Cornell University—Agricultural Experiment Station.

ELEVENTH ANNUAL REPORT

OF THE

Agricultural Experiment Station,

ITHACA, N. Y.

1898.

TRANSMITTED TO THE LEGISLATURE APRIL 28, 1899.

WYNKOOP HALLENBECK CRAWFORD CO.,
STATE PRINTERS,
NEW YORK AND ALBANY.
1899.

STATE OF NEW YORK.

No. 74.

IN ASSEMBLY,

APRIL 28, 1899.

ELEVENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION OF CORNELL UNIVERSITY.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,
ALBANY, April 28, 1899.

To the Honorable the Legislature of the State of New York:

In accordance with the provisions of the statutes relating thereto, I have the honor to herewith transmit the 11th Annual Report of the Agricultural Experiment Station at Cornell University.

CHARLES A. WIETING,
Commissioner of Agriculture.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

THE AGRICULTURAL COLLEGE AND STATION COUNCIL.

JACOB GOULD SCHURMAN, President of the University.
FRANKLIN C. CORNELL, Trustee of the University.
ISAAC P. ROBERTS, Director of the College and Experiment Station.
EMMONS L. WILLIAMS, Treasurer of the University.
LIBERTY H. BAILEY, Professor of Horticulture.
JOHN H. COMSTOCK, Professor of Entomology.

STATION AND UNIVERSITY EXTENSION STAFF.

I. P. ROBERTS, Agriculture.
G. C. CALDWELL, Chemistry.
JAMES LAW, Veterinary Science.
J. H. COMSTOCK, Entomology.
L. H. BAILEY, Horticulture.
H. H. WING, Dairy Husbandry.
G. F. ATKINSON, Botany.
M. V. SLINGERLAND, Entomology.
G. W. CAVANAUGH, Chemistry.
L. A. CLINTON, Agriculture.
B. M. DUGGAR, Botany.
J. W. SPENCER, Extension Work.
J. L. STONE, Sugar Beet Investigation.
MISS M. F. ROGERS, Nature Study.
A. L. KNISELY, Chemistry.
C. E. HUNN, Gardening.
W. W. HALL, Dairy Husbandry.
H. P. GOULD, Horticulture.
W. MILLER, Floriculture.
G. N. LAUMAN, Horticulture.
A. R. WARD, Dairy Bacteriology.
L. ANDERSON, Dairy Husbandry.

OFFICERS OF THE STATION.

I. P. ROBERTS, Director.
E. L. WILLIAMS, Treasurer.
EDWARD A. BUTLER, Clerk.

REPORT.

ITHACA, N. Y., July 29, 1898.

To His Excellency, the Commissioner of Agriculture of the State of New York, Albany, N. Y.

SIR :—

I have the honor to transmit herewith the eleventh annual report of the Agricultural Experiment Station of Cornell University, in accordance with the Act of Congress of March 2, 1887, establishing the Station.

This document contains the report of the Director and the special reports of his scientific coadjutors, as well as copies of the bulletins published by the Station during the year and a detailed statement of the receipts and expenditures.

The Experiment Station of Cornell University is supported by an annual appropriation from the Federal Treasury, and its influence has, in recent years, been greatly augmented by reason of supplementary appropriations made by the Legislature of the State of New York. I believe that the showing of the Director's report abundantly vindicates the wisdom of these expenditures.

I have the honor to be your obedient servant,

J. G. SCHURMAN,
President of Cornell University.

REPORT OF THE DIRECTOR.

To the President of Cornell University.

SIR :—

I have the honor to transmit herewith the eleventh annual report of the Agricultural Experiment Station of Cornell University. The influence of the Station has been greatly augmented by reason of the funds provided in Chapter 128 of the Laws of 1897, and Chapter 67 of the Laws of 1898 of the State of New York.

This report embraces those of the Treasurer, the Chemist, the Botanist and Plant Pathologist, the Entomologist, the Agriculturist, the Horticulturist and those of the Professor of Veterinary Science and the Assistant Professor of Dairy Husbandry and Animal Industry ; together with Appendix I. of twelve bulletins; Appendix II., a detailed statement of receipts and expenditures for the fiscal year ending June 30, 1898, and Appendix III., four Nature-Study Leaflets.

The bulletins are of unusual merit and show that the work in the various divisions of the Station has been conscientiously and intelligently prosecuted. Ten of the bulletins relate directly to problems which are of interest to all farmers, and two to special industries. The aim has been to give assistance to all who are pursuing general lines of agriculture and to help and inform those who may be disposed to specialize along difficult lines which, if successful, give promise of liberal rewards.

The leaflets, four of which have been published during the year, are, we believe, effecting great and beneficial results in two ways. They give valuable information, and create in pupils and teachers a love for nature and a desire to investigate nature's laws or modes of action. The leaflets heretofore published, seven in all, have gone to many editions, and the number of people, young and old, who are being reached and influenced directly by the bulletins and leaflets is now more than sixty thousand.

Appended is a list, by titles, of the bulletins and leaflets issued during the year:

No. 138, Studies and Illustrations of Mushrooms.

No. 139, Third Report upon Japanese plums.

No. 140, Second Report on Potato Culture.

No. 141, Powdered Soap as a Cause of Death Among Swill-Fed Hogs.

No. 142, The Codling-Moth.

No. 143, Sugar Beet Investigations.

No. 144, Notes on Spraying and on the San José Scale.

No. 145, Some Important Pear Diseases.

No. 146, Fourth Report of Progress on Extension Work.

No. 147, Fourth Report upon Chrysanthemums.

No. 148, The Quince Curculio.

No. 149, Some Spraying Mixtures.

LEAFLETS 1897.

No. 1, How a Squash Plant Gets Out of the Seed.

No. 2, How a Candle Burns.

No. 3, Four Apple Twigs.

No. 4, A Children's Garden.

No. 5, Some Tent-Makers.

No. 6, What is Nature-Study.

No. 7, Hints on Making Collections of Insects.

LEAFLETS 1898.

No. 8, The Leaves and Acorns of Our Common Oaks.

No. 9, The Life History of the Toad.

No. 10, The Birds and I.

No. 11, Life in an Aquarium.

Very respectfully submitted.

I. P. ROBERTS,

Director.

REPORT OF THE TREASURER.

The Cornell University Agricultural Experiment Station, in account with the United States Appropriation, 1897–8.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1898, as per Act of Congress, approved March 2. 1887:		Dr.
		$13,500 00
	Cr.	
By Salaries	$8,537 83	
Labor	872 96	
Publications	2,147 10	
Postage and Stationery	214 84	
Freight and Express	92 19	
Heat, Light and Water	2 56	
Chemical Supplies	31 73	
Seeds, Plants and Sundry Supplies	410 91	
Fertilizers	7 60	
Feeding Stuffs	61 48	
Library	175 51	
Tools, Implements and Machinery	9 90	
Furniture and Fixtures	10 77	
Scientific Apparatus	52 66	
Live Stock	137 48	
Traveling Expenses	148 81	
Contingent Expenses	16 00	
Building and Repairs	569 67	
		$13,500 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Cornell University Agricultural Experiment Station for the fiscal year ending June 30, 1898; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $13,500.00, and the corresponding disbursements $13,500.00, for which all proper vouchers are on file, and have been by us examined and found correct, thus leaving no balance on hand.

And we further certify that the expenditures have been solely for the purpose set forth in the Act of Congress approved March 2, 1887.

(Signed) H. B. LORD, MYNDERSE VAN CLEEF, } Auditors.

(Seal)

Attest: EMMONS L. WILLIAMS (Signed),
Custodian.

REPORT OF THE CHEMIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR:—

As the Chemical work of the Station has been carried on largely by or under the immediate direction of the Assistant Chemist, I have requested him to prepare a report, which I herewith submit.

Very respectfully yours,

G. C. CALDWELL.

To the Chemist of the Cornell University Agricultural Experiment Station.

SIR:—

The work of the Chemical Division of the Station during the past year has been along the following lines:

ANALYSES.

Reported in Bulletin No. 141.	
Powdered soaps	3 samples
Reported in Bulletin No. 143.	
Sugar beets for sugar	522 samples
Beet sugar by-products	11 samples
Reported in Bulletin No. 149.	
Insecticides	6 samples
Miscellaneous (not published).	
Fodders	5 samples
Fertilizers	2 samples
Fertilizer used to test effect on colors of chrysanthemum petals	4 samples
Soils	5 samples

Progress in work unreported.

a. Investigation of the nitrogen of the celery plant.
b. Butter colors, with particular reference to aniline dyes.
c. Condimental foods; fodder analyses, detection of condiments and determination of ash ingredients.
d. Investigations on acid soils.

Very respectfully submitted,

G. W. CAVANAUGH.

REPORT OF THE BOTANIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR:—

During the past year two bulletins have been published from the Botanical Division.

Bulletin 138, "Studies and Illustrations of Mushrooms," is the first of a series of popular bulletins upon the more common edible and poisonous mushrooms. In this first one, a full but simple account of the growth and structure of the common mushroom (*Agaricus campestris*) is given, and description of the smooth lepiota (*Lepiota naucina*) and one of the deadly amanitas (*Amanita phalloides*). These plants are illustrated by about twenty-five cuts mostly from photographs.

Many letters commending the publication of such a series and complimenting the beauty and accuracy of the illustrations have been received by me, not only from persons in this country, but also from England, Germany and France. It has led to a request from several institutions for lantern slides and prints of many of the photographs of mushrooms which we have studied here, and these have been supplied to the Regius Keeper of the Royal Botanic Garden of Edinburgh, to one of the professors of Botany in the University of Berlin, and to the Director of the Field Columbian Museum at Chicago. The bulletin has been republished entire in a number of journals and papers, and several cuts have been used in numerous publications.

Illustrations are now ready for one or more bulletins of the series, and they can be published as soon as funds are available for the purpose.

The other bulletin from the Botanical Division was prepared by Mr. B. M. Duggar, the Assistant Cryptogamic Botanist of the Experiment Station, whose report I append here.

Very respectfully yours,

G. F. ATKINSON.

To the Botanist of the Cornell University Agricultural Experiment Station.

SIR :—

During the past year a bulletin on "Some Important Pear Diseases" has been published. This bulletin comprised, especially, notes upon the leaf-spot of pear, another leaf fungus, probably often confused with leaf-blight. Leaf-blight, scab, and pear-blight are also discussed and illustrated. Spraying experiments demonstrated that Bordeaux mixture may be effectually used to prevent the leaf-spot. Other more obscure and less injurious pear fungi are under observation.

Investigations upon a mold growth occurring upon the parchment paper lining and upon the wood of butter tubs have determined the conditions of growth of the fungus. Care in the selection of tubs made from well-seasoned heart wood, the storing of tubs in a dry place, and the use of the best parchment paper will probably reduce the amount of mold. Experiments indicate that the use of one per cent. formalin solution, or a very weak solution of copper sulphate on the paper will prevent the growth of mold. These results were published through the agricultural press.

Onion fields are being closely observed for the appearance of the disease known as "onion blight." In regions frequently troubled by this disease, preventive spraying experiments are now in progress.

A rot of greenhouse tomatoes has been the subject of considerable experimentation. No fungus has been found associated with the disease, and the attempt is being made to ascertain, if possible, the conditions which may induce it.

The shot-hole fungus and the shot-hole effect on leaves of peaches, plums and apricots have received some attention, and this work may be completed during the present season.

Field spraying experiments with the late blight of celery indicate that Bordeaux mixture is effective for the prevention of the disease, and that this fungicide may be used until within about five weeks of bleaching.

Studies upon some "damping off" fungi are in progress. An effort is also being made to look more carefully into the subject of the bacterial diseases of plants.

Very respectfully submitted,

B. M. DUGGAR.

REPORT OF THE ENTOMOLOGIST.

To the Director of the Cornell University Agricultural Experiment Station :

SIR :—

As the Entomological work of the Station has been performed during the past year almost entirely by the Assistant Entomologist, I have requested him to prepare a report on it, which I herewith transmit.

Very respectfully yours,

J. H. COMSTOCK.

To the Entomologist of the Cornell University Agricultural Experiment Station :

SIR :—

The work of the Entomological Division of the Station during the past year has been along the same lines as in previous years.

That is, our energies have been devoted to a careful and exhaustive study of a few insect pests, rather than to fragmentary observations upon many insects, from which one can rarely draw conclusions of much practical value to the agriculturist.

