least two species of *Syrphus* flies devour quantities in incredibly quick time; and parasitic flies of three species lay eggs in the bodies of the aphis larvæ, to their utter destruction. Chief among these is an Ichneumon fly, named *Trionyx rapæ*, a pretty dark brown insect, with yellow rings round the lower part of its body. It has a wing expanse of nearly the fourth of an inch, and its body is not quite the sixth of an inch long.

The Raspberry Beetle. (*Byturus tomentosus.*)

(Plate VI., Fig. 1.)

The attacks of this beetle upon raspberry canes are becoming more frequent and serious, and are more generally distributed in fruit-growing districts. It was to be found last season in almost every raspberry plantation, and it was seen in June in nearly every garden in the flowers of the raspberry, feeding upon the pollen and the juicy stamens, and hindering fructification and the proper development of fruit. Later on its larvæ were noticed within the receptacles, the white fleshy cones upon which the fruit is formed. The larvæ bore into and eat away the receptacles, and by their action cause the fruit to decay. It is affirmed that the larvæ feed upon the fruit, but there is no direct evidence of this. After watching infested raspberry canes closely during the time the fruit was ripening, the conclusion was arrived at that the centre of attraction for the larvæ was not the fruit, but the receptacle. They appeared to make for this directly they came from the eggs. Upon pulling out the receptacle of an infested raspberry, the larva was invariably within its soft fleshy part, and the fruity parts showed no signs of having been eaten away, though decay was present caused by the injury to the receptacle. It was quite exceptional to find more than one larva in each raspberry, and that one in any other part than the receptacle.

Description and Life History.

The *Byturus tomentosus*, as may be seen from the figure, is yellowish brown in colour, with a thick down, or pubescence, upon it, from which it is called *tomentosus*. The male is rather smaller than the female, and differs slightly in colour, having a shade of green. The legs are yellowish, with a red tinge, and the antennæ are of the same colour, terminating in a club with three joints. It has large wings, but when disturbed upon the raspberry canes it prefers to lie still, and sometimes to curl up and feign death, rather than fly, both on sunny and cloudy days.

Early in June the beetles are to be seen on and in the flowers of raspberry canes, as well as on blackberry bushes, wild and cultivated, feeding upon the pollen and the succulent filaments of the stamens. They pair in the flowers generally, and their eggs are placed singly among the stamens close to the receptacle. To effect this, and to get the egg between the stamens, the female uses her extremely long ovipositor, which is a most elaborate instrument. The process of egg laying takes some time, and is most interesting to witness. Constant searchings

Fig. 1

Raspberry Beetle. (Byturus tomentosus.)

a. Nat size b. Magnified

Fig. 2.

Pea & Bean Weevil. (Sitones lineatus.)

a. Nat size b. Magnified

Fig. 3.

The Red Spider. (Tetranychus telarius.)

a. Nat size b. Magnified × 60.

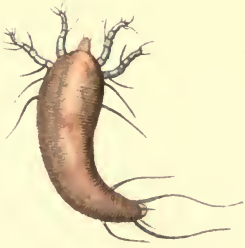


Fig. 4.

The Raspberry Mite. (Phytoptus rubi.)

Highly magnified × 250.

are made to find a suitable place for the egg, and the ovipositor sweeps round and round many times before the right spot is hit upon. It seems that the egg, which is white and rather narrow, is fastened to the receptacle with a viscous fluid.

In about seven days the larva is hatched. It is yellowish brown at first, with a brown head, and not quite a quarter of an inch long. As it grows it gets darker. The hinder extremity, or tail end, is rather narrower than the head end, and is furnished with a pair of crooked spines on the upper part, and a proleg underneath to help progression. There are three pairs of short feet, not much more important than sucker feet. It lives from 14 to 17 days within the white receptacle, upon which it feeds. When this is reduced to a pulp, and is becoming black and decaying, the larva leaves it, and getting under the loose skin of the raspberry canes, or in crannies in the supports, if there are any, or other hiding places, changes to a pupa, assuming a slight cocoon, in which state it remains until the following spring. It is probable that pupation also takes place on the canes close to the ground, and in the stocks, and even in the ground.

Methods of Prevention and Remedies.

It is clearly impossible that applications to the canes to make the beetle's food distasteful could be of any efficiency.

Some beetles might be caught by holding tarred boards under infested canes, which should be violently shaken, but, as noted above, they try to hide themselves, and when in the flowers they could not easily be dislodged.

All the old canes should be cut away, close down to the stock, and all the wood and rubbish burnt. Young canes, that is those of the year's growth, would not have any loose skin under which the larvæ could pupate.

The ground round the stocks should be dug deeply, and rubbish cleared away from the stocks, and either dug well in or burnt.

The Pea and Bean Weevil. (*Sitones lineatus.*)

(Plate VI., Fig. 2.)

This weevil feeds upon several leguminous plants, and especially upon clover, peas, and beans. It often seriously injures red clover in its early stages, when the plants are struggling along in dry seasons. Its larvæ, small white maggots, spoil "second cuts" of clover by eating the roots of the plants, and stopping their growth. Some roots of clover were forwarded this summer, whose tops were dying away, as it was suggested, from clover sickness. Upon examination, the larvæ of *Sitones lineatus* were found in these. It was stated that the crop was reduced by at least one half in consequence of this attack.

Trifolium suffers considerably from this weevil, particularly in its early stages. The injury which it causes to trifolium, however, is generally attributed to slugs and other insects.

Peas and beans, too, are very subject to the onslaughts of this insect, and in this case also slugs are usually accused, because the Sitones are not by any means easily seen, being very shy, and of a dull colour, and falling to the ground on the least alarm. This weevil eats the leaves and young shoots of the pea and bean plants, and its larvæ devour their roots. In the spring of this year complaints were made from many places of damage done to peas, and especially to early peas, by the weevils. Amongst others, Mr. Charles Howard found in a piece of early peas, Sangster's No. 1, which had been drilled on February 11th, that the Sitones were eating the plants as fast as they grew, so that a very poor yield was obtained. Other complaints were received from Bedfordshire, Essex, Kent, and Surrey pea growers and market gardeners, as to losses from this cause. In some cases the crops of peas were entirely cleared off, especially upon land that had been stale ploughed. Mr. Howard reported that upon land after barley which had been ploughed before Christmas, only a very few peas were grown, on account of the weevils, while adjoining land ploughed in February was comparatively free from them.

The Sitones were most troublesome in gardens and allotment grounds throughout the summer, and reduced the crops of peas and beans. It was noticed that they attacked sweet peas also.

Description and Life History.

The weevil is a quarter of an inch long. Its ground colour is dark, but the body is covered with greyish scales, which in some specimens are of a slightly greenish shade. There are three lines of this grey, or grey-green, hue on the thorax, and many lines on the wing cases. The antennæ are of a red colour, very slender, with club terminations. The legs are ferruginous. As Canon Fowler says, "the tibiæ of the male are curved, and

armed with a small hook."* It is not known where the eggs are placed. Egg-laying begins in the early spring. The larvæ, or maggots, which are white, legless, nearly a quarter of an inch long, and somewhat curved, live in the roots of clover, peas, beans, and other leguminous plants, and change there to pupæ.

It is certain that some of the weevils pass the winter in weevil form. Probably in other cases hibernation takes place in the pupal state, though this is not definitely known. Nördlinger observes that many weevils come from the pupæ at the end of August, and without doubt hibernate in weevil shape.† From observation, it is plain that these insects hibernate in the perfect, as well as in the pupæ state. Larvæ have also been found at all seasons of the year, among the roots of clover. A favourite resort of the hibernating weevils is in the straws of stubble. They are also carried in quantities with peas and beans into ricks and barns. These weevils feed by night as well as by day.

Methods of Prevention and Remedies.

Lime, soot, and lime and soot mixed, may be advantageously distributed over infested plants while the dew is upon them, or after rain. Guano also may be used in this way.

Fine powdery materials can be easily applied, and well distributed with "Knapsack" machines like the *Torpille*, and others of similar principle.

When peas and beans are attacked, it would be desirable to press the earth tightly and firmly close round the plants, in order to prevent the beetles from coming up from the earth. This might be done by men and boys walking with a foot on either side of each row of plants.

