

On the Disease of the Vine

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In order to preserve an accurate record of the disease which has caused, and still continues to cause, such injury to our vines, Sig. Antinori, director of the Imperial and Royal Museum, ordered models in wax to be prepared, illustrating the diseased state as well of the grapes themselves as of the shoots. I was instructed to assist at the operation, and to add, with appropriately magnified dimensions, such particulars as should be furnished by my microscopical observations. The plastic operation, confided to young Sig. Tortori, under the distinguished Lusini, head of the manufacture, has been executed by him in wax with such ability as to give to the models a perfect resemblance to the originals, and although the whole of the intended preparations are not as yet completed, yet such as are now finished have appeared to me of sufficient interest to lay them before the Academy, who, I trust, in a subject of such serious importance, will allow me to accompany this presentation by some considerations suggested to me by the recent perusal of a memoir by Sig. Berenger, inserted in the new *Giornale d'Agricoltura* entitled *Il Coltivatore*, on the 5th of August of this year. In this memoir is the following remarkable sentence, “The celebrated *Oidium Tuckeri* of the Italian vines is a chimera, and the cryptogamous plant described under that name is no other than the *Erysiphe communis* in its sterile, flocciferous state”. The author laments that such men as De Notaris, Balsamo Crivelli, Pietro Savi, and others should have fallen into such an error, allowing themselves, he says, to be led astray by some French writer. He calls the disease which has appeared on the vines in England a spot, because of the analogy of its pathological characters with the spot of the Orange tribe which appeared in Italy in the commencement of the present century, and still attacks other plants, and which appeared on the vines of Prussian gardens towards the year 1835, and was described by Nietner, and especially by Fintelmann, under the name of small-pox. Berkeley, probably not aware of these previous publications, only speaks of it in 1847, and figures in the *Gardeners' Chronicle* the little fungus under the name of *Oidium Tuckeri* in honour of the gardener who first called attention to its fatal effects on the Vines cultivated near Margate.

But if we admit with Sig. Berenger that the Grape mildew was the disease which prevailed first in Prussia and afterwards appeared in England, we must nevertheless conclude that it differs considerably from that which began to spread so much last year in Italy. Indeed no one amongst us has observed the appearances, at the end of May, from the effect of a fungus, on the epidermis of the young wood or on the leaves, of those spots which (as stated by Sig. Berenger, quoting the observations of Meyen) have the appearance of ulcers, spreading at the expense of the organic substance in which they originate, and leaving, especially on the leaves, cavities pierced like a sieve which corrode the extremity of the shoots, causing the latter to disarticulate and separate from the old wood, and the old wood itself to be finally attacked by the disease and destroyed down to the roots.

I am persuaded that not a single case has been authenticated, at least in Tuscany, in which the Vines, however strongly attacked by the prevailing parasite, have been destroyed, as in Germany and England, without the root and the main stem remaining uninjured. We have it, on the contrary, as an ascertained fact that the shoots of the Vine in the present year, 1852, are considerably more

vigorous than those of the spring of last year before the appearance of the disease. The mischief suffered by us has been confined to the total loss of the crop of Grapes in some localities, and a deterioration of the quality in others, but our Vines vegetate with the usual vigour, and give hopes that in future years we may have our usual harvest.

Passing over, therefore, the theory that the disease which has done so much injury in the northern gardens and hothouses is identical with that which has rendered our vintage less productive (a question nevertheless deserving further investigation with the assistance of data, which are not within my reach from those distant countries), I think I may affirm that the cryptogamous plant which prevails (for many others accompany it) on our diseased Grapes in Tuscany is not the *Erysiphe communis* as the Sig. Berenger asserts. To be convinced of it, it suffices to cast your eye on this voluminous green Grape as modelled in wax and magnified to one hundred diameters, from the surface of which arises a network of white filamentous mycelium, somewhat branched, and interwoven in various ways, or here and there intersecting itself, without any apparent regularity. From these filaments, which consist of tubes of extreme tenuity closed at various intervals by transverse partitions, arise, almost at right angles, others of a club shape, from the enlarged summits of which proceed a moniliform series of utricles which readily disarticulate, separate from each other, and are scattered in various directions. These constitute the vegetating frond, or the sterile plant seen by all owners of a microscope, in which an eminent botanist has thought he found characters sufficient to distinguish the fungus as a species. But no one appears as yet to have succeeded in prosecuting researches to the point of ascertaining the real fructification of the cryptogam. This fructification arises from the apex of the ascending filaments. It is first indicated by a rather transparent cell of pale yellow, which, as it increases in size, passes to an orange yellow, and at its maturity acquires a much darker hue. These cells vary in size as well as in form; some are spherical, others of an oval shape more or less elongated, some of the size of the white utricles of the frond, but in general they are larger, surpassing them sometimes by one-third of their length and breadth.