The correspondence of this Division is steadily increasing each year. It enables us to reach urgent cases quickly, and is thus one of the most valuable features of our work. Furthermore, it enables us to keep in touch, from year to year, with a corps of observers throughout the state who often render valuable aid during an insect outbreak in their locality.

Last year, the pear psylla, the apple tree tent-caterpillar, and the canker-worms ravaged orchards in all sections of the state. This year all of these insects appeared in increased numbers in many localities. Some pear growers are becoming discouraged from their apparently futile efforts to control the psylla and other insect foes. Thousands of valuable apple trees have been entirely stripped of their foliage by the apple tree tent-caterpillar, aided in many cases by its near relative, the forest tent-caterpillar.

This latter insect has also increased its ravages in the forests of many portions of the state during the past year; in many apple orchards it was equally as numerous as the former species.

It is doubtful if there was ever a time in the history of the state when the canker-worms were so numerous and destructive as during the past spring. After traveling through western New York, we are convinced that at least 3,000 acres of valuable apple orchards in Niagara, Orleans, Monroe and Wayne counties have been completely stripped of their foliage or "burned" by canker-worms during the spring of 1898. This is an alarming state of affairs, and yet but little is being done in many cases to check their multiplication or ravages. During the past year we have made a careful study of these canker-worms and the methods employed to fight them. We find that there are three other canker-worm-like caterpillars, or measuring worms, at work with the well-known fall and spring canker-worms in western New York apple orchards. We have a fine series of photographs illustrating the different stages in the lives of all five of these measuring worms; the series also include pictures of the work of the insects, of the traps used to prevent their ravages, and some flashlight photos of the moths ascending the trees for oviposition at night. During the coming year, we expect to get all of this material into bulletin form.

For several years the grape-vine flea-beetle or "steely beetle" has done much damage to the opening buds of grapes in many localities. This year the insect seems to be more numerous than ever, resulting in the destruction of the entire crop in some cases. This fact led us to undertake a careful study of the pest, with the result that some new facts have been discovered. We hope to discuss this insect in a bulletin during the coming year.

As a few new washes for peach borers have been very strongly recommended recently, we have decided to continue our extensive experiment another year to thoroughly test these washes. The results from these four-year tests of the many methods recommended for preventing the ravages of this destructive peach pest will be of incalculable value to peach growers.

During the year the following bulletins have been issued from this Division:

No. 142, The Codling Moth.

No. 148, The Quince Curculio.

And in connection with the Horticultural Division:

No. 144, Notes on Spraying and on the San José Scale.

We have prepared many articles for publication in the leading agricultural journals, and the funds from the State appropriation, Chapter 67, Laws of 1898, have enabled us to attend several important horticultural meetings, and also to do much necessary and valuable field work.

Respectfully submitted,

M. V. SLINGERLAND.

REPORT OF THE AGRICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

The work of the Agricultural Division during the past year has been very largely along the lines mentioned in my last report. The work in 1897 with potatoes was very satisfactory, and Bulletin 140, "Second Report on Potato Culture," has been issued. The results obtained verify the conclusions which were stated in the former bulletin on potatoes, No. 130.

The success of the experiments with potatoes has attracted wide attention, and many farmers of the state have adopted the Cornell method. So important is this work with potatoes that the experiments are being continued, and it is hoped that the results already secured may be still further emphasized.

The establishment of beet sugar factories in the state causes questions relating to the culture of the sugar beet to become of importance. In Bulletin 143, "Sugar Beet Investigations," were published the results obtained in 1897 not only on the home grounds, but throughout the state. The experiments of last year are being repeated, and an attempt is being made to answer some questions of importance relating to sugar beet culture.

A line of experiments has been undertaken looking towards the renovation of old pastures. Much of the land devoted to pastures is of such a nature that it cannot conveniently be tilled. Through neglect or otherwise, the pasture has become moss grown and weedy, and the soil, in many cases, is acid. If some practical way is found for renovating these pastures, it will be of the utmost importance.

Some of the field experiments, which are now under way, are a study of leguminous plants with reference to their nitrogen gathering powers; the introculture of grain crops; testing of various forage plants sent here by the Department of Agriculture at Washington, and the effect upon crop production of barn manure when shavings and straw have been used as absorbents.

What now seems to be of prime importance is that the results of our experiments should be more widely known by the farmers of the state. Where certain methods of tillage have been found superior, some means should be adopted by which these methods shall become more widely known and generally practiced. By establishing co-operative experimental plats in various sections of the state, where the Cornell methods can be illustrated, it is possible much good would result. This plan has been successfully adopted with sugar beets, and it would seem wise to adopt a similar practice with reference to some other important farm crops.

Very respectfully submitted.

L. A. CLINTON.

REPORT OF THE HORTICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

In submitting a report of the work of this Division for the year ending June 30, 1898, I beg to say, the work which was begun last year in spraying for the San José scale has been continued under the personal supervision of Mr. H. P. Gould, who has extended his work by including in his experiments a badly infested nursery. A considerable number of prepared insecticides and fungicides are being tested on orchards and various garden crops. Several orchards are also being sprayed by Mr. Gould, continuing his work of last year in this line. The third year study of the dahlia and chrysanthemum is being carried on by Mr. W. Miller with a special view to the training and manuring for the best results. A very comprehensive study of the garden pea has been taken up by Mr. G. N. Lauman, who has also under his charge perhaps the largest collection of pelargoniums ever brought together in America. This collection comprises upwards of one thousand varieties and many species, and has been collected in order to study the evolution of this genus. The experiments with fertilizers on strawberries in Oswego county, undertaken last year, have been continued, and in addition several beds have been set apart for spraying for the mildew and leaf blight of the strawberry. The work in Orange county on the culture of celery continues this year. On the Station grounds additions have been made to the varieties of fruits, a large number of scions of Japanese plums having been set. In small fruits there are recent introductions in strawberries and raspberries, most of them fruiting for the first time in this vicinity. About four hundred seedling strawberry plants are fruiting this year, these seedlings being the results of crosses made under glass in the winter of 1896–7 with a view to the fixing of character by in-breeding. In the forcing houses, the work of the year has been the growing of chrysanthemums and pelargoniums, the forcing of cucumbers, tomatoes and strawberries, the last with very marked results which will soon be published in bulletin form. The fruit trees mentioned in the last report are in condition to be forced this coming winter and a house has been arranged for forcing them.

The bulletins of this Division issued this year are:

No. 139, Third Report on Japanese plums: L. H. Bailey.

No. 144, Suggestions on Spraying and on the San José Scale: H. P. Gould.

No. 147, Fourth Report upon Chrysanthemums: Wilhelm Miller.

Very respectfully submitted,

C. E. HUNN,

In charge.

REPORT OF THE VETERINARIAN.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

Under the auspices of the Agricultural Experiment Station a series of investigations have been made into the nature and causes of contagious abortion in cows. While these were seriously restricted for lack of means, and were necessarily left incomplete, yet in reporting progress, certain points may be named as fairly indicated by the work already accomplished :

1. We failed to find in the aborting herds of New York the germ described by Bang as the cause of abortion in Denmark.

2. As the result of a very extended series of cultures from the uterine products of the aborting animals in widely different parts of the state, Dr. Moore has found in all such cases a specific bacillus, which is not found in such uterine products in the parturient cows in healthy herds, and this is, therefore, in all probability, an important factor in the production of the disease.

3. The introduction of this bacillus into the vagina of healthy cows in advanced pregnancy did not hinder such animals from carrying the fœtus the full time, but the bacillus continued to propagate itself in the vagina for months both before and after parturition. As abortions often occur at the sixth and seventh month, when the germ was presumably present at conception, this failure to cause abortion when introduced in the last half of pregnancy is not surprising.

4. Two healthy cows into the passages of which the bacillus was introduced very shortly after service, retained the germ for months, but failed to carry on gestation, the early embryo having probably passed out in a mucopurulent discharge which continued for a considerable time.

5. From extensive data collected from all parts of the state it appears that though contagious abortion often prevails in a herd for a period of ten or fifteen years, yet it is mainly in the newly purchased animals, or in animals pregnant with their first or second calf, and

hence presumably exposed to the infection for the first time. It is rather the rule than the exception that a cow does not abort a second time, and it is very unusual to have them abort a third year in succession, apart from some especial cause other than infection.

Although the cow continues to carry the germ for a length of time, she appears to become early immune from its pathogenic action on her own system, and while it is important to rid her of its presence, this is rather as a part of the general disinfection for the protection of other animals that are yet susceptible than as a means of guarding her against a new abortion.

Very much remains to be done in this field, and, to give entirely satisfactory results, a herd should be maintained under constant control and scientific observation.

Respectfully,

JAMES LAW.

REPORT OF THE ASSISTANT PROFESSOR OF DAIRY HUSBANDRY AND ANIMAL INDUSTRY.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

The work of the Dairy Division of the Experiment Station has progressed along the lines pursued in previous years. The State appropriation, Chapter 67, Laws of 1898, has furnished means for conducting Extension Work in Dairying, and for beginning investigation in Dairy Bacteriology. For this last work Mr. A. R. Ward has been chosen. Mr. W. W. Hall has done much of the work in Extension teaching, and Mr. Leroy Anderson has been a very useful general assistant through the past year.

A considerabie amount of material is now ready for publication in the form of bulletins.

Respectfully submitted.

H. H. WING.

APPENDIX I.

BULLETINS PUBLISHED JULY, 1897–JUNE, 1898.

No. 138. Studies and Illustrations of Mushrooms.
No. 139. Third Report upon Japanese Plums.
No. 140. Second Report on Potato Culture.
No. 141. Powdered Soap as a Cause of Death among Swill-Fed Hogs.
No. 142. The Codling-Moth.
No. 143. Sugar Beet Investigation.
No. 144. Notes on Spraying and on the San José Scale.
No. 145. Some Important Pear Diseases.
No. 146. Fourth Report of Progress on Extension Work.
No. 147. Fourth Report upon Chrysanthemums.
No. 148. The Quince Curculio.
No. 149. Some Spraying Mixtures.

Bulletin 138. September, 1897.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

BOTANICAL DIVISION.

STUDIES AND ILLUSTRATIONS

— OF —

MUSHROOMS:

I.

By GEORGE F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1897.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in western New York.
125. A Disease of Currant Canes.
126. The Current-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.

STUDIES AND ILLUSTRATIONS OF MUSHROOMS: No. I.

BY GEO. F. ATKINSON.

With the publication of this bulletin it is proposed to begin a series of short illustrated articles on the fleshy fungi belonging chiefly to the so-called mushroom family. While there are several thousand different species of plants belonging to this group, which are more or less striking because of size, color, or form, they seem to have attracted very little attention from people generally. There is no reason why persons who have no technical knowledge of the science of botany should not know a dozen or more of the different common species, which appear through different seasons, in the same way that they come to know some of the common birds which visit us each summer.

In cities and in the larger towns there is a growing number of persons who are able to recognize, with a fair degree of certainty, the plant which is usually understood to bear the name of "*the mushroom*," and which appears chiefly during late summer and autumn in lawns, pastures, and similar open places in fields.* This plant sometimes occurs in great abundance, and the eagerness with which it is sought, by those who know its value as a food or relish, testifies to its importance as an article of diet.

If the worth of mushrooms as food was properly appreciated, even by the inhabitants of small villages and of the country, the ability to recognize several of the common species would not be difficult to acquire by those who would give an amount of attention to the subject equal to that which they bestow upon some other natural objects.

One reason why so little is known even of the common species is because in many neighborhoods there is no one who can recognize several of them, and thus impart the information concerning the kinds, and their prominent characters, to others. A slight degree of interest

---

* In the collection of some of the material and in making some of the photographs with which this bulletin is illustrated, I have been assisted by Mr. H. Hasselbring, a student of botany.

in these objects, with some observation as to form, the parts and the color of these fungi, with some one to whom the determination of the plant might be referred for a few times, would at length enable many persons to recognize a number of the commoner species, just as they come to recognize the more common birds. Many of us come to know the common birds from childhood without any technical knowledge of ornithology. It is by observation year after year, and association with our elders, who have in a similar way come to know them, that we in turn know them.