Summer fallowing land after an attack would be very desirable. Wheat after clover ley is often infested by swarms of weevils. In this case it would be dangerous to sow trifolium at all.‡ If it is sown, the land should be "broadshared," or cultivated and ploughed. The stubble should be burnt. This practice of burning stubble, weeds, roots, and rubbish, is comparatively seldom adopted in these days. It is believed that this is one cause of the more frequent and more destructive visitations of insects injurious to crops.

Infested clover leys should be deeply ploughed, with a "skim" coulter on the plough, and thoroughly well pressed. Roots on the top should be got off, and burnt, not carted to the outsides and left in lumps.

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* *The Coleoptera of the British Islands*, by the Rev. Canon Fowler, F.L.S.

† *Die Kleinen Feinde der Landwirthschaft*, von Dr. H. Nördlinger.

‡ The failure of trifolium is generally attributed to weather influences, bad seed, or unsuitable cultivating, but in most cases it is due to the agency of insects, such as this weevil, which delight in its tender leaves; also to two or three kinds of fungi.

The Red Spider. (*Tetranychus telarius.*)

(Plate VI., Fig. 3.)

This little creature is most destructive to many of the crops of the farmer, gardener, and fruit-grower. Its mischief is frequently attributed to other causes, as it is so small that it escapes observation. Thus, its action upon hop plants, causing the leaves to turn yellow and to drop prematurely, was formerly supposed to be due to hot dry weather, and was termed "fire-blast." In Germany this is called kupfer-brand—copper-burn—because the hop leaves become copper-coloured, and, as in England, is commonly held to be caused principally by hot sunshine. It is true that this affection of hop plants is always much worse in hot seasons, and rarely shows itself in any other; but this is because heat and drought are essentially favourable to the red spider. In 1868, 1872, and 1885, there were many acres of hops quite ruined by the red spider. The leaves fell off from the bines, and not a hop was picked. During the last few years damson trees have suffered severely from its attack. The leaves have turned yellow in July and August, and the fruit has not been able to develop and ripen properly. This has caused great losses in Kent where damsons are extensively cultivated. Gooseberry bushes have also been similarly affected by red spiders in the last few years. Their leaves have suddenly turned yellow and have fallen to the great detriment of the fruit and the bushes themselves. Great complaints of this attack upon gooseberry bushes were made by growers in Kent, Cambridgeshire, Worcestershire, and other fruit-producing centres. A large grower, writing on April 22nd, said: "already at this early date the leaves of many of my gooseberry trees are covered with red spiders. This is the third year of the attack, and most of my trees are in their prime, and must, I think, be ruined unless I can do something to stop it. I am really quite disheartened, the trees are full of young gooseberries, and continually have every care and attention."

It is well known that red spiders are equally destructive to vines out of doors, as well as in hothouses, also to French and scarlet runner beans. A species of *Tetranychus*, closely resembling *Tetranychus telarius*, attacks lime trees. This summer lime trees in many parts of this country were attacked by it. The leaves turned yellow in August and many of them had fallen quite early in September.

The red spider is becoming a common pest in fruit plantations in England. It has spread rapidly in late years, being conveyed with young trees, suckers, and cuttings from plantation to plantation and from country to country. Mr. Cooke, the well-known entomologist, and late chief Executive Horticultural Officer of California, wrote as follows concerning this: "The red mite commonly called the 'red spider,' may be said to be a universal

pest of the orchard, garden, and hot-house, and has been allowed to spread to an alarming extent in orchards in this State."

Upon a considerable acreage of land planted with damson trees, red spiders were so numerous that the leaves were completely bronzed and the fruit dropped. The under sides of the leaves were swarming with these mites in all stages, which were sucking out their juices. Fine webs covered the whole.

Peach trees suffer much from red spiders, and the already most precarious crops of this fruit are frequently seriously affected by it.

Description and Life History.

The red spider, a species of the spinning mites, *Trombidiinæ*, is only just perceptible with the naked eye. (Fig. 3, Plate VI.) It is not always red. In some stages of its life, and especially upon some kind of food, it is greenish with brown marks upon it, or sometimes it is dark red or bright red. In its perfect form the mite has eight legs whose claws are furnished with hairs, or bristles, surmounted by a globular tip, said to be for the purpose of web-spinning. It has an elaborate barbed sucking apparatus. When the mites come first from the eggs they have only six legs. After a time a change, or moult, takes place, and the mite acquires the full complement of eight legs. Perfect insects, male and female, imperfect six-legged mites, together with eggs, can be seen collected beneath the webs. The eggs are colourless and oval.

Reproduction goes on throughout the summer and the mites spread from leaf to leaf. They hibernate as perfect mites in the folds and rings of the rind, in the chinks of the bark, and under the smallest mossy and lichenous growths, as well as under the dead rind, upon leaves and in the cracks of stakes used for supports. They may be found in quantities during the winter by close and careful examination under the skin of gooseberry bushes, and upon damson trees that have been infested in the previous summer.

It has been remarked by some observers that these mites hibernate also under stones and clods. This, no doubt, occurs in certain circumstances, as, for instance, in the case of infested hop plants which, as is well known, are cut down close to the ground by the middle of September, so that the mites cannot be continued and carried on throughout the winter upon the plants. They probably escape into the earth from the withered leaves upon the bines which are not collected from the hop gardens until October or November.

This would seem not to be a safe and sure harbour of refuge, especially in wet winters, and red spiders object entirely to moisture, for it is found that hop plants are not continuously attacked like gooseberry bushes and damson trees, and several seasons frequently elapse without a sign of injury from this cause.

Red spiders may possibly hibernate in the cracks of the hop poles, but these are taken down and put up again each season, and are removed generally before the leaves have become quite withered.

Fruit plantations and hop grounds should be kept clear of chickweed, *Stellaria media*, and other weeds which live through ordinary winter weather, and serve as harbours for red spiders.

In sheltered places and gardens where plants, as violets, for example, preserve their leaves throughout the winter, red spiders may be found upon them in the most severe weather. They ought to be banished from the neighbourhood of peach trees and all other fruit trees.

Methods of Prevention and Remedies.

For gooseberry bushes attacked by red spiders, the most efficacious remedy has been proved to be a solution of soft soap and extract of quassia chips syringed upon the stems and branches. From 10 to 12 lbs. of soft soap and the extract of from 7 to 9 lbs. of quassia to 100 gallons of water has been found a good solution. This may be put on with "Knapsack" machines, the Éclair, or the Antipest, or others of a similar make, or by a large garden engine, or a hop washer where there is room to get it about between the bushes. Every part of the stem, branches, and leaves should be thoroughly covered.

In the winter, and after the bushes have been pruned, those that have been badly attacked may be dressed over with a thick solution of soft soap and quassia put on with a brush and worked well in. Or, carbolic acid or paraffin oil may be substituted for quassia.

Damson trees have been treated with much advantage with syringings of soft soap and quassia solution, mixed in the same way as for gooseberry bushes. Garden engines, or hand hop-washing engines, are the best for this application to damson trees, whose stems and branches should also be dressed with the soft soap and carbolic acid, or paraffin mixture, during the winter months.

Hop plants may be syringed with the solution used with such good results for checking the attacks of the hop aphis. The unfortunate necessity for the frequent application of this remedy for hop aphides has, without doubt, considerably diminished the danger to be apprehended from red spiders.

All the cuttings from infested gooseberry bushes should be burnt at once, and after an attack in hop gardens the bines should be made up and carried away to be stacked at once, or burnt. Lime should be dug in hot in the early winter months where hop gardens have been infested.

The Raspberry Mite. (*Phytoptus rubi.*)

(Plate VI., Fig. 4.)

A new pest has been discovered, which has already caused much loss to growers of raspberries, and threatens to affect their production most seriously. It will be remembered that in the last two seasons, and especially that of 1892, many canes have died away. This was attributed in some cases to frost and to the raspberry moth, *Lampronia rubiella.* But upon careful examination of the canes in the spring, no traces of the caterpillar of this moth could be found. In October last, while examining some shoots of raspberry canes for Byturus pupæ, it was noticed that the buds in the axils of the falling leaves were brown at their tips, and that the autumnal or sheathing embryonic leaves, or scales, were brown. As seen with an ordinary pocket magnifying glass, they appeared to be injured by frost. Under the microscope, moving mites were seen in these sheathing leaves or scales, and in the inner layers of leaves; they resembled the black currant mite, *Phytoptus ribis*, but under a lens of high power they proved to be of a somewhat pinkish colour, and differed in other respects, from that species.

