HIND'S ESSAY

ESSAY

ON THE

INSECTS AND DISEASES

INJURIOUS TO THE

WHEAT CROPS.

BY H. Y. HIND, ESQ., M.A.,
Professor of Chemistry at Trinity College, Toronto.

TO WHICH WAS AWARDED, BY THE BUREAU OF AGRICULTURE AND STATISTICS,

THE FIRST PRIZE.

"The progress of agriculture ought to be one of the objects of your constant care; for upon its improvement or decline depends the prosperity or decline of empires."—*Speech of* NAPOLEON III.

TORONTO:
PRINTED BY LOVELL & GIBSON, YONGE STREET.
1857.


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INTRODUCTION.

BUREAU OF AGRICULTURE AND STATISTICS,
Toronto, 7th Sept., 1857.

ON the 18th August, 1856, there issued from this Department the following notice:—

BUREAU OF AGRICULTURE AND STATISTICS,
Toronto, 15th August, 1856.

PRIZE ESSAYS—£40, £25, AND £15.

The above premiums will be paid for the three best Essays, respectively, on the "Origin, nature, and habits,—and the history of the progress, from time to time,—and the cause of the progress, of the weevil, Hessian fly, midge, and such other insects as have made ravages on the wheat crops in Canada; and on such diseases as the wheat crops have been subjected to, and on the best means of evading or guarding against them."

The essay to be furnished to the Bureau by the 15th day of January next; and to be designated by a motto, a copy of which shall be also forwarded, in a sealed note, with the name and address of the author. The prizes will be awarded according to the decision of a committee, to be named by the Board of Agriculture for Upper and Lower Canada; or, in default of any such decision, by the Bureau. The essays selected to become the property of the Bureau. A premium will only be awarded in case an essay of sufficient merit is produced.

It is feared that the farmer, in his eagerness to produce wheat, is not paying sufficient attention to the danger of over-cropping; and it is hoped that this warning, and the information, and advice which may be obtained through the essays sought for, will aid in arresting the great scourges of the wheat.

P. M. VANKOUGHNET,
Minister of Agriculture, &c.

The time named in the notice first issued having been extended to the 15th day of April, twenty-two essays were received up to that time. The Boards of Agriculture for Upper and Lower Canada named Professor Hincks, of University College, Toronto, and Professor Dawson, of McGill College, Montreal, as a Committee, to decide upon the merits of the several essays.

According to the decision of these gentlemen, the *First Prize* has been awarded to H. Y. Hind, Esq., Professor of Chemistry at Trinity College, Toronto, author of the Essay with the motto—

"The progress of agriculture ought to be one of the objects of your constant care, for upon its improvement or decline depends the prosperity or decline of empires."—Emperor Napoleon III.

The *Second Prize* to the Rev. George Hill, Rector of Markham, author of the Essay with the motto—

"Mox et frumentis labor additus."

And the *Third Prize* to Emilien Dupont, Esq., of St. Joachim, in the county of Montmorency, author of the Essay with the motto—

"Spinas et tribulos germinabit tibi (terra) et comedes herbam terræ."

The Judges also state that they consider the four Essays bearing the following mottoes as worthy of honorable mention, as containing much valuable information :—

"Nil sine labore."

"Trunca pedum primo, mox et stridentia pennis
Miscentur, tenuemque magis aëra carpunt."

"They are all the work of His hands."

"And the Lord God prepared a gourd, and made it come up over Jonah, that it might be a shadow over his head to deliver him from his grief; so Jonah was exceedingly glad of the gourd.

"But God prepared *a worm* when the morning rose, and it smote the gourd that it withered."

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CLASSIFICATION OF INSECTS.

(*Referred to in* CHAPTER II.)

- **INSECTS**
  - **with Wings; and the Mouth**
    - **organized for gnawing. Wings in number**
      - **Four**
        - **of unequal consistency; the under pair Folded**
          - Transversely ..... Coleoptera I.
          - Longitudinally ..... Orthoptera II.
        - **of equal consistency**
          - Reticulated ..... Neuroptera III.
          - Veined
            - Naked .... Hymenoptera IV.
            - Hairy .... Trichoptera V.
      - **Two** ..... Strepsiptera VI.
    - **Organized for Sucking Wings**
      - **Four**
        - Not clothed with Scales ..... Hemiptera VII.
        - Clothed with Scales ..... Lepidoptera VIII.
      - **Two** ..... Diptera IX.
  - **without Wings**
    - Undergoing Metamorphosis ..... Aphaniptera X.
    - **No Metamorphosis**
      - Mandibulated ..... Thysanoura XI.
      - Suctorial ..... Parasita XII.

PRIZE ESSAY.

CHAPTER I.

Accounts of the ravages of destructive insects, common, 1, 2.—Remedial measures not recorded; reason of this apparent negligence, 2, 4.—Distinction between foreign and naturalized insects, 5, 6.—Certain destructive insects, common in America; general immunity in Canada, and reasons for it, 6, 9.—Locusts at the Cape of Good Hope; Europe and Africa, 9, 12,—The seventeen year locust, 12. Broods of seventeen year locust in the United States, 14.—Found in Canada, 14.—Vast abundance in Ohio, 16.—Appearance in the western prairies, 16.—Destructiveness of, 16.—Pine Beetle in South Carolina, on the Ottawa, and in the Hartz, 17.—Palmer Worm in New England, 18.—The Aphis, destructiveness of, in Great Britain, in Belgium, in America, 20, 21.—The Chinch Bug, 21.—Common in the Western States, unknown in Canada, 22.—Cost of maintaining destructive insects, in France, (22 a), in the United States. (22 a) (22 b) Food of insects, 23, 24.—Distribution of wind, 25.—Connection with rocks, 26.

1. Accounts of the sudden appearance and devastating progress of insects, injurious to vegetation, have been handed down to us from the earliest times. Few events would seem to be more likely to secure universal attention at the time of their occurrence than the excessive multiplication over wide areas of countless millions of insects, threatening the destruction of the food of man.

2. Such calamities must have appeared at all times and in all nations, as alarming omens of future wide spreading distress; while, however, we frequently find interspersed among the records of history numerous melancholy recitals of the ravages committed

by clouds of grasshoppers, locusts, and flies of various kinds, the narrative frequently stands alone, without informing us by what providential interposition the plague was stayed, or what human efforts were made to arrest the scourge and guard against its return.

3. This arose, no doubt, in great part, from the migratory character of the insect depredators, coming, as many species did, from distant and uninhabited lands, where their increase was unnoticed, and perhaps, even their presence generally unknown, thus rendering all human efforts absolutely futile in the attempt to stay the insect plague.

4. In part also from the unaccountable disappearance in a single season of the dreaded enemy, with perfect immunity from its attacks during many succeeding years, thus allowing an event which had struck terror among entire nations to pass from remembrance, until a renewal of its ravages produced similar alarm and destruction, to be again deplored and forgotten. Such, indeed, is the case at the present day, but with this difference, that while we are subject to as great or even greater dangers arising from insects which have made their home in our midst than our forefathers were, an effort is now made to guard against their destructive attacks, by acquiring and spreading a knowledge of their habits and history, so that those remedial measures may be adopted which experience and accurate information suggest.

5. It is highly important to distinguish between the sudden invasion of an infinite multitude of insects from distant lands and the gradual increase of those which have taken up their permanent abode with us, and multiply upon the fruits of our toil. The foreign invader suddenly appearing in innumerable hosts, requires for his subjection and destruction a power infinitely greater than man can call to his aid; while the increase

of our indigenous enemies or of destructive colonizers may sometimes be arrested by the uniform adoption of these remedies which a knowledge of their history and habits confers.

6. The excessive appearance of foreign insects is of common occurrence in countries situated within certain geographical limits even at the present day, and although we do not often read of such devastating legions as those which composed "the army of the Almighty, strong to execute his word," [1] we know that parts of Europe occasionally suffer from local invasions of a most alarming and threatening character. On this continent we have witnessed during the last ten years the immense local injury caused by grasshoppers, seventeen year locusts, wire worms, aphides, curculios, wheat flies, chinch bugs, turnip flies, catworms, palmer worms, and others, and some of these are of foreign origin.

7. Their ravages might be considered of secondary importance when compared with the terrible visitations of insect pests which have not been uncommon in inhabited countries during the past century, but they are sufficiently destructive and alarming as to become a subject of national importance. It may be useful to enumerate a few instances of these excessive appearances of insects, by way of contrast to that comparatively mild form of insect plague in Canada, which has been the occasion of this essay.

8. We are too much inclined to over estimate the degree of

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(1) Every one is familiar with the thrilling descriptions of insect visitations recorded in the sacred pages: "Stretch out thy rod and smite the dust of the land, that it may become lice throughout all the land of Egypt." — "There came a grievous swarm of flies into the house of Pharaoh and into his servants' houses, and into all the land of Egypt, the land was corrupted by reason of the swarm of flies." (Ex. iii.)—"And the locusts went up over all the land of Egypt, and rested in all the coasts of Egypt." (Ex. x.)—"And I will restore to you the years that the locust hath eaten, the cankerworm, and the caterpillar, and the palmer worm, my great army which I sent among you." (Joel ii.)

injury we occasionally suffer from the natural causes, because we have not always the opportunity of comparing our losses and troubles with those sustained by our fellow-men in less favoured countries than our own. It is obviously unjust to attribute to climate, geographical position or peculiarities of soil, the general appearance of destructive insects, which we have encouraged and invited by the best means in our power, or perhaps, which it was possible to devise. In the following pages it will be shown that we enjoy in Western Canada a singular immunity from insect depredations, arising no doubt from our insulated position and humid climate.

9. I do not wish to under-rate the injury sustained by the country at large by the ravages of such insects as the Hessian fly, the wheat fly, and the wire worm, &c.; but when it can be shown that we possess to a considerable degree the means of arresting the devastating progress of those we have suffered to make their home in our midst, and of so reducing their numbers as to render them comparatively harmless; it cannot fail to be a matter of congratulation and thankfulness that insect enemies over which we cannot exercise control, neither trouble nor as yet threaten us, although the gradual approach of some of them from the South is a sufficient cause for anxious watchfulness and care. (See paragraphs 14 and 21.)

10. Our sister colony at the Cape of Good Hope, has been particularly subject to the dreadful scourge of locusts, (*Gryllus devastator*,) whose invasions are invariably followed by famine in the region they devastate. The inroads of the locust are apparently periodical, according to Pringle, about once every fifteen years. In 1808 after having laid waste a considerable portion of the country, they disappeared, and did not return until 1824. They then remained for several years, but in 1830, took their departure. The proper home of the locust is yet a mystery.

Experience only tells us that at the Cape they come southwards from the north.[1]

11. It is well known that the locust sometimes multiplies in Europe to such a degree as to devastate provisions. Africa is rarely free from its ravages, and of their infinite multitude we have records from the earliest authors, fully confirmed by the accounts of recent travellers. In France, Germany, Spain, Italy and Russia, armies of locusts have appeared from time to time, and with such devastating progress that "the land is as the Garden of Eden before them, and behind them a desolate wilderness." North America is not exempt from the plague of insects, allied to locusts, and while in Europe they seldom penetrate further north than latitude 43°, their congeners have committed great ravages as far north as Lord Selkirk's settlement, at Pembina, on the Red River, in latitude 54°, coming from the Western prairies.

12. The seventeen year locust, as it is popularly but erroneously termed, is an American insect of most singular habits and destructive character. Its appearance was first recorded about Philadelphia in May, 1715, and since that date "punctually at the same month every seventeenth year, now certainly for nearly one hundred and fifty years, has this extraordinary insect been known to make its visit. No causes have affected it during that period, not even so far as relates to the month in which it appears." [2]

13. This remarkable insect appears in different parts of the United States in separate broods, which have each their appointed year for assuming the winged state, and propagating their species. An entire brood hatches in a few days time, and countless millions of these large black flies (not true locusts) suddenly appear

(1) Lake Ugasni. Page 285.
(2) W. S. W. Ruschenberger, M.D., U.S.N.

over areas occupying many thousand square miles. Dr. Fitch, State Entomologist of New York, says that three of these broods exist partly within the boundaries of the State, and there appear to be six other broods in different parts of the United States.

14. One brood inhabits the valley of the Hudson River. Its last appearance was in 1843, and it will appear again in 1860. A second brood is found in Western New York, Western Pennsylvania and Eastern Ohio. It appeared in 1849, and it is very probable that the outskirts of the brood extend into Canada. It may be looked for again in 1866. The third brood, which came forth in 1855, extends from the Atlantic to the Ohio, and into Canada; several individuals of this brood are said to have been taken near Toronto in that year, and it is quite certain that the loud note of a cicada was heard repeatedly in the woods west of the city in July of that year. Dr. Fitch, quoting a letter from Mr. Robinson, dated Pallchassie, May 24th, says, "I have heard the seventeen year locusts for ten days past, but they are not plenty here. At Park Hill, however, twenty-five miles south of this, in the Cherokee country, they are very numerous, and in these hungry times, occasioned by the severe drought of last year and this spring, the people (Indians) are glad to gather and eat them."

15. The great Pennsylvania brood before noticed reached from that State to Georgia; another or fifth brood extends from Western Pennsylvania through the valley of the Ohio River, and down that of the Mississippi to Louisiana; it appeared in 1846 and will, therefore, make its re-appearance in 1863. A sixth brood assumed the fly state in 1854 around the head of Lake Michigan, and across Northern Illinois into Iowa. Other and minor broods are recorded to have made their appearance in different parts of the Union, but Dr. Fitch thinks that some of

them may have consisted of other species, mistaken for the true seventeen year locusts.[1]

16. In Ohio it is stated on the best authority, that the grubs have been collected in such vast quantities, that they have been used in the manufacture of soap by the farmers in the localities where they are abundant. The number of them is so immense that the ground is described as riddled by their holes. Dr. Hildreth says they dwell for 16 years and ten months in a grotto of their own construction, probably near the root of some tree, for they are forest dwellers, and derive their nourishment from the roots of trees, grasses and herbs. In 1846 a large number of these locusts emerged from the earth in Dr. Hildreth's garden, in the branches of which the parent cicada had deposited her eggs in 1829. (2) In 1854 this extraordinary insect was noticed as being more wide spread in many places in Illinois than it was on its previous visit. Fruit and forest trees wherever they had been planted on the prairies, were seventeen years ago destitute of these insects, but in 1854 they came from the ground among such trees as abundantly as in the original timber lands. (3) An enemy there lying concealed and preying for seventeen years upon the choicest treasures of the garden and field, must be entitled to a place among insect scourges in the first rank. Canada is happily yet free from the destructive presence of this extraordinary depredator, but it is found in all the States of the Union surrounding her, warning us of its approach and visit. It appears to infect the oak, apple, poplar, and probably many other trees, for the purpose of depositing its eggs, for which object it punctures the small limbs and does incalculable injury,

(1) For a most interesting account of this insect see page 38 of the first report on the noxious and other insects of the State of New York, Dr. Asa Fitch, 1855.

(2) p. 216, Vol. 3, 2nd series. H. J. of Science.

(3) Dr. Fitch's Report, page 43.

so weakening the branches it attacks, that, as in Wisconsin in 1854, every gust of wind suffices to break off many of the twigs at the point where the locust had deposited its eggs. Mr. T. W. Morris speaks of having seen the tops of the forest trees in Pennsylvania and Ohio, for upwards of one hundred miles, appearing as if scorched by fire a month after this locust had left them. (1)

17. In some of the forests in South Carolina ninety pine trees out of one hundred have been killed by a small beetle. Great numbers of noble pines, three feet in diameter, and 150 feet high, stand with their naked arms stretched abroad, lifeless, like hundred and thousands of others prostrate on the ground without any successors of their kind. (2) In the great timber region of the Ottawa there is a narrow strip of dead pines extending thirty miles up the river, no trace of fire or any other agent likely to have effected their destruction is visible; their erect trunks stand in gloomy grandeur almost stript of their branches by long exposure to wind, rain and snow. Although no outward sign is visible of the destroying enemy, yet, no doubt the destructive pine beetle has been the secret cause of their decline and death. (3) It has long been known that a beetle (*Bostrichus typographus*) has several times threatened the entire destruction of the forests in the Hartz Mountains. In 1783 a million and a half of trees were destroyed by this insect in the Hartz alone. As many as 80,000 larvæ have been found on a single tree.

18. The palmer worm which visited New England and the eastern part of the State of New York with such unparalleled destructiveness in 1853, is common in Canada. In 1791 the

(1) Dr. Fitch's Report.

(2) Trans. Amer. Ins., 1846.

(3) Related to the writer by a very competent-eye witness, who spent several years with the Lumbermen.

orchards and forests of New England were overrun by this worm, and the leaves of the apple, oak and other trees devoured by it. In 1853 the trees everywhere assumed a brown withered appearance under their destructive attacks, looking as though they had been scorched by fire. On jarring or shaking a tree hundreds would instantly let themselves down from among the leaves, by fine threads like cobweb, some dropping to the ground, others remaining suspended in the air. They continued in full force until 23rd June, when rain accompanied by heavy thunder caused them to disappear.(1)

19. The Aphis tribe, of which many species were so abundant and destructive in the neighbourhood of Toronto during the dry summer of 1856, is in some countries a most dreaded and devastating pest. So wonderfully productive are the green plant lice that in five generations one aphis may be the progenitor of 5,904,900,000 descendants; and it is supposed that in one year there may be 20 generations (Reaumer). In 1810 the Pea crop was almost entirely destroyed throughout Great Britain by an aphis. Indeed next to the locust the aphidæ may be said to be the greatest enemies of the vegetable world (Kirby). The wonderful fertility of this tribe of insects exceeds that of any known species, and elevates them to a position in the scale of pests and plagues which secures for them the second, if not in many temperate climates, the first place among insect depredators. A few weeks is sufficient to convert a handful of these viviparous and oviparous insects into countless legions, which taking flight, darken the air by their numbers. In 1834 a great flight of these insects was distributed by a strong wind over Belgium. In 1836 the inhabitants of Hull, England, were seriously incommoded by a host of them loading the air in numbers so immense as

(1) See 2nd Report by Dr. Fitch.

to fill the eyes, nose and mouth of all who were in the open air at the time of their visit.(1) There are numerous species of aphis, forty-nine named species have been recorded by Stephens in his catalogue of British insects. They are found to infest most of our cultivated vegetables. Fortunately they have numerous enemies, otherwise their wonderful fecundity would enable them to destroy every blade of grass and every green thing in our gardens and fields.

20. Mr. Curtis states that from one egg, in seven generations, 729 millions will be bred; and if they all lived their allotted time, by autumn everything upon the surface of the earth would be covered by them. Dr. Fitch relates that "on the last day of October, 1854, it being a warm sunny day, after many nights of frost, I observed myriads of winged and apterous lice wandering about upon the trunks, the limbs and the fading leaves of all my apple trees, many of them occupied in laying their eggs. These were scattered along in every crevice of the bark, in many places piled up and filling the cracks, and others were irregularly dropped among the lichens and moss growing upon the bark—every unevenness of the surface, or wherever a roughness afforded a support for them, being stocked with as many as could be made to cling to it."

21. The history of the *chinch bug* is probably not familiar to the majority of Canadian farmers, as this insect does not yet appear to have crossed the Detroit and St. Clair Rivers; but while it is to be hoped that many years will elapse before it finds a home in this country, there is reason to fear that sooner or later we may have to deplore, perhaps in a mitigated form, its advent in our midst. As allusion will be made to this destructive and

(1) See Smee on the potato plant, for numerous instances of the incredible numbers and destructiveness of various species of aphidæ.

disgusting insect,(1) in subsequent pages (paragraph 52), the following account of its progress and destructiveness is submitted from Dr. Fitch's reports:—"The chinch bug has now multiplied and extended itself over all parts of Illinois and the adjacent districts of Indiana and Wisconsin, and has become a most formidable scourge. The dry seasons which have recently occurred have increased it excessively. In passing through Northern Illinois, in the autumn of 1854, I found it in myriads. In the middle of extensive prairies, on parting the grass in search of insects, the ground in some places was found covered and swarming with chinch bugs. The appearance reminded me of that presented on parting the hair of a calf that has been poorly wintered, where the skin is found literally alive with vermin.

22. Our western neighbours have for years past been congratulating themselves upon the security of their wheat crops, exempt from the midge and other insect depredators which were causing us such losses here at the east. But they now find that they have in the chinch bug a foe more formidable and destructive even than the wheat midge, since it not only cuts off their wheat, but in many localities it takes the corn and other crops also. Although it is commonly only a strip of the outer edge of the field which they devastate, yet in several instances the entire field is invaded and swarms with them, so that no grain is developed in the heads, and some have set fire to their wheat fields to consume the hosts of these vermin which were gathered therein, with the hope of thereby lessening the numbers upon their farms the following year. The disgusting smell, moreover, which these bugs emit, is most loathsome and sickening to the labourers engaged in harvesting the wheat fields. Lilley's reaping machine, made at Elgin, Illinois, has small deep boxes sunk in the plat-

(1) In 1856 the chinch bug injured spring wheat in Fayette County, Iowa.

form for the raker and three binders to stand in, that they may not have to stoop to their work as they would if standing on the platform. As the machine is in operation, the feet of the men standing in these boxes become buried among the insects and fine chaff which fall into them. The men are so annoyed by these vermin thus covering their feet and crawling up their legs, that they many times stamp to shake off and crush the tormenting things; and whether dead or alive, when thus heaped together in masses, such a stink arises from them, as, when wafted by the air it happens to come full in one's face, is the most loathsome and nauseating of any thing that can be imagined.

22. (a) It is difficult to arrive at accurate conclusions respecting the annual cost of maintaining destructive insects. In France, where great efforts are constantly made to diminish the numbers of these terrible foes to the agriculturist and public economy, upwards of four hundred thousand pounds have been paid out of the government chest in one year to armies of men, women and children, for their labours in extirpating these pests. This large outlay occurred during a season in which destructive insects prevailed to an unusual extent, threatening the country with famine. It has been said on very excellent authority, that the damages done by insects in France alone amount on the average to $50,000,000. This sum, immense as it appears to be, is actually approached in some years in the United States. The damages done by the wheat midge in 1854, exceeded, undoubtedly, $16,000,000 throughout the Union. When to the injuries committed by the terrible pest just named, those of the chinch bug, Hessian fly, wire worm, and the hosts of insects preying upon fruit trees are added, $30,000,000 would not cover the cost of their maintenance in that year. The quantity of human food annually consumed by insects in France, is equal to

the entire consumption of the nation for a period of five weeks, and two species alone are computed to consume annually more than three millions of men. (1) The celebrated curculios, and the 'terrible' Angoumois moth, so dreadfully destructive in 1760, are among the wheat pests of France.

22. (b) The progress and increase of insects destructive to cultivated crops in the United States, is a subject of the utmost importance to agriculture. So many threatening and uncontrollable circumstances govern their increase on this continent, that the danger of short harvests arising from their depredations is year by year growing more imminent, and will some day come upon the country with a blow as sudden as it will be terrible. The immense area occupied by cultivated crops, the almost total absence of rotation, and the remarkable character of some of the indigenous insects which have already proved seriously destructive in the middle States of the Ohio and Mississippi valleys, all threaten a calamity which will be felt from Maine to Mexico. As I propose to enlarge upon this subject in a future chapter, further remarks are at present unnecessary. (Chapter VIII. On the cultivation of wheat in the United States.)

23. The food of insects embraces the utmost variety the animal and vegetable world can offer. Some species are restricted to particular plants, and if these fail, the race may for a time disappear. (2) Insects appear to be the instruments designed to arrest the excessive growth and increase of certain species of plants, and it is probable that there is not a species of plant, which does not furnish nutriment for one or more tribes of insects, either in their larvæ state or in their perfect condition, whereby it is prevented from multiplying to the exclusion of others.

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(1) M. Delamane. (2) Carpenter.

24. Not less than two hundred kinds of caterpillars are supposed to feed upon the oak; and upwards of 50 different species of insects are known to live upon the nettle, which is so repugnant to quadrupeds that few will touch it, yet such is the rapid increase of this vegetable, that if it were not for its insect depredators it would soon annihilate all plants in its neighbourhood. The naturalist, Wilke, tells us that every plant has its proper insect allotted to it, to curb its luxuriance and to prevent it from multiplying to the exclusion of others. The peculiarity of the agency of insects consists of their power of suddenly multiplying their numbers to a degreee which could only be accomplished in a considerable lapse of time in any of the larger animals, and then as instantaneously relapsing without the intervention of any violent disturbing cause into their former insignificance. (1) Many instances of this sudden increase and corresponding disappearance a few days or weeks after, will be noticed in the following pages.

25. The wind seems to play a very important part in the distribution of insects over wide areas and in particular directions. A wind from the coast of Africa drove such myriads of flies upon the fresh paint of H. M. S. Adventure, then 100 miles from land, that not the smallest point was left unoccupied or uncovered. The Hessian fly, and particularly the wheat midge, both select low and sheltered places for their depredations. Elevated and exposed fields are not unfrequently untouched in the midst of the greatest devastation

26. The connection of insects with rocks is a subject which has been investigated to a very slight degree, and offers a fertile and instructive field for the enquiring agricultural entomologist. Mr. Wailes always found the larvæ of *enicoceri* on rough shiny

(1) Lyell—Principle of Geology.

stones, and he found it as great a waste of time to look for it upon a smooth limestone as to turn up a fragment of basaltic rock (whitstone), in search of a geodephagous (1) insect. "So far," says Mr. Wailes, "as my observations, whether confined to single stones, or extended over a whole district, go, any place having limestone, particularly the magnesian, for its subjacent stratum, will afford abundance of the geodephaga as well as most other coleoptera, whilst they will be found very thinly scattered over a basaltic region."(2)

(1) Geodephagous. The geodephaga form a coleopterous subdivision containing two families, the cicindelidæ and the carabidæ. Of the former there are between fifty and sixty species known in the United States and Canada. They prey on insects. The carabidæ are very numerous, predaceous, feeding upon insects and also upon vegetables. They are generally found under stones and rubbish.

