XXIX. *On the Ergot of Rye.* By FRANCIS BAUER, Esq., F.R.S. & L.S.

Read January 21st, 1840.

THE existence of this most remarkable disease in gramineous plants, particularly in Rye, has been known from time immemorial. Many authors, both ancient and modern, have written much on the subject of Ergot, but they considered it with reference only to the injurious effects which it has on the animal health.

The Abbé Tessier in his *Traité des Maladies des Grains*, published at Paris in 1783, gives an account of many important, and, generally speaking, very satisfactory experiments, as well by chemical analysis of the substance of the ergot of rye, as of the pernicious effects it has both on the human species and on brutes; but the opinions held on its nature and origin are to this day very unsatisfactory.

After more than twenty-five years' attentive observation, I am convinced that these opinions and conjectures are totally erroneous and without foundation.

The difficulty of tracing the origin of this disease undoubtedly arises from the fact, that not the slightest indication of its existence is observable either in the infected ear or in the plant till the ergot actually emerges from the husk in which it is formed, when it is too late to determine its origin.

It was about the middle of August 1805 that this disease came first under my observation, but then the rye was nearly ripe and the ergots full grown; consequently I could form no judgment: and it was not till the middle of June 1809 that I was enabled to prosecute and complete my investigation, at least so far as to ascertain *what* the ergot really is.

The rye was then just in blossom, but there being no external appearance of

the disease in the plant nor ear, however strongly infected, it required considerable trouble and patience to unravel every floret of the ears, which can only be taken up at random; from what I then observed I was soon convinced that the ergot is not an extraneous substance, as some have supposed it to be, but that it really is a monstrosity, or transformation of the embryo, and particularly of that part of the embryo which Gærtner calls the *Scutellum*; however, to make my illustration on that point more comprehensible to the general reader, I consider it necessary to explain the progress of vegetation of the grain. A sound germen of rye, before fecundation, consists of a pulpy cellular substance, enveloped in a delicate membrane, which forms the outer coat of the ripe grain; and in the middle of this cellular substance is a small cavity, lined with a dark green membrane, from which some mucous fluid seems to exude, but no traces of organization are at that time observable. At TAB. XXXII. fig. 1 is a sound young grain, about four days after fecundation, consisting chiefly of the same internal parts and substance as those of the germen before fecundation, but its shape is considerably altered, being much longer, and of a more oval form; the internal cavity with its green membrane is considerably enlarged, and the organization of the embryo is visibly advancing. At TAB. XXXII. fig. 2 is a side view of a longitudinal section of this young grain; at its base appears the first formation of the embryo, which then consists of a soft substance: in this figure and in fig. 3 the scutellum is visible, which is the first part of the embryo formed in all gramineous plants, and which in the diseased grains ultimately becomes the ergot. TAB. XXXII. fig. 4 is a front, and fig. 5 a back view of diseased grains from the same ear, and of the same age as the sound grain in figs. 1, 2 and 3: but its exterior shape is now greatly changed; the external membrane at the apex of the grain is much shrivelled and contracted, and at fig. 7, which is a side view of a longitudinal section of the same grain, the pulpy cellular substance is also much shrivelled, the internal cavity is much contracted, and the young ergot begins to be formed in the same spot as the scutellum of the embryo in the sound grain, and at that period the young ergot retains still some resemblance to the form of the scutellum of the sound grain (see TAB. XXXII. fig. 7 B., and fig. 8, which is more distinctly seen: the substance of this young ergot is at that period also very soft, of a white colour

internally, and surrounded with a light shaded purple ring, but is without any external membrane or integument, or internal fibres or vessels, which is also the case with the scutellum of the embryo of the sound grain.

In fig. 9 is a longitudinal section of an infected grain, more advanced, being about eight or ten days after fecundation; at that period the ergot is considerably enlarged, and has already torn and detached from its base the integuments and cellular substance of the original germen.

After the ergot emerges from its husk, it enlarges very rapidly, and when the rye is ripe, the ergot is often five or six times the bulk of the sound grain (see TAB. XXXII. fig. 11); and considering that the ergot is only the enlarged scutellum, the natural size of which is not quite a tenth part of an inch, it must be confessed that the enlargement is prodigious; but not all the ergots even in the same ear attain the same size (see TAB. XXXII. fig. 10). The general number of ergots in an ear is from six to eight, but sometimes there are even more, and very often there is only one single ergot in an ear, the rest of its contents being fine sound grains; but in ears which contain many ergots the sound grains are generally small and stunted. As the substance of the ergot is very soft at its formation within the young germen, it generally retains some shape of the original grain, particularly the groove at the back.