When once there are several in a neighborhood who can distinguish a few of the commoner mushrooms, this information might be handed down to generations, so that there would be no more difficulty for those who chose to observe carefully, to learn well several of the fleshy fungi, than there would be in coming to know many of the natural objects which we learn in a similar way. One might not be able to name the technical characters of the plant, but after observing it a number of seasons, it would be known on sight, or after an examination of the several parts, when these combined would present to the mind the characters of the plant as a whole, which makes up the concept of the species in the mind of those who do not make a pretense to a study of science. In addition to this, if some attention in the schools could be given to teaching the general characters of these plants (not a technical treatment), it would lay the foundation for the gradual application of this knowledge in later observations.

Another reason why so few are able to recognize no more than one, is the general impression with many persons that there are but two species of this group, the "*mushroom*" and the "*toadstool.*" That is, many persons have the impression that there is but one "mushroom," the one which is "pink underneath," while all the others are "toadstools." Still others believe that all the members of the mushroom family can be separated into two groups, mushrooms which are edible, and toadstools which are poisonous. But this is all a mistake. There is no infallible test, like the "silver-spoon" test, nor any set of characters which will enable one to clearly separate these plants into two such groups. There are quite a number of these plants which are edible, a few which are very poisonous, a large number which are more or less indigestible, and a still greater number which have not yet been tested, and therefore their properties are not known.

Botanists do not usually recognize any distinction between mushrooms and toadstools. Either name may be applied indiscriminately to any member of the group; that is, the terms are synonymous, except that in some cases the term *mushroom* is applied to the species of commerce, and which also grows in the feral state, while the term *toadstool* is applied to all others whether edible or not. The safest way is to learn to recognize certain species even though the number be few.

So much has been written in recent years upon the value of the edible mushrooms for food and the profusion in which they sometimes occur, that there is a growing desire on the part of many people to avail themselves of this article of wholesome diet. But warned by the difficulties which beset the ordinary fungus hunter in determining the species of these plants which are to be found, as well as by the crop of fatalities recurring every season, brought forth through a mistaken mushroom identity, many are deterred from making use of the quantities of nourishing and inexpensive food growing within easy reach. When one has trained himself to recognize one or more of the common edible species with certainty, they can be collected and eaten with safety. But until this can be done it is well to give all a "wide berth," unless there is some person for "referee" whom we know to possess either the technical knowledge necessary for discrimination, or who with no technical knowledge but with long personal acquaintance with the species, knows it just as we come to know some other natural objects by careful observation. It should not be understood, however, that all who profess to be connoisseurs in the art of recognizing "toadstools" as poisonous rightly judge all the species they list among their acquaintances.

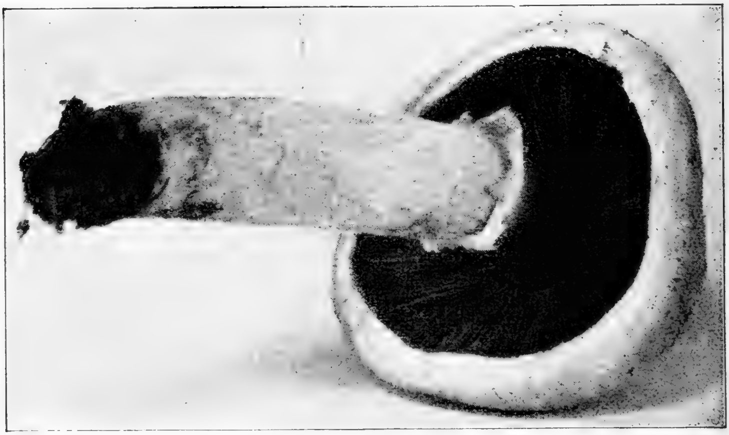
The publication in a single bulletin of careful descriptions of but a few species, with several illustrations representing the important characters and the several aspects, which the plants assume at different stages of growth, it is believed will encourage a careful study, or observation of these few, so that they will become familiar to one and easy to detect. These few facts being assimilated and the beginner having become measurably familiar with a few forms, another pamphlet devoted to a few additional species can follow with profit.

In this bulletin only three of these fleshy fungi are illustrated and described. Two of these are edible and are very common during August and the autumn months in lawns, pastures, and similar open places. The third one is a *deadly poisonous* one, and is here illustrated and described, not only because a majority of the fatalities from "mushroom-eating" are probably chargeable to its seductive appearance and virulent properties, but also because it is perhaps sometimes mistaken by the novice for the common mushroom.

THE COMMON MUSHROOM.

(*Agaricus campestris* L.)

Figure 87 is from a photograph of a specimen of the common mushroom (or pratelle) which has been pulled and is lying on the table. The parts are easily recognized and named. The stem (sometimes called the stipe) is cylindrical, or tapers a little toward the lower

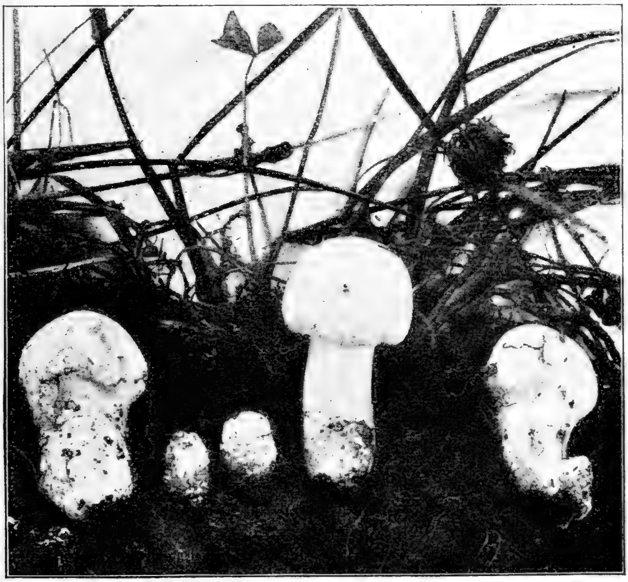


87.—*Agaricus campestris. View of under side showing stem, annulus, gills and margin of pileus.*

end. Near its upper end is a sort of a collar, usually termed a "ring" (or technically an *annulus*), which encircles it. This ring is very delicate in this plant, is white like the stem, of a very thin, satiny texture, and more or less ragged on the edge.

The more or less circular expanded disk into which the stem fits is called the "cap" (technically the *pileus*, which is the Latin for cap) The upper portion, of which we can see only the margin in this picture, is convex. (See figure 94.) The surface is usually white, though sometimes brownish, and usually is covered by a thin layer of very delicate threads, while the flesh or inner portion is more compact, and is white also

On the under side of the cap are numerous thin plates or "gills" (lamellæ), which radiate from near the stem to the margin of the cap. These are shown in figure 96 as fine radiating lines. They do not quite reach the stem, or, when they do, they are not attached to it. When

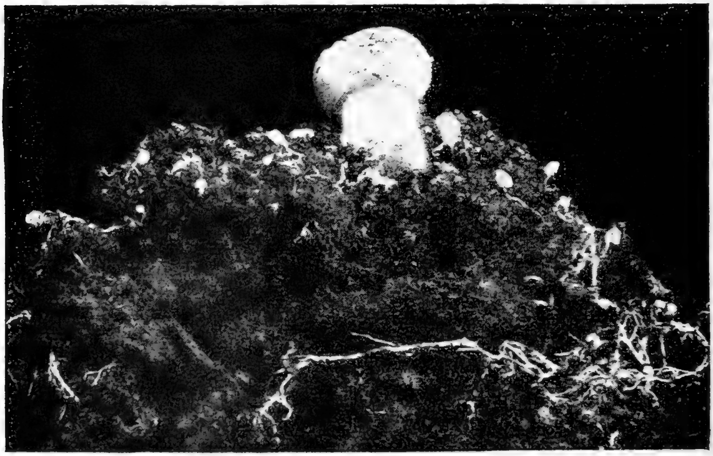


88.—*Agaricus campestris.* "*Buttons*" *peeping through the sod. Some spawn at the left lower corner. Soil removed from front.*

the plant is very young the gills are first white, but soon become a bright pink color, and in age change to a dark brown. The substance of the stem is less compact at the center, but the stem is not really hollow, though in some instances there are slight indications of it.

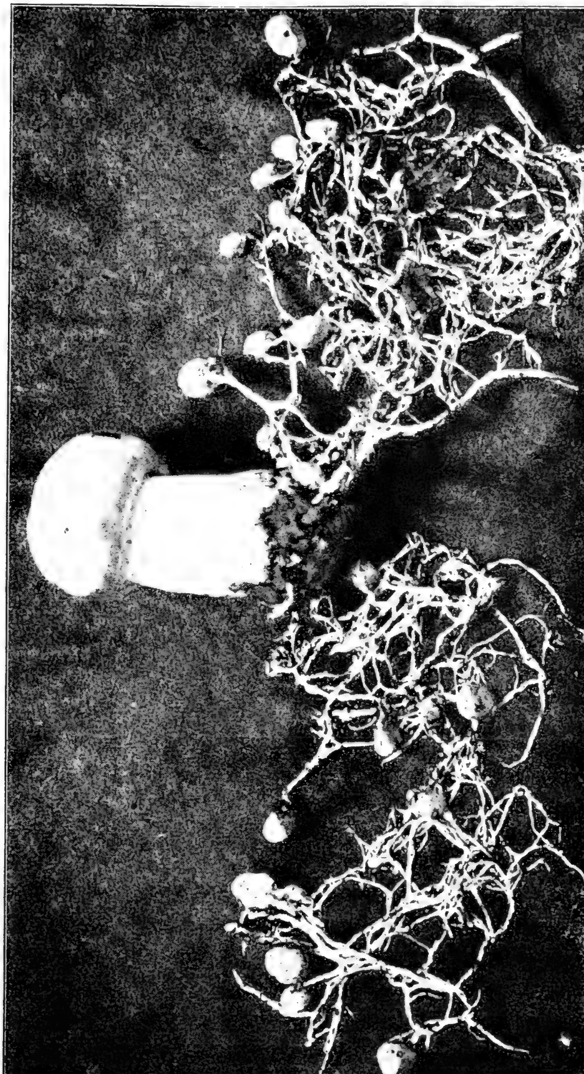
The parts of the common mushroom, then, are *cap* (*pileus*), *gills* (*lamellæ*), *stem* (*stipe*), *ring* (*annulus*). We must bear in mind, however, that there are many other plants which possess just these same parts, but that they can be distinguished by the color, form, texture, etc., of the parts. Before examining the structure of the mushroom more closely we may inquire into its history. I mean its life history; how it grows from a bit of white stuff to the size and form shown in the figure.

If we turn to figure 88 we see some quite small plants of the common mushroom, which are just peeping through the sod, and are lifting their caps among the clover and blades of grass. The earth was removed from one side before the photograph was



89.—*Agaricus campestris. Soil removed to show large "button," and numerous small "buttons" attached to the "spawn" or strands of mycelium.*

taken, so that the short stems in the soil are laid bare. At this age the plant is popularly called a "button," because of its form. Two quite small "buttons" still underneath the sod have been bared by the removal of the earth. At the left lower corner of the picture are some small white bits of mushroom stuff yet "unformed." This is known popularly as the "*spawn.*" In another photograph (figure 89) this "spawn" is better shown. This has also been uncovered. Here the spawn is shown to consist of rather coarse whitish strands, or cords. One large button is present, and scattered on either side are several minute rounded white masses. These are miniature buttons,



90.—*Agaricus campestris.* *Soil washed from "spawn" and "buttons," showing the minute young "buttons" attached to the strands of mycelium.*

and are very young. Some of them can be seen attached to the strands of spawn. Figure 60 is from a photograph of the same group, a little enlarged, after the soil has been washed away from the spawn and the buttons. Here the connection of the very young buttons with the cords of spawn can be very clearly seen. These strands or cords are made up of numerous minute whitish threads, known to botanists as *mycelium*. In the group of fungi to which the mushroom belongs, the mycelial threads are often interwoven into such strands in somewhat the same way as fibers are woven into cords or ropes, though not in such regular fashion, and of course they grow in this form. They are often spoken of as cords or strands* of mycelium. In the soil the mycelium grows and forms new strands, obtaining its nutriment from the decaying humus and other vegetable matter.