(2) Quoted in Enc. Britt. 8th Ed.

CHAPTER II.

Use of scientific terms common and necessary, 27, 28.—Reasons why an outline of entomological classification and nomenclature is necessary, 28, 29.—Importance of Entomology, 30, 31.—Reasons why the study of insects has not been popular, 33, 34.—Definition of insects, 36.—Changes which they undergo, 37.—Breathing organs of insects, 38.—Systematic arrangement of, 39.—Definition, 40.—Scheme, 40.—Order I., Coleoptera, 41.—Order II., Orthoptera, 47.—Order III., Neuroptera, 48.—Order IV., Hymenoptera, 49.—Order V., Trichoptery, 50. Order VI., Strepsiptera, 51.—Order VII., Hemiptera, 52.—Chinch Bug, 52.—Aphidæ in the United States, 53.—Order VIII., Depidoptera, 54.—Order IX., Diptera, 56.—Technical characters of the Cecidomyia, the genus to which the wheat midge belongs, 56.—Order X., Aphaniptera, 57.—Order XI., Thysanoura, 58.—Order XII., Parasita, 59.

27. Every agricultural publication contains from time to time descriptions of insect depredators, in which are frequently employed many of the scientific terms used by entomologists to designate the species, genus and order, to which the marauder belongs. The use of some scientific terms is very often absolutely necessary in giving even a popular description of a fly, a beetle, a weevil, a parasite, or a so called bug.

28. Every one is familiar with the frequent occurrence of such terms as coleopterous insect, dipterous insect, parasitical insect, larva, pupa, &c. Farmers ought to be familiar with these terms, and to be able to form a correct idea of the nature of an insect depredator, which may occasion injury or alarm, whether they acquire their information from the perusal of a popular but sufficiently accurate description, or whether they seek to convey in written words an account of what they observe with such accuracy and distinctness as would enable any one acquainted with

the outlines of entomology to identify the insect, if among well known destructive species, here or abroad. It is for the purpose of affording a general view of insect classification and nomenclature that the following brief definitions and descriptions are given. They contain merely those terms which are continually occurring even in popular descriptions of insects, and without which most attempts to convey in words an idea of a new, a strange, or even a common species, must necessarily be comparatively worthless, because indistinct and imperfect.

29. The definitions and outlines of classification are prefaced by a few remarks upon the distribution and importance of insects, the science which treats of their history, habits and relation to man, and the difficulties which prejudice and a want of a proper appreciation of its merits have thrown in its way as a subject of popular instruction and enquiry. The increase and ravages of insects injurious to many of our cultivated crops have already become matters of the highest importance on this continent, and year by year threatens us with a terrible calamity. Like many other unseen yet impending evils, the magnitude of this one is unappreciated, and it is only when a devastation similar to that which occurred in New York State in 1854, or in the Niagara Townships in 1856, become as wide spread as the Union itself, that men generally will regard the subject in a proper light.

30. There is no branch of natural history which can claim so many distinct objects of study and admiration as that of Entomology. (1) The number of distinct species of insects contained in collections, probably amounts to 200,000. In the Museum at Berlin about 100,000 species are arranged and classified, among which are upwards of 40,000 coleoptera or beetles, and it is com-

(1) Entomology. *Entomon*, an insect, *logos*, a discourse.

puted that all the species of insects taken together, which exist in nature do not fall short of 400,000.

31. It is, however, probable, that there are more known species of plants than insects, but the vegetable world has been far more sedulously studied and ransacked than the apparently less striking and less important world of insects. A very large number of plants have been collected in distant parts of the globe, without the insects which live on them or near them being brought at the same time. But if we limit, says Humboldt,(1) the estimates of numbers to a single part of the world, and that the one which has been the best explored in respect to both plants and insects, viz., Europe, we find a very different proportion, for while we can hardly enumerate between seven and eight thousand European phœnogamous (flowering) plants, more than three times that number of insects are already known.

32. The relations of insects to man are not only remarkably numerous but of the utmost importance, and with the exception of the domesticated animals, they exceed those of all other classes in this kingdom of nature. Nevertheless, we find that the study of entomology is still in its infancy, and has neither progressed so rapidly nor won so many admirers as her sister science botany, or some of her kindred departments in zoology.

33. From the time of Pliny to that of Linné in Sweden, Reaumer in France, Sulzer in Germany, Ray, Kirby and Spence in England, Say in America, entomologists have found the necessity of seizing every opportunity of showing that their favorite science was not a frivolous amusement or devoid of utility, as popular opinion seemed inclined to consider it. (2) Old impressions, says Reaumeur, are with difficulty effaced. They are

(1) Aspects of nature.

(2) See introduction to Kirby and Spence's Entomology.

weakened, they appear unjust even to those who feel them, at the moment they are attacked by arguments which are inadmissable; but the next instant the proofs are forgotten, and the perverse association resumes its empire."

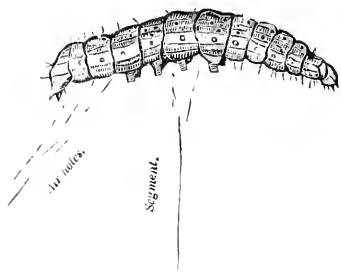
34. During the last half century the low estimation in which the science of entomology was formerly held, has been slowly giving way to a more correct appreciation of its value and of the benefits which a general study of its details might confer upon mankind. At times like the present, when a vast province is trembling at the prospect of one of its staple productions dwindling away under the attacks of minute but numberless insects, all are willing to listen to the teachings of the entomologist, and would seek to elevate to the position of an invaluable science, the study which, when proofs are forgotten, will probably be allowed, in popular estimation at least, once more to subside into a harmless or frivolous pursuit.

35. It would be an easy task to show by numerous illustrations the great economical value of the science of entomology, but as this would swell out the pages to too great an extent, I shall content myself with a reference to the statistical facts interspersed throughout this essay, which may serve to create, where it is most needed, a proper appreciation of the magnitude of those evils which are growing upon us, by the selfishness, indifference and neglect, which a mistaken impression of individual security has cherished.

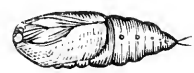
36. Insects may be defined as animals without vertebræ; six-footed; with a distinct head furnished with two antennæ, and a pair of compound immoveable eyes; breathing through openings which lead to internal air tubes or trachæ; sexes distinct; adult state attained through a series of changes called metamorphosis.

37. Nearly every insect undergoes three changes, (fig. I., II.

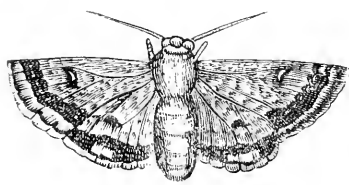
and III.) before it reaches its perfect condition. From the egg to the larva; from the larva to the pupa; and from the pupa



CATERPILLAR.—FIG. I.



PUPA.—FIG. II.



MOTH.—FIG. III.

MOTH.

or chrysalis to the imago or perfect insect. The larvæ of insects are commonly distinguished in popular phraseology in the following manner:

Grubs are the larvæ of the coleoptera or beetles; maggots the larvæ of the diptera or two winged flies; caterpillars the larvæ of butterflies, moths and sphinges.

38. Most insects breathe through small openings called stigmata, spiracles or air holes, placed on the side of each segment of the body. These air holes can be distinctly seen without difficulty in naked caterpillars (fig. I.) The opening can be closed at will by the insect. The air holes are connected with ramifying tubes called air tubes or trachæ.

39. The following scheme of a systematic arrangement of insects is based upon the peculiarities in the construction and

number of the wings or organs of flight, as appears from the derivation of the names given to the several orders. This arrangement must be considered as representing the most marked peculiarities of each particular order, and susceptible of various modifications as our knowledge of insect structure and analogies increases; it is in fact but one out of many systems which have been proposed by entomologists, and is selected because it recognizes many primary divisions which are employed in popular descriptions, and which have been approved since the time of Linnœus, their originator.

40. The primary divisions are termed orders; the orders are divided into sections; the sections into families; the families into genera, and the genera into species or individuals. As it will be absolutely necessary to refer from time to time to the differents parts or organs of an insect, the annexed diagram of

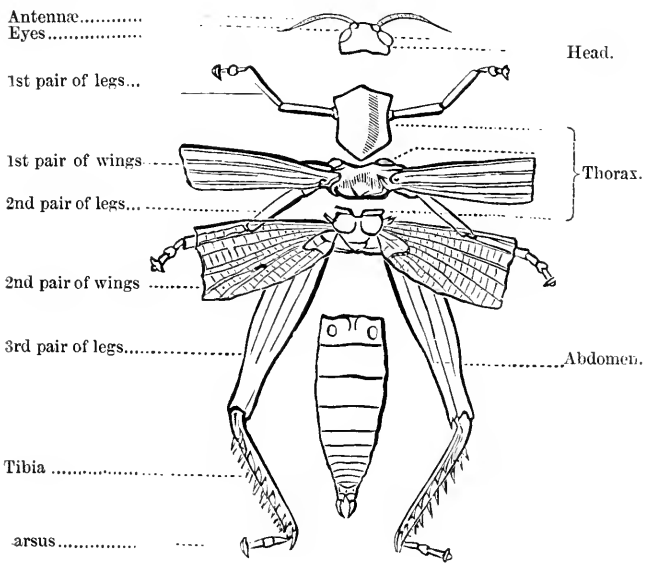


FIG. IV.

these organs, with their scientific designations, should be consulted before perusing the description of the orders into which insects are divided for the purpose of classification.

Order I.

Coleoptera. (*Koleas*, a sheath; *ptera*, wings.)

41. The Beetle tribe. Wings four in number; two for flight, two for protection, and termed *elytra*, or wing cases. The elytra are hard and horny. There are exceptions to this general rule, which it is not necessary to mention here. The under wings are membranous and transparent.

42. The larvæ are popularly termed grubs, and commonly possess twelve segments, exclusive of the head. The pupæ are incomplete, that is, each part of the perfect insect is visible, and enclosed in a separate sheath, thus differing from the pupæ of butterflies in which the parts are all cased in one sheath. Beetles are composed of three distinct parts, the head, the thorax, and the abdomen. (Fig. IV.) The most prominent and important parts of the head are the compound eyes, the two antennæ, the two mandibles or jaws, and the two maxillæ or under jaws. The insects of this order are all masticators.

43. The thorax is composed of the three segments of the larvæ body next to the head. In the larvæ these are generally very distinct; in the perfect insect or beetle one of the segments is often greatly enlarged at the expense of the other two. To the thorax are attached the wings and the legs.

44. The abdomen is generally distinguished by the absence of all external appendages, but in some insects we find an ovipositor, a pair of forceps, a hook, &c. The abdomen consists of segments not exceeding nine in number. The openings for

the breathing organs may be observed near the lateral margin of each segment.

45. The legs consist of five parts, the first joint, coxa or hip, the second or trochanter, the third, the femur or thigh, the fourth, the tibia or shank, and the fifth, the tarsus or foot. The tarsus is composed of three, four or five joints, and terminates generally in two-hooked claws. The tarsus is sometimes made the basis of the sections into which the order coleoptera is divided.

46. This order of insects is one in which the agriculturist is particularly interested. It contains the tribe Rhincophera, (snout beetles,) which is so numerous in species that not less than 8,000 different insects belonging to it have been described by one entomologist (Schœnherr.) It includes the insatiable evils which are justly distinguished and dreaded for their attacks upon grain and seeds. Immense quantities of Indian corn and wheat in the crib or granary are destroyed every year in the United States by the grain weevils, *calandra granaria* and *calandra remotepunctata*.

Order II.

Orthoptera. (*Orthos*, straight; *ptera*, wings.)

47. This order includes crickets, grasshoppers, locusts, earwigs, cockchafers, the mantis tribe. Most of these insects are eminently destructive to vegetation. Upper wings of the consistency of parchment; mouth with mandibles and maxillæ.

Order III.

Neuroptera. (*Neuron*, a nerve; *ptera*, wings.)

48. Dragon flies, May flies. Termites; wings membranous, naked and reticulated; masticators.

Order IV.

Hymenoptera. (*Hymen*, a membrane; *ptera*, wings.)

49. Wasps, bees, ichneumons, flies, &c. Many insects belonging to this order exhibit very remarkable peculiarities in providing for their young, by laying up a store of food for winter use. The busy bee, it is almost needless to mention. Some members of the families into which this order is divided lay up a stock of provisions consisting of larvæ, and complete insects by the side of their eggs, in holes gnawed in branches and trunks of trees, and sealed up when full. The insects thus imprisoned do not appear to be quite deprived of life, but only so much injured as to deprive them of the power of resistance to the young larvæ, whose food they are designed to be. The admirably constructed cells of the mud wasp, found under the eaves of nearly every house and barn in the country, is filled with a store of spiders for its young. The "wise ant" belongs to this order. Their burrows and mounds may be observed in every garden and field. The natural history of the Hymenoptera is full of instructive and most interesting facts, furnishing examples of wonderful instinct and exquisite adaptation. Wings naked and membranous, but not reticulated.

Order V.

Trichoptera. (*Trichos*, hair; *ptera*, wings.)

50. Caddece flies.

Order VI.

Strepsiptera. (*Strepsis*, a turning; *ptera*, wings.)

51. This order embraces a few minute parasitical species.

Order VII.

Hemiptera. (*Hemion*, the half; *ptera*, wings.)

52. Bugs; Aphidæ, Cicadæ, &c. The peculiarity of the in-

sects belonging to this order is found in the beak or rostrum, which is formed for piercing and sucking, thus enabling them to find food in vegetable and animal juices. The chinch bug is a noted member of this order. The following description of this destructive insect will perhaps not be considered misplaced: "Length, one and two-third lines, or three-twentieths of an inch; body black, clothed with a very fine greyish down, not distinctly visible to the naked eye; basal joint of the antennæ honey yellow; second joint the same, tipt with black; third and fourth joints black; beak brown; wings and wing-cases white; the latter are black at their insertion, and have near the middle two short irregular black lines, and a conspicuous black marginal spot; legs dark honey yellow; terminal joint of the feet and the claws black. The youngest individuals are vermillion red, the thorax or anterior part of their bodies inclining to brown, and a white band across the middle of the body, comprising the two basal segments of the abdomen. As they increase in size they become darker, changing first to brown, and then to a dull black, the white band still remaining. The antennæ and legs are varied with reddish. In their final or perfect state they acquire white wings, varied with a few black spots and lines."(1)

53. Dr. Fitch enumerates and describes many species of Aphis infesting fruit trees, forest trees, crops and garden vegetables in the State of New York. Most of these are common in Canada. A list of them will most probably serve to give us an insight respecting the extraordinary variety and incredible destructiveness of this single genus of insects.

1. Aphis Caryella.—The little Hickory Aphis lives on the under surface of the leaves.

2. Aphis Punctatella, the little dotted winged Aphis.

(1) Dr. Le Baron,—*Prairie Farmer*, 1850.

3. Aphis Maculella, the little spotted winged Aphis.

4. Aphis Fumipennella, the little smoky winged Aphis.

5. Aphis Marginella, the little black margined Aphis.

6. Aphis Cerasi, the little cherry plant louse; very destructive to the cherry tree. Dr. Fitch calculated that on some small cherry trees which he examined, ten feet high, not less than *twelve millions* of these creatures were on each tree.

7. Aphis Cerasifoliæ, the cherry leaf plant louse; found on the choke cherry.

8. Aphis Cerasicoldus, found on the common black cherry.

9. Pemphigus Caryæcaulis, the hickory-gall Aphis.

10. Aphis Maidis, the maize Aphis.

11. Aphis Mali, the apple plant louse.

12. Aphis Malifoliæ, the apple leaf louse.

13. Aphis Prunifoliæ, the plum leaf louse.

In this order the Mandibles and Maxillæ are replaced by a sheath and sucker.

Order VIII.

Lepidoptera. (*Lepis*, a scale; *ptera*, wings.)

54. Butterflies, Moths, &c.—This order comprehends the most beautiful and richly ornamented individuals of the insect world. In the caterpillar state they are exceedingly voracious, feeding upon vegetables, hair, wool, &c., and not unfrequently causing serious apprehension on account of their numbers and ravages. In the perfect state they feed upon the nectar or liquids of flowers, and it is stated that some species do not require food in the adult state. Among the destructive insects belonging to this order, we find the *Tinea Granella*, whose larvæ feed upon stored grain; the *Gallerea Cereana*, living in beehives; the *Carpocapsa Pomonella*, whose larvæ feeds upon and lives in apples, hence called the apple worm. Others eat the

buds and leaves of pine trees, &c. Some species are of the utmost importance to the industrial arts, as the silkworm family. Others again greatly destructive, as the larvæ of the *Cossus Lignperda*, which burrows in willows, poplars, the ash, and other trees. In another family of this order we find the peach worm, the larva of *Ægeria Exitiosa*, the palmer worm, the larva of *Chætochilus Pometellus*, and a host of others.

Order IX.

Diptera. (Dis twice, *ptera*, wings.)

55. The distinguishing character of the Diptera is the single pair of wings. The mouth is furnished with a proboscis, and behind the true wings are placed two small organs, called poisers or balancers, *(halteres)* one on each side. The larvæ of these insects are found in every conceivable situation ; some are aquatic, others live in and on fungi, in carrion, in flowers, in galls, in meat vats, &c., &c. The perfect insect feeds upon the juices of vegetables, or the blood of animals, or decaying vegetable and animal products, or on other insects. Many of the species are eminently noxious and troublesome ; such are bot flies, grain flies, mosquitoes, and numerous flies which torment and sometimes destroy domestic animals. It is sufficient to mention the Hessian fly and the wheat midge to stamp this order with due importance.

56. The technical characters of the genus *(cecidomyia)* to which the Hessian fly and wheat midge belong, are as follows :— Wings resting horizontally, and having three longitudinal nervures ; head hemispherical ; antennæ as long as the body, and generally twenty-four jointed, the joints hairy ; (in the females fourteen-jointed ;) the two basal joints short ; legs long ; basal joint of the tarsi very short, second long.

Order X.

Aphaniptera. (*Aphanes,* inconspicuous ; *ptera,* wings.)

57. Fleas are emblematic of this order. It is said that common fleas *(pulex irritans)* not unfrequently lay their eggs under the toe-nails of uncleanly persons ; the larvæ is white and active, acquires maturity in a fortnight, and spins for itself a cocoon in which it assumes the pupa states. The tropical chigo, is a much dreaded pest in hot countries.

Order XI.

Thysanoura. (*Thiazo,* to dance ; *oura,* tail.)

58. Insects belonging to this order are often found on the surface of water in summer and on snow in winter. In Pennsylvania vast multitudes of a certain species were noticed in February, 1849, covering the snow for about a quarter of a mile with a breadth of several rods. The species was probably the Podura nivicola, one not uncommon in Canada.

Order XII.

Parasita.

59. This order embraces the disgusting parasitical insects called lice. The *pediculus capitis,* infests the human head. Leenwentrock, actuated by a desire to acquire information respecting the habits of this insect, kept a male and female louse in his stocking for eight weeks. He ascertained that in that short space of time they might increase to five thousand. A species of parasite is found infesting the human body in connexion with a dreadful disease of the skin, named Phthiriasis. Many historical names are associated with this terrible infliction ; among them we find those of Herod, Plato, Antiochus, Epiphanes, and the Emperor Maximilan.

60. Another family of those insects are appropriately named bird lice, from the animals on which they are found. Every farmer is familiar with the parasitical insects found on sheep, dogs, horses, oxen, &c.

The gnawing louse infecting the sheep *(Trichodectes sphærocephalus)* destroy the wool by cutting it near the root. The ox is attacked by two kinds of lice, one being a sucking and the other a gnawing insect. Indeed, it may be said generally that every species of quadruped is inhabited by one or more species of the louse tribe.

CHAPTER III.

The Hessian Fly.

Degree of attention excited by this insect, 61.—Little that is new can be said about it, 62.—Additional points in its history noticed in this essay, 63.—*Origin of the Hessian Fly*, 64.—Importance of knowing whether it be a native or a foreigner, 64.—Australian wheat ravages in Canada, 65.—The Hessian fly, a European insect, 67, 69.—Its progress on the American continent keeps pace with the cultivation of wheat, 68.—Testimony of the Russian Entomologist, Motschulskey, quoted by Dr. Asa Fitch and others, conclusive that the insect is of European origin, 70.—*History of its progress*, in Long Island, New York, New England, Middle Atlantic States, whence it crossed the Alleghanies, appeared in Lower Canada, in Mississippi valley, in North-western States of the American Union, from 1776 to 1859, 71. *Description of the Insect:* the head and thorax, 73.—Dr. Harris' description, Dr. Fitch's description of the female, 74.—The antennæ, 74.—The ovipositor, 76.—The male Hessian fly, the antennæ and abdomen, 76. *Habits of the Insect:* Lays her eggs in autumn and in spring, two broods each, 77.—Autumn brood, 78.—Maggots of the Hessian fly, 78.—Effects on the straw, 79, 80, 81, 82.—The underhill wheat, 82.—Injury to the stem in the first instance, 84.—Change of maggot to pupa, 85.—Flag-seed state, 85, 86.—Dormant larvæ, 87.—Pupa, 88.—Change to the fly, 88.—Wonderful adaptation shown by the fly, 89.—Resistance of insects to cold, 90.—Illustrations of this, 91.—*Second generation of the Hessian Fly*, 92.—Gall fly characteristic of the Hessian fly, 93.—*Parasites*, 94, 95, 96.—Parasites prey upon the spring generation chiefly, 97.—*Remedial Measures*, 98, 99.—Enumeration of different remedial measures, a fertile soil, 101.—Vast crops of wheat in Niagara County, N.Y., analysis of soil on which these extraordinary crops were grown, 103.—Late sowing, 104.—Grazing, the roller, mowing, 104, 108.—Fly proof, wheat so called, 108.—Underhill wheat, Elima, Mediterranean, white flint, Mr. R. Harmon's opinion of the white flint, 109.—Peculiarity in the deterioration of wheats, 110.—Tillering of wheat, 111.—The Chidham wheat, 112.—Early nob wheat, 113.—Steeps for the seed, 117.—Mr. Pell's steep and success of, 115.—Steeps, experiment on, 116.—Steep for smut, proportions, 117, 118.—Oats as a decoy, wheat as a decoy, 118.—Deeply covering the seed, 119.—Proper depth for sowing, 119.—Procuring seed from uninfected districts, 120.—Sun drying the seed, 121.—Sprinkling salt, &c., 121.—Burning and ploughing up the wheat stubble, 122.—General consideration of remedial measures, 123.—Benefit of steeping wheat, 124.—'Sow Late,' 125.—Spring wheat, 126.—Fife wheat, 126.—The cause of the spread of the Hessian fly, 127.—Apparent periodicity, 128.—Sudden increase in various insects, 129.—Cause of sudden increase, Dr. Fitch's opinion, 130.—Cultivation of its favored food without rotation, 131.

The Hessian Fly.

(Cecidomyia Destructor.)

61. The distinguished entomologist of the State of New York, Dr. Asa Fitch, in a history of the character, transforma-

tions and habits of the Hessian fly,[1] written and published more than ten years ago, tells us that no other insect of the tens of thousands which teem on this continent has received a tithe of the attention or been chronicled with a tithe of the voluminousness that has been assigned to this species. As a natural consequence of this close investigation, every point in its history has from time to time been made public, so that very little that is new can now be embodied in an account of the insect.

62. In strict agreement with the preceding paragraph, the following account of the Hessian fly brings down its history to the present day, briefly describes the extent and frequency of its ravages, and the means which have been adopted, successfully or otherwise, to guard against them, but does not profess to announce anything new with respect to the habits and economy of this alarming depredator.

63. Some few points in its history have been amplified, more especially those which relate to the effect which it, in conjunction with the wheat midge, is likely to have upon the cultivation of wheat in the north-western States of the American Union, and the practical but expensive lesson it teaches the Canadian farmer to recognize and adopt—that first law of good husbandry—rotation of crops.

Origin of the Hessian Fly.

64. It appears at first sight to be a matter of little moment to farmers whether the Hessian fly be a native of this continent or an importation from Europe. As a question of natural history and public economy it is both interesting and important, as it shows the necessity of acquiring information respecting the

(1) The Hessian Fly, its history, character, transformation and habits; by Asa Fitch, M.D., American Journal of Agriculture and Science, Vols. IV., V. Also, in the transactions of the New York State Agricultural Society, 1846.

habits of both indigenous and foreign insects injurious to cultivated crops, so that the introduction of new species into this continent, in the ordinary way of commercial traffic, or by the curious in such matters, may, if possible, be prevented; and if by any means a new foreign insect should take up its residence with us and attract public attention by its ravages, much valuable and available information might be speedily disseminated from a familiarity with the history of the depredator in those countries where it had long been known, and of the means which were there adopted to arrest its progress or lessen its destructiveness.