These mites, like the mites of the black currant, feed upon the juices of the tender leaf- and blossom-buds of the raspberry canes all the winter, and prevent them from putting forth leaves and flowers. It appears that the lower buds are attacked first, and the mites move on up the stems of the canes from bud to bud.

Description and Life History.

This mite is an undescribed, and, it is believed, a hitherto undiscovered species of the Phytoptidæ, or gall mites. It is quite invisible to the naked eye, and seems only as a mere speck of dust with a pocket magnifier. It is of a light pink hue, with four legs having six joints. (Fig. 4, Plate VI.) The end joint terminates in a sort of claw, which is furnished with branching arms looking like feathers. There are three long hairs on each side of the body, and one pair of very long hairs at the extreme end. There are bristles, also, at the tail-end of the body, placed between the long hairs, which appear in some way to be connected with the locomotion of the mite. In moving, its tail end is bent round from side to side, apparently to help it along. Specimens of the mite under observation traversed the field of the microscope in less than one minute.

Eggs were seen upon the scales and leaves of the buds, glistening specks, more of a round than oval shape. Mites of all stages of growth, as well as cast skins of mites, were also noticed among the colonies between the scales and leaves.

As pointed out previously, the lower buds had been first attacked, and it would seem that the mites move on from bud to bud. Having exhausted one, they go to another. Some infested buds were placed on glass, and after a few days, when they were becoming shrivelled, it was found that the mites had left them, and were straying over the glass.

Modes of Prevention and Remedies.

It is almost hopeless to attempt any remedial measures. One mode of prevention is to sacrifice the fruiting canes which should bear raspberries the next summer, and cut every stem of cane close down to the ground, and to clear away every particle of growth from the stocks. All this should be taken away and burnt immediately, before the mites have time to escape. The stocks should then be brushed over or syringed over with a strong mixture of soft soap and carbolic acid or paraffin.

Canes for planting should be carefully examined, and rejected if they show signs of infestation. This may be detected by the buds being brown or blackened at their tips in an unusual manner.

Care must be taken to stamp out this pest, if possible. It is far more widespread than is imagined, and bids fair to be as destructive as the mite peculiar to black currant trees, *Phytoptus ribis*, which has been allowed to spread in a disastrous manner in many plantations.

ig of Black Currant, infested.

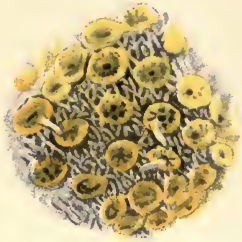


Fig. 2.

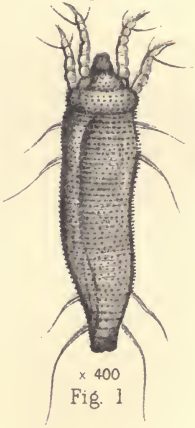


Fig. 1

Twig of Black Currant, I

Fig 1. Phytoptus ribis. *magnified 400 times.*

Fig 2. *Galls and mites.*

The Black Currant Mite. (*Phytoptus ribis.*)

(Plate VII.)

Complaints of the prevalence of this mite in the black currant plantations have come from many parts of the country during the last twelve months. It has increased rapidly in the past four years, having been transmitted from one place to another with cuttings and young black currant bushes. In some plantations this infestation has spread so fast that at least 50 per cent. of the buds are full of mites. A black currant plantation of 20 acres in extent in Kent was visited in January of this year, and it was found that almost every bud was distorted from the action of the mites within it. The mites were feeding upon the contents of the buds, as was seen plainly when a section was placed under the lens of a microscope. The effect of this will be that these buds will be abortive, or at least fruitless. Stunted leaves may be put forth which will in all probability fall off in the early summer, but no blossoms can be formed from these infested buds. There were no eggs in the infested buds that were examined in January. Examinations made in the spring of last year showed that there were many eggs in the infested buds, and mites in different stages of growth. Mites were also detected in the act of travelling from one bud to another. At least they were upon the spaces of the shoots between the buds, so that it may be inferred that they were moving on in search of food. They have remarkable locomotive power considering their minuteness, and get across the field of the microscope so quickly that it is difficult to examine them while alive.

Life History.

The *Phytoptus ribis* belongs to the sub-family Phytoptidæ, gall mites, of the order Acarina, according to Andrew Murray's classification, as given in his useful work on the Aptera written in 1877. There are many species of these gall mites. One attacks lime trees; another much injures the pear crop. The apple, hornbeam, yew, alder, willow, maple, plum, birch, peach, and other trees have their respective species. The vine also is injured by one species, and it has been recently discovered that the raspberry is attacked by one of these creatures, which has been styled *Phytoptus rubi.*

The *Phytoptus ribis,* like all the species of Phytoptidæ, has only four legs. These are six-jointed and furnished with

bristles upon their last joints, and are prolonged into a pointed claw having underneath slightly toothed hooks. The mite has a snout for sucking the juices of the buds. At the tail is a pair of long stout bristles, and there are three other pairs of shorter bristles upon its body, one pair near the long tail bristles, and two pairs near the head. These seem to help locomotion or to steady the creature in its movements, which are wonderfully rapid. In colour it is light grey. Its body is thickly covered with spots or striæ. It is indistinguishable with the naked eye, and nothing can be made of it with the strongest pocket lens.

Eggs are found in the buds during the spring. They have been noticed as early as the 10th of February. They are rather more round than ovoid in their early stages, and are colourless and abundant. It is not known when egg laying ceases, but probably as soon as the buds have expanded, or in cases of bad infestation, when the buds have shrivelled up and the mites are ousted from their homes. They stray about upon the leaves and the shoots, and as they make their peculiar gold-coloured galls (Fig. 2) upon the young and tender twigs, as well as upon the sheathing scales, or embryonic leaves of the buds, it is believed that they live upon these, if not upon the leaves also until the buds are again formed. In January many deserted galls were noticed upon young shoots and less frequently upon older shoots; they still retained their golden hue in some cases, though many had become blackened.

Some infested buds were examined in November, 1892, and the mites were found under the first sheathing scales. During the hard frost of the first week in January, 1893, the mites were found either under the third sheathing scale, or quite within the centre of the whorl. Though the thermometer registered from 20 to 29 degrees (Fahr.) of frost during the week, the mites were most active and feeding, as taken from buds hard frozen.

Modes of Prevention and Remedies.

When black currant bushes are planted they should be carefully examined for the Phytoptus. If there are any signs of unnaturally swollen buds the young trees should not be planted. In taking cuttings in the late autumn those from infested bushes must be rejected absolutely. Infestation is easily seen then by the abnormal buds.

Infested bushes should be cut very hard, and every particle of cutting carried away and burnt. In the spring the bushes should be syringed well all over with a solution composed of 1 ounce of Paris Green to from 11 to 12 gallons of water, with 2 ounces of fine wheat flour added, or 2 ounces of soft soap, to make the solution adhere better.

The Éclair "Knapsack" pump may be employed for this, and it must be impressed upon the labourers to direct the spray over every part of the currant bushes.

Another solution for spraying, to be used in a similar manner may be composed of 5 to 6 lbs. of soft soap, mixed with the extract of 8 or 9 lbs. of quassia chips, to 100 gallons of water, 3 quarts of carbolic acid might be substituted for the quassia.

Spraying with these solutions should be repeated in the autumn before the weather becomes cold, and just after the leaves have fallen, if possible. This will economise liquid and labour, and will affect the mites before they get into the buds.

Directly the leaves have fallen it would be desirable to put hot lime round the stocks and dig it in at once, so as to bury the leaves with any mites that may be upon them, and thus prevent any chance of their getting up the stems.

In very bad cases it would pay to cut the bushes close to the ground, and in the autumn and early spring to syringe the stocks with the Paris Green solution or the carbolic acid solution. This would entail the loss of one year's crop only.

The Apple Blossom Weevil. (*Anthonomus Pomorum.*)

(Plate VIII.)