After the ergot has emerged from the husk, its substance soon indurates, and assumes a dark brownish-purple colour, and gradually becomes very hard, and after having been in contact with the air and exposed to the sun for some time, the ergot, having no integument, cracks in many places; and I think it is such fissures which some authors consider to be perforations made by insects,—an opinion, however, which is totally unfounded, for there exist no perforations in the ergot at any period of its formation or vegetation. If cut through while yet in a green or fresh state, the internal substance of the ergot appears of the firmness of an almond or nut. If the ergot is soaked in water a month or longer, it gets soft, but never dissolves, and if bruised, the substance is found to consist of smaller particles than the albumen of the sound grain, and if examined through a microscope under water many large blotches of oil appear to be mixed with it, and when an ergot is lighted at one end, it burns with a bright flame like a wax candle; this is also the case with

the minute scutella of sound grains, the substance of which is precisely of the same nature.

From the facts above stated, I think no doubt can remain in the mind of any unprejudiced observer, that the ergot is solely a monstrosity or transformation of the embryo of the germens of the rye, and those gramineous plants which are subject to this disease. But what is the cause of this monstrosity or transformation? This is a question which I confess I cannot answer; but my attentive observations and continued researches on the subject of the diseases in corn have convinced me that rainy and wet seasons are not the cause; for during that period the various states of the weather had never produced a corresponding effect on the corn, for the disease was often more prevalent in a dry than in a wet season; neither can I agree with those who consider that insects cause it, for those minute flies and insects so often found in infected ears, are also found, not only in the soundest ears of rye and other gramineous plants, but are likewise found abundantly in all species of Syngenesious and other plants, where they seem to rummage the pollens of the anthers.

Whether some particular soil might cause this disease, I had no opportunity of ascertaining, because in the neighbourhood of Kew very little rye is cultivated; but it would be very interesting and desirable if some practical agriculturist would make the experiment on an extended scale, by sowing a certain quantity of sound rye seed-corn, from the same sample, on different soils, and attentively observing, at the proper season, on which soil the disease was more or less prevalent, and then analyse the component parts of the soil. Such experiments would undoubtedly lead to some satisfactory result.

The only experiment I was enabled to make, was collecting a small quantity of rye grains from ears which were strongly infected with ergots, and sowing these separately, but they did not produce one infected ear.

The cause of this disease being yet totally unknown, it would be presumptuous and idle to talk of remedies to prevent or cure it; that must be left till the real cause is discovered.

The pernicious quality of the ergot of rye, and the severe and often fatal diseases engendered by the careless admixture of that substance with sound corn, for human nourishment, has been recorded by many eminent authors.

Galen mentions fever, delirium, gangrenous ulcers, &c., occasioned by it: and Tessier gives the results of many experiments, which not only confirm what Galen said of the ill effects the ergot has upon the human frame, but he also ascertained that it produces the same ill effects upon the health of brutes, such as dogs, swine, and poultry,—which all instinctively refuse to eat the ergot of rye; but by disguising it, and by forcibly feeding them with it, he found the same injurious and frequently fatal effect was produced on these animals as that on the human species.

The discovery of the very beneficial and almost wonderful medicinal qualities of the ergot of rye is but of very recent date; Tessier, about 1783, says “It is asserted by some that it is successfully employed in hastening labour, and in pleurisy;” but, he observes, “those assertions are not authenticated; and even if they were true, they would not disprove the injurious qualities it has in other cases, and under other circumstances.”

Dr. Stearns, of New York, seems to be the first who found the ergot of rye to be the most efficacious remedy in cases of protracted labour and excessive hæmorrhage; in such cases, about 1822, he employed it most successfully, and since that time it has been almost generally adopted in this country with equal success. The periodical publication, *The Lancet*, since 1828 to this time, records many most interesting and successful cases, reported by eminent and extensive practitioners, from which it appears, that the lives of many patients, whose cases had been considered hopeless, have been saved by the instantaneous effects of this substance.

The ergot of rye is now an article provided in every dispensary; and since its important and beneficial medicinal quality is ascertained, even if an efficient remedy for preventing this disease were known, it would not be advisable to extirpate it; and there is no doubt, that, when those valuable qualities of the ergot get generally known among the cultivators and farmers, and that a bushel of ergots will probably fetch more than four or five bushels of the finest rye, they will think it worth their while to collect, and carefully separate, the ergots from the corn; by so doing, they would not only be compensated for their trouble by the sale, but at the same time purify the corn, and thus prevent the pernicious effects of the ergot.