65. Instances are continually occurring which illustrate the value of the kind of information referred to. During the last few years two new importations of insects from Germany, destructive to the turnip, have been made in Great Britain. These new arrivals are described in a paper (have mislaid the reference) published in a recent agricultural Scottish journal.

The Australian wheat ravager, so destructive to the splendid crops of grain produced in many parts of that magnificent country, has been brought to Canada as an entomological curiosity; and I am very credibly informed that several *living specimens* are now in this country, closely, and it is to be hoped securely imprisoned, in a glass bottle.

66. It is quite possible from the habits of the Hessian fly in its larvæ and pupa states, that it may have been brought into America in straw or otherwise from some of the many European countries, where it appears to have been well known long before it committed on this continent those terrible devastations which threatened at one time to arrest the cultivation of wheat in some of the Atlantic States of the American Union.

67. A common impression prevails that this insect was introduced into America by the Hessian troops in their straw from Germany, during the year 1776, at which time the British Army,

then in occupation of Staten Island, received large reinforcements of Hessians under General de Heister. This idea has been ridiculed by many European entomologists, who have asserted that the insect is strictly American. It appears, however, that its existence has long been established and known in France, Germany, Switzerland and some of the larger Islands of the Mediterranean ; probably for more than a century it has attracted attention in those countries, although the extent of its ravages may not have been known and consequently not recorded.(1)

68. This insect was first noticed in America in Long Island in the year 1776, or 80 years ago. It proceeded inland at the rate of fifteen or twenty miles a year, and in 1789 it had reached 200 miles from its original station.(2) It is now found as far west as Iowa and Minnesota, following the cultivation of wheat, wherever that cereal is introduced in the westward progress of settlement on this continent. The Southern States have suffered greatly from its ravages, and it seems to adapt itself without any difficulty to all the climates which admit of the cultivation of its favourite food.

69. In a communication with which the writer of this Essay was favoured by Dr. Fitch, during February of the present year, the following interesting notice occurs of the ravages committed by the Hessian fly in the Provinces of Simbirsk and Saratov in Russia during the year 1852.

In addition to the evidence I adduce, showing the Hessian fly to be a European insect which has been introduced into this country, I meet with the following in the "*Etudes Entomologique*" of the Russian naturalist, Motschalsky, page 23 :—

"*Cecidomyia funesta*, Motsch, voisine de la *cec. destructor*

(1) See an article by Mr. Herrick in the 12th vol. of the American Journal of Science and Art. The Essay by Dr. Fitch, trans. N.Y.S.A.S., 1846.

(2) Kirby and Spence.

" Say, mais de couleur moins foncée, qui parait avoir des mœurs " analogues avec l'espèce d'Amérique. Elle a causé l'anné passée " des grands ravages au froment des Gouv. Simbirsk et Saratov. " Je l'ai décrite avec son parasite le *platygaster funestus* m., " dans le Journal du Ministère de l'Interieur, 1852." I have no doubt that this Russian insect is identical with our Hessian fly, which, when first hatched, is paler than afterwards.

70. The foregoing paragraphs seem to show, without any remaining doubt, that the Hessian fly is a European insect, and that its depredations have been known and lamented many years before it was heard of or observed in America. We may, therefore, accept the popular narrative of its introduction here, and avail ourselves of all the information which the experience of its past history, habits and ravages in Europe can afford.

History of its Progress.

71. The following records of the appearance of this destructive insect in the United States and Canada, have been collated from various resources, but chiefly from the United States Patent Office Reports; Dr. Fitch's Essay; the transactions of the New York Agricultural Society; American and Canadian agricultural periodical publications, correspondence, &c.

About the year 1776 the Hessian fly was introduced into Staten and Long Island from Europe.

1779.

Caused great damage to wheat in Long Island.

1786.

Appeared in New Jersey, 40 miles south-east of Staten Island; east end of Long Island; Shelter Island.

1788.

Very destructive near Trenton, N.J.; commenced its ravages in the State of Pennsylvania.

1789.

Reached Saratoga, 200 miles north of its original station; very destructive there in 1791; continued until 1803, when it disappeared. Re-appeared in 1845. Common in the middle Atlantic States.

1790.

Very common and destructive in the middle Atlantic States of the Union.

1791.

Less common in the middle States; arrived in Delaware in vast multitudes.

1792.

Destroyed in Delaware an immense quantity of wheat.

1797.

Appeared west of the Alleghany Mountains.

1801.

First appeared near Richmond, Virginia.

1802–3 and 1804.

Very destructive in Virginia.

1805, 1816.

Ravages not recorded; probably not general or in great excess in the United States. Prevalent and destructive in some parts of Lower Canada.

1817.

Ravages renewed in New York State, Pennsylvania, Maryland and Virginia.

1818, 1819.

Noticed in Pennsylvania.

1820.

Common in Maryland and Pennsylvania.

1830–6

Disappeared in Lower Canada.

1831.

Crops much injured in Seneca County, New York.

1842.

Very destructive in Pennsylvania; Maryland and Ohio visited by it.

1843.

Western Pennsylvania, Maryland, Virginia and Ohio all suffered this year.

1844.

Very destructive in Illinois, Indiana, Michigan, Wisconsin, Iowa, Ohio, Western New York, west end of Long Island, Pennsylvania.

1845.

Destructive in Illinois and Maryland, very destructive in Georgia; disappeared from the districts in Michigan and Indiana, where they had committed havoc the preceding year.

1846.

Very destructive in Maryland and ruinous in Georgia. Common in New York, parts of Western Canada and Eastern Pennsylvania. In Illinois, Wisconsin and Iowa, near the Mississippi. Unusually destructive this year. In Georgia the Hessian fly was observed to issue from its pupa case May 6th.

1847.

Common throughout the wheat growing States of the West. Common in New York, but not generally destructive this year. General, but not destructive, in the County of York, U. C. It was observed very generally in the autumn depositing its eggs on the young wheat over wide areas in the United States; also in County of York, Canada West. Great fears excited in the United States for the safety of the harvest of the ensuing year.

1848.

"The crop of 1848 was, undoubtedly, one of the best and largest ever grown."(1)

(1) Hon. C. P. Halcomb, of Delaware, U. S. P. O. Rep. 1849-50.

1849.

Very general and destructive in some of the counties of New York—Oswego, Albany, and Columbia Counties. Ravages great in Ohio.

1850.

Disappearing from parts of Ohio, also from parts of Michigan. "The Hessian fly, one of the enemies to our wheat growers, visits us at intervals of from four to six years, continuing its ravages through two or three seasons, and then apparently disappears."(1)

1851.

General improvement in Pennsylvania and Maryland; Hessian fly not troublesome. Virginia much improved; the fly "scarcely dreaded." No Hessian fly in Gallea County, Ohio; disappearing in Oakland County, Michigan, "for years." Not troublesome in Indiana; general insecurity from its ravages. In Buckingham County, Vermont, 1851, the Hessian fly had almost disappeared, and from its great diminution the farmers thought they could sow their wheat in September, which resulted in the immediate increase of the fly, and a consequent falling back to late sowing and proper preparation of seed.

1852.

Hessian fly attacked wheat in Fauquier County, Virginia, when sown before October. The same in Buckingham County, Vermont. Not known to any extent in Penobscot County, Maine.

1853.

Committed great ravages in some parts of Pennsylvania—Centre County and Clinton County.

1854.

Visited Niagara County, N. Y. "The Hessian fly is another enemy of ours, and in trying to get an early crop of wheat by

(1) Northville, Wayne County, Mich. J. D. Yukes, P. O. R., 1850.

early sowing, we *constantly* incur danger from the Hessian fly in the fall of the year. If frost occur soon after wheat is sown in the fall, in time to kill the Hessian fly, we rarely suffer much from it.—Onondaga County, N. Y.[1] Wheat more or less injured in Kent County, Michigan, when sown before the 20th September.[2] Destructive in Maine,[3] Aristook County.

Description of the Insect.

72. Numerous descriptions of the Hessian fly are to be found in scientific and agricultural publications; in all of the most important features these descriptions coincide. Perhaps the most popular, and at the same time one of the most accurate delineations, is from the pen of the late Dr. Harris, in his admirable "Report on Destructive Insects."

73. "The head and thorax of the fly are black; the hind-body is tawny, and covered with fine greyish hairs. The wings are blackish, but are more or less tinged with yellow at the base, where also they are very narrow; they are fringed with short hairs, and are rounded at the end. The body measures about one-tenth of an inch in length, and the wings expand one-quarter of an inch or more. * * * * * The transformation of some in each brood appear to be retarded beyond the usual time, as is found to be the case with many other insects; so that the life of these individuals, from the egg to the winged state, extends to a year or more in length, whereby the continuation of the species, in after years, is made more sure."[4]

74. In the admirable essay on the Hessian Fly, by Dr. Asa Fitch, before referred to, a very exact description of the male

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(1) Address of the Hon. G. Geddes, 1854.

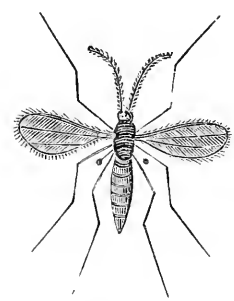
(2) Pat. Off. Report, 1854. (3) P. O. R.

(4) I have not lately had an opportunity of referring to Dr. Harris' work, the description given in the text is consequently second hand.

and female insect is given, of which the following is an abstract. The illustrations to which reference is made are taken from the drawings of the same author. The high standing of Dr. Fitch, as an entomologist, coupled with the attention he has devoted for many years to the history and habits of insects injurious to vegetation and to the agriculturist, confers the utmost value upon his delineations and descriptions.

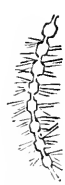
The Female Hessian Fly.

75. The head and thorax of the female (Fig. I) are black. The antennæ (Fig. *e*) are about half as long as the body, and composed of sixteen joints, each of a cylindric oval form, the length being about double the diameter; each joint is clothed with a number of hairs, surrounding it in a whirl. The joints are separated from each other by very short translucent filaments, having a diameter about one third as great as the joints themselves. The thorax is oval and black; the poisers are dusky; the abdomen is of a black colour above, more or less widely marked at the satures (joints) with tawny fulvous, and furnished with numerous fine blackish hairs.



(FIG. I.)
HESSIAN FLY—FEMALE (*C. destructor.*)

Nat. Size.



(FIG. *e.*)
JOINTS OF THE ANTENNÆ.

75. The ovipositor is rose-red. The wings are slightly dusky. The legs are pallid brown, the tarsi black. The several pairs of

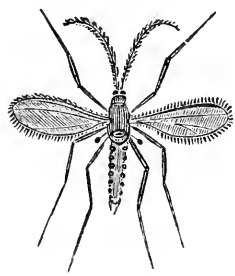
legs equal each other in length, being about one-fifth of an inch long when extended, of which length the tarsus embraces one half. Short basal joint indistinct.

The Male.

76. In the male (Fig. II) the antennæ (Fig. *d*) are three-fourths the length of the body.

The abdomen (Fig. II) consists of seven joints besides the terminal one, which (viewed from beneath Fig. *c*) consists of a transversely oval joint giving off two robust processes, armed with in-curved hooks at the tips.

In the living specimen the abdomen is of a brownish-black colour, more or less widely marked at the satures with pallid fulvous or smoky whitish lines. In all other points the male coincides with the female in its character.



HESSIAN FLY—MALE (FIG. II.)

(FIG. *b.*) *Nat. Size.*

(FIG. *d.*) *Joints of Antennæ (Male.)*

(FIG. *c.*) *Ventral view of the terminal segments of the abdomen.*

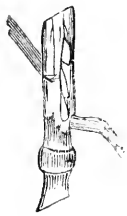
Habits.

77. The Hesssian fly lays her eggs upon the young leaves of wheat in the autumn (September) and in the spring (May). Many observers have witnessed the fly in the act of depositing her eggs at these seasons of the year.(1) The eggs are placed upon the upper surface of the young leaves of the autumn wheat,

(1) Mr. E. Tilghman of Maryland; Mr. Merritt of Yale College, &c., &c.

and sometimes exceed thirty in number. They are generally arranged in the longitudinal depressions between the minute ridges of the blade. Their appearance is that of very small reddish coloured points or spots. Their length is considerably greater than their diameter, and appears to bear the ratio to the latter dimension of five to one, the length being about one fiftieth of an inch, the breadth or diameter about one-two-hundred-and-fiftieth. The form is cylindrical.

78. The eggs of the autumn brood are hatched within a week of the time they are laid, if the weather be warm; during the prevalence of cold and unfavorable weather they may remain unhatched for a period of three weeks. The white colored maggot as soon as it is liberated from the egg, passes down the leaf, between the sheath and stem, until it reaches the first joint, (the crown); here it becomes stationary and apparently fixed upon the stem (Fig. *m* and Fig. *a* §, par. 80), nor does it change its position until it assumes the form of the inert worm or its pupa. (*n*) It reposes with its head towards the root of the plant.



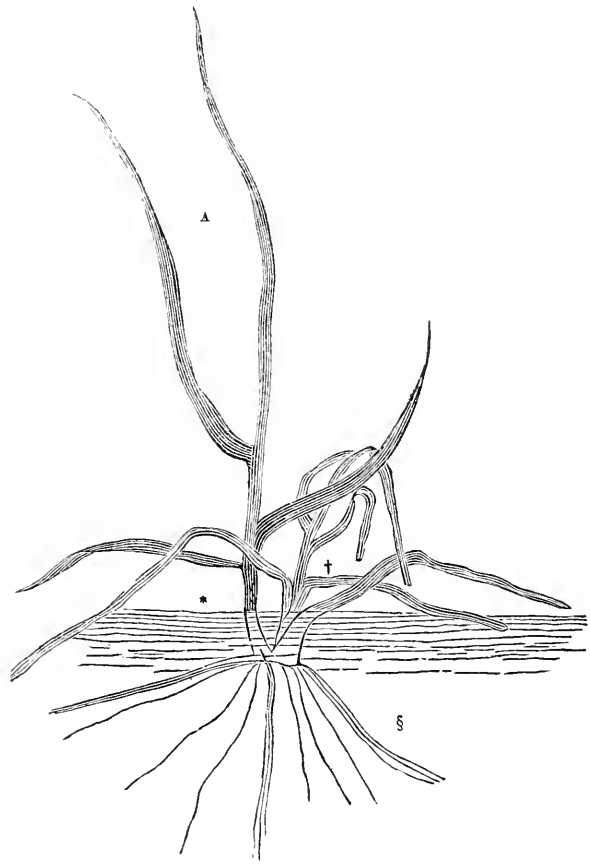
(FIG. *m.*)

(FIG. *n.*)

79. When young autumnal wheat is attacked by one or more of the maggots, the infested shoots will be seen in the following spring to be withered and changed to a straw colour. If two or more shoots proceed from the crown of the root, those only to which the maggot is attached will wither and die. In young plants, death of the part affected is produced by the abstraction of the nutritious juices which would otherwise be appropriated to the nourishment of the shoot. The increased power of absorption and assimilation of food possessed by the plant when the spring brood of the fly appears, (in May,) enables it to re-

sist to a great extent the wasting attacks of the maggot, whose attachment is then made to the second and sometimes the third joint.

80. In young autumnal wheat the base of the sheath is at the crown of the root, as shown in figure (A. §), and it is here that the autumn brood of the fly must be sought for.



Appearance of a healthy (*) and of a diseased (†) shoot of wheat in autumn;—the worms lying at (§).

In the preceding diagram the right-hand shoot is represented as withered and lifeless from the attacks of the maggot at the crown of the root under the suface of the soil. The left hand stem is free from any attack and consequently uninjured. The process of tillering would throw out a number of new shoots from the crown of the root to replace those which are destroyed.

81. The maggots appear to live wholly by suction. They do not penetrate the stem, or make any apparent incision; they produce, however, a depression, caused by the obstruction they offer to the growth of that part of the plant where they are seated. These depressions, though not always apparent on the outside, when produced by several maggots of the second brood in the early summer months on the first or second joint, greatly weaken the stem, and render it liable to be blown down and broken by a light breeze of wind, when it has attained the attitude it acquires on approaching maturity. Sometimes a swelling or gall is the result of the attack as shown at (§ §) in Fig. B, page 56, (paragraph 92.)

81½. The manner in which the maggot of the spring brood affects the stem in the early summer months, seems to arise from its presence preventing the deposition of the necessary amount of silica or flint immediately under its body. It is well known that the great strength of the hollow cylindrical stem of the wheat plant is due to the large amount of silica it contains, and where there is a deficiency of this strenthening material, the stalk is unable to support the weight of the ear when agitated by wind; were the usual quantity of silica present the small reduction in the diameter or dimension of the stalk (supposing no gall to be formed) at the point where one or more of the maggots are seated would not materially interfere with its strength. The

absence of silica seems to be the chief cause of its liability to be broken by agitation.

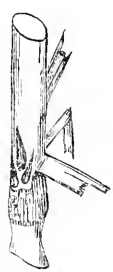
82. The underhill wheat, so long cultivated and celebrated for its immunity from the attacks of the Hessian fly, affords an admirable instance of the silicious shield of the wheat stem resisting the attacks of the fly. Those varieties of wheat which produce strong flinty stalks have long been known not to suffer much injury from the presence of the spring maggot. The natural tendency of these varieties to assimilate large quantities of silica, enables them to withstand the weakening effect due to the insect, under which other varieties, naturally less rich in silica, would succumb.

83. The preceding remarks refer solely to the injury caused to the wheat plant by the weakening of the stem, and its fracture before arriving at maturity. It is to be observed, however, that the presence of two or more of the spring larvæ of the Hessian fly must operate very disadvantageously in other respects. On thin-stemmed varieties the growth of infected stems is often altogether arrested by fracture, if the maggot descends to its seat above the first or second joint before the plant has acquired a strong and healthy growth, and under such circumstances the field has been very appropriately likened to one through which a herd of cattle had been making their way.

84. Since the injury occasioned by the larvæ of both broods of the Hessian fly is produced in the *first instance* upon the stem, whether above the crown of the root in young wheat, or at the first, second or third joint of that which is farther advanced, it necessarily follows that a more or less healthy condition of those parts of the plant will enable it to resist to a corresponding degree, the attacks of the insect. A strong and vigorous tillering growth in the fall (111) and spring is required to maintain a condition of comparative health under the attacks of one or two of these para-

sites, until maturity is attained. Hence the reason why vigorous well-grown flinty stemmed varieties survive and yield a fair return, while weak and sickly plants or thin-stemmed varieties fail, no new stalks or shoots being formed in the fall or early spring when the infested ones die, and in the early summer the weak stems which have survived sink under the exhausting drain of the spring brood. So far then the depredations of the Hessian fly when not present in overwhelming numbers, may be greatly lessened and in part overcome by good husbandry, and a careful selection of seed of approved varieties.

85. When the autumn maggot has arrived at its full growth, its outer skin, at the approach of winter, becomes detached from the body, and serves first as a larva, and ultimately as a pupa or chrysalis case. This separation arises from a general contraction of the body of the maggot, whereby it occupies less space than the outer skin, which invested it during its growing state. The outer skin now acquires a tough consistency, and a dark brown colour, somewhat similar to a flax-seed in appearance, hence the name of this state of the insect, which might be more properly distinguished as its cased larva condition. The figures (*o*) and (*n*) show the position and appearance of these cased larvæ of the Hessian Fly (flax seed state) on the stems of wheat plants from which the leaves have been torn away.



(FIG. *n*.)

(FIG. *o*.)

86. The maggot remains in this protecting case throughout the long and cold winter months, without any marked change of form, and is represented in Fig. (*k*), which shows a magnified appearance of the worm when taken out of its larvæ case, &c. (*i*) and (*j*).

(FIG. *k*.)

(FIG. *g.*)

(FIG. *h.*)

(FIG. *i.*)

(FIG. *j.*)

DORSAL VIEW OF THE DORMANT LARVA TAKEN FROM THE LARVA CASE.

g. Magnified dorsal view of the worm or active larva. *h*. Magnified view of the 'flax seed' or larva case. *i*. Magnified ventral view of the same. *j*. Magnified lateral view of the same.

87. At the advent of spring the dormant larva assumes the pupa or chrysalis state, still remaining within its now pupa case, which has become quite brittle, "breaking asunder tranversely if rudely handled, and one of its ends slipping off from the enclosed pupa, like a thimble from the end of the finger."(1) Fig. 1 shows the pupa removed from its pupa case, and magnified like the preceding illustrations.

FIG. 1.

88. After remaining in this condition for ten days or a fortnight it wriggles out of its case, works its way up to light and air, emerges through its cracked pupa skin, and takes the form of the fly, to live its short life ten days or more. Dr. Fitch thinks that in all parts of the United States the Hessian fly will probably be found in its fully formed pupa state, about a week after the liverwort, (Hepatica triloba), the trailing arbutus, (Epigæa repens), and the red or swamp maple first appear in bloom, and simultaneously with the flowering of the dry strawberry (Comaropsis Fragarioides), the common five-finger (Potentilla Canadensis), the hill-side violet (Viola Ovata).

89. The wonderful adaptation exhibited during the winter sleeps of the larvæ of the Hessian fly in its larvæ case, to resist atmospheric influences, such as great extremes of temperature, moisture and drought, throughout the winter months, is perhaps

(1) Dr. Fitch.

the most remarkable feature in the economy of this insect. A somewhat similar provision is noticed in one of its kindred, the wheat midge, which will be referred to hereafter. We see at the close of autumn the larva preparing for its long dormant winter state, not by changing its position, and seeking security from wet, or frost, or drought, (for dry air is common in the winter months), nor by spinning a cocoon, in which similar protection may be secured, but by shrinking within itself, and allowing its outer skin to form a hard and impervious protecting shield to its tender body, which remains soft and pliant within, and, as far as we know, safe from all ordinary atmospheric changes.

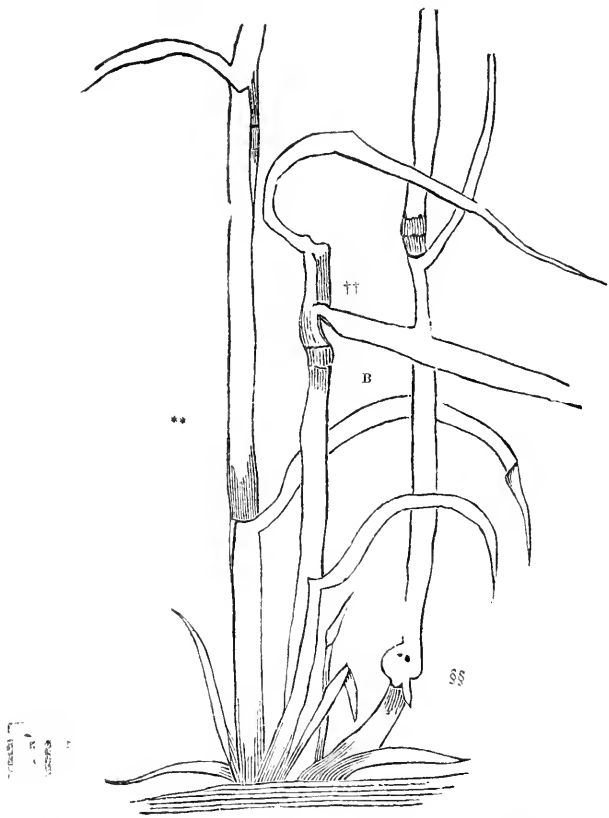
90. The resistance of insects to the influence of intense cold has long been known, but the source of the heat which enables them to preserve their flexibility within their pupa cases during the greatest extremes of temperature, still remains a mystery. Dr. Wyman lately stated, at a meeting of the Boston Natural History Society, that he had examined chrysalids of the common mud wasp, a species of *pelopœus*, and found that they were not frozen during the coldest weather.

91. On the morning of February 7th, 1855, when the thermometer had fallen as low as 18 deg. Fah., or 50 degrees below the freezing point, and had risen to 8 deg. Fah., the chrysalids were still unfrozen, and when removed from their pupa cases made obvious muscular motions. The pupa preserved its usual transparency and flexibility; but when crushed upon the surface of the material on which they rested, the fluids of the body instantly became opaque, and were congealed. Dr. Wyman has also examined the eggs of the moth of the canker worm, and found their contents unfrozen.

Second Generation of the Hessian Fly.

92. The following concise history of the second generation of

the Hessian fly is from Dr. Fitch's admirable essay on this insect: "About the first of May the fly appears, and deposits its eggs upon the same crop of grain that had already reared one brood, and also upon any spring wheat that is sufficiently forward for its purposes. The radical leaves of the winter wheat are now more or less withered, and the fly therefore selects the more luxuriant leaves that have put forth above these. The



Appearance of a healthy (**) and two diseased stalks of wheat, at harvest-time. (††) Stalk broken, from being weakened by the worms. (§§) Base of sheath swollen from worms having lain under it, and perforated by parasites coming from those worms.—*From Dr. Fitch's Report.*

worm hatches, and again makes its short journey to its future home, at the base of the sheath; it consequently now nestles at the first and second joints of the young stalk, and is sometimes, though rarely, as high as the third joints. Even before the worm reaches the base of the sheath, it has frequently grown nearly to its full size, (as shown Fig. *m.*, para. 78.) The stalk has now attained such vigour and hardiness that it is seldom destroyed by this spring attack. A slight swelling immediately above the joint, (Fig. B §§) commonly indicates the presence of the larva beneath."