This insect frequently causes much harm to apple and pear trees. In the last four or five years its injuries have much increased in fruit-producing districts, and in some instances they have been attributed to the caterpillars of the Winter Moth. Close examination of the blossoms has, however, shown that the larvæ, or maggots, of the beetle were in the centres of the flowers, destroying their powers of fructification, though at the same time caterpillars were feeding upon the blossoms and leaves. The action of this beetle upon the fruit-blossoms of apple and pear trees is also often taken for the effects of white frosts, when the petals have become brown or rusty coloured; but if they are closely examined, either the pupa of the weevil will be found within them, or the little round hole in the side of the withered flower-bud will be noticed, showing that the perfected weevil has cut its way out of its cradle.

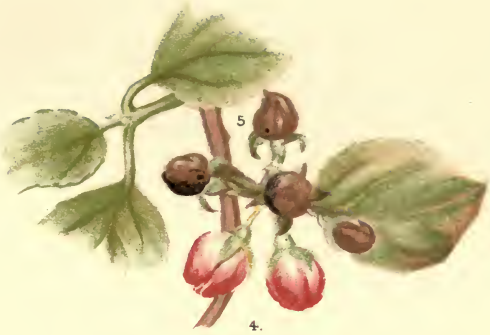
The blossoms of pear trees are attacked in a similar manner by this weevil, and great mischief is sometimes caused, especially in orchards where pear and apple trees are planted together.

In France this weevil has lately occasioned incredible damage in the orchards of Brittany and Normandy. So great have the losses been in the Department of Morbihan that a syndicate of defence against it (Syndicat de défense contre l'Anthonome) has been formed at Pontivy, consisting of a committee in each Commune, to carry out a series of operations calculated to destroy this enemy of apple-growers. It is only by unity of action among cultivators that injurious insects of this and many other kinds can be stamped out, and their baneful effects upon crops materially decreased.

Description of the Weevil.

The apple blossom weevil is a very small creature, only about one-fourth of an inch long, and not the eighth of an inch across its body. It is reddish, or chestnut brown, with down, or pubescence, of a greyish hue upon it. Some specimens are almost piceous in colour. The wing-cases have pale marks upon them below the middle. There is a conspicuous white mark, or scutellum, at the base of the wing-cases. The legs are reddish; the thighs of the anterior, or first, pair are large and furnished with a formidable tooth on each; and the feet, or tarsi, are darker coloured. Its rostrum, or snout, is the most remarkable feature, being half as long as its body, slightly curved, with antennæ near its extremity, furnished with oval clubs having four joints.

Like many other weevils it falls down when disturbed, tucks in its snout and legs, and remains motionless, feigning death until the danger has passed.



Apple Blossom Weevil.

(Anthonomus pomorum)

1. Pupa. Nat. size.
2. Larva. —,,—,,—
3. Weevil —,,—,,—
4. Healthy Apple blossom.

1a. Pupa. × 6.
2a. Larva. × 8.
3a. Weevil. × 7.
5. Apple blossom attacked.

Its Life History.

In the first warm days of spring the weevil issues from its winter retreat under the bark of trees, among lichens and mosses upon their branches, or under stones, grass, leaves, and rubbish under them. Curtis and Schmidberger considered that the females seldom use their wings, but that the males fly freely. Dr. Henneguy, to whom a special mission was entrusted by the French Minister of Agriculture to fully investigate the habits of this insect in Brittany, states that both sexes fly easily, and with equal frequency.*

Either by flying, or by crawling, the female finds its way to the blossom buds of apple and pear trees, and boring a hole with its snout, places one egg within each bud, and carefully closes up the aperture. This is the mode of oviposition described by Curtis and other economic entomologists. M. Petit, Departmental Professor of Agriculture in Morbihan, who has studied this insect, states, however, that the female does not perforate the flower-buds with its snout for egg deposition, but with a stylet placed in the extreme end of its body, like a bee's sting.† M. Petit remarks that by pressing the body of a female weevil this stylet is protruded, and can be seen with a glass. "It is hard to admit," he adds "that the insect should execute a complicated manœuvre obliging it, after having pierced the bud with its snout, to turn round and place the egg in an invisible hole, smaller than the egg."

A female lays from 15 to 20 eggs, but places one only in each flower-bud. The process of laying one egg takes about three-quarters of an hour. The egg is yellowish white, and oval. Authorities agree that the period of egg laying in an individual female may be continued for at least a fortnight. The eggs are hatched in from five to nine days, according to the conditions of the temperature.

The larva, or maggot, is without feet, about 4 lines long—the third of an inch—when full grown. It is wrinkled, and white at first, gradually becoming of a yellowish hue, having a brown head with two little brown spots on the first segment. It lies in the bud in a curved form, and attacks the stamens and pistils, but, it rarely touches the ovary. It soon causes the petals to wither; the flower-bud changes to a rusty hue, and decays.

Then the larva turns into a pupa, close upon a quarter of an inch long, yellowish white, with its long rostrum, or snout, and feet folded on the under side of its body. It remains in pupal state for about 10 days, when it assumes weevil form and bores a hole through the petals and emerges.

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* *Rapport sur l'histoire naturelle de l'anthonome du pommier, et sur les moyens proposés pour sa destruction*, par le Dr. F. Henneguy. Bulletin du Ministère de l'Agriculture. France, dixième année No. 8, December 1891.

† *Guerre à l'Anthonome*, par P. Zipcy, Professeur à l'Ecole d'Agriculture du Morbihan. Journal d'Agriculture Pratique, 1892, Tome I., No. 1. 7 Janvier.

Most practical entomologists have held that the weevils live during the summer feeding upon the leaves of apple trees. Dr. Henneguy, from close observation, has come to the conclusion that they do not feed at all, but derive sustentation from a reserve of fat, *corps grassieux*, stored up in their bodies during the pupal state. Towards the end of September the weevils can no longer be seen. They retire for hibernation to chinks in the bark of apple and pear trees, also in the lichenous and mossy growths upon their branches, as well as under stones and rubbish beneath and around the trees, and possibly in many other refuges. They also pass the winter under the bark of other trees than apple trees, as they have been found upon oaks during the summer.

Circumstances of the Attack.

According to the natural and unfailing instinct of insects, the weevils do not appear until the weather is mild and the flower buds have begun to swell. If the season is, and continues, warm and growing, the effects of the attack are usually of a comparatively slight character. But should the weather be cold and changeable, as is so often the case in Great Britain and in the north and western parts of France, the flower buds are slowly developed, and the weevils consequently have time to lay their full complement of eggs, whose period of hatching is accomplished before the buds have become full flowers.

The varieties of apple trees which blossom very early and very late are more likely to escape the attacks of the weevil than those of the main crop whose blossom comes late in May in ordinary seasons. In 1888, some varieties resisted the attack in France, especially one known as Douce du Jarrell, a very free blossoming sort, three parts of whose buds produced flowers from the 14th to the 29th of May, and another variety named la Goupillière, which blossomed from the 17th to the 31st of May without having a bud invaded by the weevil.

Remedies and Methods of Prevention.

A method of prevention adopted in France and strongly recommended by M. Petit, who has been before referred to, is to spray the limbs and branches of apple trees between October and February with a solution of sulphate of iron, in order to destroy the lichens and mosses which serve as harbours for the weevils and other insects.* M. Petit's receipt for this solution is one pound of sulphate of iron to one gallon of water. This can be sent up among the branches by means of a strong garden engine with a powerful pump.

A most excellent way of killing lichens and mosses on fruit trees, adopted in Kent, is to throw freshly slaked powdered lime

* This treatment with sulphate of iron would materially benefit the trees by clearing them of lichenous and mossy growths.

over the branches in foggy weather in winter. This is done by men having scoops like flour scoops fastened to poles.

It is advised that all long grass, leaves, and rubbish, should be cleared away underneath fruit trees on grass land, and on cultivated land it would be well to dig round the trees and apply lime or lime ashes, or soot and lime mixed.

The tarred, or greased, bands put round fruit trees to prevent the ascent of the female winter moths would hinder the female weevils from ascending, assuming that Curtis, Schmidberger, and others, are correct in their opinion that the female weevils do not care to fly.

In Brittany, some apple growers scrape the bark of the trunks and large branches of the apple trees with a scraper, and brush every part with a stiff carpet brush, having placed a cloth round the tree to catch the pieces of bark and the beetles that are dislodged. These are collected and burnt. Some limewash the trunks and limbs after this process. Others apply a composition of lime and napthaline, but it is said this is not quite effectual in keeping away the weevils.