91.—*Agaricus campestris. Sections of "buttons" of different sizes, showing formation of gills and veil covering them.*

At certain points on the strands the mycelium grows to form these rounded bodies known as buttons. At first they are of the size of pin heads, and soon increase to the size of bird shot, then peas, when a minute stem begins to appear with the button growing on its free end. This increase in size, as well as the increase in the length of the stem, lifts its head and the upper part of the stem from the ground, and it rapidly expands into the mature mushroom. If we split several of these buttons of different sizes down through the cap and the stem,

* The term *rhizomorph* is also applied to these strands of mycelium.

we shall see the curious way in which the gills and the ring are formed. The photograph shown in figure 91 represents five of these stages. In the smaller ones the young gills in the sections resemble two eyelets. These have been covered over on the outside by the mycelium growing downward from the cap, and upward from the stem, the ends of the thread interlacing to form a veil which extends all around the stem covering the constricted portion at the junction of the stem with the button. If we cut across the button at this point the gills would show as a ring with the veil outside.

92.—*Agaricus campestris. Nearly mature plants, showing veil still stretched across the gill cavity.*

As the plant grows all these parts increase in size, the gills extending downward by the growth of the mycelium in radiating lines to form the plates. As the cap expands the veil is stretched and a cavity appears between the free edges of the gills and the veil. If we now look at figure 92, which is from a photograph of the underside of two nearly mature plants, we can see the veil stretched over the gills from the margin of the pileus to the stem. Here we can see how delicate the texture of the veil is, and how easily it is torn. During these stages the gills are pink in color, except in the very youngest, when they are white, unless by some accident the plant becomes old before the veil breaks. The cap now expands more and more, and the veil is ruptured, as shown in figures 93 and 94. In both of these photographs the fragments of the veil are shown clinging partly to the stem and partly to the margin of the pileus, where the dripping tender fibrils lend a weird aspect to the spectre-like plant as it lifts its head from the sod at night.

Because of the very delicate and fragile character of the veil, it does not in many cases remain clinging to the stem as a complete ring, and it is also in some cases quite evanescent. In figure 87 the

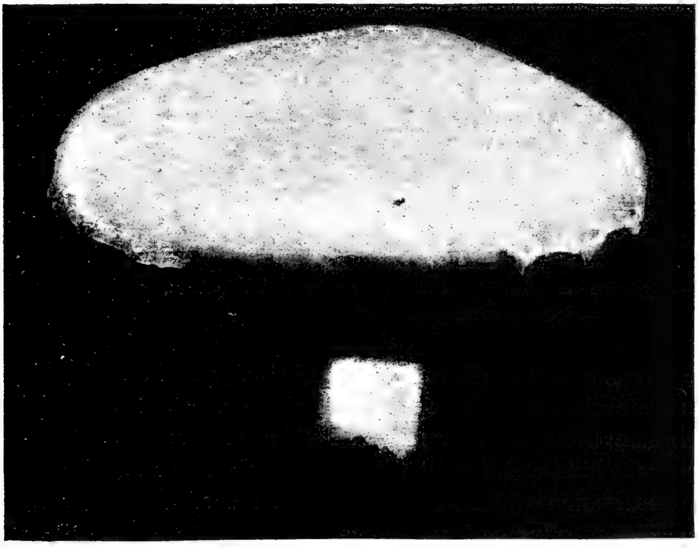
93.—*Agaricus campestris. Under view of two plants just after rupture of the veil, fragments of the latter clinging both to margin of pileus and to stem.*

ring is well formed. In figure 94, where the photograph was taken soon after the rupture of the veil, the edge of the ring has a tendency to be double where the threads break away from the inner and outer edges of the cap. In some other mushrooms this double character of the ring is quite pronounced, but here it is quite rare.

Sometimes the fibrils on the surface of the pileus are drawn into triangular patches which point outward, as shown in figure 95. This gives a scaly appearance to the surface of the pileus. While in the ordinary form of this mushroom the surface of the cap is white, often the fibrils on the surface are brownish. In one form of the plant the triangular scales are dark brown, and give it a quite different aspect. This dark scaly form sometimes appears early in the spring.

If we note the position of the gills carefully, as we can by referring to the photograph (represented in figure 96) of the under side of the pileus, it will be seen that they do not quite reach the stem and are rounded at the inner end. They are thus only attached by their upper edges to the under surface of the pileus. Between the

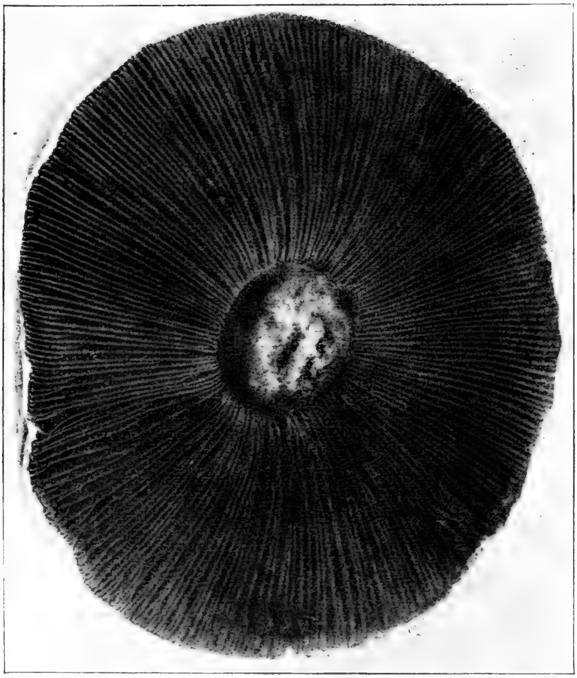
94.—*Agaricus campestris. Plant in natural position just after rupture of veil, showing tendency to double annulus on the stem. Portions of the veil also dripping from margin of pileus.*



95.—*Agaricus campestris. Plant showing loose fibrils on surface of pileus drawn into triangular scales.*

longer ones are shorter ones which reach, some only a little distance from the margin of the pileus, while others reach half or two-thirds the way to the stem. The space is thus used to good purpose, and the entire under surface of the pileus is crowded with these gills or lamellæ.

The shape of the gills as well as their position can be well seen in figure 97, which is a photograph of a longitudinal section of a mature plant. On the right is represented an entire or long gill, which reminds one somewhat of the blade of a knife. On the left are represented two of the short gills which lie in front of one of the long ones. The surface of these gills forms what is termed the fruiting surface of the mushroom, or *hymenium*.

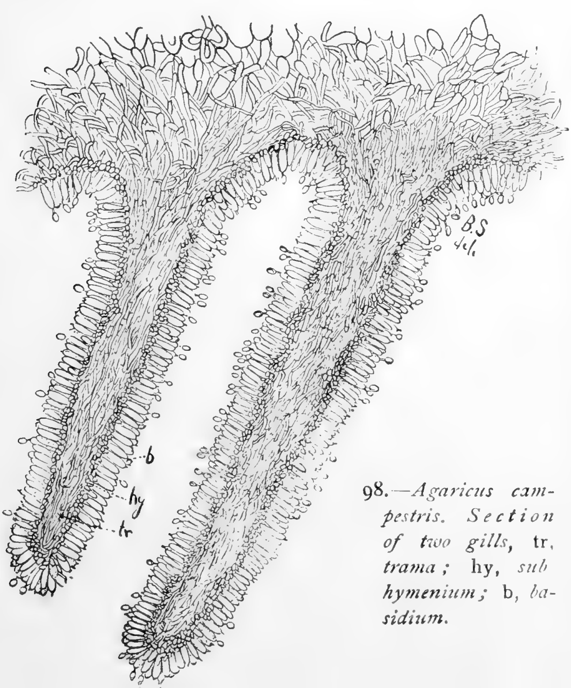


96.—*Agaricus campestris. View of under side of pileus, showing arrangement of gills.*

The structure of the gill is quite specialized, and here we find parts which are characteristic of the great group of plants to which the mushroom belongs. If we cut very thin slices or sections across a few of the gills, and mount them in water under a thin cover glass for examination with the microscope, we shall see revealed these peculiarities. Figure 98 represents such a section of two gills. We see here that even this part of the plant is largely made up of fine threads of mycelium closely interlaced and woven together. Through the center of the gills the mycelium continues down from that of the pileus. This middle portion of the gill is termed the *trama*. Just outside of this, on either side, is a layer several cells deep of short cells termed the *sub-hymenium*. From the cells of the sub-hymenium are borne the club-shaped bodies which

97.—*Agaricus campestris. Longitudinal section through stem and pileus:* a, *pileus;* b, *portion of veil on margin of pileus;* c, *gill;* f, *fragment of annulus;* e, *stipe.*

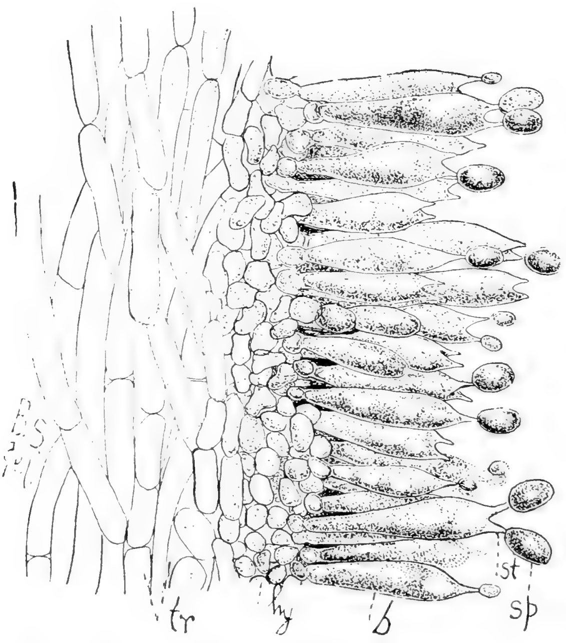
stand closely parallel in a layer on each surface of the gill forming the *hymenium*. Each of these club-shaped cells is termed a *basidium* (the Latin word for club) Each basidium bears at its free extremity two slender processes, which lend to the basidium a forked appearance. Each one of these pro-



98.—*Agaricus campestris. Section of two gills,* tr, *trama;* hy, *sub hymenium;* b, *basidium.*

cesses is termed a *sterigma** (plural, sterigmata). Each sterigma bears a spore, which is a nearly rounded or oval body, so that each basidium in the common mushroom (*Agaricus campestris*) bears two sterigmata and two spores, while in a majority of the members of the group the basidia bear four sterigmata and four spores.

At maturity these spores easily fall away from these little forked processes (sterigmata) and give a dark brown coating to the objects on which they fall. The spores are purple brown in color, and as they mature, their number on the surface of the gills accounts for the dark brown color of the latter. One can obtain what is sometimes called a "spore-print" of the under surface of the mushroom, or arrangement of the gills, by cutting off the stem and placing the pileus on white paper for a few hours. It should be placed where there are no drafts of air and covered with a bell jar or other closely fitting vessel to avoid the shifting currents of air, since the spores are so light they would not fall perpendicularly, but drift and thus confuse the print. A photograph of such a spore-print of *Agaricus campestris* is shown in figure



99.—*Agaricus campestris. Portion of gill in section;* tr, *trama;* hy, *sub-hymenium;* b, *basidium, layer of basidia forms hymenium;* st, *sterigma;* sp, *spore.*

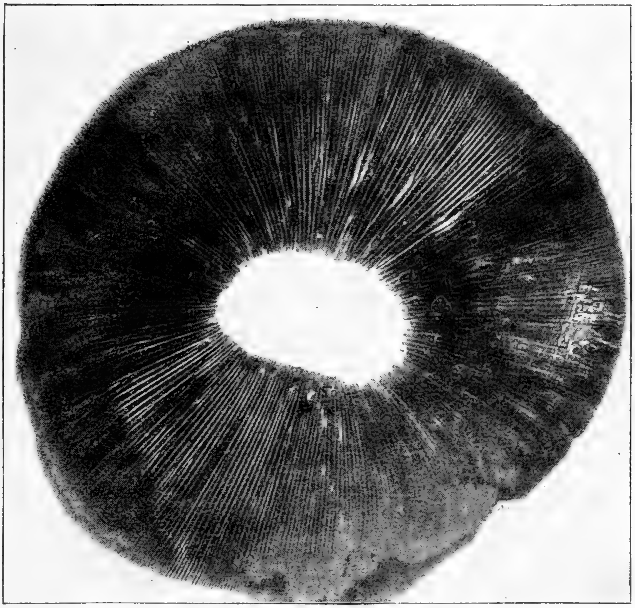
* Pronounced ster-ig′ma; ster-ig′ma-ta. Figures 98 and 99 were drawn from nature by Dr. Bertha Stoneman.