It was in October, 1851, that I first found a fructification nearly similar to the one in question, on an analogous cryptogam on the gourd, but, as I had then no means of demonstrating its origin, I did not venture to publish it, as there remained doubts in my mind whether the organs I then found intermingled might not belong to two different plants. But ulterior observations have caused these doubts to disappear entirely, for, adopting the use of reflected light in order to observe the objects without altering their natural position, I could see the stalks of the sporangia inserted into the same filaments of the mycelium from which proceeded the sterile fronds. Besides that, I often met with fructifications having one of the white utricles directly attached to their free extremity, so that the evidence of the passage or transformation of one organ into the others became perfectly clear; sometimes also I met with fructifications contracted in the middle as if they were formed of two joined together. All these details are faithfully introduced in the preparation No. 2, which shows at a glance on a highly magnified scale the whole development of the cryptogam¹.

On carefully examining with transmitted light, and with a magnifier of at least 600 diameters, the sporangia of our cryptogam, we find them to consist of a coloured cellular membrane, with the polygonal faces somewhat convex, and which includes some hundreds of spores, which, at their maturity, issue in jets by the mere action of water (I counted as many as 289 in one heap). The form of these spores, which are tolerably transparent, much resembles that of the sporidia of some

¹ The publication of the present paper as it was communicated to the Academy of Georgofili required the addition of some figures for the elucidation of the descriptions, to supply the place of the preparations in relief, which could not be placed before the eyes of the reader. The distinguished botanist, Adolfo Targioni Tozzetti, having offered to furnish some drawings corresponding to the principal figures in wax, I have here to express my obligations to him, which I feel the more from the circumstance that as he has drawn all the details faithfully from what he has seen himself under the microscope, his figures give an authentic testimony in confirmation of the facts I have described.

Fig. 1 represents a small portion of the surface of a Grape on which the cryptogam has spread itself, magnified to 300 diameters. From the mycelium arise moniliform filaments *m*, and the sporangia *s*. Two of the latter have an utricle directly attached to their upper extremity.

lichens. They are reniform and ovate-oblong, and under a very powerful object-glass, two little cavities may be observed at their extremities, containing a most minute globule of some denser matter. The preparation No. 3 represents a sporangium with its contents magnified to 1800 times the diameter².

Probably the spores which I have mentioned are the reproductive corpuscles, which Professor Pietro Savi saw vegetate under the microscope, believing them to have issued by a regular longitudinal dehiscence from the utricles of the moniliform filaments which had been supposed to be the sporangia. But this opinion, although maintained by other eminent botanists, is at variance with the facts shown by my own observations. The preparation No. 4 includes five of the above-named utricles, magnified to 1800 diameters. The first utricle is in the ordinary state, attached to the apex of the ascending filament, with a portion of the corresponding mycelium. Two other utricles are in the process of germination, and vegetate, and reproduce the plant after the manner of grafts or cuttings. The appendage which they emit from one extremity of the axis (which is always excentric) resembles the pollen tube issuing from its grain. It is very easy to obtain this result. It suffices to moisten a bit of glass with the breath, to cause a number of fresh utricles to attach themselves to it, disarticulating from the filaments. After about three hours nearly the whole of them will vegetate, and the germs will grow under the eye of the observer, till after one or two days, the nutriment supplied to them by the internal substance of the utricle being exhausted, they will die and dry up. A fourth utricle in the above-mentioned preparation No. 4 shows the manner in which these organs usually shrivel and dry up. On losing by evaporation or any other cause the fluid by which the membrane was distended, it compresses on three sides. The extremities, being of a more compact substance, do not give way so much, and hence three longitudinal ribs or angles are formed, and the central one, by an optical illusion occasioned by the manner in which the light is refracted, may easily be mistaken for an aperture, whilst it is in fact nothing more than a plait or fold. The fifth utricle in the preparation is a representation of an artificial section in order to show the very variable globules, and the mucilaginous liquor which the membrane contains³.