In Great Britain it has been found that limewashing trees is not effective against insects unless the bark is thoroughly cleared off and the wash worked well into every cranny while it is fresh and hot.

Insecticides have been tried in France at the time of flowering, but without good results. Sulphur is burnt in a vessel at the end of a pole and applied close under the branches of the trees. It takes, it is said, about a quarter of an hour to treat one tree, at a cost of about 5*d*. According to some who have tried this it has answered, but experiments made at Rouen and Saint Ouen de Thouberville proved far from encouraging.

It is most difficult to employ insecticides with advantage, as compositions strong enough to kill, or drive away the weevils would probably injure the tender buds, and after the larva is in the bud it is hopeless to attempt to reach it.

A mode of decreasing the number of these weevils adopted in parts of France and recommended by several who have practised it, is to shake the branches of the trees to make the insects fall on to a cloth spread below. The cloth, an old rick-cloth being best, is cut and arranged so as to fit close round the trunk of the trees. A labourer gets up into the tree and shakes the branches violently, while two others, having long poles with hooks at the ends, also shake the branches within their reach. Other labourers sweep the cloth with stiff carpet brooms, and shovel up the débris together with the weevils into a sack. This must be done rapidly, and before the weevils can fly away. It is stated that four men and two boys treated 110 trees in a day in this way.

Experiments proved that it is necessary to perform this operation two or three times on each tree, as the weevils are not all shaken off at first. From a tree, for instance, which at

the first shaking nearly 1,000 weevils had fallen, 385 were shaken off five hours later, and 145 the next day. In the orchard of the Éole pratique d'Agriculture des Trois Croix, near Rennes, with 347 apple trees on 8 acres, the cost of treatment which occupied three days, was only 1*l*. Nearly 450,000 weevils, were destroyed, and there was a satisfactory crop of apples.

This operation must be carried out before the weevils lay eggs, and in order to accomplish this it is necessary to watch closely for their first appearance, and to begin with the earliest varieties of trees.

It is, of course, most desirable that the apple growers in a district should combine and arrange to wage war in this fashion simultaneously, and with the same care and energy.

This mode of destroying the apple blossom weevils might advantageously be practised in Great Britain. It would also be useful in the case of the attacks of other insects, as the Winter Moth caterpillars, for example.

There are several parasitic Hymenoptera which destroy the larvæ, and some kinds of birds devour both larvæ and weevils, as the robin, tomtit, and chaffinch, and some species of linnets. It is believed that the tomtit and chaffinch extract the larvæ from the buds.

Club Root.

Plasmodiophora brassicæ Wor.

Explanation of Plate IX.

Figs. 1.2.3. *Seedling Turnips attacked by Plasmodiophora at B.C.D.E.F.G.H.*

Fig. 4. *Cellular tissue from point A — spiral tissue at J.*

× 300.

Fig. 5. *Cellular tissue from B, with early condition of Plasmodiophora in cells.*

× 300.

Fig. 6. *Cellular tissue with Plasmodiophora in a mature or sporiferous condition*

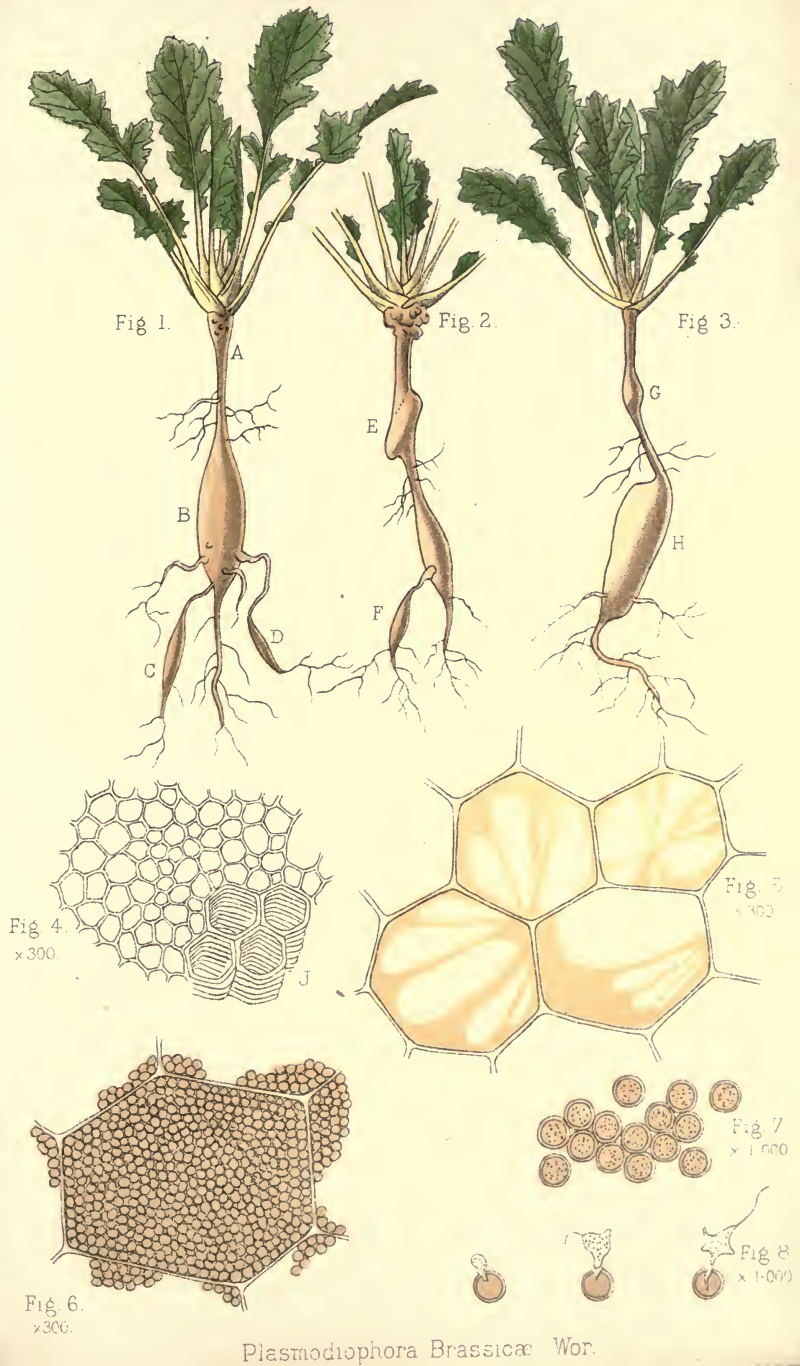
× 1000.

Fig. 7. *Spores* × 1000.

Fig. 8. *Spores perfectly ripe & emitting Amœba-like Zoospores.*

× 1000.

Judd & C.



Plasmodiophora Brassicæ Wor.

Club Root. (*Plasmodiophora brassicæ.*)

(Plate IX.)

The excrescences and malformations of turnips and cabbages are well known to all cultivators. In some cases the roots are twisted in the most fantastical manner; in others, there are merely warts, or knobs, upon them. It is not only that the roots are malformed, but their growth is hindered; and as the plants are usually attacked in their early stages, the crop is frequently almost entirely ruined. Specimens of distorted young white turnip plants were sent in July last from a field in which all the plants were similarly affected. The state of these plants is accurately described by the Figures 1, 2, and 3, delineated by Mr. Worthington G. Smith; and it will be seen from these that it would be almost impossible for plants thus infected to yield a crop of any value. Other specimens came to hand of much older plants, whose roots were forked and twisted, and covered with protuberances. Some had large cavities in them, in which were decaying matter, moulds, and millepedes. Though there was a certain amount of food, there was a very great deficiency in its quantity, and apparently in its quality, though the late Dr. Voelcker, in a paper upon "Anbury," in the Journal of the Royal Agricultural Society, found that, "compared with sound turnips, the diseased roots are much richer in nitrogen. The root which was most affected by Anbury contained nearly the same proportion of nitrogen which was found in the finger and toe excrescences of the second root. This is more than double the quantity of nitrogen which is contained in sound roots." *

Cabbage plants attacked by this slime-fungus have gall-like lumps also upon their roots, which prevent them from properly developing leaves and forming hearts. In the case of affected cauliflowers and broccoli, the heads are small and misshapen, and sometimes only stunted leaves are produced.