EXPLANATION OF TAB. XXXII.

- Fig. 1. A front view of a sound germen of rye, about four days after fecundation: magnified eight times in diameter.
2. A side view of a longitudinal section of the above germen: magnified in the same degree.
3. A front view of a longitudinal section of the base of the above germen, or rather young grain, which shows the first beginning of the formation of the embryo: magnified sixteen times in diameter.
4. A front, and Fig. 5. a back view of an infected grain, from the same ear as Fig. 1., soon after fecundation, when the disease makes its first external appearance: magnified eight times in diameter.
6. A front view of a transverse section of the above infected grain, cut at letter A, Fig. 7.: magnified sixteen times in diameter.
7. A side view of a longitudinal section of the same infected grain: magnified eight times in diameter.
8. Front view of a section of the same infected grain, cut at letter B, Fig. 7.: magnified sixteen times in diameter.
9. A side view of a longitudinal section of an infected grain, about eight or ten days after fecundation; the young ergot is enlarging, and has already torn up the integument of the germen, and detached it from the base: magnified eight times in diameter.
10. A full-grown ear of rye, strongly infected with ergot: *natural size*.
11. A full-grown ergot, within its floret: magnified five times in diameter.
12. A transverse section of the same: magnified five times in diameter.
13. Albumen of a sound grain of rye: magnified two hundred times in diameter.
14. Internal substance of the ergot of rye: magnified two hundred times in diameter.
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Observations.—Thus far I had carried my investigation and illustrations of that singular disease the Ergot in Rye, during the years from 1805 to 1809, and which illustrations have been for many years in the British Museum; and

though since that time some ergotized plants came occasionally into my hands, I never examined them with an intention to discover anything new in them, till in October 1838, when Mr. John Smith, the chief assistant in the Royal Botanic Garden at Kew, brought to me some specimens of ergotized plants of a species of *Elymus*, which were not only infected with ergot, but of which every external part was infected with a minute filamentous fungus, bearing an infinite number of sporidia, which I never before had observed.

Mr. Smith has given a very detailed and correct account of this fungus, in a paper which was read before the Linnean Society on the 6th of November, 1838. He also communicated his discovery soon after he showed it to me to his friend Mr. Quekett, who read on the 4th of December before the Linnean Society a long and very elaborate paper on the same subject, and in which he quotes some very interesting works by M. Leveillé, Dr. Phœbus, and Philippiar, which, to judge from Mr. Quekett's quotations and copies of figures, seem to be very correct observations and illustrations of that subject; but these original works I have not yet seen, and from all these observations and illustrations I am not yet convinced that these filamentous fungi with numerous sporidia are the cause or the consequence of the ergot, because,

1st, Every gramineous plant is equally infected with that minute filamentous fungus, yet very few of these plants produce ergots; and amongst agricultural grains, the rye is the only one that is subject to that disease; among the many hundred ears of wheat that I examined in every stage of its growth, I found only one spikelet that produced three ergots, and one spikelet with only one ergot.

Because, 2nd, in autumn all decaying plants are infected with such filamentous fungi and minute sporidia; and Mr. Smith, when he brought to me the first specimen of his ergot, brought me also a specimen of a flower of *Canna indica*, in which not only the inside of the anther was infected with this filamentous fungus, but also the individual pollen grains were strongly infected with it.

For these reasons, I cannot yet consider the question, of the cause of the Ergot, as finally and satisfactorily settled; but I hope those naturalists who have already done so much on that subject will persevere in their researches and experiments till they finally succeed.

EXPLANATION OF TAB. XXXIII. A.

- Fig. 1. A young ergot, with its anthers and bracteas, about ten days after fecundation: magnified ten times in diameter.
2. The same young ergot, with its anthers and bracteas removed: magnified ten times in diameter.
 3. A millionth part of a superficial square inch, filled with the sporidia, which appear on the external surface of the ergot of *Elymus*, as well as on those of ergot of rye, and which appear on every part of these plants, and ultimately are washed off by the dew or rain, and mixed with the water: magnified a thousand diameters.
 4. A portion of an anther, bearing the same filamentous fungus.
 5. A group of the filamentous and articulated fungus which infests every part of the plants of *Elymus*, and almost every gramineous plant, whether infected with ergot or not: magnified a thousand times in diameter.
 6. A millionth part of a square inch, filled with the sporidia of the external surface of the red or orange-coloured ergot: magnified a thousand diameters.

FRANCIS BAUER.

Kew Green, December 14th, 1839.

A

Franz. Bauer, 1839.

B

E. J. Quekett del.

G. Jarman Sc.