100, the dark lines representing the long heaps of spores where they fell from the surfaces of the gills.

BRIEF DESCRIPTION OF AGARICUS CAMPESTRIS.

The common mushroom (*Agaricus campestris*) grows in lawns, pastures and similar places. It averages 5–8 cm. (2–3 inches) in height, the pileus being 5–12 cm. in diameter.

Pileus.—The cap or pileus is convex or more or less expanded, the surface being nearly smooth, or more or less silky hairy, these fibrils



100.—*Agaricus campestris. Spore-print.*

sometimes being collected into triangular scales. The color of the surface is usually white, but varies to light brown, while the flesh is white.

Gills.—When the plant is very young the gills are first white, but soon become pink, and later purple brown or dark brown from the numerous purple colored spores on the surface. The gills are free from the stem, and rounded on their inner ends.

Veil and Annulus.—The veil is thin, white, silky and very frail. As the pileus expands, the veil is stretched and finally torn, when it clings as a thin collar or ring (annulus) around the stem, or fragments dangle from the margin of the pileus. As the plant becomes old, the annulus shrivels up and becomes inconspicuous.

Stem or Stipe.—The stem is white, nearly cylindrical, or slightly tapering at the lower end. It varies from 3–8 cm. long and 1–2 cm. in diameter. The flesh is solid, though less firm at the center.

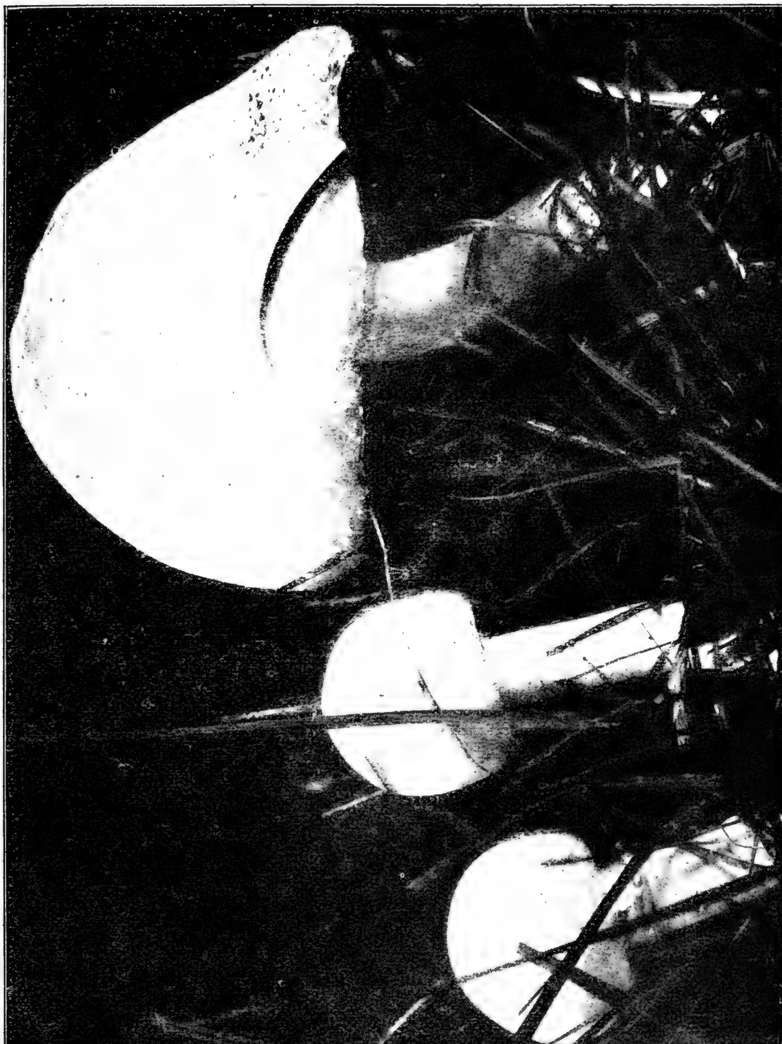
GROWTH OF THE MUSHROOM.

The mycelium in the form of delicate threads or stouter strands (called spawn) lives in the soil, absorbing in solution certain of the substances of decaying vegetable matter, which it appropriates for growth and increase. It lives here for several months, or in some cases for years, before developing the fruiting portion which is the "mushroom." This first appears as a minute rounded mass on the strands of mycelium. It grows in size to form a "button" with a stem. The young gills are formed by the mycelium growing downward in radiating ridges from the under side of the margin of the button, the gills at first being covered by a delicate veil of interlacing threads. As the pileus expands it bursts through the sod, ruptures the veil, when the characters of the fully formed mushroom appear.

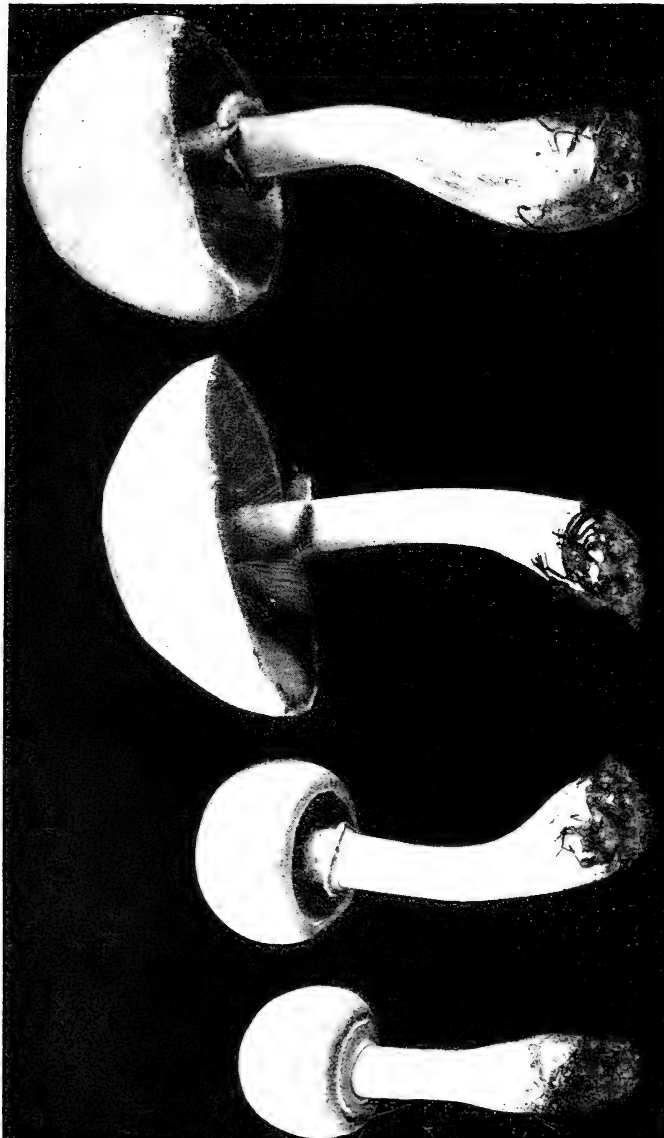
LEPIOTA NAUCINA FR.

The next mushroom, or toadstool, described here is one which occurs during the same season as the *Agaricus campestris* (common mushroom), and in similar localities, *i. e.*, in lawns, pastures, etc. It is known as *Lepiota naucina*, the short stemmed parasol, or smooth *Lepiota*. Because of this similar seasonal and local occurrence it might at first be taken for the *Agaricus campestris*, especially since the plant is about the same size, is usually white or light tan, and possesses an annulus. The gills, however, are white from the youngest stages to maturity, only becoming pinkish when very old, and drying a light brown or dirty pink.

A photograph of this plant as it occurs in lawns is represented in figure 101. On looking at the gills of a freshly growing plant one would readily distinguish it from *Agaricus campestris*, because of their white color. The spores of this plant are white, as one can readily

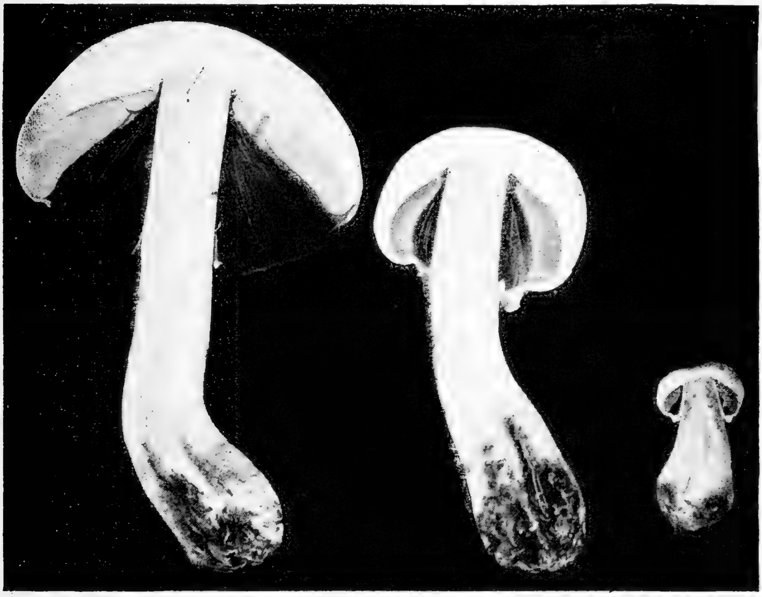


101.—*Lepiota naucina. Plants natural size in lawn.*



102.—*Lepiota naucina.* *Plants natural size in four stages; showing formation of annulus from veil.*

determine by making a spore-print as shown in figure 105. The color of the spores is one of the most constant characters which the members of the mushroom family possess, and in studying these plants some of the spores should be caught on white paper for the purpose of determining their color. Figure 102 represents four different sizes and stages of this *Lepiota*. In the plant at the left the veil still covers the gills. In the next one it has broken away from the margin of the pileus, and forms a collar around the stem. In the third the



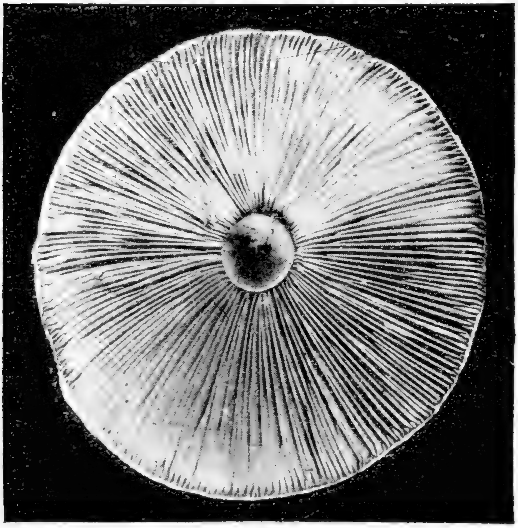
103.—*Lepiota naucina. Section of three plants of different ages.*

pileus is still more expanded. In figure 103 are shown sections of three plants of different ages. We see here that the gills are free from the stem. The general character, then, with the exception of the color of the spores, are the same as those of the *Agaricus campestris*.

This distinguishing feature, the different color of the spores, is regarded as such an important one that it is used to separate genera, and so this plant is placed in the genus* *Lepiota* instead of in *Agaricus*, though all the other generic characters are identical.

A few specific points might be described more in detail. The pileus is usually quite smooth, though in some specimens the surface shows numerous very fine cracks, which give it a granular appearance. The pileus is usually very symmetrical, rounded when young and strongly convex when mature. The flesh is soft and white, but remains much firmer in age, and when picked, than does that of *Agaricus campestris*.

The veil is also firmer than in the case of *Agaricus campestris.* It separates cleanly from the margin of the pileus, as well as from the stem, so that it forms a perfect collar or ring, which in some cases may be moved on the stem. The lines of separation and the firm veil are clearly shown in the plant at the left hand in figure 102. In old specimens the ring sometimes is torn, and may disappear.