Rape, mustard, and kohl rabi are liable to be infested by this slime-fungus, as well as charlock and probably other cruciferous weeds. Sorauer states that in Germany it has been found in *Iberis umbellata*, common candytuft, and *Matthiola incana*, hoary shrubby stock.† Woronin, who has written the most important treatise upon this slime-fungus, puts the loss caused by it in 1876, in the neighbourhood of St. Petersburg, at 50,000*l.*

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* Journal of the Royal Agricultural Society of England, vol. xx., 1st series.

† *Handbuch der Pflanzenkrankheiten*, von Dr. Paul Sorauer.

It was first known in Scotland in 1780, but caused inconsiderable harm until 1820, but of late years it has seriously injured swedes and turnips in that country. Marshall speaks of it as being known in Norfolk, in his *Rural Economy of Norfolk*, written in 1790.

In Australia, in the market gardens around Melbourne and Brighton, club root is very prevalent.* In the United States it is most destructive, and is considered one of the most dangerous enemies of market gardeners, especially in Connecticut, New Jersey, Rhode Island, Delaware, and the southern parts of New York and Pennsylvania.

Professor Eycleshymer, in a recent paper in the *Journal of Mycology*, published by the United States Department of Agriculture, says: "Among cabbages and, indeed, all members of the genus *Brassica*, there seems to be no variety exempt from attack. Many varieties were sown in the same soil, under similar conditions, and, so far as could be determined, no differences were present. From correspondence the same conclusion is reached. It is claimed that the Rutabaga (Swede turnip) is less liable to attack than the common variety, and when sown in alternate drills with 'purple top' they produce a fair crop, while the latter is much affected."

It was considered, and is even now considered by some, that club root is caused by insects. Curtis, writing in 1841, remarks: "That these malformations are occasioned by insects, I very much doubt; yet it is unquestionable that the bulk of the turnips, when thus affected, are inhabited by multitudes of beetles, maggots, &c. . . . I therefore consider insects to be, not the cause, but the effect of anbury, though their united efforts combine in no small degree to the more speedy dissolution of the bulbs."†

There are larvæ of several flies and beetles that infest the roots of cultivated brassicæ, but the injury done by them is totally distinct from that of the *Plasmodiophora brassicæ*.

Description and History.

The *Plasmodiophora brassicæ*, which causes "Club Root," belongs to the group of fungus-like organisms, known as Myxomycetes, or Slime-Fungi. *Plasmodiophora* means the bearer of Plasmodia, which are masses, or congregations, of protoplasm, with amæboid, that is to say, creeping, life-like movement. From these plasmodia, spores (Fig. 7) are evolved from which, in favourable conditions of moisture and temperature, minute independent portions of protoplasm escape. These are able to move about by means of the cilia, or thread-like appendages shown in Fig. 8. It is presumed that these

* Bulletin of the Department of Agriculture, U.S.A., No. 14, December 1891.
† Journal of the Royal Agricultural Society of England, vol. iv., 1st series.

atoms at first derive sustenance from the rain-water washed into the soil. After a short time these atoms, called zoospores by some, myxamæbæ by others, and swarm cells by De Bary, unite together, and form plasmodia growths, either in the soil, or in their host—some cruciferous plant. The swarm cell enters the young plant by the root hairs, according to some writers. Zopf, in his *Pilzthiere oder Schleimpilze*, says that entry is made by the root hairs, or through the cuticle of the young plant, and Sorauer agrees with this.* De Bary holds that "the swarm cell with cilia penetrates without undergoing division into the epidermis of the young root, and from thence into the parenchymatous tissue."† Dr. Comes, the Professor of Botany at the Royal Agricultural School at Portici, accepts De Bary's view of this entry, in his useful work, entitled *Crittogamia agraria*. Mr. Worthington Smith, in his *Diseases of Field and Garden Crops*, states that the plasmodia are absorbed into the young plants by their rootlets. Further experience has shown him that the plasmodia may also enter through the first formed stomata of seedlings. Professor Eycleshymer writes, that "the organism is supposed to penetrate the root hairs and thus gain access to the deeper parts of the cortex. Repeated endeavours were made by means of slime cultures to observe the penetration of these swarm cells, but without success. This is a point that needs observation. The penetration has never been observed, and it is possible that it is through ruptures in the tissue caused by insects and worms, and other forms which are constantly present in the soil."‡

When the swarm cells have gained possession of a turnip plant they form aggregations of plasmodia of a slightly yellow colour, mobile, and increasing in volume as the cells of the root tissue are broken down and their contents absorbed by the invading slime fungus. All the food supplies of the plant are concentrated upon these affected parts, which causes hypertrophy, or unnatural enlargement, resulting in the swellings and deformities known as "Club-root." In these circumstances the plants cannot grow properly and finally die, or become mere distortions.

The plasmodia in the roots of these infected plants may be washed from them by rains, or they may move from them into the ground with their peculiar streaming movement, and remain centres of infection of future crops of brassicæ. This power of movement is remarkable, and is evidently used for the purpose of seeking food supplies. Mr. Arthur Lister, in his most interesting account of the plasmodium *of Badhamia utricularis* and *Brefeldia maxima*, slime fungi, parasitic upon various

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* *Handbuch der Pflanzenkrankheiten, Zweiter Theil*, von Dr. Sorauer.

† *Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria*, by C. de Bary.

‡ *Club Root in the United States*, by Professor Eycleshymer, in *The Journal of Mycology*, published by the United States Department of Agriculture.

fungi, states that, for twelve months, *Badhamia utricularis* was under daily notice, and that during this time there was no break in the "constant rythmic motion" of the organism. Mr. Lister says that his investigations "offered no clue to the mystery of the rythmic streaming motion, any more than they explain why, at uncertain intervals of hours or days, the plasmodium will rouse up, without provocation, from a quiescent condition and flow over a glass shade, and then return to its former state. We may suppose that it is searching for food, but this is far from accounting for the unity of action that appears to pervade this creature."*

Though De Bary classifies *Plasmodiophora brassicæ* among the "doubtful mycetozoa," it is clear, at least, that it possesses the "rythmic streaming," and most of the other attributes common to the undoubted forms of this group of myxomycetes.

Woronin was the first to discover that *Plasmodiophora brassicæ* is the cause of Club Root. He sowed cabbage seed in soil in which were clubbed roots, with the result that the plants from these seeds were almost invariably clubbed. Cabbage plants from seed sown in soil free from clubbed roots, and watered with sterilized water, were free from disease. Many similar experiments, made by other persons, have confirmed Woronin's experiences.

Remedies and Modes of Prevention.

From the nature of this infection it would appear that remedial measures can hardly be of efficacy, as the slime fungus invades the plants in their early stages. It would, however, be desirable to apply a good dressing of lime when the first symptoms of the infection are noticed, and work it into the soil with horse hoes, and round the plants with hand hoes.

Lime has been proved frequently to be a preventive of Club root. Mr. Clare Sewell Read, in his "Farming of Oxfordshire,"† written in 1854, points out that, on the Green Sand in that county, "lime is principally applied as a dressing to cure 'Club root' in turnips. Some land requires 10 quarters of lime every 8 or 12 years before roots can be grown with any certainty. Not only do turnips suffer, but even mustard and rape. While hot, the lime is applied to the land; a man follows the plough, sowing the lime from a seed-cot at the bottom of the furrow, which is covered over by the next turn of the plough to the depth of three or four inches. If applied in this manner it is a *certain cure* for this disease, *and has never been known to fail.* Stone lime is much more powerful than that made from chalk. If chalk lime is used the dressing must be repeated every four, or at the most, eight years."

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* *Notes on the Plasmodium of Badhamia utricularis and Brefeldia maxima*, by Arthur Lister, *Annals of Botany*, vol, ii., No. v., June 1888.

† Journal of the Royal Agricultural Society of England, vol. xv., ser. 1, p. 195.

It was considered that soils having calcareous constituents escaped this affection, but Dr. Voelcker wrote, in 1859, that "it must not be supposed that the absence or deficiency of lime is *always* the cause of the fingers and toes in turnips, and that liming is a *universal* preventive of the disease. I have seen fingers and toes in roots grown on calcareous soils, probably containing from 30 to 40 per cent. of lime."* In a field badly attacked by club root Dr. Voelcker found that, upon a small spot, the turnips were free from the disease, and he found that a load of gas lime had been spread there the year before. Dr. Voelcker therefore recommended gas lime as a preventive of this disorder.