39. "This is a fact which has been overlooked, or at least not distinctly stated by writers hitherto. We only find it noticed by Mr. Bergen, (Cultivator, VIII, 133,) who informs us that in a crop of barley which was destroyed by the Hessian fly, many of the stalks were 'at the joints, as thick as a man's finger.' The insect is, therefore, a true gall-fly, although when but one larva succeeds in reaching the joint, the swelling caused by it is little if at all apparent. More commonly, however, the straw becomes so weakened that it is unable to sustain the weight of the wheat-head, and it accordingly bends down (as represented, Fig. B ††,) with the force of the wind and rains. The appearance of a badly infested field, as harvest time approaches, cannot better be described than in the words of M. Kollar. The grain looks as though a herd of cattle had passed through it, so broken and tangled together is the straw. The worm attains its growth and enters its flax-seed state about the first of June, and the flies of this second generation come forth about the last of July, and in August."

Parasites.

94. The excessive multiplication of all kinds of insects is providentially kept within bounds by a well known law, which

appears to assign to each species one or more destructive parasites, which prey upon them during all stages of their existence. Were it not for this wise provision, some of the most prolific and hardy tribes, being exclusively vegetable feeders, would prevail to the exclusion of all others. The Hessian fly has numerous parasites, which have been studied with marked success by Mr. E. C. Herrick. Mr. Herrick's papers, published in the "American Journal of Science," (vol. XLI.,) and in the Patent Office Reports for 1844, are most favorably spoken of by Dr. Fitch, who states that these papers evince the close and patient investigation which the writer has made, and the utmost carefulness in announcing nothing beyond what he had clearly ascertained.

95. In Dr. Fitch's essay, published in 1846, he introduces the following brief sketch of that part of Mr. Herrick's papers on the Hessian fly, which relates to parasites:

"The Hessian fly is preyed upon and devoured by at least four other insects. When its eggs are layed upon the wheat leaves, they are visited by an exceedingly minute four-winged fly, a species of *Platygaster,)* which punctures the egg, and deposits in it four or six eggs of its own. The Hessian fly worm hatches, grows, and passes into the flax-seed state, with these internal foes feeding upon it. It now dies, and its destroyers in due time escape from the flax-seed shell. Three other minute four-winged flies, or bees, as they would be called in common language, destroy the fly when in its flax-seed state. The most common of these, by far, is Say's *ceraphon destructor*. Alighting upon the wheat stalks, instinct informs them precisely where one of these flax-seeds lies concealed. They thereupon 'sting' through the sheath of the stalk, and into the body of the worm, placing an egg therein, which hatches to a maggot, lives upon and devours the worm."

96. "Such are the means which nature has provided for pre-

venting this pest from becoming unduly multiplied. And so efficient and inveterate are these foes, that more than nine-tenths of all the Hessian fly larvæ that have come into existence are probably destroyed by them, Mr. Herrick thinks, and we have strong reasons for believing that his estimate is within the truth."

97. It has been suggested that it is principally the second or spring generation upon which the parasites prey. The immense abundance of these parasites is easily ascertained by collecting the infested straw at harvest time, and securely enclosing it to preserve all the insects which hatch from it. Parasites in abundance will be obtained, and only occasionally a Hessian fly; whereas young plants taken up in April by Dr. Fitch, evolved only Hessian flies. The observations of a single season are not considered sufficient to establish a point like this, but coupled with the apparent difficulty of the short ovipositors of the parasites reaching the flax-seeds of the first generation at the first joint of the plant, and consequently *under* the surface of the earth to a slight extent, favours the suspicion that the second generation is chiefly infested by parasites, and the first comparatively free from them. This supposition appears quite in accordance with the operations of other agents limiting the produce of the first generation, for they have all the vicissitudes of a long winter, and the changeable atmospherical conditions of spring, to overcome.

ON THE MEANS THAT HAVE BEEN ADOPTED IN ORDER TO LESSEN THE RAVAGES OF THE HESSIAN FLY.

98. No one, even remotely familiar with insect economy, and the admirable purposes these minute creatures are designed to fulfil in preserving a proper equilibrium between the vegetable and animal world, will suppose that any remedy, properly so

called, fitted to arrest the devastations of the Hessian fly altogether, could ever be put in general operation, even were such a remedy found to exist.

99. We can check, and partially avoid, their ravages, but we cannot obtain entire immunity at all seasons from the attacks of this insect. Where good husbandry prevails, we may indeed so far diminish their depredations that they will cease to be regarded with anxiety; but we shall be at all times liable to temporary invasions from other quarters where a careless, selfish or ignorant system of farming practice obtains, and also when seasons remarkably favorable for insect multiplication occur. (Par. 24.) These contingencies need only compel that degree of watchfulness which every farmer should continually exercise upon all natural phenomena.

100. I now propose to enumerate the different methods which have been adopted in the United States and elsewhere to arrest the progress and destructiveness of this insect, and to state in a few words the nature of the result obtained. As this part of the subject is one of much importance, I have not scrupled to dwell upon each so called remedy according to its merits. We must bear in mind too, that while endeavouring to secure a way of escape from the depredations of the Hessian fly, we do not blindly point out the road to certain destruction from the *wheat midge* on the one hand, and *rust* on the other.

101. 1. *A fertile soil.* "We regard this as a primary and indispensable measure and one which must accompany others in order to their full success."(1) From what has been said in preceding paragraphs (84), good husbandry must necessarily play the first part as a remedial measure. And good husbandry implies a fertile soil. In other words the application of manure, deep ploughing, and the introduction of a judicious rotation of

(1) Fitch.

crops. The Hessian fly has in some instances been instrumental in compelling farmers to have recourse to a rational system of farming practice. Mr. Ezra L'Houmediea tells us in the Genessee farmer, that in his county (Suffolk, N.Y.) the land was so constantly tilled without manuring, that on an average not more than five or six bushels to the acre of wheat was raised. The Hessian fly put an end to this kind of husbandry, no other way being found to prevent injury to this crop by the insect than that of highly manuring the land.

102. We need not cross the frontier for examples of the encouragement which has been afforded to the Hessian fly and the wheat midge, during the past quarter of a century, to take up their abode in our midst. We everywhere find a practice similar to that related by Mr. L'Houmediea obtaining in Canada, and there are many reasons why such a system should have prevailed before railroads opened up the country and created a market for produce, and few cared to look forward to the future condition of their farms.

103. By way of contrast to the foregoing paragraphs, it may be well here to notice the magnificent crops of wheat obtained in 1852 in Niagara County, N. Y., on the Canadian frontier; they are recorded in the Patent Office Report for 1853, by Mr. Heman Powers of Lewiston. In 1849-50 Mr. William Hotchkiss had a field of six acres which averaged 63½ bushels to the acre, weighing 63lbs. to the bushel. The seed was 'Soule's wheat.' Mr. Thomas Powell of the same County, raised in 1853, 489 bushels from a field of seven measured acres; this showing a yield of nearly 70 bushels to the acre. The circumstances under which this large yield was produced were as follows:—

In the fall a heavy dressing of swamp muck was applied. During the winter the field was used as a yard for stock, including a flock of sheep. In May was carted on a liberal coating of

arm-yard manure which was immediately ploughed in very deep. Up to the 15th August, it was used at night as a sheep yard, when the field was again ploughed three times, until the soil was perfectly pulverized. Two bushels to the acre of 'Soule's wheat' was then sown broodcast, and covered with a light plough which completed the process. The variety known in Western New York as "Soule's Wheat" is in fact no other than the very best Genessee "White Flint," having a *stiff straw* and *maturing early*.

The following is Professor Emerson's analysis of this soil :—

Water of Absorption	3.00
Organic Matter	7.75
Silicates	76.93
Carbonate of Lime	2.82
Phosphate of Alumina	0.15
Magnesia	0.25
Peroxide of iron and Alumina	8.82
	99.72

104. 2nd. *Late Sowing.* "We regard it as one of the most efficient, as it certainly is the most facile of any that can be resorted to."(1) "It is universally admitted that it is the earliest sowed fields which are always the most infested."(2) Objections, —winter killing, rust and wheat midge. Remedies to these,—draining, protecting with litter or cow dung, and for rust see paragraphs 190 to 227. Time of sowing, about the last week in September, seed being properly prepared for reasons given elsewhere and in appendix. Depth of sowing, 2—2½ inches. Depth of ploughing, 6 to 8 inches or more. In parts of Ohio late sowing is found to be a very excellent artifice, the varieties sown being the "Soule and white-blue stem;" these have nearly

(1) Fitch. (2) Ibid.

"driven the Illinois, Mediterranean, Redchaff, Bald, &c., out of cultivation," (1852.)

105. 3rd. *Grazing.* This measure is alluded to as worthy of attention, "we cannot, therefore, but regard this as a most judicious and important measure if seasonably resorted to."(1)

106. 4th. *The Roller.* "No doubt this measure is a judicious one."(2) It shakes off the eggs, and crushes the young worms, the condition of the ground must be particularly attended to before this remedial measure is employed.

107. 5th. *Mowing.* A valuable proposal for exterminating the second or spring brood from a wheat field.(3)

108. 6th. *Fly-proof Wheats.* 'That there are any kinds of wheat which are perfectly "fly-proof" (to use a common and expressive term) as has been sometimes stated, we wholly disbelieve.'(4) Among famous varieties we find the following:—

1st. *Underhill Wheat*—a strong silicious stemmed variety—flour good.

2nd. *Spelter Wheat*—flour indifferent.

3rd. *China Wheat*—ripens early, and yields largely.

4th. *Mediterranean Wheat,* introduced into Maryland in 1837—very prolific, very coarse, ripens early, and a very general favourite in the United States. Is considered almost fly-proof, but soon becomes acclimated, and, although it improves in quality, it loses its "fly-proof" qualities (see paragraph 110). The Mediterranean wheat is a slight red chaff, with a long stiff beard, and a long red and very flinty berry.

7th. *The Etrurian Wheat*—very prolific, very early ripener, and has none of the defects of the Mediterranean. A bald wheat, with a round plump white kernel, and very thin bran.

8th. *The White Flint Wheat.* 'One of the choicest varieties

(1) Fitch. (2) Ibid. (3) Ibid. (4) Ibid.

of Western New York, withstands the attack of the fly better than any of the other kinds there in use.'

109. Mr. Rawson Harmon, in a report of experiments on the varieties of wheat cultivated in the State of New York, and to whom a premium for the experiments was awarded by the N.Y. S. Agricultural Society, says that the white flint variety has withstood the Hessian fly better than any other now cultivated. The solidity of the straw at the root gives the fly less chance of destroying it. "Some of the stalks of this variety will be so eaten (?) as to fall down, yet *mature the berry*; while in other varieties, after it has fallen from the injury of the fly, the greater part of it fails to mature."(1)

110. Mr. H. G. Stewart, of Montrose, Lee County, Iowa, reports that the variety of winter wheat called the 'Mediterranean' is the only kind known there which escapes the attacks of the Hessian fly. At the same time, Mr. Stewart reminds us of the very important peculiarity of rapid deterioration which is frequently observed in change of climates. The Mediterranean wheat does not ripen in Iowa so soon, by *ten days*, as it did *five years* ago, and is consequently more liable to rust, and the attacks of other wheat pests.(2) The white blue-stem is also fast deteriorating in the State of Pennsylvania. "Our crops this year fall below 10 bushels to the acre."(3)

111. Certain varieties of wheat possess the property of 'tillering' to a much greater extent than others under the same or similar conditions. It is evident that this power of throwing out fresh stalks is one of great importance in resisting the autumn attacks of the Hessian fly. Certain stems are sacrificed to its ravages, these are replaced by others which shoot out after the

(1) Transactions of the N.Y.S.A. Society. Page 218, 1843.
(2) Patent Office Report, 1854. Agriculture.
(3) Ibid. Page 147.

first stems are weakened or destroyed, and so preserve the crop from the autumn attack, while it is well known that on good soil the spring brood is not half so destructive as its predecessor. Tillering is largely increased by *room*, and limited by *crowding*. Late tillering retards the ripening of the crop, increases the danger of rust and the midge, and deteriorates the quantity of the grain. Fall seeding recovers the tendency to tiller by occupying the ground, and thus hastens the maturity of the crop.

112. *The Chidham Wheat*, introduced by the Secretary of the N.Y.S.A. Society into America in 1851, and distributed by him in various localities, fulfils the condition of 'tillering' to a remarkable degree. "A remarkable feature in its character is its great multiplicity of stalks, many of which were counted, averaging from 50 to 60 to each stool."(1) Cultivation has a vast deal to do with 'tillering,' so also has the variety of seed. This property is of importance sufficient to merit careful and exact enquiry into the best modes in which it may be made available. Mr. Lance, of Blackwater, Bagshot, England, obtained from one seed, by subdivision and cultivation, 43,000 grains.

113. In a Report furnished to the Patent Office, dated February 5th, 1855, "on the seeds and cuttings recently introduced into the United States." A variety of wheat from the central part of France is highly recommended for trial. It is named "Early Noé Wheat" (blé de l'Ile de Noé) after M. de Noé, who first introduced it into France. It is hardy and productive, has the property of ripening some days before the common sorts. It is generally known in the parts of France where it is cultivated by the name of 'blé bleu.' This property of ripening early is of *immense advantage* if coupled with a strong flinty stem, as

(1) W. R. Coppock, Esq., Black Rock, Erie County, N.Y. Trans. N.Y.S.A.S., 1853. Mr. Miller, the curator of the Botanical Gardens at Cambridge, England, obtained, by continued division of the growth of a single grain of wheat, 500 plants which yielded, by computation, 567,840 grains.

one plant will then furnish two highly important qualifications required to resist the *Hessian fly, the wheat midge* and *rust* conjointly. (Para. 224.)

114. 7th. *Steeps for the Seed.* "Much lies within the compass of human instrumentality to accelerate the growth of vegetation, by means of this kind."(1) It is probable that a great advantage in many respects will be found to flow from a judicious adoption of this artifice. Not only is growth accelerated, but the steep may be made to possess great fertilizing properties; and steeps are constantly employed as a preventive to smut.

115. Mr. Pell, of Penam, N.Y., prepared his seed wheat by soaking in brine, scalding with hot water containing common salt, mixing with pearl ashes, and when distributed nicely over a barn floor by sifting a composition containing charcoal dust, guano, sulphate of ammonia, and various other mineral ingredients over it. It was sown at the rate of two and a half bushels to the acre; at the expiration of fifteen days the wheat was so far above ground as to be pronounced by a neighbour far in advance of his which had been sown in the usual way on the first of September, nearly four days earlier. The crop weighed 65 lbs. per bushel, and was eminently rich in gluten, containing 18 per cent. The yield per acre was about 70 bushels.(2)

117. In another part of this essay a steep for wheat as a preventive to smut is noticed, (par. 230) and it may be remarked here that the following proportions will serve the purpose:—

Two and one half pounds of sulphate of soda (Glauber's salts) dissolved in one gallon of water, will serve for ten bushels of wheat; the moistened or soaked grain may be dried with quicklime. Arsenic and sulphate of copper (blue vitriol) should be avoided; both are poisonous, especially arsenical compounds.

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(1) Fitch. (2) Pat. Off. Rep.

118. In steeping or pickling wheat in strong chamber ley, a practice both common and beneficial, the use of lime for drying should by all means be avoided. Gypsum should be employed instead; but of all substances, finely powdered charcoal, as a most efficacious absorbent of the ammonia of the urine, is to be recommended. For further observations on the pickling or steeping of wheat, as a method of preparing the seed for rapid growth and immunity from smut, see paragraphs 231, 232, 232a.

8th. *Oats as a Decoy.*—The oats being ploughed in after the deposition of the egg—"*if* the fly will deposit its eggs upon oats." This remedy is equivalent to late sowing.(1)

9th. *Wheat as a Decoy.*—If two or three acres across the middle of a large field be sowed with wheat about the middle of August, all the flies in the vicinity will be attracted to this point, and there retained, so that it will be safe in ordinary seasons to sow the remainder about the middle of September. Plough the early sowed wheat under, and bury the unhatched eggs and maggots. In years when "clouds" of Hessian flies migrate, it is evident that this remedy would be of little avail, if the season were at all late. The measure should receive a fair trial from some intelligent wheat grower, in a district suffering under this pest.(2)

119. 10th. *Deeply Covering the Seed.*—"Good as a subordinate measure, but it falls far short of ranking as a primary one."(3) I am much inclined to doubt the value of this remedial measure; late and shallow sowing, with a properly steeped seed, and deep preparation of the soil, should go together. The most trustworthy experiments have shown that deep sowing is destructive to a very large majority of the seeds committed to the ground. Out of 150 seeds of wheat sown at different

(1) (2) (3) Fitch.

depths, 140 out of the number came up from a depth of 2 inches, 40 from a depth of $4\frac{1}{2}$ inches, and 14 from a depth of $6\frac{1}{4}$ inches. Another experiment gave the following result:(1)

Seed buried	$\frac{1}{2}$	inch deep,	up in	11	days	7-8ths	of	them.
"	"	1	"	"	"	12	"	All of them.
"	"	2	"	"	"	18	"	7-8ths of them.
"	"	3	"	"	"	20	"	6-8ths " "
"	"	4	"	"	"	21	"	4-8ths " "
"	"	5	"	"	"	22	"	3-8ths " "
"	"	6	"	"	"	23	"	One came up.

120. 11th. *Procuring Seed from Uninfested Districts*—Of no utility; the eggs are not deposited in the seed. The only possible value of this artifice would be to obtain early varieties of wheat, or seed from a considerable distance (two or three degrees) to the *south* of the locality where it is intended to sow, whereby to ensure it maturity, for a few years, some days earlier than acclimated varieties.

121. 12th. *Sun Drying the Seed.*—Germination retarded, therefore equivalent to deferring sowing for a few days.

13th. *Drawing Elder Bushes over the Plants.*—A fancy.

14th. *Sprinkling Salt, Ashes, or Caustic Lime, over the Young Plants.*—This top dressing serves as a manure, and nothing more. It will strengthen the plant and accelerate the period of its maturity.

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(1) Petri.

(2) This applies to the seed obtained from the shores of the Mediterranean, and sown in Canada or the Northern States, but whether its peculiarity be dependent upon change of soil or climate, or both, is not yet fully established. It is known that in Sweden the farmers are in the habit of obtaining their seed from the north of the Gulf of Bothnia, and sowing it on the most exposed farms of the southern part of the country, where the season is short. The effect is to advance the ripening by several days the first season. Whether wheat grown at the Saguenay, or in districts below Quebec, would ripen much earlier than an acclimated kind in Western Canada, does not appear to have been fully tried. Both this and the opposite experiments are well worthy of trial.

122 15th. *Burning and Ploughing up the Wheat Stubble.*—Dr. Fitch says: "We commenced our account of this remedy, impressed with a belief that it was the best that had ever been proposed; we close it, persuaded that it is the very worst." By burning the stubble, you burn the parasites of the fly, which, as has been shown, destroy nine-tenths of each generation. (See paragraph 96.)

We cannot give assent to the very sweeping denunciation of this remedial measure contained in the foregoing sentence. It is quite clear that *before* the parasites accumulate so as to overcome the Hessian fly, the artifice is worthy of adoption. With the exception of certain seasons, the ravages of the fly are local, and may therefore be arrested by this artifice. It has received so many favorable notices from different quarters, that it is certainly worthy of trial. We subjoin an extract from the "Genesee Farmer" (1849) on this subject:

"This destroying insect is becoming more and more plenty over the whole wheat district, subject to slight variations through the effect exercised over them by the severe and open winters and frosts. That they are extremely local, and, when once colonized, do not emigrate far, when they can find a proper pabulum for subsistence near home, we have been a long time satisfied. A respectable and extensive farmer in Pennsylvania states that he has, for ten years past, almost entirely prevented their depredations by burning over the stubble directly after cutting his wheat, and before they had changed from the larvæ to the winged state; while fields in his immediate neighborhood were destroyed.

"This view of the subject is remarkably confirmed by a case related to us a few days since by one of our best wheat farmers in this section. His crop was so entirely destroyed that it did not pay for harvesting, and the land being in fine tilth he resolved

to follow it again with wheat, and consequently turned it over pretty soon after. About the first of September he commenced cross-ploughing, and when about half the field was finished, the other half looked in such good order that he omitted ploughing it, and sowed his wheat. The next summer the grain was so destroyed on the part twice ploughed, that he did not harvest it, while the other was a full average crop.

"The *rationale* is plain; the insect, when in the worm state, was ploughed under with the stubble, and on that part twice ploughed was brought up again, hatched out, and attached their eggs to the young wheat—while in that part but once ploughed they were buried beyond their power of getting to the surface, and were destroyed."

In 1851 Mr. John Delafield, in a general view and agricultural survey of the County of Seneca, N. Y., taken under the direction of the New York State Agricultural Society, tells us that the Hessian fly has *ceased* to be a formidable enemy there, probably for two reasons; "first, the period of sowing the seed grain has been retarded until a period too late to offer a nidus to the fly; and second, the soil is better prepared by due fertility, to give the plant vigour to resist the influence of the larvæ."

123. The remedial measures which have been enumerated, either imply the presence of the Hessian fly in destructive abundance, or contemplate invasions from neighboring districts. They may be thus briefly summed up for *winter wheat*:

1st. Have your soil in good heart and order.

2nd. Drain as much as is consistent with true economy in Canada, and plough deep.

3rd. Sow late an approved flinty stemmed variety, and an early ripener.

4th. Prepare the seed for rapid germination and growth by

steeping, and afterwards drying in some special manure.(1) (See Appendix for drying manure.)

124. With reference to steeping wheat before it is sown, there can be no longer any doubt as to the benefit it confers, when properly done, both in accelerating germination and future growth, and in preventing, or greatly diminishing, the affection of smut. (See Smut, ¶ 231.)

125. The recommendation "Sow Late," to avoid the Hessian fly, appears to be diametrically opposed to the advice given in paragraph 121, &c., to avoid the ravages of the wheat midge, and that dreadful scourge "rust." It is to meet the case of a simultaneous presence or appearance of both Hessian fly and wheat midge, that late sowing, with a forcing preparation of the seed, is recommended and practised. If acting with special reference to an individual insect, one would sow late to avoid the Hessian fly, or early to avoid the wheat midge; but it is very manifest that under ordinary methods of culture, if both insects prevail (and they may now *always* be *expected)* during the same year, or if they succeed one another, the crops must suffer from the attacks of one of them. Therefore, it is better to be ready for both contingencies, sowing late on well prepared land to avoid the Hessian fly, and anticipating the arrival of the midge by stimulating your crops to attain, before winter sets in, the same development of parts which they would have acquired by being a fortnight longer in the soil, taking care at the same time to select a good variety of seed, flinty stemmed, and an early ripener, and one which is *not* acclimated. This subject of ripening early will be more particularly alluded to in the chapter on the Wheat Midge.

126. With respect to spring wheat, it has been urged that the

(1) Lime (?) Gypsum, Charcoal, &c. Experiments on this subject not complete. (See Appendix.)

election of varieties which can be sown so late as to escape the May attack of the Hessian fly, the June and July attack of the midge and rust will cover all contingencies. Can this be accomplished? Have we such a variety of wheat as will satisfy these conditions? The late lamented Mr. Wade, of Cobourg, recommends the 'Fife Wheat,' which is described in paragraph 161. The 'Fife Wheat,' or as it is called in the Townships east of Lake Simcoe, Scotch wheat, is there a great favorite. It is not 'liable to rust,' may be safely sown much later than many other varieties, and it is at the same time very productive. For additional notice of the Fife Wheat, see paragraph 161.

The Cause of the Spread of the Hessian Fly.

127. A point of interest in the history of this insect is the stated apparent periodical character of its visits. A little reflection will show that this seeming regularity may be attributed to causes which are independent of one another, but yet have an important bearing upon its multiplication or diminution. The first and probably the most influential relates to the general wide spread cultivation of its favourite food; the second to the favourable meteorological conditions of the season: these stimulate and encourage its increase; the third affects the diminution of its numbers, and involves the excessive multiplication of the parasites which prey upon it.

128. Under the article 'Wheat Midge,' paragraphs 158-9, a much more apparent periodicity is observable in the successive appearances of that insect. The following notices of the excessive appearance of certain insects in the United States and Canada, with the character of the season during and immediately preceding their visit may prove interesting. They are not advanced with any expectation that a near approach to a clue to the cause of the greater or less distribution of the Hessian fly

in different years will be attained, but rather to direct attention to a class of extremely interesting natural phenomena which cannot fail to become of value as they accumulate.

129. (1) It has long been known in Germany that the race of pine beetles increased most in warm dry summers, followed by cold dry winters. 'Hot weather shortens the period of transformation, and thus affording time for the maturation of the several broods, causes a superabundant number of insects to be found.'(1)

(2.) The oak trees in Devonshire have suddenly appeared studded with gallnuts during the last three or four years, and in numbers so abundant as nearly to equal the leaves.(2) The Hessian fly and wheat midge are true gall flies, and the sudden increase of one of their kindred giving rise to the common gallnut in countless multidudes, shows how universally the capability of rapid and unexpected increase is shared by different species of this allied generation.

(3.) See paragraph 160.