104.—*Lepiota naucina. View of gills on under surface of pileus.*

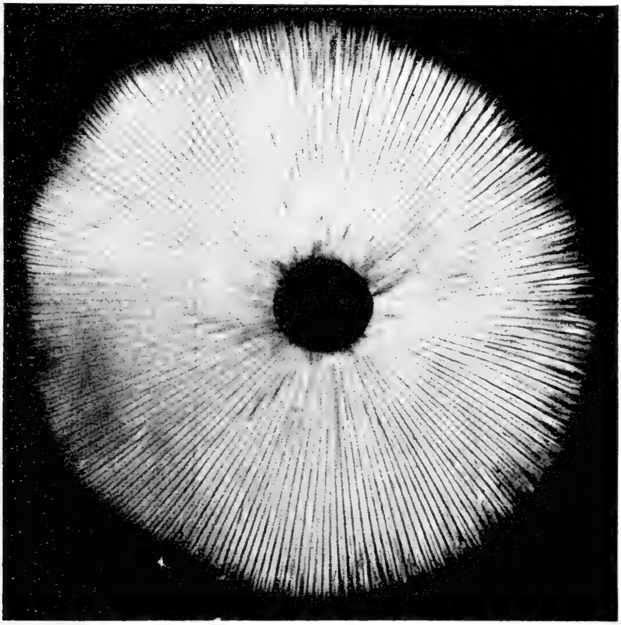
The stem is nearly cylindrical, 5–10 cm. (2–4 inches) long and ¾–1½ cm. in diameter, and is slightly enlarged or bulbous below. It is nearly hollow, as shown in figure 103, though this cylindrical space is usually stuffed with loose cottony threads.

The *Lepiota naucina* is an edible species, and is valued as highly as the *Agaricus campestris* by many who have eaten it.

Like the *Agaricus campestris* it is also an European species,

* Subgenus according to some.

though the description in European botanical works are quite meager, and much confusion exists in reference to the shape of the spores. The spores of the European specimens are usually described as "round," though Mr. Massee in his British fungus Flora describes them as subrotund. This confusion regarding the shape of the spores has led to the belief on the part of some in America that our plant is different from the European one, for the spores in our plant are elliptical or oval, not rotund. For this reason the plant in America



105.—*Lepiota naucina. Spore-print.*

has been called by some *Lepiota naucinoides.* After careful study and observation of our plant, and by comparison with illustrations and descriptions of the European species, the conclusion is irresistible that the two are identical. In order to have our plant compared with the European one, the writer sent some specimens to Mr. George Massee, of the Kew Herbarium, London, England. The director of the herbarium has kindly replied that our plant is "*Lepiota naucina, typical.*"

AMANITA PHALLOIDES FR.

(*The deadly amanita.*)

The third and last plant described here is one of the "deadly" amanitas, the *Amanita phalloides*. It is mentioned here not only because it is probably responsible for a majority of the deaths from eating mushrooms, but because by the novice it might well be taken for either the *Agaricus campestris* or *Lepiota naucina*, especially the latter. It usually occurs in woods, while the two other plants here described occur in open places. The *Amanita phalloides* sometimes occurs in borders of lawns near woods. I have this year, in the early part of September, found four or five specimens of this deadly amanita in the border of one of the lawns on the campus of Cornell University.

One form of the plant is represented from a photograph in figure 106. It is pure white and possesses an annulus or collar, *but what is most important the base of the stem rests in a cup-like envelope called the volva.** In this specimen the margin of the volva is cleft into three parts which are somewhat spreading. This specimen was collected in a beech woods along a damp ravine in the month of July. The veil has separated by an even line from the margin of the pileus and hangs as an annulus in the form of a broad collar from near the upper end of the stem.

The pileus in this form is smooth, viscid to the touch, and pure white, as is also the annulus, stem and volva, though the latter is soiled by particles of earth. The stem is nearly cylindrical, tapering slightly from the bulbous base. It is hollow, or stuffed with cottony mycelial threads. The gills are usually pure white, even in age, and are nearly free from the stem. When decaying the plant emits a very disagreeable odor.

Because this plant is sometimes found in lawns and in fields bordering on the woods great care should be exercised in the collection of the *Agaricus campestris* and especially of the *Lepiota naucina*, to be certain that a *volva* is not present on the lower end of the stem. Until one is certain he knows the plant he is collecting, the plants should not be picked by simply taking hold of the pileus, but the stem should be carefully dug up. In the case of some plants of *Amanita*

* Popularly termed the "poison-cup," "death-cup," etc.

phalloides which I found in a lawn the stem was about 7 cm. (nearly three inches) deep in the ground, so that by simply picking the plant by the cap, the most important character, the *volva*, would be lost, and by a novice the plant might be taken for the *Lepiota naucina*. Some of the specimens of *Amanita phalloides* which I have collected this summer might even be taken by a novice for the *Agaricus campestris* if the volva were not obtained. In some of the young specimens the gills were *decidedly pink*, so much so that several persons who saw the plants remarked on the pink color of the gills and they were not aware of the significance of this fact. It should he stated, however, that the pink color of the gills in these young specimens of *Amanita phalloides* is not nearly so deep as the pink color of the gills of *Agaricus campestris*.

106.—*Amanita phalloides. White form, showing pileus, stipe, annulus and volva.*

A pure white plant very closely related to this white form of *Amanita phalloides*, which occurs in the spring or early summer, is considered by some to be a distinct species called *Amanita verna*. These pure white forms of some amanitas, because of their deadly poisonous property, are sometimes called "the destroying angel."

Shortly after the pileus of these plants breaks through the volva and the stem is elongating, they are very sensitive to the directive influence which the earth, or gravity, exerts on the growth of many plants. One of the reasons why the plant grows in an upright position is that this influence directs it away from the earth. This is easily observed in placing young and rapidly growing specimens in a horizontal position. In a few hours the stem end near the pileus begins to turn upward, and the plant has taken the form shown in figure 107. This plant was lying on its side for only about one or two hours, and the stimulus which it received in this position during the short period caused it to turn after it had been stood upright again. A view of the under side of this same plant is shown in figure 108, and in figure 109 a diagonal view, which represents well the form and attachment of the annulus to the stem.

107.—*Amanita phalloides. Plant turned to one side, after having been placed in a horizontal position, by the directive force of gravity.*

Other forms of the *Amanita phalloides* occur in which the pileus is yellow, or greenish, instead of white, and sometimes bits of the *volva* remain adherent to the surface of the pileus in the form of whitish patches. There are other species of the genus *Amanita* which cannot be discussed in this bulletin, but will be illustrated in a future one.

Those who are not familiar with the three plants here illustrated, and who desire to be able to recognize them, are advised to search the pastures, etc., for the *Agaricus campestris* and *Lepiota naucina*, and also the damp woods for the *Amanita phalloides* and to compare the plants found there with these descriptions. In this way familiarity with the species may be acquired which will serve as a means of determining them in the future. The two former species often occur in such abundance during the autumn that basketsful of them can easily be gathered.

Those who wish to preserve these plants in the herbarium, or for

108.—*Amanita phalloides. View of under side of pileus, showing form and position of annulus and volva.*

109.—*Amanita phalloides. Another view of Fig. 22.*

future determination, if there is not an opportunity to determine them in the fresh state, should dry them carefully after first taking careful notes on form, color, size, texture, position, etc., of the various parts of the plant. Full directions for taking careful notes or for drying cannot be given here, but may be attempted at some future time. The *Agaricus campestris* and *Lepiota naucina* can be dried in the sun, and may then be kept in boxes. Or when moistened again a little by dew, may be pressed lightly between sheets of absorbent paper, and then glued to herbarium sheets or folded in paper packets, as shown in figure 112. Specimens of *Amanita phalloides* contain proportionately more water and consequently shrivel more in drying. They are apt to decay before they can be dried in the sun, except in very bright weather. Artificial

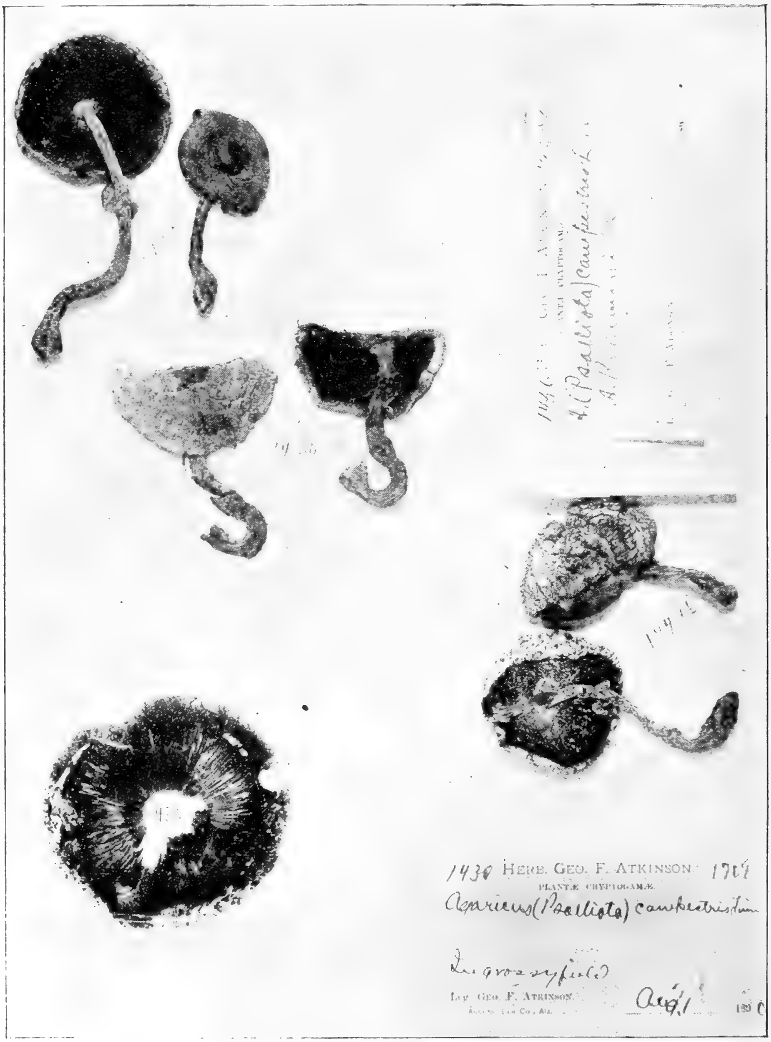
108.—*Agaricus campestris.*

heat can be used, but this causes the plants to shrivel still more, unless the process of drying is very slowly accomplished. In this case they should be placed over the source of heat where currents of warm air are rising, and then dried very slowly. In the case of the large and watery ones some cut the plants down into two halves through the stem, then cut out the inner fleshy part of the pileus and stem, and then placing the inner faces on an herbarium sheet, dry under pressure by hot driers, which should be changed frequently. This process preserves well the external form and characters where properly done. If this rule is followed other plants should be preserved whole. In order to have a record of the characters, however, careful notes on all the characters should be taken while the plants are fresh, since so many of the important ones are evanescent and disappear in drying. The notes can be supplemented by pencil sketches, or even by photographs, if the collector so desires. A spore-print should also be preserved for a record of the color of the spores, since one cannot use the color of the gills in all cases to determine that of the spores, and a few spores under the microscope do not in many cases give the tint which a mass of spores show, and which is very important to know.

III.—*Lepiota naucina.*

Some liquid fixative like gum arabic should be spread on the portion of the white paper covered by the pileus previous to taking the spore-print, so that the spores will adhere well to the paper; or they may be later fixed by using material like Rouget's fixative with an atomizer, though with this latter treatment the figure of the print is apt to be disturbed somewhat.

In the preparation of mushrooms for the table, information may be obtained from other sources if it is not already at hand, since we cannot here enter into a discussion of the culinary treatment. But as a matter of course all wormy and very old specimens should be discarded.



112.—*Agaricus campestris. Photograph of sheet from herbarium.*

In communities where there is a desire to become acquainted with the common fleshy fungi, those interested might combine to form a "mycological club." A number of persons thus associated together might purchase a small reference library to be kept in a club room, at a trifling cost to each member. Here specimens could be brought, the literature and illustrations compared and an exchange of opinions between the members on the various plants would assist in a more ready determination of the plant, and in the acquisition of useful information as to occurrence, habits of growth, etc. Some few in such a community would become more expert than others, and could at length be regarded as "specialists" to whom more doubtful matters could be referred, or who themselves in doubtful cases could consult by correspondence with some one possessing greater opportunity at some botanical center. Such a club would undoubtedly become interested in other nature subjects which would afford both pleasure and profit.

A few books and pamphlets which might be obtained to start such a reference library are enumerated below with the price. Some of the larger useful books are not here mentioned because of the cost.