Writing in 1876, Dr. Voelcker says: "My attention has been directed to the investigation of the cause of Anbury, or finger and toe, which did much damage in certain districts in the past season, and I have traced the disease, in a soil sent from Westmoreland, to the deficiency of the available potash and lime in the land upon which the turnip crop was much affected by this disease."† There is no doubt that gas lime, ploughed into the land in the manner described by Mr. Sewell Read, at the rate of two to four tons per acre, would be more efficacious than ordinary lime. It is believed that it is not the absence of lime in the soil constituents that causes Club root, since this is found in all soils; but that lime and gas lime applied hot actually destroy the slime-fungus or their fine particles affect its progress.

As a means of preventing the slime fungus, Sorauer suggests that plants infected with it should be pulled up and burnt at once, before the plasmodia escape into the soil.‡

It is also very important not to take crops of cruciferous plants, as turnips, cabbage, rape, kohl rabi, and mustard, for some time after an infected crop. Where it is difficult to avoid this, as, for instance, in the case of market gardens, the land should be ploughed deeply, or dug two spits deep, and lime, or gas lime, put on in considerable quantities. Cruciferous weeds should be rooted out from turnip and cabbage land. Charlock is especially subject to the attack of the *Plasmodiophora brassica.*

Mr. Jamieson has frequently stated in the reports of the Agricultural Research Association that sulphur in the form of manures, acted on by sulphuric acid, increased club root in turnips. He says, "Chief among the predisposing causes seems to be the acidity introduced by manures soaked with sulphuric acid (Superphosphate, dissolved bones, and turnip manure mixtures generally.) This point, which was brought out first by the Aberdeenshire experiments, seems to have been confirmed beyond doubt by Professor Ward in a paper read before the Royal Society. It had also been borne out by the experience of

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* Journal of the Royal Agricultural Society of England, vol. xx., ser. 1, p. 102.
† Journal of the Royal Agricultural Society of England, vol. xii., ser. 2, p. 299.
‡ *Handbuch der Pflanzenkrankheiten.* Von Paul Sorauer.

farmers in practice, but a difficulty in the way of complete acceptance of the idea was the inability to explain how sulphur or sulphuric acid would have this action. An explanation is now, however, afforded, Professor Webb, of Aspatria, having found that the fungus requires an acid medium for proper development and the point now seems not only proved, but explained."*

It has been noticed that this affection is worse upon wet soils, and upon heavy soils undrained. This has been proved in Victoria, as shown by the following passage in the Report of the Victorian Department of Agriculture. "Where the soil was of a deep and somewhat moist black, sandy nature, and free from stagnant water, there was generally no club, but in heavy, shallow soil, with a clay bottom and stagnant water allowed to remain, there the club was very prevalent."

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* Annual Report of Agricultural Research Asssociation for the North-eastern Counties of Scotland, 1891.

Black Mould of Corn.

Cladosporium Herbarum Lk.

Explanation of Plate X.

Fig. 1. *Ear of barley, impoverished before maturity, the injury starting from the attack of the Cladosporium upon the stamens.*

Natural size.

Fig. 2. *Inner & side view of grain of barley showing the attacked stamens & the fungus spreading over the grain.*

Enlarged 4 diameters.

Fig. 3. *Ear of wheat attacked by Cladosporium Herbarum Lk.*

Natural size.

Fig. 4. *Cladosporium Herbarum Lk. Olive-brown in colour, as seen as a transparent object under the microscope.*

Enlarged 500 diameters.

Judd & Co. Ltd. Lith. 425.

Black Mould of Corn.

Cladosporium Herbarum Lk.

Black Mould in Corn. (*Cladosporium Herbarum.* Link.)

(Plate X.)

This fungus is termed "common" by Mr. Cooke in his "Handbook of British Fungi," and it was certainly common enough in the season of 1892 in many corn-growing districts. In some of these it caused serious harm to wheat, almost as much as the ordinary mildew, *Puccinia graminis.* The *Cladosporium herbarum,* or "black mould in corn," as Mr. W. G. Smith well describes it, was especially prevalent in the Eastern Counties. Mr. Plowright says that "no district has probably suffered more from than it the Eastern Counties." It was very injurious, however, in Kent, Hertfordshire, Gloucestershire, and Hampshire, and, it is believed, was very frequently taken for the ordinary wheat mildew, *Puccinia graminis.* Badly blighted wheat fields were examined, in which there were but few signs of *Puccinia graminis,* the harm having been occasioned by the *Cladosporium herbarum,* whose peculiar olive-brown conidiophores were easily identified. The straw was infected by this fungus, and the ears and the grains were especially attacked. In some cases the grains were more shrivelled than those upon plants infested by *Puccinia graminis,* and the *Cladosporium* was found in considerable quantity upon the grains at the apex, or upper end, among the fine hairs, or down, upon them. The ears had an unnatural colour, so that one passing by infected fields could see at a glance that the wheat plants were in an unhealthy state; while observers noted that the state and colour were not like those of wheat plants infected with the ordinary mildew (Fig. 3.). There was much brownish dust upon the plants, causing the labourers engaged in cutting the wheat with hooks, in the old-fashioned way, to be, as a newspaper correspondent said, of the "colour of Red Indians," and this dust was very annoying to the men with the thrashing machines when the wheat was thrashed. Wheat with downy chaff seemed to be especially affected. A field of "velvet-eared white" in Kent was noted as being far more affected and injured than smooth-chaffed varieties.

Barley was also attacked by the *Cladosporium herbarum.* Among the most striking illustrations of this novel attack were specimens of infected ears of barley, taken from several fields in Hertfordshire, forwarded by Mr. James Forbes, of Old Trinity House, 4, Water Lane, Mark Lane, on the 26th of August. In these ears the fungus had established itself on the apex, or upper part, of the grain, at the base of the long, bristling awns; and, as it appeared, upon the withered remains of the stamens. It was most exceptional to find a grain without the fungus upon it in the position shown by Fig. 1. Now and then a grain was

infected, as seen in Fig. 2, and the infection was spreading within the folds and tissues of the pericarp. There had not, however, been much harm occasioned to the barley at that time. The rows were fairly well filled on the whole. There were blanks here and there, and abortive grains in some cases both at the top and the bottom of the rows. The *Cladosporium* was found upon the straw of these barley ears, but not by any means extensively.

Barley plants came from East Kent a few days later whose straw was much infected and discoloured by the *Cladosporium.* The rows were not well filled; the upper and lower grains were either very small, or had aborted. Here also the fungus was upon the stamineous end of each grain at the base of the awn, and had spread considerably into the pericarp on both sides of the grains (Fig. 2). Upon the sheathing leaves and straw of these plants the fungus was so abundant as to materially spoil the straw as fodder for stock.

At the meeting of the Committee of the Royal Horticultural Society, on the 13th of October, it was reported that Mr. Plowright had sent specimens of wheat showing *Cladosporium* upon it. Mr. Plowright remarked that "such a development of parasitic life cannot but be detrimental to the wheat affected by it, and it is probable that the *Cladosporium* has much to do with the poor yield so many agriculturists complain of this year."