130. In the communication to the writer, (before referred to) dated Feb. 2nd, 1857, Dr. Fitch says: "It has long been my opinion that the great multiplication of the insect depredators on wheat, and of insects generally, which takes place in particular years, is caused in part, at least, by certain peculiarities of the atmosphere of that and of the preceding year. This subject is alluded to under several of the species in my reports. What those atmospherical peculiarities are, in the case of any particular insect, is yet unknown to us. One of the general laws relating to this matter, I think, will be found to be this—that whatever peculiarities of the season occasion a luxuriant growth of a particular plant, will also favour the multiplication of the insects feeding upon that plant. But we are here treading upon slippery

(1) David Gorrie, Esq.,; Farmers' Note Book; Highland Agr. Soc. Trans.
(2) Illustrated London News, March, 1857.

ground. It is a very obscure subject, requiring an extended series of very careful observations to lead us to the exact truth. And in such enquiries as this we are very liable to be misled, and to mistake mere coincidences for established laws. For instance, if an insect has been observed in two or three instances to be very numerous, say, after an unusually wet season, we should confidently conclude such a season to be the cause of its multiplication. But it may perchance again show itself in equal abundance after a dry season. Authors have so often been humiliated by having their speculations falsified in ways analogous to this, that I have felt disinclined to venture upon such precarious ground, except with the utmost caution. It is a most important topic, however, and all the facts which fall under our observation, having a bearing upon it, should be recorded, and in time such records will lead to correct theories in the premises."

131. There can be no doubt that the excessive and continuous cultivation of its favourite food, wheat, without rotation, has fostered, encouraged and cherished the Hessian fly, and indeed, all other wheat depredators, until they have become firmly established in the country, and always to be looked for and guarded against. Little or no rotation has been allowed to interfere with their progress. They have been provided with all situations of exposure or shelter in one locality or another, to ensure the propagation of their species ; and all that the sensible farmer can do to protect himself from the swarms which will continually be thrown off from the nurseries maintained through selfishness or ignorance in this country, is to adopt the artifices which will enable him to escape the attacks of the depredators.

132. It has been suggested that the name 'Hessian Fly' should be discontinued and the term 'wheat stem-fly, substituted for it. The change, however, is decidedly objectionable, on the ground that there exists in Europe an insect which has long borne the name of the 'wheat stem-fly,' *(chlorops pumilionis.)*

CHAPTER IV.

The Wheat Midge *(Cecidomyia trilici)*.

Origin of the Wheat Midge, 133.—Destructiveness in Vermont, &c., in 1832, 134.—The Wheat Midge an importation, 135.—Destructive in Scotland in 1740, 136.—History of the progress of the Midge in Western Vermont, Ohio (?) Lower Canada, New York, Maine, Michigan, Pensylvania Western Canada, Saguenay, L.C., from 1820, 1856, 137.—Description of the Midge, 145.—The clear winged Wheat Midge, 146.—The Female, 146.—The Male, 146 (a).—The spotted-winged Wheat Midge, 147, 148.—Habits of the Midge, 149.—Eggs deposited, 150.—Young hatched, 152.—Figure of Maggot, 152.—A peculiarity in the Maggot, 153.—Multitudes of these Maggots in 'screenings,' 154.—Differences in the Habits of Individuals, 155.—Mr. Principal Dawson's experiments, 159.—Dr. Fitch's observations, 157.—Mr. D. J. Browne's observations, 157.—Apparent periodicity in the Habits of the Midge, 158.—Prevalent in particular years, 158.—Dr. Fitch's opinion, 159.—Influence of season on the Midge, 160.—Remedial Measures, 161.—Smoking the Flies; Sowing lime or ashes; Early Sowing of Winter Wheat, Late Sowing of Spring Wheat; Fumigating with Sulphur; Fly-proof wheats, so called; Turkish Flint Wheat; Burning of Orpiment; Fife Wheat, 161.—Sound practical suggestions, 162.—Suggestions of Mr. Hutton, 163.—Change of seed, 163 (a).—Remedial Measures suggested by a study of the Habits of the Midge, 163(b), 163(c), 163(d), 163(e), 163(f).—Its Parasites, 164.—European Parasites, 165.—Swallows, 166.—Yellow Birds, 167.

Origin of the Wheat Midge.

133. This destructive insect has long been known in Europe, and during the latter half of the past century it attracted general attention on account of the ravages it committed in various parts of Great Britain. Simultaneous with its appearance in America in the northern part of Vermont in 1828, it occasioned great havoc in Scotland and England, creating universal alarm in many of the best wheat growing districts of those countries.

134. In 1828 the ravages of the wheat midge in Northern Vermont became so general as to cause serious apprehensions for the wheat crop. In 1829 these fears were confirmed by the appearance of the fly in such countless numbers as to threaten the

entire destruction of the growing grain. Its spread was so rapid and uniform in all directions where its favourite food was cultivated, that, in 1832, we find the wheat crops greatly injured or altogether destroyed in Vermont, New Hampshire, part of New York and Pennsylvania, and damaged over a large area in Lower Canada.

135. Doubts have been expressed by European entomologists as to the identity of the American wheat midge with the *cecidomyia tritici*, described by Mr. Kirby. In the spring of 1855, however, Dr. Fitch sent some specimens of the American insect to M. Amyot, a distinguished French entomologist. At the meeting of the Entomological Society of France, November 14, 1855, M. Amyot announced the results of a most rigid examination, which he, in company with M. Lucas, had submitted the specimens sent to him by Dr. Fitch. These entomologists find the American insect perfectly identical with the European cecidomyia tritici, or wheat fly. This announcement leads to the conclusion that our wheat midge is an importation as is the Hessian fly; and an examination into the habits of the insect exhibits no peculiarity which can militate against the adoption of this conclusion.

136. In 1740 the wheat fly was destructive in Scotland, during the winter of which year the Thames was frozen over. In Ellis' Modern Husbandman for 1745, the attacks of the vast numbers of black flies (the ichneumon parasites) are noticed in the following quaint terms: "after this we had a melancholy sight, for as soon as the wheat had done blooming, vast numbers of black flies attacked the wheat ears, and blowed a little yellow maggot which ate up some of the kernels, in others part of them, and which caused multitudes of ears to miss of their fulness, acting in some measure like a sort of locust, till rain fell and washed them off; and though this evil has happened in other

summers to the wheat in some degree, and not done much harm, yet if the good providence of God had not hindered it, they might have ruined all the crops of wheat in the nation."

History of its Progress.

137. The following records of the appearance of this destructive insect will furnish a tolerable idea of the extent of its ravages on the American continent:—

1820.

Wheat midge first appeared in Western Vermont.(1)

1827.

Occasioned local injury in Athens County, Ohio(?)(2)

1828.

Committed extensive depredations in Northern Vermont, and the frontiers of Lower Canada.

1829.

Greatly destructive in Vermont and parts of Lower Canada and New Hampshire.

1830.

Appeared in North-eastern New York.

1831.

Considerable injury in Eastern New York.

1832.

Very destructive in Eastern New York; cultivation of wheat abandoned.

1834.

Commenced its depredations in the State of Maine. First appeared in numbers in Lower Canada, near Montreal.

1835.

"7th or 8th July, 1835, I discovered the fly on my wheat in myriads. They disappeared on the 11th or 12th July. They

(1) Mr. Jewett—New England Farmer.
(2) Statement of Mr. Elner Rowell, page 252. Pat. Off. Rep., 1852-3.

appeared to be depositing their eggs in the glumes of the ear in the 7th or 8th July. Six or eight days subsequently live maggots were produced. The earliest wheat was all destroyed. A part of my wheat that was not fully in ear when the fly appeared, was not so much injured. The tops of the ear had the maggots, but the lower part that was not shot out was uninjured" (Evans). Considerable injury from the wheat midge on the Island of Montreal.

1836.

Fly seen June 29th, and commenced depositing eggs in Lower Canada on the 4th July. Wheat on the Island of Montreal greatly damaged. The fly extended its ravages west and northward of Montreal for many miles.

1842.

Appeared in Western New York.

1845.

Very destructive in Western New York.

1846.

Approaching Seneca County, New York.

1847.

Destructive in Townships north of Seneca County, New York.

1848.

Appeared in Seneca County, New York.

1849.

Committed ravages in the county of Lennox, Upper Canada. Prevalent in Addington, Hastings and Frontenac. Disappeared from Monroe County, New York. Destructive in Seneca County, New York.

1850.

Wheat midge greatly increased in the County of Hastings, Upper Canada. Also in Prince Edwards and adjacent counties.

The following notice of its progress contains some facts and observations both interesting and valuable:

"To account for this (the low average of the crop) it must be observed that the weevil (wheat midge) has been very destructive, having been two years in the county, and in its journey westward has reached about the centre of our western tier of townships; some few instances have occurred of its having been found beyond that limit. We cannot but expect that next year it will be still more destructive; one fact, however, is well established, that in *early* situations, on *early* spots, where the seed was sowed *early*, there was little or no weevil (wheat midge.) In low, damp, late situations, and where late sown, it has been extremely destructive, especially in the eastern part of the country, where it first appeared. This important fact ought to be well remembered by our neighbours to the west of us, where they will have it undoubtedly in a very short time, and exertions ought to be used by them to sow early, and early kinds of seed, to drain the land well, and make small ridges, and otherwise expedite the growth as much as possible. The early sowed sole wheat escaped last year, in many instances, in the very centre of the weevil's destructive ravages. The maggot is generated from a fly blow deposited in the blossom by a very small greyish fly, with a small stripe of orange down the back, and it is most busy when the wheat is in full blossom, about the first of July.[1]

138. In the Canadian Census Report for 1851, we find the following remarks on the progress and destructiveness of the wheat midge in certain counties of Upper Canada during this and the following year. They are from the pen of the able Secretary of the Board of Registration and Statistics, William Hutton, Esq., whose experience, position and practical knowlege, confer the highest value upon his views and statements:

(1) Prize Report, county of Hastings, 1852. W. Hutton, Esq.

"With perhaps equal advantages we find an enormous discrepancy in some of our own wheat-growing districts. In the year 1850, the township of Esquesing, in the county of Halton, produced 26 bushels of wheat to the acre, and that of Adolphustown, in the county of Lennox, only six bushels to the acre, and this with soil and climate perhaps equally good. This is at once accounted for by the ravages of that fearful plague to the farmer—the weevil. The worst wheat crops in Canada West, in the year 1851, were in those counties where the weevil was prevalent. It committed the most serious depredations, in very many cases having rendered whole fields of most promising wheat not worth the threshing. This fly, which deposits its larvæ in the blossom of the wheat in order to feed upon the milk of the grain as it ripens, was, unfortunately, in that year most abundant in the counties of Frontenac, Lennox, Addington, Hastings, and Prince Edward, and is travelling gradually west at the rate of about nine miles every summer, and remains from five to seven years in a locality. The only prevention yet discovered has been to sow early seed on early land, and very early in the autumn, so that the wheat may blossom before its enemy takes wing, the period for which depends much upon the earliness of the season. So destructive was the fly in 1851, that the fine agricultural county of Lennox produced only six bushels per acre, Hastings about ten, and Prince Edward, Addington and Frontenac, about eleven. It had not in that year reached the county of Northumberland, but was very destructive in that county the following year, 1852."

Contrary to expectation, did not commit ravages in Seneca County, New York.

1851.

Very destructive in Frontenac, Lennox, Addington, Hastings, and Prince Edward Counties, Upper Canada. Destructive in the great wheat district west of Cayuga, New York.

1852.

Committed excessive ravages in late wheat in the county of Hastings. Destructive in Northumberland; travelling westward. The subjoined notice is by the author of the preceding quotation:

140. "They are numerous in this county in late wheat—*very* numerous in later, and *very, very* numerous in the latest. I should say that very probably one-half (certainly one-third) of the whole wheat of this county is destroyed by this weevil. I saw the fly about the first of this month, (July, 1852,) almost forming a little cloud, proceeding *westward*. It will be in Murray and Sydenham this season, and will proceed westward from seven to nine miles each year. The only remedy I can perceive, as yet, is *very early* sowing on very early ground, well drained, of very early kinds of grain. I have four fields of wheat; in the *earliest* there is little or none, except where there was aftergrowth, but it becomes worse in each field in proportion to its lateness, either in whole or in spots. Perhaps, through your valuable journal, you will be able to hurry the farmers west of us in their preparations for wheat sowing, and thus do a world of good, as the progress of the weevil is as certain as the progress of time itself, and how great a scourge it is—few of our brother farmers in the West are aware. The Sole and Hutcheson wheat appear to be the earliest, and will be ready for harvest with me, and around me, on the 22nd of July, which is early for this season. I cannot say exactly *why* the earliest wheat is the safest, but I dare say nature provides that the fly comes to its natural strength at the *usual* time for wheat to blossom; and if the wheat be *earlier than usual*, the grain is too forward to nourish its deposit. This year the coldness of the season retarded the *animal* creation probably more than it did the *vegetable* creation, and this may be another reason why the fly was too late for early *sown* wheats." * * * * * *

Weevil (wheat midge) common and destructive in Vermont. Not generally prevalent in New York. "The weevil has done us no injury yet in Genesee County, New York." Destructive in Westmoreland, Pennsylvania.

1853.[1]

141. "The weevil has made its appearance in some localities in this part of our State, but not in sufficient numbers to injure our crop."—J. D. Verres, Wayne County, Michigan.

"The midge or weevil has done a great deal of damage to our white wheat." "The Hessian fly has not for many years done us any injury."—G. Wiborn, Ontario County, New York.

"The wheat crop was less with us than an average last season, in consequence of injury by the weevil."—James De Mott, Seneca County, New York.

Midge appeared in moderate abundance in Northumberland and Durham, Canada West.

In Mr. Principal Dawson's "Scientific Contributions," we find the subjoined general notice of the wheat midge in Nova Scotia: "The wheat midge has in recent times been the most destructive of all wheat blight." Hence we may consider it established in Nova Scotia.

1854.

142. *Maine.*—Wheat midge destructive. "Wheat has been almost entirely neglected for some years past on account of the weevil; but it is again assuming a place in the fields of our farmers with fair success."[2]

Western New York.—Committed dreadful ravages. Estimated loss in the State exceeding nine million dollars.

Pennsylvania.—Destructive.

Northern Ohio.—Destructive.

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(1) See Patent Office Reports.

(2) E. Weston, Somerset County, Maine. P. O. R.

Very general and destructive throughout the northern wheat growing districts of the United States. In 1854, at the August meeting of the American Institute, in New York, Mr. Solon Robinson stated that the red weevil (wheat midge) is the most terrible pest ever encountered by wheat growers. Destructive in Grand Bay, Saguenay, L. C.

143. "In almost every section of the State of New York, where the wheat crop is grown, the ravages of the wheat midge have been most extensive, especially with the white wheat. The Mediterranean wheat, when early sown, has generally escaped. Assuming that the loss was one-third from this cause—although it was probably considerably greater—it is represented in money value (at $2.15 per bushel, the average price,) by $9,403,012,85. (Abstract from N. Y. S. A. S., 1854. Seg. Agr. Meeting.")

"The pecuniary loss which our country has sustained from this insect, is incalculable; but it is truly appalling, nay terrific. Some writers have thought that a wet season favored the increase of the midge, but in this country it has never been more destructive than it was in the summer of 1854, noted as one of the driest seasons known. In gathering the agricultural statistics of that year, our State Agricultural Society inserted in its circular the query: 'To what extent was the wheat crop in your vicinity injured by the midge?' And the answer to this inquiry furnishes us with quite authentic information upon this topic. The able and efficient Secretary of the Society, Hon. B. P. Johnson, informed me, that on getting together all the replies to this inquiry, and placing everything at the lowest figure, so as to be certain the estimate was within truth, the wheat which this insect had that year destroyed in our State, at its then current market price, exceeded in value *fifteen millions of dollars!* This amount would be more than a third larger, if estimated at the price to which wheat afterwards arose last winter. Truly, it

is a formidable enemy, that has the power to take such an amount of money from the pockets of our citizens in a single year."(1)

As every fact connected with the midge is of importance, the following caution from the "Genesee Farmer" is appended:

"*Weevil.—Caution to Farmers.*—The Hon. E. Blackman, of Newark, N. Y., exhibited to the writer samples of Timothy seed obtained by him at Buffalo, which was literally alive with weevils. The seed was understood to be from Ohio; and most of the seed from many parts of that State, having been obtained from grass in the wheat crop, the weevil falls into their timothy seed and thus is sown broadcast over the land. As the insect lives through winter, or in some other way appears in the same locality every season, it may be possible that the sowing of this seed containing them may hasten the general prevalence of that dread scourge throughout the entire wheat-growing section of our State. Ought not farmers to be on their guard against thus distributing destruction to their crops of wheat?"

1855.

Very destructive in the counties of Northumberland and Durham, C. W.

In Lower Canada, wheat badly damaged by fly in Grand Bay, Saguenay.

Not generally prevalent in the United States. This is one of the peculiarities of insect life before referred to, in paragraphs 24, 159. Being most abundant and destructive generally in 1854, and in certain localities absolutely ruinous, the succeeding year finds it dwindling away into an insignificant and almost forgotten pest; yet numberless examples show how little the causes which govern its increase are understood, and how immensely

(1) Asa Fitch, M. D., "Rural New Yorker," 1856.

deserving they are of most careful study over the wide areas on this continent where wheat is cultivated.

1856.

144. Wheat fly common on the lake shore counties west of Toronto. Committed excessive ravages in the counties bordering on the Niagara River. Estimated loss in Canada from the wheat fly in 1856 probably exceeds $2,500,000. Made its first appearance in the county of Middlesex, C. W. General but not destructive along the Detroit River. County of Wellington affected. Common in the county of Peterborough. Common in parts of Maine. Destructive in County of Saguenay, L. C. In the township of Thorah, C. W., hitherto considered altogether free from all insect wheat pest, except "grasshoppers;" in some instances the top kernels of wheat were found partially attacked by a "small light brown worm, with a black head," thought to be the "weevil." The intervention of a thunder shower preserved the infested ears. Whether this insect be the larvæ of the midge, is quite uncertain, and a notice of it is introduced to show that even so far north and east, as the Townships of Saguenay and Thorah, the midge, *or another* wheat depredator, is attracting attention, and perhaps silently establishing a home.

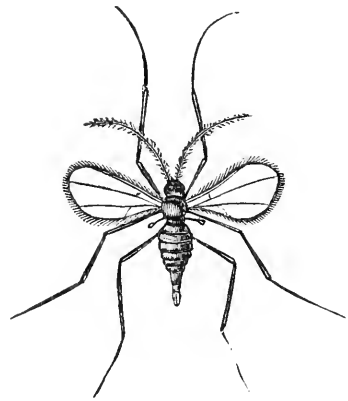
Description of the Wheat Midge.

145. A small orange-colored fly, (or flies, as there are several species,) with delicate, transparent, irridescent wings, and long slender legs. The length of this insect is about the tenth of an inch, rather less than more; the breadth of its expanded wings slightly exceeds the tenth of an inch. A good magnifying glass is required in order to distinguish the following particulars.

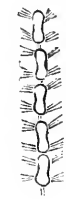
The Clear-Winged Wheat Midge.

146. The eyes of the female (Fig. I) *clear-winged wheat*

midge (Cecidomyia Tritici) occupy two-thirds of the entire head.(1)



WHEAT MIDGE.
(*Nat. Size.*)



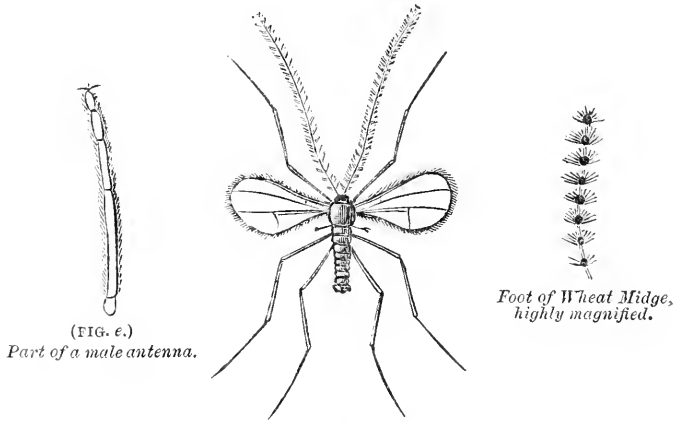
(FIG. *h.*)
Part of a Female Antenna.

FIG. I.—MAGNIFIED CLEAR-WINGED WHEAT MIDGE.—(*Cecidomya tritici.*)

They are large, of a deep black colour, and are separated from each other on the top of the head only by a light and almost imperceptible cleft, so that when viewed in front they appear like a continuous broad black band surrounding the head. The face is pale yellow. The antennæ are of a deep brown or black colour, less intense than the eyes, of the same length as the body and composed of twelve joints. Each joint (Fig. *h*) is commonly oblong, with a contraction in its middle, and is surrounded with a row of hairs near its base, and another near its apex. The joints of the antennæ are connected by a slender thread. The thorax is of a pale yellow colour; the abdomen throughout of an orange colour; the wings are colourless, appearing like thin plates of mica. Their margins are densely ciliated with hairs. The legs are pale yellow; the basal joint of the tarsi is the shortest of all, its length little exceeding its diameter. All parts of the body are clothed with minute hairs.

(1) For a full and complete technical description of the Wheat Fly, or Midge, see Dr. Fitch's Report, in Vol. V. Trans. N. Y. S. A. S., 1845. Many scientific terms are omitted in the text, for obvious reasons.

146 (a). The male wheat midge is a rare insect, and differs from the female in one particular point by which it may be easily distinguished (Fig. IV.) The antennæ are double the length of the body, and twenty-four jointed. The joints are of an exact globular form, and encircled with a row of hairs. (Fig. *e.*)



(FIG. *e.*)
Part of a male antenna.

Foot of Wheat Midge, highly magnified.

FIG. IV.—MALE OF THE CLEAR-WINGED WHEAT MIDGE—MAGNIFIED.

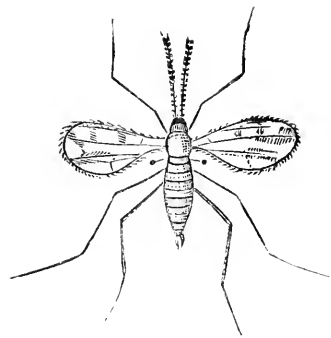
The Spotted Winged Wheat Midge.

(Cecidomyia arealis. Fitch.)

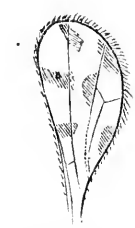
147. The spotted winged wheat midge is distinguished from the preceding insect by having spotted wings; six spots are commonly found on each wing. The length of this insect is about one-twentieth of an inch, while that of the common clear-winged wheat midge is about one line, or the twelfth part of an inch, although much smaller specimens are not unfrequently met with.

148. In the Rural New Yorker, for June, 1856, Dr. Fitch says, in an admirable communication on the wheat midge:—

"The fact then is, there are two species of this insect devastating our wheat. But as these species are alike, so far as we yet know, in their habits, transformation and external appear-



SPOTTED-WINGED WHEAT MIDGE—MAGNIFIED.
(*C. cereales.* Fitch.)



Magnified wing of C. cerealis.

Wheat Midge at rest, with its wings in their natural position,—magnified.

ance, and can only be distinguished from each other by their wings when in their perfect state, it will be more convenient to designate them collectively as the WHEAT-MIDGE, and only in cases where technical accuracy and precision is required, is it worth while to discriminate them by the names "spotted winged wheat midge," *(C. cerealis,)* and "clear winged wheat midge," *(C. Tritici.)*

Habits of the Wheat Midge.

149. In Canada the wheat midge appears during the latter part of June, and remains until the middle of August.(1) It prefers low and sheltered places, being always found in greater abundance in vallies than on hills, under the lea of fences, or the forest rather than the open field. It is most active at sunset, and during the day may be found lurking among the lower leaves of the plant, and especially among the weeds which are frequently suffered to grow in profusion among our crops. At twilight and during the night it is chiefly occupied in depositing its eggs. It does not confine its attacks to wheat but infests the ears of various

(1) The precise time varying by a few days with flowering of wheat.

kinds of grass, such as the couch grass, (Triticum repens), the wild bearded oats, (Avena Festuca,) and other grasses.

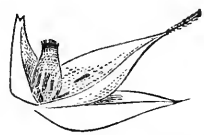
150. The eggs are deposited in the germ of the still undeveloped grain, through its chaff or sheath.[1] When the chaff is far advanced, or very silicious in its nature, the insect cannot puncture it, a fact which is important to bear in mind, and of value as a guide in the selection of varieties of wheat for seed where the fly abounds. The number of eggs deposited in one floret rarely exceeds 10, but it often happens that several insects lay their eggs in the same floret, hence from 10 to 40 larvæ have been counted in the same floret.

151. "Go into an infested wheat-field in the evening, with a lantern, and you will find a swarm of these flies, everywhere dancing up and down along the heads of the wheat, intently engaged in selecting the kernels, upon which to deposit their eggs. They are all females. The males are very rare, and have never been found, I believe, except by the German naturalist, Meigen, and myself. Having discovered a kernel, the chaff of which is not too old and hard, the fly alights upon it and pierces the chaff with her sting or ovipositor, which is a slender tube resembling a fine hair. This she protrudes from her body, insinuating it through the chaff until its point reaches the germ or young soft kernel. She then leisurely passes her eggs one after another through this tube, thus dropping them upon the surface of the germ or embryo seed. The same fly probably visits several kernels in this manner upon successive evenings, until her whole stock of eggs is disposed of, by which time she, having completed her labors, has become so exhausted that she is often unable to draw her ovipositor from the chaff, and thus dies.