Farlow, W. G. Notes for Mushroom-Eaters (published in *Garden and Forest*, January and February, 1894). Published also as a separate. 25 cents.

Gibson, W. H. Our Edible Toadstools and Mushrooms. $7.50.

Massee, G. British Fungus Flora. 4 vols. $2.00 each.

Peck, C. H. Mushrooms and Their Use. 50 cents.

A recent work by Dr. Peck, with many colored illustrations, published in the forty-eighth annual report of the New York State Museum of Natural History, and issued as a separate, has been exhausted, but a new edition is being published. This can be obtained when issued for about one dollar by applying to S. B. Griswold, State Library, Albany, N. Y.

"A Text Book of British Fungi," by Delisle Hay, contains a fairly good glossary of terms used in descriptive works, and also an analytical key arranged after W. G. Smith. A chart of colors, which is useful in taking notes, can be found in Saccardo's "Chromotaxia"; 60 cents. This latter, as well as Dr. Peck's "Mushrooms and Their Use," can be obtained from the Cambridge Botanical Supply Company, Cambridge, Mass. This pamphlet contains also a list of other works on fungi.

GEO. F. ATKINSON.

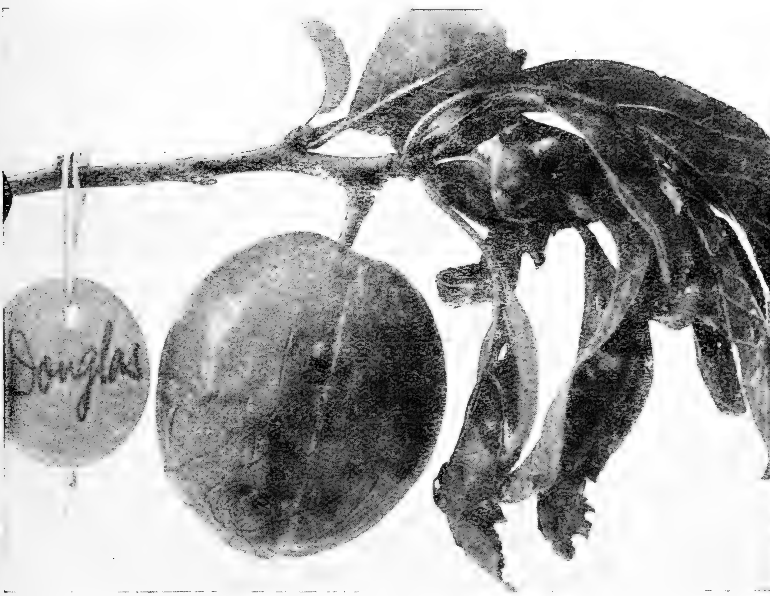
Bulletin 139. **October, 1897.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

THIRD REPORT UPON JAPANESE PLUMS.



By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1897.

ORGANIZATION.

BOARD OF CONTROL:
THE TRUSTEES OF THE UNIVERSITY.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, the following persons have been appointed investigators and instructors in the College of Agriculture of Cornell University to serve throughout the state according to the needs of the several localities for a portion or all of the year.

J. W. SPENCER,	B. M. DUGGAR,	A. L. KNISELY,
G. T. POWELL,	J. L. STONE,	C. E. HUNN.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in Western New York.
125. A Disease of Currant Canes.
126. The Currant-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums for Western New York.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.

THIRD REPORT UPON JAPANESE PLUMS.

In two bulletins (Nos. 62 and 106) we have made reports upon the history and varieties of plums which have recently come into this country from Japan. A crop of many of the varieties upon the Cornell grounds in 1897, enables us to make a third report. The nomenclature of this class of plums is in the greatest confusion, and the plums themselves are too little understood to warrant unqualified recommendation. It will be several years yet before we can expect to thoroughly classify our knowledge of them. This confusion is of itself a strong reason why these reports should be made, for, while we do not expect that we have arrived at a full knowledge of the varieties, the confusion would increase rather than diminish if no attempt were made to record the tests from year to year. The confusion among these plums has arisen because the Japanese class-names have been retained in this country, and because various parties have disseminated the varieties under numbers or without names. The writer has therefore given new names to varieties which are passing under class-names and numbers; but the renaming of any variety is not to be regarded as a recommendation of it. At first it was intended to include in this report copious extracts from the current press respecting the varieties of Japanese plums, but it so frequently happens that persons have different varieties under the same name that there is danger of adding to the confusion rather than diminishing it by too free quotations from contemporaneous writings. We have merely set down the behavior of such varieties as have fruited with us this year, making such corrections of nomenclature as seem to be necessary in order to clarify the subject.

I am still convinced that the Japanese plums have come to stay. By this I do not mean that they are destined to supplant the domestica and native plums, but that they are bound to supplement those types with varieties that are adapted to particular purposes and conditions. As a class, they are vigorous, hardy and productive in tree, and the fruit is handsome, long keeping, and covers a long season.* Thus far, they have been comparatively free from black-knot, and until this year our trees have not been seriously attacked by the shot-hole fungus or leaf-blight. During the past season, however, this leaf-blight has been much worse upon the Japanese varieties than upon the domesticas alongside them, and this, too, in spite of the fact that they were thoroughly sprayed. The leaves did not drop to any extent, however, even though they were badly riddled by the fungus.

The following notes must not be taken to be complete or final descriptions of the varieties. In many cases they are made from the first crop on young trees. But they record the present state of our knowledge respecting this new and much confused type of fruits. It is our habit to set the wood of new varieties (either as buds or grafts) in the tops of Lombard plums, and several of the varieties have been fruited only in this way. The pictures are all natural size, and are made from average specimens. The reader should be told that the pictures always look smaller than the objects, even though they are of the same size. Other true pictures of the fruits and trees of Japanese plums may be found in our Bulletin 106. That bulletin attempts to describe all the varieties known at that time (1895), but the present report concerns itself only with those varieties which we have fruited.

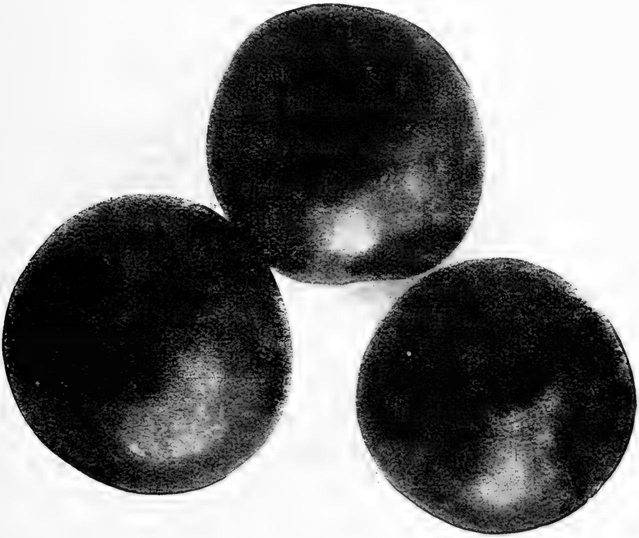
A most perplexing feature of the Japanese plums is the variation in the season of ripening in different years. In our first Japanese plum bulletin, we said that the Burbank "is from two to four weeks later" than the Abundance. We had not then fruited the varieties side by side. In our second bulletin, we said that the difference in ripening was only "a week or two," and added that upon our grounds the Burbank, in 1895, "was less than a week later than Abundance."

---

*These plums are now beginning to attract attention in Europe; and the following report comes from South Africa (E. Tidmarsh, in Rep. Grahamstown Botanic Gardens, 1895, 5): "The Japanese plums, although not quite equal in flavor to the best sorts grown in Europe, have valuable properties for this climate. For one thing, these varieties, so far as I have tried them, grow freely grafted on the peach. A number of the European sorts refuse to grow on the peach, and this is a drawback in two ways. First, the peach stock is, on the whole, best adapted to this climate, and secondly, it is a difficult matter to raise suitable plum stocks in this country."

Persons in the South should consult Bulletin 85, Alabama Exp. Sta., on "Japanese Plums," by F. S. Earle.

These same trees were compared this year (1897), and the Burbank was fully three weeks later than Abundance. In 1895, the Red June ripened from July 28 to August 1; this year the fruit upon the same tree was not ripe for eating until August 23. These differences may be due to the differences in the two seasons, for in 1895 the late summer was hot and dry and this year it was cold and wet; but one would not expect that season would make so great comparative difference between any two varieties as we found between Abundance and Burbank.



113.—*Berckmans.*

This report has had the benefit of notes made upon the early varieties by S. D. Willard during the writer's absence.

ABUNDANCE.

The best known of the Japanese plums, although it is not yet clearly distinguished from some of its allies. We have two types of Abundance—one a very narrow grower with a small pointed early fruit and small leaves, which may be Babcock; the other a moderately spreading tree, with the type of fruit shown in figure 1, Bulletin 106, ripening a week or ten days later than the other, and having large leaves. This latter I have taken as the type of Abundance. We have trees propagated from the original Lovett stock of Abundance, but they have not yet borne. We shall hope to clear the matter up in our next report.

The Abundance is a good plum, considering its season (ripened with us this year about August 25, being about two weeks later than hitherto), beauty and productiveness. It must be thinned if good specimens are desired. It is also subject to fruit-rot. Its quality is fully equal to that of the Lombard.

BAILEY: see Chabot.

BERCKMANS.—Figure 113.

(*True Sweet Botan*, at least mostly.)

The description in Bulletin 106 seems to be characteristic, except that I should designate the color upon the fruits this year as bright deep red rather than "dull deep red." It is a handsome plum, with a soft flesh, and of medium to good quality. Tree a spreading grower. Two weeks later than Abundance this year.

BLOOD NO. 4.

This was indistinguishable from Satsuma with us this year. I suspect that Heikes is the same.

BURBANK.

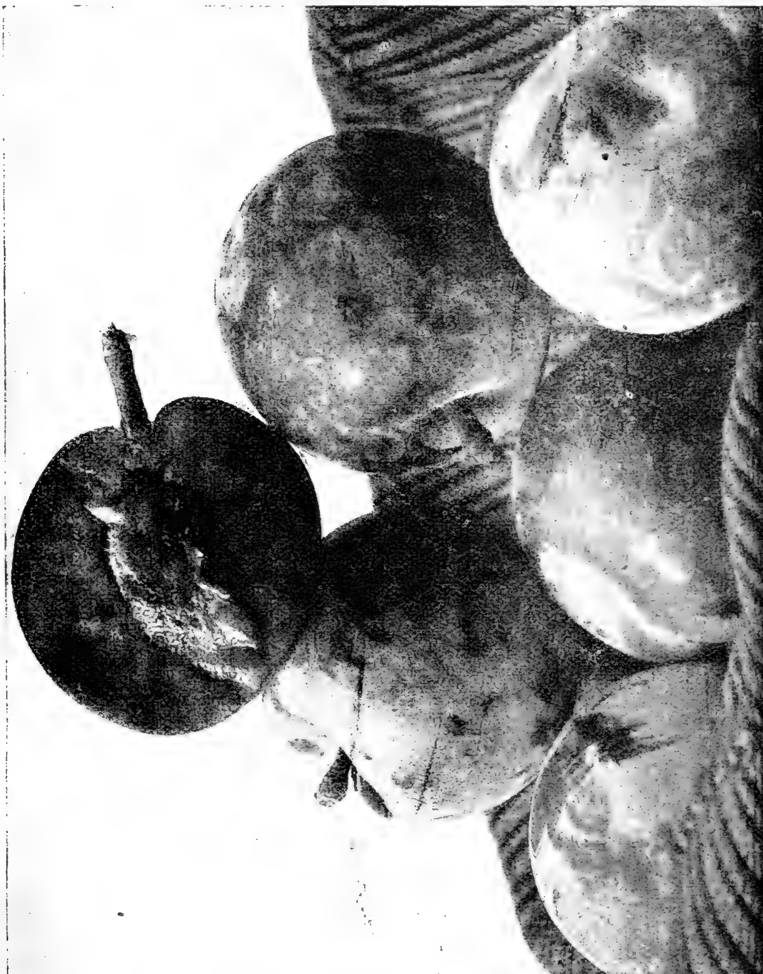
Now too well known to need comment. The best single variety of Japanese plum yet thoroughly tested in this state. Ripe with us this year from the 10th to the middle of September.