From the above data it clearly results that the cryptogam prevailing on our grapes, which is identical in all the specimens I have been able to procure within a radius of twenty miles round Florence, is a very different plant from the *Erysiphe communis*, which no one has observed to appear upon the Grape berry⁴. I have indeed observed upon other plants the true *Erysiphe* with characters far too decided to confound it with this cryptogam of the Vine. It is a beautiful object when seen through the microscope with reflected light, when the field comprises a number of conceptacles in different stages of maturity. Their brilliant colours, which pass gradually from a pale yellow to orange, to red, to dark blood-red, or almost to black, have a pleasing effect on the white ground, formed by the filaments radiating from each of the globose sessile fructifications. Every one of these fructifications when detached carries with it, like a Medusa's head, its radiating serpentine hair, and as the greater part of these filaments separate from the entangled ground without laceration, that is, with their extremities closed and convex, I conclude that these filaments have no connection for the purpose of suction with the interior of the plant, on which the *Erysiphe* fixes itself. I am rather disposed to consider them as aerial roots, or rather as fronds analogous to

² In Fig. 2 the sporangium is represented magnified to 600 diameters, and by its side are the spores it has emitted, which, taken separately, are as transparent as white glass; seen in a mass they have a very slight yellow tint. In Fig. 3 are three spores magnified to 1800 diameters, in order to show the nuclei or globules at their extremities.

³ Fig. 4, magnified 1000 diameters, shows at *x* three utricles in germination. At *y* are two fresh utricles showing the little globules, and the mucilaginous liquid contained in them. At *z* is an utricle shrivelled up by lateral compression, which has given rise to the optical illusion of a longitudinal slit.

⁴ The Chevalier Rendu, Inspector-General of Agriculture in France, has had the kindness to transmit to me diseased Grapes from the neighbourhood of Bastia and of Marseilles, in which I have recognised the same cryptogam as that which attacks our own Vines. So also Sig. Ferrari, Secretary of the Agrarian Society of Bologna, has sent me Grapes from eight different localities of that pontifical province, on which was the same plant in fructification. From these more recent observations I am led to conclude that the cryptogam which has spread over the Vine in various countries forms everywhere but one species.

those of lichens, an analogy which appears to me to extend to other parts the fructification. The oval spores of the *Erysiphe communis*, from 4 to 8 in number, are contained in extremely transparent utricles formed of a coarse membrane of 0.045 millimetres in length, implanted on the conceptacles by a connecting surface of 0.11 millimetres in diameter, not unlike the asci of lichens. It is not my intention to enter into any more circumstantial description of the *Erysiphe*, or of its mode of propagation. I have only incidentally mentioned its structure, in order to show more clearly how very different it is from the cryptogam of the Grape⁵.

Having cleared up this point, there yet remains the most important question. Is the cryptogam the cause or the consequence of the disease of the Grape? I have not the presumption to solve this difficult problem; it would be necessary to have data more evident, more incontestable, and more detailed, to establish any undeniable demonstration. I will only state, that I am for various reasons disposed to adopt rather the opinion that the appearance of the mildew is owing to a morbid change which the Grape has previously suffered.

Last year I collected bunches of grapes branches of Vine, leaves of gourds, roses and chrysanthema, all covered with their respective mildews, and shut them all up in a wooden box, with the intention of scattering in the following spring, over healthy individuals of different kinds, the reproductive sporules which it was to be presumed existed amidst the mycelia, and thus, as it were, to inoculate the disease. The experiment was carried out in June this year without producing any cryptogam. It might be supposed that the spores had lost their vegetative powers by too lengthened a state of desiccation. I therefore repeated the experiment in the month of July, making use of fresh mildews which had appeared naturally; the result was the same, the healthy grapes were not attacked. From this it would follow that the mildew does not produce the disease, or at least that one condition was wanting – the predisposition to contract a disease. I feel indeed the force of the objections that may be made to my experiments as being made upon too limited a scale, but, however small, still some value must be attached to them.