(1) It has been said that the eggs are deposited on the chaff scales. Perhaps both localities are selected under different circumstances. As the maggot is footless it would find the greatest difficulty, except when the chaff scales were moist, in entering inwards to the young grain or germ.

These dead flies may frequently be found thus suspended by their tail-like ovipositors, to the outer scale of the chaff."(1)

152. About a week suffices to hatch the young maggots, and three weeks enables them to attain maturity. They feed upon the juices of the grain, and, as it were, dry it up. When full grown the maggots wriggle in damp weather, or when the stalk is wet with dew or rain, down to the ground, and penetrate about half an inch or an inch below the surface. Here they remain until the following spring, still retaining their maggot state. In the month of May they assume the pupa condition, and preserve it for two or three weeks, when they wriggle themselves to the surface of the ground, break their pupa skin, and assume the form of the midge.



Kernel of Wheat, the chaff pulled down to show the Maggots in their usual situation.

A mature Maggot—highly magnified.

153. It frequently happens that the maggots are gathered with the grain and carried into the barn, but instead of remaining soft and pliant, they become stiff and inactive, and their bodies losing a portion of their moisture by evaporation, contract and separate from the thin outer skin, which forms a case in which the little yellow worm is enclosed. It thus reposes in the wheat heads until the grain is threshed and winnowed, when most of these larvæ are collected with other screenings, and often emptied out among the litter of the barn-yard. Here their bodies imbibe moisture, and swell until they fill the case or skins in which they are enclosed, and the worms crawl or wriggle away

(1) Asa Fitch, M.D. Rural New Yorker, 1856.

to a place of security. (Asa Fitch—Rural New Yorker, January, 1856.)

154. We may form some conception of the innumerable multitudes of these insects which accumulate among the screenings of infested wheat by attempting to estimate the number which are annually swept out of barns in those districts where they abound. Mr. Dawson relates in his 'contributions towards the improvement of Agriculture,' that a friend informed him that not less than four bushels of larvæ had been obtained from the wheat of eight acres. After making a large deduction for dust this quantity must have contained about 150 millions of these insects.

155. It thus appears that these differences in the habits of individuals hatched and so far matured in the same field are dependent upon atmospherical conditions. Some of the full grown maggots leave the grain at the close of a shower, or heavy dew, and wriggle down the wet straw to the earth. Others which are later in arriving at maturity, or in finding suitable weather for making their descent to the earth, are carried during harvest with the grain into the barn, and become subject to the singular condition or state described in paragraph 153.

156. Some very excellent observations on the habits of this insect have been made by Mr. Principal Dawson, of McGill College, Montreal, of which a record may be found in a work by that gentleman before noticed, entitled, "Scientific contributions towards the improvement of Agriculture in Nova Scotia." The following are the observations referred to:—

"I procured a quantity of the larvæ, full grown and in that motionless and torpid state in which they usually appear when the grain is ripe. A portion of these larvæ were placed on the surface of moist soil in a flower pot. In the course of two days, the greater number of them had descended into the ground, *previously casting their skins which remained at the surface* (p. 157.)

I afterwards ascertained that they had penetrated to the depth of more than an inch, and were of a whitish colour, softer and more active than they had previously been. The fact is thus established, that these apparently torpid larvæ, when they fall from the ripe wheat in autumn, or are carelessly swept out from the threshing floor into the barn yard, at once resume their activity, and bury themselves in the ground.

"The larvæ thus buried in the ground, were allowed to remain undisturbed during winter and spring, the flower-pot being occasionally watered. About the end of June they began to reappear above the surface, in the winged form; the little grubs creeping to the surface, and projecting about half their bodies above it, when the skin of the upper part burst and the full grown winged midge came forth and flew off. This completes the round of changes which each generation of these little creatures undergoes, and we have thus actual evidence of each stage of its progress from the egg to the perfect insect."

157. Dr. Fitch's observations do not agree in one particular with those of Mr. Dawson. The following extract from the paper published in the Rural New Yorker, before referred to, explains Dr. Fitch's views:—

"The insect does not moult or cast off its skin from the time it leaves the egg until it enters its pupa state, nor do I think the larva skin forms a case or envelope within which the pupa lies, but that the skin of the larva gradually changes and becomes the skin of the pupa, as it certainly does in our willow gall-fly *(Cecidomyia Salicis.*—FITCH.) I infer this from the fact that in those instances in which I have reared these flies from the larvæ, the empty pupa skins were the only ones which I found remaining." * * * * * * *

"Gather a number of the worms from the wheat at the time of harvest and place them in a pill box. They all soon cease

crawling about, and ere many days become cased larvæ—the yellow worms being shorter than the semi-transparent pod in which they are inclosed. They may now be kept for months, even in a dry, stove-warmed office, without losing their vitality. Then, upon placing them between the folds of a wet cloth, they will next day be found actively crawling about within the cloth, till reaching its outside they with a skip throw themselves away from it, not one of them leaving a carse or empty skin behind in the cloth."

Mr. D. J. Browne, in the Patent Office Report for 1854, page 74, says, "towards the last of July or beginning of August, the full grown maggots cease eating, and become sluggish and torpid, *preparatory to shedding their skins*, which takes place in the following manner :—The body of the maggot gradually shrinks in length within its skin, and becomes more flattened and less pointed, as readily may be seen through its delicate transparency. This torpid state lasts only a few days, after which the insect casts its skin, leaving the latter entire, excepting a little rent at one end of it. These empty cases or skins may be *found in great abundance* in the *wheat ears* after the moulting process is completed."

Apparent Periodicity in the visits of the Wheat Midge.

158. A singular apparent regularity in the periods of its recurrence in vast numbers so as to prove eminently destructive, has been hinted at by Dr. Fitch in 1844.(1) When these instances of periodicity are associated with its late destructive depredations in the United States and Canada, they seem to acquire a peculiar although perhaps speculative interest. Its appearances at different periods are as follows :—

(1) See succeeding paragraph.

1st. Very prevalent in Scotland in 1740.(1)

2nd. Abundant a few years previous to 1771, or about 25 years after its first appearance, and in that year (1771) eminently destructive.(2)

3rd. After 25 years or in 1796, it was again observed by Messrs. Kirby and others, in abundance in different districts for three or four years.

4th. After about 25 years more, or in 1825 to 30, it once again became destructive and appears in America as well as in Europe.

5th. After a fifth epoch of about 25 years it occasioned in New York State damage to the extent of £15,000,000 to the wheat crops in 1854, and in Canada West exceeding £2,000,000 in 1856. The season of 1854 was one of unexampled drought in the State of New York.

159. In a letter from Dr. Fitch to the writer, (before referred to) the following reference to this curious subject is made :—

Though I allude to a seeming regularity in the recurrence of the wheat midge in England, after long intervals, I have no idea there really is any such regularity in the return of this or any other insect. We thought the midge had run its race in this section of country, some years ago, and that the general cultivation of wheat might be resumed. But in 1854 it suddenly reappeared, as numerous as it had ever before been ; indicating that it has become a naturalized insect in our midst, ready to multiply whenever those circumstances which favor its increase recur. And all over the western country, this and other wheat insects are introducing themselves, to remain there no doubt, as long as wheat is cultivated there, ever and anon multiplying and devastating the crops for one or more years, and then diminishing and for a time ceasing to attract notice.

160. There can be no doubt that certain peculiarities in the

(1) Ellis' Modern Husbandry. (2) Mr. Gullet.

season have a marked effect upon the increase of the wheat midge. The year, perhaps, of its greatest ravages, on this continent, 1854, was one of unparalleled drought, and it has been observed that numerous species of insects appear in incredible numbers during dry and hot summers.(1) The palmer worm which committed such ravages in the orchards during the summer of 1853, was preceded by remarkably dry and hot weather. The chinch bug in 1839 became excessively numerous in Virginia and the Carolinas, and was preceded by a very dry spring. In 1850 this insect was abundant in Illinois, but during the two following years it was little noticed, "but the three dry summers which have now occurred have increased it prodigiously."(2) Numerous other examples might be quoted to show that hot and dry weather favours in a remarkable degree the excessive multiplication of insects. The green plant louse was excessively common in gardens near Toronto in 1856, during the dry early summer months (129.)

On the Remedial Measures which have been adopted and suggested with a view to lessen the Ravages of the Wheat Midge.

161. The remarks under this heading made in the chapter on the Hessian fly may be here repeated; we can employ remedial measures to check the destructive increase and devastations of this insect, but we cannot provide a remedy against its general appearance from time to time, under favourable conditions.

The following plans have been adopted in the United States, and also recommended frequently in Canada. The general result is, as before, attached in a few brief words :—

1. *Smoking the flies when in the act of depositing their eggs*

(1) For various instances of the concurrence of hot and dry weather with the sudden appearance of insects of different kinds, see Dr. Fitch's Reports.
(2) Ibid.

—Not generally practicable, and too much dependent upon wind to be of much utility.

2. *Sowing with lime, or ashes, or gypsum* when the flies are in the act of depositing their eggs. Experience and observation have shown this artifice to be without any effect. Instances have often been cited when it has proved of value, in Ohio, Vermont, Canada. The true reason must have escaped observation. Wheat in blossom *strewed* with lime will not *deter* the insect from depositing their eggs, as observation has most distinctly shown.

3. *Early sowing.*—In the *absence* of the Hessian fly this artifice is no doubt valuable with regard to winter wheat.

4th. *Late sowing of spring wheat*—of value where rust is not likely to prove equally destructive as the midge. With *good* varieties of wheat this remedy is probably the best that can be suggested. Many instances are recorded of the very successful employment of this simple artifice. In the Canadian Agriculturist for September, 1856, the late Mr. John Wade, of Hamilton Gardens, county Northumberland, describes a kind of wheat adapted to late spring sowing, which appears to possess the required qualities.

"The Fife is now as good after being grown 7 years as it was at first, without the least sign or vestige of failure in any shape *except* from weevil; and to know that you can be sure of a crop of wheat sown as late as the 10th of June, and to fill and ripen without a speck of rust, and yield 20 to 30 bushels an acre, is surely a consideration."

5th. *Fumigating with sulphur.*—Is not the remedy, when practicable, as bad as the disease? Sulphurous acid—the result of burning sulphur in air, is a most deadly vegetable poison.

6th. *Fly-proof wheat* (so called). See paragraphs 108-112. The Black Sea wheat has long been a favourite in Canada, it is now fast deteriorating in some of the qualities which commend-

ed it some years since; it has become acclimated. Fresh seed would no doubt be in full possession of its most valued properties.

The *Turkish Flint Wheat,* from near Mount Olympus, in Asia, is a hardy fall variety, and has recently been introduced into the United States through the Patent Office. It has a dark coloured chaff, a very heavy beard, and a long, flinty, white-colored berry, and is thought by the Commissioner of Patents likely to prove highly profitable to the farmer and miller, from its superior weight and the excellence of the flour it produces. It has withstood the severity of an American winter in the middle States, and "from its long thick beard will probably be protected in a measure from the depredations of insects in the field as well as from heating or moulding in the stalk." P. O. R. 1855.

7th. *Burning of Orpiment.*—This is a most dangerous recommendation. If it were attempted on a large scale, sufficient to be of practical utility, the destruction of many flies would be very probable, but the poisoning of a manipulator now and then would be absolutely certain. This suggestion has been copied from a "Canada Journal," into the Patent Office Report for 1847.

162. Sound and practical advice on this subject is given to a correspondent whose wheat was beginning to suffer from the 'Weevil' in the county of Middlesex, by the editor of the Canadian Agriculturist, in the Sept. number, (1856) of that Journal. The extract is subjoined.

1st. Prepare your land *well.* 2nd. Sow early *(winter wheat)*; —for this neighbourhood, we should say not later than the second week of September, (of course the *absence* of the Hessian fly is here supposed.) 3rd. Select early and hardy varieties of wheat, such as the *Improved White-Flint; Kentucky White-bearded,* or as it is commonly called, *Hutchinson's;—Blue*

stem; Soule's, and *Hume's White Wheat.* There may be other kinds equally valuable, but the above are the earliest, hardiest, most prolific, and produce the best flour of any with which we are acquainted. Ploughing wheat stubble in the fall has been recommended, with much show of reason in its favour, but it is evident that the practice must become general before much good can be expected from it. One large field left unploughed would furnish flies enough in the spring to spread the mischief over the whole neighborhood, or settlement. (?) (?)[1]

There is no variety of wheat entirely exempt from the attacks of insects. The *Mediterranean* is said to be less liable to their attacks than any other, but it is a coarse, red-bearded wheat, and makes inferior flour. It is an early kind, but the grain is as dark as the rye, and seldom plump. It is not grown in Upper Canada to any great extent.

163. It will be well here to draw attention once more to the suggestions of Mr. Hutton, although given at length in paragraph 137.

"One fact is well established, that in *early*[2] situations, on early spots, where the seed was sown early there was no Weevil, (wheat midge.) In low, damp, late situations, and where late sown it has been extremely destructive. This important fact ought to be well remembered by our neighbours west of us, where they will have it undoubtedly in a very short time, and exertions ought to be used by them to sow early, and early kinds of seeds, to drain the land well and make small ridges, and otherwise expedite the growth as much as possible. The early sowed Soule wheat escaped last year in many instances, in the very centre of the Weevil's destructive ravages." Prize Report, county of Hastings, by W. Hutton, Esq., 1852.

(1) The notes of interrogation are the author's—it is very improbable that one large field would spread the mischief if the other artifices above noticed were adopted.

(2) In the absence of the Hessian Fly.

163(a). With reference to change of seed of the same variety it should be borne in mind that it is advisable to obtain the fresh seed from a soil and climate better and earlier than those of the locality in which it is sown. In America, where our winters are so prolonged that vegetation in the summer months progresses as in a hothouse, it seems very probable that seed obtained from the north would ripen earlier for a year or two in southern districts, than acclimated varieties. (2)

163(b). The remedial measure which appears to be immediately suggested by a study of the habits of the wheat midge, is of the simplest description, and everywhere practicable. It will be seen from paragraphs 152, and 156, that the maggot of the midge, previous to assuming its larvæ condition, buries itself an inch or a little more below the surface of the ground. That when the time arrives for their assuming the fly state, they *wriggle* themselves to the surface for that purpose. It is only by a series of alternate contractions and expansions of one side and the other that they can make their way up from an inch below the surface to the light and air, for they possess no feet or other exposed members when in the pupa case. If, therefore, the pupa be buried, say six inches below the surface, it is *permanently imprisoned*, for nature has not provided any apparatus to enable it to effect its escape under such circumstances. If, therefore, at any time between August and May of the following year the ground be ploughed to a depth of at least 6 inches, and in such a way that the furrow slices lie as compactly as possible, there can be no doubt that a vast majority of the pupæ will perish from inability to escape from their imprisonment.

163(c). But how much greater will be the probability of every individual pupa perishing if the ground be ploughed seven inches deep immediately after harvest, and left untouched until the fol-

(2) See paragraph, or rather note to paragraph 120, page 86.

lowing August? Every one knows that it is not possible, in ploughing, to turn a sod or furrow slice completely over, so that all parts shall be altogether reversed. The furrow slices may be made to lie with great compactness, but there will be instertitial spaces into which the pupa may fall or wriggle themselves, and eventually escape. When the field is ploughed immediately after harvest, not only will the autumnal rains fill the spaces beneath and between the furrow slices by washing down fine particles of earth, but the influence of the many months of winter and spring will consolidate the furrow slices, and their compactness may be ensured by rolling in May or the early part of June, before the fly appears.

163(d). Rolling the land immediately after ploughing is accomplished, will give further security to the prison in which the pupa are enclosed by this simple artifice.

163(e). We may now consider the feasibility and adaptation of this artifice of *after harvest ploughing* and *rolling*, to those sections of Canada where the fly has not yet appeared. The country about Lake Simcoe has not yet apparently suffered from the depredations of this insect, and we know that the districts between London and the Detroit River are now only threatened at their borders with the invasion of the wheat midge. The question proposed is, what ought the farmers of these favored districts to do in order to avoid the slow but sure progress of the devastator.

163(f). Every one will say, first banish the idea from your minds that you are safe from an invasion; let the experience of half a continent foreshadow the contingencies of a few townships. Acknowledging, then, the necessity of preparing for the invasion, what is to be done? The answer depends upon the presence or absence of another insect. 1st. Are you liable to the attacks of the Hessian fly? No; then sow early, &c., &c.

(See Art. 162.) Yes; then sow late; prepare your seed with steeps, choose *earliest* varieties, and have your land in good order. Watch the progress of the midge, but do not depend upon that; plough as soon after harvest as possible, and let that field remain untouched, except by the roller, until after harvest the succeeding year. Whatever invaders may have appeared unobserved, (and millions will have so done, sooner or later,) will be buried beyond their powers of restoring themselves to light and air.

Its Parasites.

164. These are not well known in this country. Several have been recognized in Europe, and described by distinguished entomologists. One American species, found by Dr. Fitch, is a hymenopter of the family Chalcididæ. It is probable that the wheat midge, like the Hessian fly, has several parasites, which increase with it until they finally overcome it, and for a time arrest the destructive ravages of this terrible devastator.

165. In Europe, nature herself has provided a considerable check to the multiplication of these flies, by making them the prey of no fewer than three kinds of ichneumons, viz: *Encyrtus inserens,* about half the length of the wheat fly; another, *Platigaster tipulæ,* which commits its eggs to the larvæ of the wheat fly; and the third, *Eurytoma penetrans.* Some of these ichneumons appear in great numbers where the fly abounds, and multitudes must become their victims.—*Quarterly Journal of Agriculture, vol.* 12.

A very full description of these ichneumons, taken from Mr. Curtis' celebrated works and papers, is given in the February (1857) number of the "Canadian Naturalist and Geologist," by E. Billings, Montreal.

166. Many birds prey upon the maggots. Mr. Elmer Rowell,

of Athens County, Ohio, has a colony of swallows amounting to one hundred individuals, which he thinks secure him from the ravages of the midge. It is probable, however, that the most destructive to the midge maggot among the feathered tribes is the beautiful little yellow bird. (Fringilla Tristis—Lin.)

167. In Madison County, New York, during the prevalence of the wheat midge, in the years 1838 and '52, flocks of yellow birds were seen busily employed in the wheat fields, much to the *alarm* of the farmers, who, observing these active and beautiful little creatures picking the heads of wheat to pieces, immagined that they were destroying the crop, and hence resorted to various means to kill them, and drive them away. The same warfare has been frequently noticed elsewhere, and should at all times be discouraged to the utmost by all who desire to cherish the most interesting, beautiful and useful class of insect destroyers the world contains. Birds, and especially the insectivorous birds, ought to be encouraged in every way on this continent. Facilities so unusual have been furnished by man for the increase of certain destructive insect tribes, and no corresponding effort made to maintain a check upon their excessive multiplication, that we have permitted a host of enemies to obtain a firm footing in our midst, which are at all times liable to paralyze our industry in the most alarming and grievous manner.

CHAPTER V.

The Wheat Stem Fly, and other Depredators.

Wheat stem fly, 168.—Origin of its name, 169.—Probably not *identified* on this continent, 168.—Description of the wheat stem fly, 169.—The American Meromyza, 170.—The Obese Siphonella, 171.—Habits of the insect. 172.—The common chlorops, 173.—The feathered horned chlorops, 174.—The shank-banded oscinis, 175.—The yellow-hipped oscinis, 176.—The thick-legged oscinis, 177.—The deceiving wheat fly, 178.—The similar wheat fly, 179.—The wheat mow fly, 180. The wheat thrips—the three-banded thrips, 181.—Gaylord's grain worm, 182. —The wire worm, 183.—The larva, 184.—The pupa, 185.—The perfect insect, 187.—Remedial measures—ammonia, 188.—Sir Joseph Bank's remedy, 189.—The Hon. A. B. Dickenson's remedy, 189(a).

168. *The Wheat-Stem Fly*, (Chlorops Pumilionis.)—Perhaps this species has not yet been identified on this continent, nevertheless it is quite certain that numerous insects belonging to the same genus infest the wheat crops in America. As every kind of information bearing upon the subject of wheat culture and wheat depredators is of the utmost value in Canada, the following notices of insect depredators, which may be met with in our wheat fields, are subjoined. Their habits and distribution have not been much studied on this continent; it is to be hoped, however, now that attention is so painfully drawn to the insects preying upon wheat, that observers will be found in Canada zealous to record the approach, and describe the habits, life and history of the unknown insect pests on this most valuable cereal.

169. The wheat-stem fly derives its name from the colour of its eyes, and the effect it produces upon the plants it attacks. It destroys the central shoots, and thus occasions the dwarfing of the many lateral ones which are pushed out during the decline of the main stem. These side shoots are not only short in height, but carry a small head irregularly filled with grains. The

colour of the fly is black;[1] the under side of the head and two narrow longitudinal lines in the thorax yellow; under side of the body pale yellow, with two black spots on the mesosternum; halteres or poisers white; the legs ash grey, and black at the tips; maggot small and white; pupa yellow, smooth and shining, and rather more than one-twelfth of an inch in length.

170. *The American Meromyza*, (Meromyza Americana[2]—Fitch.)—Length about one-fifth of an inch from tip to tip of its wings; colour yellowish white, with a black spot on the top of its head, continued backward towards the neck; thorax with three black stripes; abdomen with three broad blackish stripes; wings semi-transparent; eyes bright green; found in the latter part of June.

171. *The Obese Siphonella*, (Siphonella Obesa—Fitch.)—About the size of the preceding insect; body short and thick;—colour black; under side of the body yellow, with a tinge of green under the abdomen; legs tawny yellow, with their tips black; head yellowish white; antennæ tawny yellow, their tips black; an egg shaped spot on the crown, two dark stripes on each side of the breast, and the anterior pair of feet black.

172. The larvæ of these insects burrow in the stalk, rendering them dwarfish, and often causing the heads to perish; small, slender, pale green and watery white shining maggots.

173. *The Common Chlorops*, (Chlorops Vulgaris.—Fitch.)—Length about one-fifth of an inch from tip to tip of its wings; colour, pale, tawny yellow, with a round black spot on the top of its head; tips of antennæ and feelers black; two black bristles at the end of the middle shanks, and one at the end of the forward ones, with rows of black bristles upon the thorax; on

(1) Duncan, quoted by Stephens.

(2) For notices of these insects, see Dr. Fitch's Report on the Insects of New York, 1856.

the top of the head two pairs of bristles incline forward, and two backward.

174. *The Feather-horned Chlorops,* (Chlorops antennalis.—Fitch.)

175. *The Shank-banded Oscinis,* (Oscinis tibialis.—Fitch.)

176. *The Yellow-hipped Oscinis* (Oscinis coxendix.—Fitch.)

177. *The Thick-legged Oscinis* (Oscinis crassifemoris.—Fitch.)

Several of the above species have been met with on wheat in the State of New York; too little is known of them, however, to make further remarks upon them necessary.

The Deceiving Wheat Fly (Hymelyia deceptiva.—Fitch.)

178. Very common in the latter part of June in Eastern New York. A quarter of an inch in length from tip to tip of its wings. Colour ash gray, legs, antennæ and feelers black. A row of brown black spots form an intercepted stripe down the middle of its abdomen. A tawny yellow spot upon the front of the thorax, passing into a black stripe upon the top of the head.

179. *The Similar Wheat Fly* (Hymelyia similis.—Fitch.)

The Wheat Mow Fly (Agromyra tritici.—Fitch.)

180. Showing its larvæ in the form of myriads of pale maggots crawling from the mow of wheat soon after it is placed in the barn; the kernels of the grain shrivelled and dwarfish. The flies are like the common house fly, very much reduced in size. Colour black, with a pale reddish yellow band upon the front, above the base of the antennæ, the mouth margined with dull yellow. The legs brownish-black. The wings notched on their outer margin near the base.

The Wheat Thrips (Thrips tritici.—Fitch.)

The Three-banded Thrips (Coleothrips trifasciata.—Fitch.)

181. Found upon the heads and stalks of wheat in June and July, exhausting the juices of the kernels and rendering them dwarfish and shrivelled, exceedingly minute, long and narrow,

six-legged insects, of a bright yellow or of a shining black colour; very active. First noticed by Dr. Fitch from specimens sent from Wisconsin, July 9th, 1855, where it was causing some alarm in the neighbourhood of Geneva. Seen near Geneva in countless numbers. Found in the blossoms of wheat and clover. The *thrips cerealium* is a most destructive insect, and is said to have destroyed, in 1805, one-third of the wheat crop in Piedmont. According to Mr. Kirby it is by far the most numerous of any insect upon the wheat in England; he does not think he ever examined an ear of wheat without meeting with it.

Gaylord's Grain Worm—(undescribed.)

182. Common in Western New York, Pennsylvania, Maine, Connecticut, &c., and in parts of Canada (Northumberland Co.) A small caterpillar, orange coloured, and longer and darker than the maggot of the wheat midge; feet distinct, and twelve in number. They are found half an inch long, and when disturbed they let themselves down by a thread from the ear. They feed on the grain in all stages of its growth. The perfect insect is unknown. In some agricultural publications this insect is described as Gaylord's Wheat Caterpillar. (See Canadian Agriculturist, page 81, 1856.)