Mr. Plowright also mentioned that it had been considered that *Cladosporium* on rye in Sweden produced diarrhœa, vomiting, and derangement of nerve centres, causing dizziness and a staggering gait, like that of a drunken man, in persons who partook of bread made from grain thus infected. Last year Professor Woronin, the well known mycologist, was called in by the Russian Government to investigate a series of cases in which these same disorders were occasioned by rye-grains infected by *Cladosporium herbarum,* at Vladovosky, on the coast of the Sea of Japan, in the extreme east of the Russian Empire, and found, from careful experiments, that though *Cladosporium herbarum* was present, the extraordinary symptoms caused in men and animals from eating the infected grains were not due to it, but to another fungus, *Fusarium roseum,* also present upon them.* Professor Woronin gave an account in the *Botanike Zeitung,* 1891, No. 6, of the experiments made as to this curious affection, termed Oer-räg in Sweden, and Taumel Getreide, or intoxicating corn, in Germany. He attributes this entirely to the *Fusarium roseum,* though he points out that *Cladosporium herbarum* was found in abundance upon the sheathing leaves and straw as well as on the chaff and grains, whose upper parts it had injured the most. It should be noted here how accurately this description of the position of *Cladosporium herbarum,* as given by Professor Woronin, corresponds with the experiences recorded

* The inhabitants of the Corea and the parts of China near also suffer from the same fungoid affection of the corn.

above in respect of wheat and barley this year. Dr. Lopriore records experiments made upon a horse, rabbits, rats, dogs, and chickens with *Cladosporium herbarum*, and states that no injury or discomfort was occasioned to them from taking it in quantities.*

Cladosporium herbarum was supposed to be wholly saprophytic, living only upon dead, that is, decaying matter. Mr. Cooke says it is found "on all sorts of decaying substances."† Mr. Plowright, in the communication above referred to says, that "until recently the *Cladosporium* was regarded as a saprophyte, but recent investigations show me that it can also exist as a true parasite." Sorauer states that it destroys and feeds on plant tissues, that it is, in fact, parasitic as well as saprophytic. He adds it is mostly saprophytic and is seen upon withered and withering parts of plants; also that it is probable that the fungus is first of all supported as a saprophyte, independently of the living plant, before it is in a position to attack it and live upon it.‡ This is precisely the case of the *Cladosporium herbarum* upon the barley grains. First, it is supported on the withered and withering stamens, and then on the living tissues. Sorauer adds, that after a long period of existence upon dead substances, when it comes in contact with living organisms, it rapidly penetrates and destroys them. This is exactly the action of the tomato fungus *Cladosporium lycopersici*, which is first seen upon the withering and decaying pistils, being then saprophytic, and afterwards is parasitic on and most destructive to the tomato fruit.

The life history of *Cladosporium herbarum* is somewhat intricate. De Bary groups it with the family Ascomycetes, though he says "there are forms which strongly resemble the members of the development of some well-known species, some even exhibiting the same comparatively minute distinctions, but in which the formation of an ascocarp such as belongs to the particular development, has never been observed, while at the same time there is no reason for considering that they belong to any group outside the Ascomycetes. We are compelled by this condition of our knowledge to regard these isolated forms as homologous with those which are like them, and the positions of which are known in the course of development of other species, and to call them accordingly spermogonia, conidiophores, pycnidia, or the like."§ De Bary gives a list of these forms, among which is *Cladosporium*, adding: "These forms are for the present arranged with the Ascomycetes because from what we know of them they appear to have more connexion with

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* *Deutsche Landwirtschaftliche Presse*, xix. Jahrgang, No. 89.

† *Cooke's Handbook of British Fungi*, p. 582.

‡ *Die Schäden der einheimischen Kulturpflanzen*, von Dr. Paul Sorauer, 1888.

§ *Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria*, by A. de Bary, pp. 252–3.

that division than with other fungi; but they are known only to us under one form, which may be considered to be that in which they produce conidia." De Bary instances the common" *Cladosporium herbarum* Lk. as among the forms which never produce anything but mycelium with serially abjointed conidia. Sorauer terms these chain-like, kettenartig.*

Cladosporium herbarum Link. synonymous with *Dematium herbarum*, is the conidiophore stage of *Sphæria herbarum* whose synonym according to Tulasne is *Pleospora herbarum*.†

Other forms or stages of *Sphæria*, or *Pleospora herbarum*, are *Macrosporium sarcinula*, Berkeley, and what is termed by De Bary the *Alternaria* form, which consists of "conically pear-shaped pluricellular compound spores, having a smooth light brown membrane, and arising at the extremity of the hyphœ in long branched rows."

Though at some risk of creating confusion, it is important to deal with the various forms of this fungus, and to endeavour to identify them and their host plants, in order, if possible, to discover means to prevent its spread in the stage dangerous to corn. A Macrosporium, called *Macrosporium commune*, (Rabenhorst) on leaves of beet, is said by Berkeley to be probably a condition of *Sphæria herbarum*; and *Macrosporium brassicæ*, upon the leaves of decaying cabbages and of other cruciferous plants, is said by Cooke in his handbook of British Fungi to be intermixed with *Cladosporium herbarum*, "of which it is probably a condition." Dr. Comes, Professor of Botany at the Royal School of Agriculture at Portici, says, that *Cladosporium herbarum* has been found on the leaves of turnips, and in favourable circumstances reproduces *Pleospora herbarum*.‡ Trumen also reports the same of some experiments in Bohemia.

Mr. Carruthers, however, believes the fungus which did so much harm to wheat and barley this year in Norfolk and elsewhere is identical with *Scolicotrichum graminis*, which has been placed by some botanists in the species *Cladosporium herbarum*.

Dr. Lopriore has recently recorded§ a series of most interesting experiments with *Cladosporium herbarum*.—Among these were three, in order to ascertain:—

1st. Whether artificial infection of sound corn plants with the fungus produces destructive results.

2nd. Whether corn plants attacked by the fungus are contagious.

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* *Op. Cit.*, p. 231.

† De Bary remarks: "Even if Tulasne's view that the *Cladosporium herbarum* "belongs to *Pleospora herbarum* is not confirmed, its connection with one of the "allied *Sphæriaceæ* is more than probable." *Op. cit.*, p. 67.

‡ *Crittogamia agraria*, par Dr. O. Comes, 1891.

§ *Deutsche Landwirtschaftliche Presse*, No. 86.

3rd. What is the parasitic action of the fungus in favourable circumstances.

In the first experiment Dr. Lopriore found that young wheat plants artificially infected with *Cladosporium* spores obtained from the spotted chaff of wheat, and put with the fungus in some drops of sterilized water upon their blades, were much checked in growth, and only attained to a height of from 20 to 24 inches, and produced but few grains, which, however, showed no traces of fungus infection.

In the second experiment, wheat grains free from the attack of the fungus, and some that were attacked by it, were sown in two flower pots filled with earth—the affected grains in the middle of the pots, those unaffected near the edges. The result was, that the roots of the sound grains were penetrated by mycelial filaments. The stems showed no traces of infection, but the ears and grains at ripening time were seriously affected by the fungus.

For the third experiment, wheat grains with the fungus upon them were sown in two flower-pots filled with earth, which were put in a hot-house in a light situation. The fungus in the warmth and dampness of the surroundings soon destroyed these plants. The further investigations as to the course of the fungus showed that it either attacked the wheat plants in a young state, so as to quickly destroy them, and to develop itself abundantly in the lower part of the stem in the usual form of conidia; or it attacked the plants in other and less serious ways, and finally reached the ears without breaking through the framework of the plant. Dr. Lopriore's conclusion is that all the pathological circumstances, from the germination to the full ripening of the ears, indicate that the fungus has a very clear and defined progress in its host plant, and that there can hardly be a question as to accidental infection. The power of the spores to propagate from year to year, and the formation of sclerotia, and of chlamydospores in the stalk, solve the question of the destructive nature of the fungus, and show that it is able, by many modes, to maintain itself and to spread.

Dr. Lopriore warns cultivators against sowing corn infected by *Cladosporium herbarum*, and to take care to steep the seed, and to be careful concerning changes of seed. In Sweden, barley is steeped in weak sulphuric acid, a solution of from 1 to 1½ per cent. Dr. Lopriore adds that there is no doubt that steeping seed corn in this solution does destroy the spores of the fungus.

Mr. Worthington Smith, who has furnished the admirable illustrations of *Cladosporium herbarum* for this report, states that the mycelium of this fungus will do well in the ground, and that he has seen it growing on and in the ground often, also growing on wood, and even on painted wood, and this being the case it is reasonable enough to believe that the Cladosporium would grow with the corn from sowing time until harvest.

It is quite evident, from examination of wheat and barley grains taken from fields infected by the *Cladosporium herbarum*, that the fungus is upon them among the hairs, and on and under the pericarp. Dr. Lopriore has showed that infected grains reproduce the fungus, therefore it is most desirable to steep infected grains most thoroughly, as wheat is steeped to prevent the spread of smut, either in sulphate of copper solutions, which have been proved over and over again to be fatal to the spores of fungi, or with sulphuric acid solutions, as adopted by Swedish barley growers.

It may also be that infection is caused by the other forms of the *Sphæria herbarum*, which are found upon beet, mangels, and cruciferous plants. The leaves of these plants, when infected, should therefore not be left on the ground, but be collected or ploughed deeply in. Infected straw and chaff should be all passed through well heated mixens.