The Secretary of Correspondence of our Academy has suggested to me that I should try the inoculating grapes already diseased, first removing carefully the mildew which may be upon them. I

⁵ Those who are firmly convinced that the cryptogam of the Grape is an *Erysiphe*, may perhaps maintain that the fructification I have described is no more than a lower degree of development of the plant, and that if it reached the same state of perfection it would show the characters peculiar to the genus.

It is not impossible indeed that such a thing may happen, but it is highly improbable, for if we consult the works which treat of the *Erysiphe*, and especially the fine memoir of M. Leveillé inserted in the *Annales des Sciences Naturelles*, we do not find, among all the species known and well analysed, a single one which shows any change of structure, leading to any suspicion of two modes of fructification so very different; the one being represented by a pedunculated sporangium full of several hundreds of free spores; the other by a conceptaculum, either sessile or only inserted on several filaments, and containing a small number of large spores enclosed in a very small number of sporangia.

I consider, therefore, that my proposition, that the cryptogam of the Grape is not an *Erysiphe*, is sufficiently proved, and I do not think that the contrary opinion is admissible, until some instance has been authenticated where the same mycelium will produce the three different degrees of development, that is to say, the sterile state with moniliform filaments, the fructiferous state like that I have described, and lastly, another fructiferous state, such as understood by Sig. Berenger. The finding even of the three states visible at once on the field of the microscope would not be sufficient to support the opposite doctrine; it would be necessary to prove distinctly the origin of each – for it is not an uncommon occurrence that several of these productions are found so intermingled together as to appear at first to arise from a common mycelium.

In Fig. 5, magnified to 230 diameters, is to be seen a conceptacle of the *Erysiphe communis* taken from a leaf of *Convolvulus arvensis*, on which I found at the same time the other cryptogam with a fructification analogous to that of the Grape. I say analogous and not identical, because some slight differences are observable which might constitute a variety. There also may be varieties which I have observed to fructify in such abundance on *Chrysanthema*, on *Clovers*, on *Chicory*, on the *Plantago major*, on *Artemisia campestris*, on *Lucern*. On all these plants, excepting on the *Chrysanthema* I have likewise observed the different species of *Erysiphe* which are peculiar to them, and which are well known. On the *Chrysanthema* I could never discover a single conceptaculum which gave any indication of the *Erysiphe*. So, on the other hand, on the *Acer campestre*, on which the *Erysiphe* abounds, I never succeeded in finding any sporangia analogous to those of the cryptogam of the Grape. (*This figure 5 is not reproduced here, no one in this country supposing Oidium and Erysiphe to be identical*).

purpose to take it in hand during my next stay in the country; in the mean time, what I am about to state may supply the place of the experiment, and I think speaks pretty clearly. In a vineyard outside the Porta S. Niccolò near the walls, I was a few days back examining a Vine covered with grapes in the worst state; the farmer observed to me that they had been medicated, and that for a time they had appeared to be cured. I took two grapes and placed them under the microscope: I found on the grapes many crystals of urine mixed with other matter which showed that they had been drugged. But the cryptogam had reappeared as fresh as usual, and as thick as upon the non-medicated grapes. I hear that a great number of similar facts might be quoted, and they appear to me to prove two things; first, the inefficacy of the remedies hitherto used, and secondly, that the evil originates in the grapes themselves, or in other words, in a predisposition to contract disease.

The authors who have treated of the *Oidium Tuckeri* as the cause of the disease, admit the predisposition. The same Berenger, speaking of the Erysiphe, says, "Its luxuriant development (*Generatio floccipara*) is the true and natural cause of the immense diffusion of the cryptogam, and consequently the immediate cause, *although not the only one*, of the present malady of the Vines; I say *not the only one*, because it is not only probable, but almost certain, that it would not produce that pernicious effect, if a certain number of vines, either by individual constitution, by asthenia, or by some other pathological state, were not in a certain manner *predisposed* to receive it".