The Wire Worm *(Elater lineatus.)*[1]

183. The wire worm is a name frequently given by farmers to the larvæ of numerous species of beetles belonging to the genus elater. Upwards of sixty different species of this destructive insect are known in Britain, and the same numbers in Massachusetts,[2] and it is probable that they are equally numerous in this country. These larvæ feed upon the roots and the under-

(1) Called also *Agriotes lineatus*; *Agriotes*, &c., and *Cataphœzus lineatus*; *Cataphœgus*, &c.

(2) Harris.

ground stem of wheat, indian corn, the grasses and most varieties of cultivated vegetables. They continue in the larvæ state for several years, and where they prevail are excessively injurious to growing crops.

184. Wire worms have a long, slender and very tough cylindrical body, composed of twelve segments, with six feet attached to the three segments next the head. The length of the larva of *Elater lineatus* is about an inch, colour yellow, head more inclined to brown, skin tough and rigid, legs conical, body smooth, with a few scattered hairs.

185. The pupa is whitish, with two black spots over the eyes, it is about a quarter of an inch in length. At the extremity of the abdomen are two short spines, terminating the tenth ring of which it consists.

186. The perfect insect or beetle is one of those popularly called "snapping bugs;" colour brown, legs dark yellow, length of body a third of an inch.

187. Sometimes the wire worm is found in such destructive abundance that it cuts off most crops as fast as they appear two or three inches above the surface. Under such circumstances, starving them out perhaps is the only remedy; a field kept perfectly free from vegetation can afford them no nourishment, and they must either perish or forsake the field in search of food. Crops of white mustard seed are particularly obnoxious to this insect and have frequently succeeded in eradicating them. It is questionable, however, whether the remedy in this country would not prove as terrible as the disease; every one knows what a noxious weed the mustard becomes where land is not kept clean.

188. Liquid ammonia has been tried with most favourable results for the destruction of this insect. Also, steeping wheat seed in wine and then drying it with sulphur has been strongly recommended, but although the sulphur may and does prevent

the wire worm from destroying the young root, yet it can have no effect in protecting the stem which is so frequently cut off. Ammonia, even in a state of great dilution, kills the worm, which brine fails to do. Under all circumstances, the most certain method of conquering the wire worm is to starve him out by frequent ploughing and keeping the land perfectly clean.

189. Sir Joseph Banks suggested the burying of slices of potatoes and turnips strewed over the field as traps to catch the worms. The insectiverous birds are perhaps among the greatest enemies of these ravenous depredators. In Europe they are preyed upon by an ichneumon parasite, also by a small black shining beetle, (*Steropus madidus*) and several other insects.

189(*a*). The Hon. A. B. Dickenson, in an address delivered before the Cortland County Agricultural Society, 1854, thus facetiously describes his efforts to destroy the wire worm; "ploughing late in the fall will not kill all of them, but most of them. In three years, I think they may all, or nearly all be destroyed, and it is the only remedy I know of to destroy the most mischievous and ruinous of insects the farmer has to contend with. I have heard it said that five bushels of salt to the acre would destroy them, or 100 bushels of lime. I have tried both, and have sowed 10 bushels of salt to the acre, and they only laughed at my folly, and tried 100 bushels of lime, as recommended, and they fattened on my bounty. I have only proved one remedy for the rascals, and that is to break the sod, and sow it with buckwheat; plough late and as often as possible in the fall, and then sow peas in the spring; with the like ploughing next fall, they will not disturb any crop the next season."

CHAPTER VI.

Rust—Smut—Pepper Brand—Ergot.

Rust, 190.—Devastating character of this enemy to wheat, 190.—Notices of the appearance of rust in the United States and Canada, 192, 197.—Isolated tracts of country affected, 198.—Description of Rust, 199.—Mode of growth and nutrition, distinction from mildew, smut, bunt, and other fungi, 199.—Magnified drawing of rust on wheat, 199(a).—Description of the fungus, showing spores and mycelium, or organs of reproduction and organs of nutrition, 199(a), 199(b).—Description of fungi generally, 200.—Conditions of the growth of fungi, 201.—Necessity for abundance of Ammonia, 201.—Description of the cuticle and epidermis of plants, on which fungi appear, 203.—Stomata, their functions, 204.—Cellular tissue, its mechanical composition, 204(a).—Mode in which water passes through plants, 205.—Evaporation and exhalation, 205.—Exhalation, 206.—Influence of *light* upon the opening of the Stomata, 208.—Evaporation, independent of vitality; exhalation in a measure dependent upon vitality, 210.—Under suppressed evaporation and exhalation, the juices of plants stagnate and become fitted for the growth of fungi, 211.—Conditions favourable to the growth of Rust, 212.—Ammonia in the atmosphere, 212.—Nitric acid in the atmosphere, 212, 213.—Effect of free Ammonia on vegetation 214.—Growth of fungi in foggy weather, 215.—Presence of Ammonia in fogs, 216.—Conditions for the appearance of rust fulfilled, 216.—Rust prevalent on new land, reason of this, 217.—Remedy for Rust, 218.—Powdered charcoal as an absorbent of Ammonia, 218, 219.—Quantity of Ammonia in the atmosphere, 220(a).—Water absorbed by the roots of plants alone, 220(b).—'Cure' for mildew; also, 'cure' for Rust, 221.—Influence of salt—of sea air, no Rust on sea coasts, 221.—Chemical action of salt with regard to Ammonia, 222.—Mode in which salt operates in arresting Mildew and Rust, 222.—Johnson's explanation of the action of salt erroneous, 223.—In the portions with water described it acted as a poison, 222.—Mr. Theodore Perry's experiments with salt, 223(a).—Dr. August Voelcker's experiments with salt, 223(b).—Effect of salt on wheat, 223(c).—Early sowing of prepared seed one of the best remedial measures, 224.—Connection of Rust with Ammonia exemplified, 225.—Rust not found on unexposed parts of the wheat plant, 226.—Size of the sporules of certain fungi, 226.—Size of the sporules of Rust, 226.—Professor Henslow's opinion that Rust is a miniature form of mildew.—Rev. Mr. Sidney's opinion, 227.—It is probable that American Rust is not identical with the European, Rubigo, 227.—So called Rust proof wheats, 228.—Virginia White May, Siberian wheat, Black Sea, Piper's set wheat, protection wheat, 228.—Valuable instance of checking the progress of Rust by Toronto Gas Lime, and rationale of its operations; early taking of the crop, 229(a).

Smut—Bunt Ear, 230.—Remedial Measures; commission at Rouen, 231.—Soda and lime, 231.—Meltzer's method of steeping and preparing seed, 232.—Rationale of washing in pure water, 232(a).

Pepper Brand—Bunt; stinking rust; characters, 234.—Appearance of a grain affected, mode in which the sporules enter, 235.—M. Bauer's experiments, 235.—Common effect of the mycelium of a fungus, 236.—Rationale of the use of certain steeps, 237.

Ergot—Cockspar; nature of this body no longer a mystery, 238.—Early opinion regarding, 238; M. Tulasne's opinion and discovery. 238(a).—Medical effects of ergot, 240,—Localities where it appears, and dreadful results from the consumption of ergoted wheaten bread in England and rye bread in France and Germany, 241.—Ergot common in pastures when undrained; common in certain grasses.

Rust—Uredo Rubigo.

190. Many eminent American agriculturists consider 'rust' to be the greatest enemy which the farmer has to encounter in the cultivation of wheat on this continent. Compared with the ravages it sometimes occasions, the depredations of the Hessian fly and wheat midge fall into the second rank. Its attacks are so unexpected and universal that it has been likened to a sudden whirlwind of blight, which sweeps over thousands and tens of thousands of square miles of country in the short space of a single night. 'Struck with rust' is an expression more common and more to be feared than that frequent visitation in the early spring months, which we are accustomed to hear deplored under the term, 'nipt by the frost.' "In the Northern States generally it produces more disaster to the wheat crop, than all other diseases and all insects put together."(1)

191. It is quite needless to enumerate the different theories, as they are termed, which have from time been advanced, to account for the appearance of rust. Every purpose will be answered for the objects contemplated in this essay, if the origin of rust be traced and described. It will be useful to enumerate a few instances of the appearance of rust in the United States and Canada.

192. In 1837 rust was common in many parts of the States. Its appearance was preceded by very hot weather, followed by rain. In many districts the wheat crops were suddenly and totally destroyed.

193. In 1840 an extensive rust blight occurred in Northern

(1) Prize Essay, N.Y. S.A.S., John J. Thomas, 1843.

Indiana, affected with almost equal destructiveness all kinds of wheat crops, and on all sorts of soil.

194. From 1840 to 1846, rust was common and most destructive in the States of the Union, but in 1847 little complaint was made of its ravages.

195. In 1849 it was very destructive. Mr. A. Ruff of Xenia, Ohio, states that rust destroys much wheat and has been constantly increasing for the last 12 years.(1)

196. During the same year, and on the same authority, we read: "The enemies of wheat in this vicinity (Racine) are the weevil, mildew, and rust, the last having the present season destroyed one-half of the crop.

197. In 1850 rust caused almost an entire failure of the wheat crop, in all North-western Virginia. Every year more of less rust is found in the States and Canada. It is, indeed, everywhere prevalent, and we are always liable to rust years. It is equally common in the high northern as in the middle wheat growing States. In 1855 and 1856 it occasioned considerable damage to the wheat crop in the County of Saguenay, C.E., common in Thorah, Canada West.(2)

198. It often happens that the crops over isolated tracts of country are affected, generally in stripes, narrow and long. These stripes are found to lie in valleys, or low situations; on new land rust is very destructive, the experience of every Canadian farmer will serve to assure him of the tendency 'to rust' exhibited by crops grown on virgin soil or new land in low damp situations.

199. Rust is a fungus, a minute vegetable growth, which throws that part of its structure serving the purposes of roots through the tissue of the wheat plant, and lives upon the nou-

(1) P. O. Report, 1849.

(2) Rust has occasioned the almost entire destruction of the wheat crop in part of this township, during its universality. It is everywhere prevalent in America.

rishment which should be appropriated by the growing grain. Before proceeding further with a description of 'rust,' it is essential to acquire information respecting the structure, mode of growth and reproduction of the tribe of vegetables called fungi.

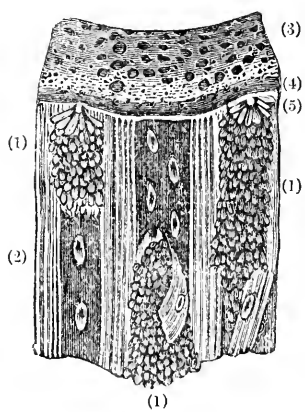
Mildew is occasioned by a minute fungus called *Puccinia Graminis.*

Rust is the growth of two kinds of fungi, *uredo rubigo* and *uredo linearis.* It is probable that the rust of this country differs from the 'rust' in England, certainly there is a great difference between the appearance of the fungus on growing wheat stems here, and the delineations given in European works on this subject.

Smut, is *uredo segetum.*

Bunt, is *uredo fœtida* ; 'stinking rust.'

199(a). Many other fungi prey upon other vegetables. Mr. Berkeley thought that the potato disease was due to a parasitical fungus found in the haulm, the *botrytis infestans.* Martius also ascribed the potato malady to a fungus, differing from the one last named.



SECTION AND PORTION OF A STALK OF WHEAT AFFECTED WITH RUST.

(1) (1) (1) Masses of the Rubigo. (2) Stomata, or breathing pores. (3) Cellular tissue. (4) Cuticle. (5) Epidermis.

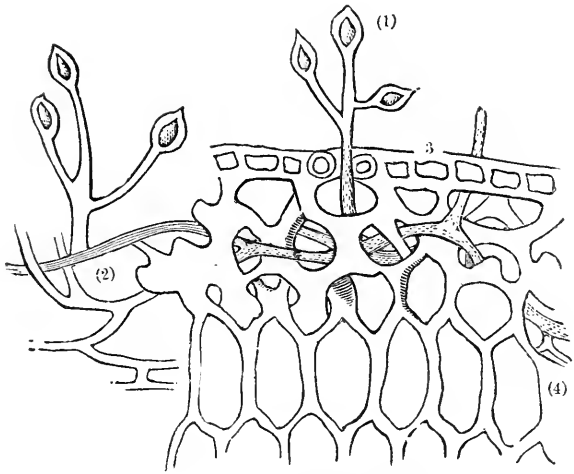
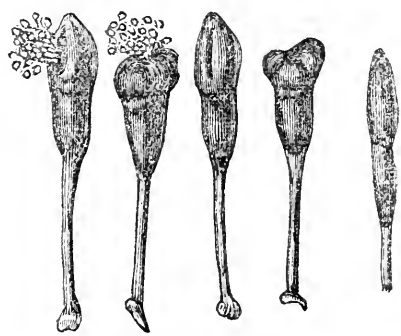


FIG. 1.—BOTRYTIS INFESTANS.

(1) Head, or spores of the fungus. (2) Mycluim, or spawn. (3) Cuticle of leaf of potatoe. (4) Cellular tissue.

The figure shows the manner in which the mycelium or spawn of the fungus ramifies through the cellular tissue of the leaf.



(1) UREDO RUBIGO (*Common Rust.*)

200. The minute vegetable organisms called *fungi*, are cellular plants having neither leaves, stems nor roots. Their organs of nutrition consist of a series of filaments called the *Mycelium* (fig. 1, 2), (*mykes*, a fungus) or spawn, which spread like a net-

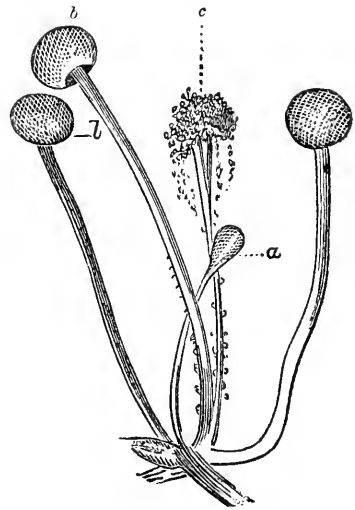
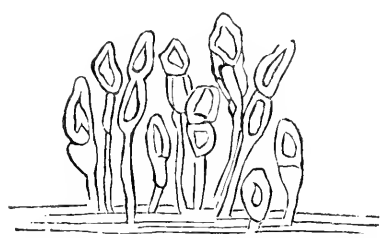


FIG. II.—FUNGUS (SMUT) FOUND ON ROTTEN POTATOES, VERY SIMILAR TO RUST.

(*a*) Young head, or spore. (*b*) More matured state. (*c*) Shedding or scattering the seeds or sporules.

work through the substances on which the fungi grow. They represent the roots of the fungus. From this network proceed bodies resembling globes, (fig. 1) circular disks, mitres, cups and coralline branches, which bear the organs of reproduction.(1) The



(2) PUCCINIA GRAMIUS (*Common Mildew.*)

(1) Ency. Brit., 8th Edi.

mycelium is developed either under ground, or in the interior of the substance on which the plant grows. The filaments of the mycelium are composed of elongated colourless cells. Fungi are propagated by seeds or *sporules* enclosed in sporule cases or spores (*b*, *c*, fig. II.)

201. Fungi most commonly grow upon vegetable or animal substances in a state of decomposition. They require a very large supply of carbonic acid and *ammonia* for their nutrition. The proportion of nitrogenous matter contained in their tissues is much greater than in those of any other vegetable; so that their substance, if capable of being digested, is almost as nutritious as flesh.(1)

202–3. All cultivated plants are covered with a membrane, termed the *cuticle*, and composed of cellular tissue (fig. I, p. 113.) The cells of the cuticle are filled with a colourless fluid, and their walls are thickened on the outside with a deposit which is usually of a waxy nature and nearly impervious to moisture. In plants growing in temperate climates, the cuticle is composed of a single row of thin-sided cells, in tropical plants several layers of thin-sided cells occur, evidently with a view to resist, by their non-conducting power, the great heat of a tropical sun. Externally to the cuticle, there is an exceedingly delicate transparent membrane called the *epidermis*.

204. In particular parts of the cuticle of nearly all plants, minute openings exist which are termed *stomata*; these may be opened or closed by an alteration in their form. They are not found upon the roots of plants, on the ribs of the leaves, or in plants growing in darkness, but they exist in general on all leafy expansions. They are most abundant on the under surface of leaves, except when these float on water, and then they are found

(1) Carpenter. Prin. of Comp. Physiology.

on the upper side alone; but they exist equally on both surfaces of erect leaves, as in the lily tribe and grasses.(1)

204(*a*). Cellular tissue(2) exists in all plants, and composes a large portion of turnips, carrots and other fleshy roots. It constitutes the pith and outer bark of trees, and the central part of rushes. The little cells of which this tissue is composed vary in size. They are found from $\frac{1}{1000}$th to $\frac{1}{100}$th part of an inch in diameter. The general average diameter is from $\frac{1}{20}$th to $\frac{1}{100}$th of a line, and that of the cellular spores of fungi $\frac{1}{500}$th of a line or $\frac{1}{6000}$th of an inch in diameter.

205. Vapour of water passes from the surface of plants in two ways, either by *evaporation* or *exhalation*. Evaporation from the surface of plants is dependent upon the moisture in their tissues, the temperature of the air and the dew point. When air is saturated with moisture, or in other words, when the dew point is the same as the temperature of the air, evaporation from the surface of plants ceases. It is entirely independent of vitality. Exhalation is a function of the plant; is altogether dependent upon vitality, and bears a strict relation to the number of stomata on the plant.

206. Exhalation is greater in summer than in autumn, and is much less active during the winter than at other periods of the year. A laurel parts with as much fluid in two days in summer, as during two months in winter.(3) Hales found that a common sunflower transpired on an average 20 oz. a day. The weight of the plant was 3lbs., its height $3\frac{1}{2}$ feet, and the surface of its leaves 5,816 square inches. On one warm day it exhaled as much as 30 oz. of fluid; on a warm dry night 3 oz.; when the *dew* was *sensible*, though slight, it neither *lost* nor *gained*, and by heavy rain or dew it gained 2 or 3 oz.(4)

(1) Carpenter. (2) Called also *Parenchyma*. (3) Guettard, quoted by Carpenter (4) Quoted by Carpenter, Prin. Comp. Physiology.

207. These and numerous other experiments establish the fact that exhalation from the stomata is greatly dependent upon the moisture of the atmosphere, and that an atmosphere saturated with moisture totally arrests this function in plants. Light exercises a most important influence upon exhalation, for it has been established that if plants in which the process is being vigorously performed be carried into a darkened room, the exhalation is *immediately stopped*, and that the absorption by the roots is checked almost as completely as if the plant had been stripped of its leaves.[1]

208. "It would not seem improbable, then, that the effect of light is confined to the *opening of the stomata*, which it is believed to effect; and that the large quantity of fluid discharged from them may be due to simple evaporation from the extensive surface of succulent and delicate tissue which is thus brought into relation with the air, and to the constant supply of fluid from within, by which it is maintained in a moist condition." [2]

209. As is shown in the foregoing paragraphs, evaporation may take place from all parts of the surface of a plant in small quantity when air is not saturated with moisture; and in the absence or presence of light, it is, in a word, independent of vitality. Exhalation, on the contrary, is dependent not only upon the dryness of the atmosphere, but upon the opening of the stomata of the plant under the influence of light, it is therefore so far subordinate to vitality.

210. The stomata opening under the influence of light, the rise of the sap[3] in plants becomes due to evaporation and the pressure of the atmosphere. "By the evaporation of water at the surface of plants, a vacuum arises within them, in conse-

(1) Senebier, quoted by Carpenter. (2) Carpenter, Prin. Comp. Physiology.
(3) The rise of the sap in spring is probably greatly increased by a species of germination liberating gas in the plant.

quence of which water and matters soluble in it are driven inwards, and raised from without with facility; and this external pressure, along with capillary attraction, is the chief cause of the motion and distribution of plant juices."[1]

211. When the plant has taken up a maximum of moisture, and evaporation is suppressed by a low temperature, or by continued wet weather, the supply of food, the nutrition of the plant ceases; the juices stagnate, and are altered; they now pass into a state in which they become a fertile soil for microscopic plants.[2] When rain falls after hot weather, and is followed by a great heat without wind, so that every part of the plant is surrounded by an atmosphere saturated with moisture, the cooling due, to further evaporation, ceases, and the plants are destroyed by fire-blast or scorching.[3]

212. I now proceed to consider the conditions favorable to the growth of rust, whose spores and sporules are at all times floating in the air. Having already discussed this subject at some length before the Horticultural and Agricultural Central Club, at Toronto, in April, 1856, I venture to append the views of the rapid appearance of rust then advanced, with some additional proofs and remedial suggestions.

212. Ammonia, we know, exists in the atmosphere, probably to the extent of one part in ten million parts on the average. At times the quantity of ammonia present is much greater than the above ratio, at other periods less. Rain water contains on an average nearly one part of ammonia to the million, and of nitric acid about five parts to the million.[4] Dew always contains ammonia, and mists have prevailed so rich in this substance that the water had an alkaline reaction. Barral analyzed the water

(1) Leibig on Hales' Experiments—"Motion of the juices in the animal body."
(2) Leibig on the motion of the juices of the animal body. (3) Ibid.
(4) Experiments of Dr. Gilbert and Mr. Lawes.

collected in the rain guage of the observatory at Paris. He found that in one year 10.74 lbs. of ammonia fell with the rain, and 10.7 lbs. of nitric acid. In July he found the amount of the ammonia to be the greatest; in September, the amount of nitric acid to be the greatest. The ammonia was least in March, and increased gradually to July. In August it diminished suddenly, and continued to diminish until October, attaining its second maximum in February.

213. These observations, although very interesting, are not satisfactory, because they were made in the neighborhood of a great city. Hence we find that Boussingault discovered much less ammonia in the air far away from towns—a gallon of rain water containing only one twenty-fifth of a grain of ammonia. As a general fact, however, the water collected during fogs was extraordinarily rich in ammonia, containing on an average one-third of a grain to the gallon—but an instance has been known —before referred to—of a gallon of water from a fog containing not less than four grains of ammonia. The constant presence of this substance in the atmosphere is not only now fully established, but its influence upon vegetable growth in this gaseous form is of the highest interest, and possibly, of the highest importance.

214. The experiments of M. Ville upon the effects of ammonia in air upon vegetation, show how rapidly and remarkably its influence is felt. If ammonia be artificially introduced into air in the same proportional average as carbonic acid is found to be constantly present, namely, about one part in 2500 parts of air, its influence soon shows itself upon the leaves, which continually acquire a deeper and deeper tint. The presence of such ammoniacal vapours not only stimulates vegetation, but changes the growth of the plant, and causes the developement and enlargement of particular organs. In prosecuting a series of experiments on the phenomena of vegetation, with a view to ascertain

whether nitrogen was directly absorbed from the atmosphere and assimilated, M. Boussingault observed the growth of minute green cryptogamia on the outside of the flower-pots, which had been exposed to the air, but he failed to detect any vegetable growth on those from which fresh air had been carefully excluded.

215. The sudden growth of varieties of fungi during misty weather has often been noticed, and their appearance may be accelerated by the introduction of a small quantity of vapour of ammonia into any confined space where they are observed. I am not aware that any extensive experiments have been made upon the growth of fungi in an atmosphere rich in ammonia, such as certain fogs. I have, however, remarked with surprise their absence in an atmosphere from which ammoniacal vapours were probably abstracted by powdered charcoal, without, however, drawing any conclusions from the observation until attracted by the curious discovery of M. Boussingault, that fogs are eminently rich in ammonia.

216. The presence of a large quantity of this important plant food in certain fogs is not difficult to account for. Not only does the gradually increasing quantity of aqueous vapour in the atmosphere before the positive appearance of mist in any locality, collect and condense rare and widely diffused ammoniacal vapours, but the exhalations from the soil produced by decomposing vegetable matter, are arrested and accumulate. The period of the year when fogs rich in ammonia may be expected depends naturally upon the frequency of the fall of rain—upon the moisture of the atmosphere, and upon the winds. In Canada it appears reasonable to suppose that we may expect to find fogs rich in ammonia during the hot months of July and August, when the rain fall is not so great as in September. During these months mists frequently hang over the fields, particularly in low situations. The exhalation of vapour of water from the leaves of plants be-

ing then checked, and their juices partially stagnating in an atmosphere often rich in ammoniacal vapours, all the conditions for the appearance of the fungus called "Rust" on the stems and leaves of the cereals appear to be fulfilled.

217. It is commonly remarked that rust is most prevalent on new land; this is perhaps explained by the large amount of vegetable matter thrown into a state of decomposition by excess of air and the consequent production of ammonia. There is no doubt that much of the ammonia thus generated would combine with vegetable acids, and be fixed by clay, &c.; but some portion could not fail to combine with carbonic acid and escape into air in the form of the volatile carbonate, as is observed to a greater degree on manure heaps even where gypsum or other solid fixers of ammonia are employed to avoid it. We must regard new land as a storehouse of ammonia and other plant food, which become liable to volatilize when liberated by too free an exposure to air without proper precautions.