Now, I ask, if you grant the predisposition, in what consists, what is, this particular anomalous state of the Vine? If it had been a small vineyard only, or a few plants situated here and there in special localities, it is possible that conditions might be found to account plausibly for the phenomenon. But the question is that of a most extensive fact, of a disease, which, like an epidemic, has spread successively over the whole of Europe where Vines are cultivated. In this case how can the predisposition be explained? It appears to me that the cause of the predisposition remains as obscure as the cause of the disease.

I have said that I incline to believe that the cryptogam does not produce the disease. My opinion founded on the experiment of inoculation is confirmed by the fact, that, among the numerous observations I have made, I have never succeeded in seeing a single filament of the mycelium of the cryptogam without discovering also an alteration in the cellules of the epidermis of the Grape immediately under the cuticular membrane. Such alterations first show themselves in a cellule by a change of colour of the chlorophyll, which from green passes to a pale yellow, the fluid contained thickens and loses its transparency, subsequently crystals are formed, and granulations of various sizes, first of a bay, then of a brown colour. The cellulose, or the membrane which forms the sides of the cell, at the same time thickens and becomes coloured. This organ is now dead, and the lateral adjacent cells, going through the same changes, end also by losing all life. Thus are formed broad dark-coloured spots visible to the naked eye, and which extend even over the whole subcutaneous stratum of the epidermis, when the alteration has commenced at several points at once, and the spots have extended so as to run together and unite with each other. Sign. Adolpho Targioni Tozzetti gave last year to the Academy a very clear account of the changes which took place successively in the Grape, and of the apparent seat of the malady. My observations confirm his; I likewise agree with him that the connection between the fungus supposed to be parasitical, and the organs of the Grape, cannot be established but through the cuticular membrane, which in no one instance, not even immediately over the diseased cellules, is found to be perforated. No sucker can be discovered to proceed from the mycelium and penetrate into the internal membrane of the Grape.

When the cryptogam has appeared, its horizontal filaments extend, passing chiefly over the spotted spaces, which circumstance may be alleged in favour of the opinion that by some invisible communication the fungus exercises some pernicious influence on the Grape; but, for myself, having put forward the idea that the cryptogam is not the cause of the disease, an idea which is also mentioned by Sign. Brignoli in his learned Memoir on the Crambe, I am disposed to interpret this fact differently, and I say that if the fungus vegetates on the diseased Grape, it is because it there finds the proper aliment for its support. This aliment is most probably derived from the fluids exuding from the decomposed cells of the epidermis. It is therefore most natural that the filaments

in lengthening should follow the direction of spots where they find a nutritive fluid. This fluid must be in an exceedingly minute quantity, for when the Grape bursts, the fungus never spreads or penetrates into the interior, where it might be supposed to find in greater abundance, and to absorb more readily, the fluids it requires.

As I have mentioned the bursting, the final destruction of the Grape, I will add the manner in which I account for it. In the circular field of the microscope, I counted up the number of angular cells on the surface of the portion of the epidermis comprised within it. Having subjected to the same test green and ripe grapes of various sizes, I always found that the number of cells contained in the same visible surface corresponded very nearly in an inverse ratio to the squares of the diameter of the Grape. From this I conclude that the Grape in enlarging in size does not increase the number of its cellules, but that these are distended in proportion. Now if by the effect of the disease or from any other cause, the cellulose, as it happens in this case, loses its life and consequently the faculty of distending, it is evident that the growth of the internal unaffected parts would cause a pressure, and force the epidermis to burst.

I will not enlarge further on this disease of the Vine. This subject, deserving the most serious study, cannot be better investigated than by your commission, which has been charged to collect all facts and reports relating to it, to which commission the illustrious President Marchese Ridolfi has done me the honour to associate me, together with my colleague the Cavaliere Parlatore. By connecting our different observations and researches, and discussing the subject together, we may possibly attain the object which the Academy is desirous of reaching.