218. If the supposition be correct that "Rust" is mainly occasioned by the concurrence of mists or fogs in July and August, rich in ammonia, stimulating the growth of the sporules in the stagnated juices of the plants; and that the active agent in inducing the sudden appearance of that destructive parasite is really ammoniacal vapours, we have a remedy at hand which promises, when properly and carefully applied, if not entirely to check, at least so far to arrest the growth of the parasite as to claim a general trial, especially as its effects would probably prove equally availing in arresting mildew. What we require is an available absorbent of ammonia and its votatile compounds, not an absorbent which will destroy this valuable plant food, but one which possesses the property of inducing it to assume another form, perhaps equally available as a fertilizer, although of much slower action. Recent observations show that powdered charcoal

answers these requirements. Charcoal not only absorbs ammonia to an immense extent, but it also oxidizes it to nitric acid, and thus renders it temporarily inert, but not unavailable to future fertilization.

219. Powdered charcoal is distributed with the utmost ease over large areas. Being an extremely light substance and easily reduced to a fine state of division, the least breath of air is sufficient to carry it for hundreds of yards. Any one who tries the experiment of gently shaking a muslin bag, containing coarsely powdered charcoal, in a gentle wind, will find that the operation of sowing, as we may technically express it, a ten acre field, would certainly not cost one-tenth part of the labour of sowing the same field with plaster; and as that operation is not unfrequent in this country, a practical guide is at once furnished of the amount of labour the operation involves. Powdered charcoal thus sown is very uniformly distributed by the least motion of air, and its effects are marvellous. In a stable, for example, strongly smelling of ammonia from fermenting urine, an ounce of powdered charcoal, shaken by means of a muslin bag or any fine network, rapidly and uniformly distributes itself, and instantly absorbs the ammoniacal vapours. A curious instance of the action of this deodorizer occurred at Balaclava during the heat of summer, when the stench was almost intolerable in that painfully celebrated harbour. A ship load of charcoal arrived, packed in bags, and the men who were engaged in transferring the cargo to the shore were covered with the dust, as was every object in the neighbourhood—the stench which before prevailed suddenly and completely disappeared.

220. Nothing is more simple than the manufacture of charcoal—a few billets of wood are to be piled like cordwood, then well covered with sods, with the exception of two orifices, one to admit a little fire, and the other to allow the smoke to escape,

until the heap has well taken, and then to be firmly closed for the purpose of allowing slow combustion to go on in the absence of air. When cool the charcoal may be crushed in a stout canvass bag by a lever, not by blows, and when sifted, furnishes the required material for sowing.

220(a). If we assume with Fresenius that the quantity of ammonia in the atmosphere amounts to less than one ten-millionth; the amount it would contain would exceed 50,000,000 tons, while that of the carbonic acid in the atmosphere is 3,300,000,000,000 tons, the weight of the air itself being 5,050,000,000,000,000 tons or five thousand and fifty billions.

220(b). Water is absorbed by the roots of plants alone; and the same water may repeatedly pass through the same crops, for the amount crops exhale during their growing season greatly exceeds the rainfall, hence they must derive much water from dew which is absorbed by the soil, and taken up by the roots, to be again exhaled and again deposited in the form of dew. The amount of dew may be equal to one-half of rainfall during the summer months.

221. Whatever "specific" will cure mildew, will also arrest rust.(1) Both are fungi, very nearly allied to one another, so much so, indeed, that it has been supposed by very eminent botanists that rust is merely a state in the development of mildew, and both species are produced under similar climatic conditions. Cuthbert Johnson says, "Salt, if not a complete preventive, is an effectual cure of the mildew." Mr. Chatterton, in the annals of agriculture, tells us that "on the sea side the wheat is little damaged by the mildew, yet within three miles inland the crops are as much affected as those still further from the sea." "This fact can be supported by the experience of most farmers whose fields skirt our native shores." Not only does the soil in such

(1) Mildew and rust are often found together.

situations contain an abundance of common salt, but every sea breeze bathes the growing crops near the coast in moist air, holding in solution a quantity of common salt.

222. What will be the chemical action of common salt upon the ammonia of fogs and dews? The form in which the ammonia is present is that of a carbonate; its *exact* constitution is not of the slightest consequence. As a carbonate the chemical changes which would occur are as follows:

Common salt or chloride of sodium, acting upon a carbonate of ammonia, would produce bi-carbonate of soda, chloride of ammonium, and free ammonia. The free ammonia would combine at once with free carbonic acid, and be again decomposed, and another portion fixed by the common salt present in the moist air, and so on. The real effect of the salt is, then, to fix the ammonia of fog, mist or dew, and in that way it is most probable that this substance operates so beneficially in arresting mildew and rust.

223. Johnson, in his "Essay on Salt," explains the action of this agent in the following way: "The certainty and celerity of its operation I account for thus: the mildew, it is now well ascertained, is a parasitical plant of the fungus tribe, the principal constituent of which tribe is water; when salt, therefore, is applied to them, the aqueous particles are immediately absorbed, and their vitality destroyed." The objection to this view is, that in the experiments made to test the effect of salt on mildew, it was used in a state of *solution*, in the proportion of one pound of salt to one gallon of water, so that the salt was fully *saturated* with water, and could not possibly have acted on the fungi in the manner described above. It might have acted as a poison, but its action arose, no doubt, from the fixation of the ammonia, so stimulating to mildew and rust, as described in the preceeding paragraph.

223(a). Mr. Theodore Perry tells us in the "Prairie Farmer," that he sowed one-half of a ten acre field with one-and-a-half bushels of salt, just after seeding it with spring wheat; the result was that the salted portion was ready for the sickle five days earlier than the unsalted part, and not a particle of rust or smut could be found; and the increase of crop he estimated at five bushels to the acre. The effects of salt, it must be remembered, are always rather variable and uncertain.

223(b). A number of experiments were undertaken by Dr. Aug. Voelcker, of the Royal Agricultural College, Cirencester, with a view of studying the effects of salt on vegetation in general, and a notice of the results he arrived at is to be found in the Report of the British Association for 1850. The plants selected for experiments were cabbages, beans, onions, lentils and radishes. The lentils watered with a salt solution containing twenty-four grains of salt per pint of water, were greatly improved. Grasses were affected by salt more readily than any other of the plants experimented on. Solutions containing twenty-four grains of salt, decidedly benefitted radishes, lentils, onions and cabbages. Many of the plants tasted like strong brine.

223(c). The effect of salt on wheat is said to increase the weight of the grain, and diminish that of the straw.

224. Early sowing, with properly prepared seed, to escape the time when those climatal conditions occur favourable to rust, is, perhaps, one of the best remedies which can be recommended. If to this we add the selection of flinty-stemmed varieties, whose stomata on the stalk will have in great part closed before the "time for rust," little damage may be expected in ordinary years. The use of charcoal and common salt, as before described, will serve very materially to lessen the dangers arising from the appearance of this most destructive parasite. Common salt, or

gypsum, finely powdered, may be sown broadcast; under all circumstances they will act in a favorable manner either as a partial preventive of mildew and rust, or as a manure, by fixing the ammonia of the atmosphere.

225. The connection of rust with ammonia is exemplified in many different ways. We often find, for instance, that richly manured fields are liable to rust; and where isolated patches of manure or droppings of cattle occur in a field of wheat, the grain growing on those patches will be rusted generally, but not always. Charcoal beds have long been considered "rust proof" in the United States. Liquid manure, when applied to crops, has proved very beneficial in enabling them to escape rust, while neighboring crops, manured in the ordinary way with solid farm yard manure, were much affected. In one case the ammonia would be all absorbed, in the other case part would return to the atmosphere. Damp situations, fogs, and the season of the year when the decomposition of vegetable matter is most active, and therefore the atmosphere often charged with ammonia, are all conducive to the propagation and development of this fungus.

226. Rust does not appear to be found on those parts of the wheat plant which are not exposed to air and light, such as the roots, and those portions of the stem enclosed in the sheath of the leaves. This arises from the simple circumstance that there exist no stomata in those parts which are not exposed to light, hence a species of negative evidence that a large proportion of the sporules of rust enter the stomata directly from the air, and vegetate there. Fries states that the sporules of certain fungi are so inconceivably minute that they rise like thin smoke into the air by evaporation, and are dispersed in innumerable ways. (1) He calculated that in one individual fungus the number of seeds exceeded ten millions; and Mr. John J. Thomas, of Wayne

(1) Quoted by the author of "Blights of the Wheat."

County, New York, has estimated the number of plants of rust on a single wheat stalk to be twenty millions.

227. In a paper published by Professor Henslow, in the "Agricultural Journal" for 1841, on the "Specific Identity of the Fungi producing Rust and Mildew," he endeavored to establish the position that rust, or uredo rubigo, is an immature or imperfect form of another fungus, the puccinia graminis, or mildew. The author of "Blights of the Wheat" (the Rev. Edwin Sidney) says: "All that the author can, as yet, venture to assert is, that some *puccinia* have clearly the appearance of uredo before the septum or division of the spores into chambers is fully developed." (See Figs. 1 and 2, page 113(a). The figure by Corda confirms the opinion that Mr. Sidney's observation is safe and accurate, as far as regards the British or European species. I am rather inclined to suppose that the American rust is distinct from the American species. I have often seen forms very similar to those shown in figure 3, page 114(a).

228. The following varieties of wheat have been recommended as in part "rust proof:"

1. *Virginia White May Wheat*—resembles the white flint; ripens six or eight days earlier than the white flint, and has not been injured by rust.[1] It is said to have deteriorated by culture in New York, in other words, it has become acclimated, and lost some of the properties for which it was distinguished. Fresh importations of seed are required.

2. *Pea wheat* or *Siberian wheat* "is not subject to rust,"[2] (spring wheat.)

3. *Black Sea wheat*; (spring wheat;) well known in Canada, and although much deteriorated, still supposed to possess certain immunity from rust.

(1) Emmons' Nat. His. of New York,—Agriculture.
(2) *Vide* Emmons as before.

4. *Fife wheat*—(see paragraph 161, No. 4.)

5. *Pipers' thick set wheat* is said to be the shortest and stiffest strawed wheat in cultivation. (New edi. of Ency. Brit., 1853.) It is a yellow grained, rather coarse variety, and has been introduced into Scotland under the name of protection wheat.

229. A valuable instance of good husbandry in checking the progress of rust, is related by Mr. Curtis McFarland, under date, Toronto, 1849, and will be found in the Canadian Agriculturist for March, 1849. No doubt the application of lime greatly improved the quality of the straw, and forwarded the ripening of the crop. The surface draining alluded to is also an artifice admirably adapted, as every good farmer knows, to increase the returns, improve the sample, hasten the maturity, and in many other ways benefit the crop.

"In the spring of 1845, being my first year in Canada, I went on a rented farm, in the Township of Whitchurch, on which there were three acres of fall wheat, which when harvest came I found to be very much injured by the rust. The wheat grew on dry ground, and had been early sown, and otherwise well laboured. It was fallow the first time broken up, and had received a dressing of farm-yard manure.

To endeavour to prevent this disease in my wheat crop the ensuing season, and to do so with as little outlay of money as possible, I took occasion every time I went to Toronto with the waggon, to bring back a load of lime from the gas works; this I got at about half the price I would have paid for it at the lime kilns. I kept it dry until I was going to use it, and applied about forty bushels to the acre on the fallow, harrowing it in with the seed.

Wherever I applied the lime, there was no rust in harvest, but where it was omitted there was very considerable of it.

The lime cost 6d. per bushel, thus the expense was only £1

per acre, the benefit derived was, that where the lime was used, I had thirty bushels of good sound wheat per acre, and where it was not used, I had only eighteen of poor shrunk grain. The account stood thus:—

LIMED ACRE.

To 30 bushels of wheat, at 4s.	£6	0	0
To 40 bushels of lime, at 6d.	1	0	0
	£5	0	0

UNLIMED ACRE.

By 18 bushels, at 2s. 3d.	£2	0	6
Balance in favour of limed acre	2	19	6
	£5	0	0

This I repeated the following season, and with a similar result, and I am satisfied that any person adopting the like course will find a similar result.

There is nothing from which the Canadian farmers suffer so much as from the rust in their wheat crops, and if by the simple and cheap application of a few loads of lime to every acre of fallow, and at the same time taking care that a free passage be given to carry off the surface water, they can in a great measure remedy this evil; I am certain there is no one will regret having tried it, and when they have once tried it, will continue to do so on every possible occasion."

229(a). *Early taking of the crop.*—It is now agreed on all hands that grain should be reaped before it becomes what is called dead ripe. In the case of wheat and oats, when the grains have ceased to yield a milky fluid on being pressed under the thumb nail, and when the ears and a few inches of the stem immediately underneath them have become yellow, the sooner they are reaped the better. (Ency. Bri., new Ed., 1853.)

Smut—Bunt Ear.

(Uredo Segetum.)

230. Affecting the flower of the wheat plant, and reducing the ears to black masses of sooty powder. The spores of this fungus are extremely minute. M. Bauer says, that the one hundred and sixty thousandth part of a square inch contained forty-nine of them, therefore, it would require seven millions eight hundred and forty thousand to cover a square inch of surface. How inconceivably great the number required to fill one cubic inch! and yet every field of wheat contains thousands of grains of smutty wheat. The extreme smallness of the sporules leads to the supposition that they enter the plant through the spongioles of the root, and rise with the ascending sap.

Remedial Measures.

231. In 1842 a commission was appointed at Rouen, in France, to determine the best process for the preparation of wheat for the prevention of smut. Their labours extended over several years, and resulted in the recommendation of the use of sulphate of soda, and lime, in preference to sulphate of copper, (blue vitriol,) arsenic, and other poisonous preparations. They also decided that wheat steeped in a solution of sulphate of soda, and dried with lime, yields the soundest and most productive grain. (See paragraph 117, for proportions.)

232. Metzger, in Germany, after a trial of 22 years, found only one single injured ear in all his crops, by mixing the seed with soap-suds and slacked lime. The wheat was prepared three days before it was sown, or until it began to germinate. He says, "If sown earlier after mixing with the lime it will be liable to smut."(1) The object aimed at in preparing seed wheat against

(1) See a paper on the selection, change, preparation and sowing of wheat seed, by D. J. Browne, in P.O.R., for 1855.

smut, is to wash off or kill the sporules of the fungus which adhere to the seed. Soaking in brine and chamber ley is a common artifice in Canada. The last named substance is very valuable as a quickener of germination when the moistened seed is dried by means of sulphate of lime, or gypsum, or charcoal.

232(a). The specific gravity of the spores of smut is greater than that of water, hence *well* washing in running water will remove a very large proportion of the spores; this artifice is particularly to be recommended in preparing wheat for seed as a *forerunner* of other modes of preparation. The rationale of the use of lime and other alkalies is said to be based upon the formation of a soap with the supposed oily matter which invests the smut sporules, which then admits of their being washed off by water.

Uredo Fœtida.

Bunt—Stinking Rust—Pepper Brand.

234. A fungus with a very peculiar and disgusting odour, filling the grains in which it has made a lodgment, and replacing the stalk by a black mass of spores with their mycelium attached. Under a very powerful microscope, when magnified at least one thousand times, the spores have been observed to burst and emit a cloud of inconceivably minute sporules or pepper brand seed. A grain of wheat may contain several million spores, but the numbers of sporules contained in these intelligible numbers fail to express.

235. The appearance of a grain affected by this fungus is similar, as far as external form and colour is concerned, to that of the sound grains until they approach maturity. The diseased grain is then larger, more plump, and of a dark green colour, and emits when broken a fœtid smell. From the experiments of M. Bauer, it is very probable that the sporules of this fungus

enter the roots and remain within the system of the plant until such a change occurs in the process of its development that the ovum of the future seed affords the appropriate nursery for its growth. M. Bauer found the *uredo fœtida* in the cavity of the ovum *before* the ear emerged from its sheath, and the young fungi in partial occupation. In this experiment the *seed* had been purposely inoculated.

236. The peculiar dark green colour of the infected grains is a common effect of the presence of the mycelium of a fungus. It stimulates the formation of the green colouring matter of plants called the *chlorophyle*. Hence the rich tint of the so called fairy rings, so often seen in pastures and on lawns, which are produced by fungi. Dark green patches are occasionally seen on leaves, and if the opposite under surface be examined, it will probably be seen that a fungus has established itself there.(1)

237. The investing coat of the spores is of an oily and sticky nature, whereby they adhere to the substances with which they may happen to come in contact. Hence in preparing seed the use of alkalies or substances which will make soluble compounds with the oily matter, or insoluble compounds destitute of adhesive properties may be effectually employed to disinfect the grain used for seed. The mode of steeping wheat noticed in paragraphs 232, 232(a), 231, will serve the necessary purpose. It is very probable that a large proportion of the so-called smut of this continent is nothing more than pepper-bread, and both are certainly common in our wheat fields.

ERGOTA *(Sclerotium clavus.)*—ERGOT *(Cockspur.)*

238. The exact nature of this curious substance is no longer open to discussion. The observations of Dutrochet, Léveillé, and Quekett seemed to show that ergot is a disease of the grain

(1) Berkeley, on the Potato disease.

caused by a parasitical fungus. The so-called mature ergot projects beyond the chaff-scales. Its colour is violet-black. The number of infected grains in each ear may be from one to the whole. This remarkable substance has long been a fertile subject for discussion. Its singular mode of growth, the appearance of infested grains among a host of sound ones, and the painful maladies to which the incautious use of ergoted bread has given rise over extensive areas, have all tended to clothe this distinct vegetable production with a painful and serious interest. It is popularly supposed to infest only rye; this is a dangerous error, and doubtless numerous untoward results have arisen from this belief.

238 (*a*). The enigmatical nature of ergot has lately been cleared up by M. Tulasne, who has shown that the body of the ergot, which is externally of a blackish colour and internally white, and which has been described as *Sclerotium clavus* is only the vegetative rudiment of a claviformed fungus, which is not developed until it has fallen to the earth. The fungus is very closely allied to the *Sphæriæ* growing upon caterpillars, and is described by M. Tulasne under the name of *Claviceps purpurea*.(1)

240. The medicinal effects of ergot are well known, and when taken into the animal system to a considerable extent, as in the consumption of ergoted bread or of grasses by cattle, the results are most lamentable. It originates terrible gangrenous diseases in man, mortification of the limbs, and ultimately death.

241. On undrained lands cattle have often been made seriously ill by the ergot present in the natural grasses growing there; good drainage effectually removes this poisonous disease. Many instances are recorded in England of local epidemic diseases of a most shocking description, which have been caused by the consumption of ergoted *wheaten* bread. Ergot is common in

(1.) Dr. Braun—on the diseases of plants—Journal of Microscopical Science, 1854

America, and a considerable quantity is exported to Europe for medicinal purposes besides that required for home consumption, which, it is stated, forms by no means an insignificant item of the annual production for medicinal and other purposes of this curious and dangerous substance. Ergot is common in maize. In South America mules fed on this diseased grain are said to lose their hoofs and hair. In France the consumption of ergoted rye-bread has often filled villages and hamlets with the most painful records of the diseases it is capable of engendering.

241(*a*). Dr. R. G. Latham found ergot on eighteen species of grasses, and over large areas in 1842. It is commonest on the *Lolium perenne*, rarest on the *Hordeum murinum*. The *Pheums* and *Fescues* are very subject to it, so is the *Dactylis glomerata;* in other words, some of the best pasture grasses. The *Cynosurus cristatus* is remarkably free from it.[1]

(1) Rep. of the British Association, 1845.

CHAPTER VII.

Insects affecting stored grain of Wheat.

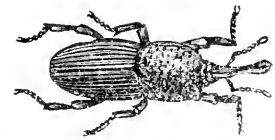
The Weevil (Calandra granaria.)

242. A snout-beetle, about one-eighth of an inch in length, with a slender body of a dull reddish brown colour, furrowed wing cases and long punctured thorax. A single pair of these insects may produce six thousand descendants in a year. They are destructive to stored grain in both the perfect and larva state. The female lays her eggs in wheat in the granary. The young maggots burrow into the grain and consume its contents, leaving only the husk. Their transformations are perfected within the husks they have chambered out in the larva state, and so secretly are their operations conducted, that it is impossible to detect thei operations by simple inspection of a heap of wheat.

243. The presence of these insects may be detected by the weight of the grains. On throwing a handful into a bucket of water the diseased grains will float. After the female has, by means of her rostrum or beak, deposited an egg in the grain, she covers it up with a sort of glue of the same colour as the husk, hence the difficulty of detecting the presence of this depredator in the granary during the time when it is in the larva state.

244. On the approach of cold weather the weevils retire from the heaps of wheat, and seek shelter in crevices and cracks of

WHEAT WEEVIL.—*Calandra Grandaria.* (*Natural Size.*)



WHEAT WEEVIL.—(*Magnified.*)

the floor and walls. They remain torpid for a while, and after having paired soon die. They avoid the light, hence one reason why constant turning of the wheat and sifting is advantageously employed to drive them away. They lie in general four or five inches below the surface of the heap, and here the majority pair. Kiln drying appears to be the only certain destruction to this pest. Frequent turning and airing of the heaps, whitewashing the walls, and keeping the granaries clean, with abundant ventilation, are artifices strongly recommended for the purpose of diminishing the numbers of this pest. It is not likely, however, that farmers in Canada will suffer much from its depredation for some years to come. Where large quantities of wheat, and particularly of foreign wheat, are allowed to accumulate in store; there, no doubt, the ravages of this insect will be felt.

245. *The Wolf, or Little Grain Moth, (Tinea Granella.)*—Mr. Curtis says that this moth is completely established in Britain, as well as in every part of Europe. The late Dr. Harris says that from various statements, deficient, however, in exactness, he was led to believe that this insect, or an insect exactly like it in its habits, prevails in all parts of the country. Since its existence is quite established in America, and its known habits are such that it may at any time appear in destructive numbers in Canada, a notice here of its general appearance and peculiarities, will not be out of place. From April till August (1) the moth is found in granaries or magazines, resting by day on the

(1) Curtis.

walls and beams, and flying about only at night, unless disturbed.

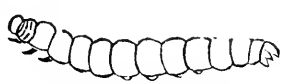
246. The female lays one or two eggs on each grain of wheat, until she has deposited thirty or more. They require the assistance of a magnifying glass in order that they may be distinguished. The small white worms penetrate grain, and close up the aperture with their roundish white excrement, which is held together by a fine web. When a single grain is not sufficient for its nourishment, the larva unites a second grain to the first by the same web, and thus ultimately adds together a great number.

247. In August and September they arrive at maturity, when they leave their wheat heaps, and seek for a place in which to undergo their metamorphosis. They form cocoons by working bits of wood into their web, in any chink of the floor, walls or roof. These cocoons look like grains of wheat dusted over. They assume a chysalis state in March, April and May, according to the season. In two or three weeks they take the form of the perfect insect or moth.

Nat. Size.

THE WOLF.—*Magnified.*

CATERPILLAR.



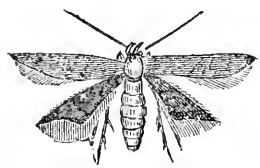
CATERPILLAR.—*Magnified.*

248. The following remedies are suggested by Mr. Curtis: Floor of granary scoured with soft soap, and well brushed with a stiff broom; roof and beams whitewashed. The moths may be destroyed in spring by burning lights or lamps in the granaries

where they abound. All cracks in the floor or walls should be stopped with plaster of Paris, and apertures for ventilation secured by fine gauze. Burning sulphur will kill the moths. Grain should be cut early to anticipate the appearance of the moth. (See Patent Office Report for 1849-50, for further information on this subject.)

249. *The Angoumois Moth (Anacampsis Cerealella.)*—In the Southern States of the American Union the larva of this moth is said to feed upon the grain in the open fields. In the Northern States it is found in granaries, and of course we may expect to find it in Canada.

250. The Angoumois moth (*b*) is a four-winged insect, about three-eighths of an inch long when its wings are shut (*a*.)



ANGOUMOIS MOTH.(1)

(*a*) (*b*)

Its upper wings are narrow, and of a light brown colour, with the lustre of satin. The lower wings and the rest of the body are ash-coloured. The female lays from sixty to ninety eggs on the ears of wheat and other grains. Sometimes the eggs are laid in the field, sometimes in the granary. They breed twice in the year, there being an early summer and an autumnal brood. Each worm, like caterpillar, selects a single grain into which it burrows, and on the flower of which it subsists.

251. The caterpillar is about a fifth of an inch long; colour white, with a brownish head; it has six small-jointed legs, and

(1) From the Patent Office Report for 1854.

ten extremely small wart-like prop legs. (1) Its chrysalis state is assumed in the grain, after having curiously provided a means of escape by gnawing a small hole in the husk of the grain for its emergence in the form of a moth.

CATERPILLAR.—*Nat. Size.*

Magnified.

252. The summer brood of caterpillars come to maturity in about three weeks, and assume the form of the moth in autumn, to propagate their kind among the stored grain. The autumn brood feed upon the contents of the granary, and remain in their pupa condition until the following summer, when they emerge and seek the young growing crops to lay their eggs.

253. Exposure to a temperature of 170° Fah., for twelve hours in a kiln, will destroy this insect in any one of its states; but, at the same time, it renders the grain useless as seed by destroying the power of germination. Mr. D. J. Browne says, in the Patent Office Report for 1854, that a very small quantity of chloroform dropped into close vessels containing these insects, destroys them in a few minutes—an artifice, however, of little practical value.

(1) See Harris' Treatise on Insects.

FINIS.

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