BURBANK NO. 1: see Hunn.

CHABOT.—Figure 114.

(*Bailey. Chase*, mostly. *Yellow Japan.*)

This plum certainly deserves all that we said for it in Bulletin 106 (under the name of Chase). The tree is a strong upright grower, productive, and the fruit is handsome, very firm, and of good quality. In general appearance the fruit is much like Burbank, but it is more pointed and from one to three weeks later; and the tree, which is an upright grower, is very different. This year it ripened with us from September 15 to 25. There seem to be two things passing as Chase, the other one being an earlier plum and perhaps identical with



114.—*Chabot.* (*Known also as Bailey, Yellow Japan and Chase.*)

Douglas. I can detect no difference between Chabot, Bailey, Chase and Yellow Japan, and the same also passes as Hattonkin; but Chabot, being the oldest name, must hold.

CHASE: see Chabot.

DOUGLAS: see title-page illustration.

(*Sweet Botan* of some. *Hattankio* of some.)

This is the plum which I called Munson in Bulletin 62, but which Price renamed Douglas (Bull. 32, Texas Exp. Sta.) because there was already a Munson, one of the natives, upon the lists. The fruit is medium to large, oblong, deep dark purple; flesh firm, quality good; freestone, or very nearly so. Tree upright and vigorous, making a rather close, round head. Ripened with us this year a week ahead of Abundance. Looks like a promising early plum.

EARLIEST OF ALL.

(*Yosebe* of Bulletin 106.)

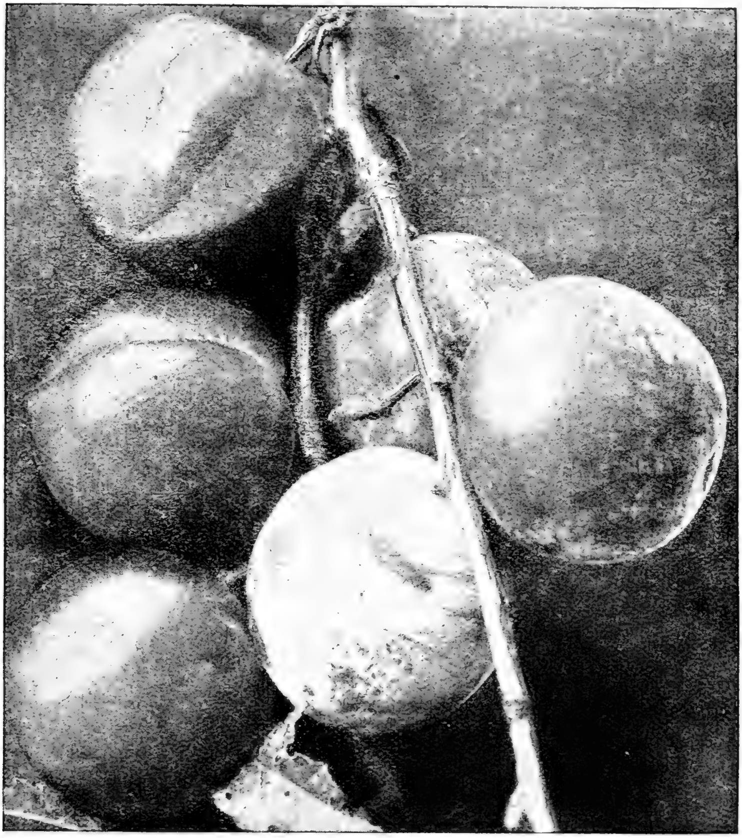
We shall drop the name Yosebe (which see) and take up Stark Bros.' name, Earliest of All, for the variety which we illustrated in figure 13, Bulletin 106. It is a strongly marked type, both in tree and fruit, and ripens here late in July. The description under Yosebe, in Bulletin 106, is characteristic. Fruit falls from the stem as soon as ripe, and can be gathered by shaking the plums onto sheets, or into a curculio catcher. No doubt useful for very early, but quality poor with us.

ENGRE.

Ripens with Earliest of All, but a half larger and quality distinctly better. Fruit flattened at both ends, the cavity broad and deep; color dark-red, with many minute white specks, and a delicate bloom. Promising for very early.

GEORGESON.—Figure 115.

Most of the plums passing as Hattankio belong here. It seems to be the only clear yellow Japanese plum known in this state, except Ogon. It assumes various forms. In Bulletin 106 we showed the flattened or rounded form. We now show a pointed form. I am convinced that these forms are only incidental variations of the same variety. It is a very solid golden yellow plum, of fair to good quality, and a long keeper. Ripe this year



115.—*Georgeson. The pointed type.*

at Cornell September 15 to 20. A sprawling, forking grower, in form of top intermediate between Abundance and Burbank. The best yellow variety that I know. Kerr, another yellow variety, we have not fruited.

HALE.—Figures 116, 117.

With us the size and color of Burbank, and a week or so later.

116.—*Hale.*

117.—*Hale.*

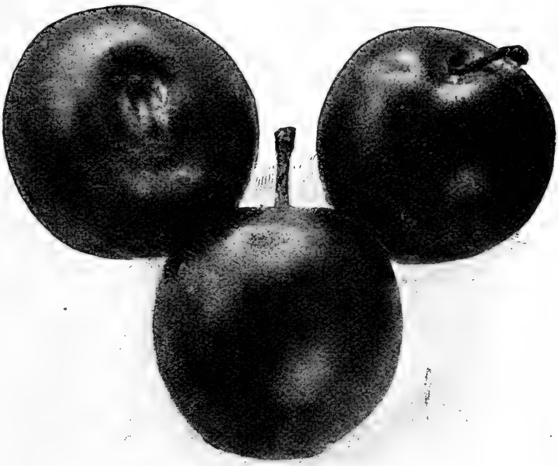
A handsome globular, red and speckled plum, parting easily from the stem; flesh rather soft and juicy, of good quality and a peachy flavor, tending to be sour rather than sweet; tree (figure 117) moderately spreading, and a good grower, and evidently productive. Ripened with us this year from September 8 to 15. One of the most promising of the lesser known varieties.

HEIKES: see Blood No. 4.

Hunn.—Figure 118.

(*Burbank No.* 1.)

Early, ripening just after Red June—August 26 with us this year—but keeping until September 3. A small plum, with a slight point as in Abundance, deep claret red with many minute golden dots; flesh thin and juicy, sweet and of medium quality; cling. Fruiting on Lombard; apparently productive and of upright habit. It may deserve a place among the early plums.



118.—*Hunn.* (*Burbank No.* 1.)

Louisiana.—Figure 119.

(*Normand No.* 15.)

Tree a spreading and rather weak and slender grower, with foliage and spray very strongly suggesting hybridity with the Wild Goose type of plum. Plum green in color even when fully ripe, dotted with light specks and marked with a faint and dull red blush in the sun; medium size; pointed or heart-like; flesh juicy and sweet at the center while it is still hard and rind-like near the exterior; fruits running very uneven in size and shape, some of the specimens on our tree being much misshapen (see figure 119). A curious fruit, in some respects suggesting Kelsey. Falls from the tree very early. Perfectly hardy with us thus far. Mr. Normand says that it is a "seedling of a Japanese crossed with a native plum."

MARU.

(See description in Bulletin 106). It was a week or two later than Abundance with us this year. Tree upright-spreading, a good grower, with rather small leaves. Handsome, but rather small, and quality poor.

119.—*Louisiana.* (*Normand No.* 15.)

NORMAND.

Described as a very early, somewhat conical yellow freestone, and specimens of fruit which I have had from Normand, the importer and introducer, answer the description. As fruited with us this year on Lombard stock, cions from Normand, it is a midseason clingstone and is indistinguishable from Georgeson. Ripe with us in 1897, September 15 to 20. It remains to be determined whether there are two varieties passing under one name, or whether the same variety behaves differently under different conditions.

OGON.

A handsome, clear yellow, freestone plum, already well known, and fully described in Bulletins 62 and 106, and illustrated in the former. It is very early, ripening at Cornell this year about August 10. It is excellent for canning. The Ogon is generally regarded as a shy bearer, but our little trees were loaded this year. The fruit often cracks badly on the tree. The tree is an upright-spreading strong grower, with very large leaves which did not suffer from fungus.

RED JUNE.

Surely an excellent plum, maintaining the high character—for earliness, beauty and productiveness—which we gave it two years ago. The quality is not so good as that of the Burbank or Chabot. At Cornell this year, trees upon hard clay land ripened their fruits twelve days later than trees upon gravelly loam.

RED NAGATE.

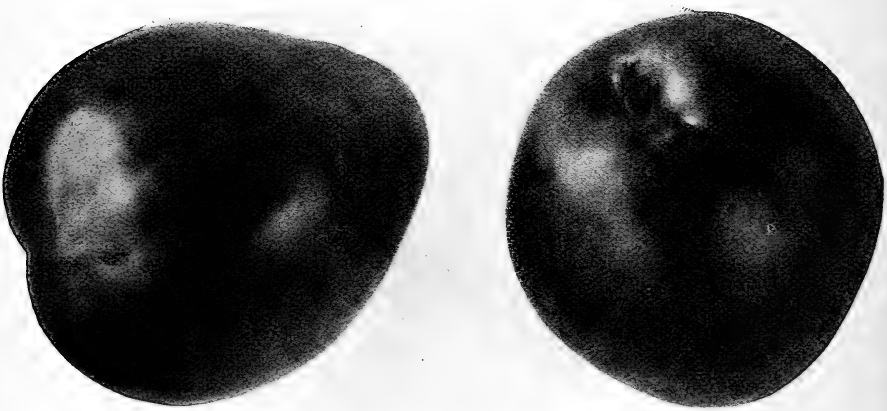
I think that this name will have to be given up. It is most commonly applied to the variety which is now properly known as Red June, but we have Chabot under the same name.

SATSUMA.

One of the best marked of all Japanese plums, the fruit being dark, dull red and the flesh blood-red. It is late, ripening from the middle to the last of September this year. The color of the fruit is against it for a general market plum, but its keeping qualities, and excellence for culinary uses, make it worth a place in the orchard. The quality is austere, until fully ripe, when the fruit becomes fairly sweet. Tree a vigorous spreading-upright grower. Fairly productive with us, but reported unproductive by others.

STRAWBERRY.

A small fruit, flattened upon the ends, with a broad and deep cavity, light red, meaty flesh, quality good, with flavor of domestica plums. Ripe here the very last of July, in 1897. Tree strong, upright spreading, with large foliage. This variety affords an excellent illustration of the various behaviors of Japanese plums. The tree was sent us by Stark Bros., who named it, but finding it not productive and not so good as Earliest of All, they discarded it. Yet at Cornell this year it was a good plum. It is evidently the same as Uchi-Beni, Ura-Beni, and is the Honsmomo of some.



120.—*Wickson.*

UCHI-BENI AND URA-BENI: see Strawberry.

WASSU.

In both tree and fruit indistinguishable from Burbank. Tree from Normand, the introducer.

WICKSON.—Figures 120, 121.

Although we have this plum growing, it has not borne; but since we have tested fruit of it grown by E. Smith & Sons, on Seneca Lake, we give it place in this report, and the engraving (figure 120) is made from specimens of their growing. They write as follows: "Our experience with this plum is limited, but we are more than pleased with its habits and characteristic points. We find it a good grower, also very hardy, and the size of fruit superior to any of the Japanese plums. The quality we find a little under the average, but good enough to warrant us in planting. We have 100 trees of them, planted out one year ago in orchard form, and will set at least 500 more."

I am impressed with the Wickson and expect to find it an acquisition to New York. The fruit is very large, deep maroon-red, firm and long-keeping, with an aromatic, almond-like quality, and deep, dull yellow, meaty flesh. The tree has been perfectly hardy with us. It has the habit of *Prunus Simonii* (figure 121), being the narrowest grower of all the Japanese plums which we have tested. Its habits suggests that *Prunus Simonii* entered into its parentage, but Mr. Burbank, the originator, says that it was grown from Burbank seed which was fertilized by Kelsey pollen.

121.—*Wickson.*

WILLARD.

We have no new report to make upon this variety (see Bulletin 106). Its only merit is earliness. The quality is very poor. It is a very strong, tall grower, but shed its leaves early with us this year.

YOSEBE OR YOSOBE.

We shall discard this name. The variety which we described and figured under this name in Bulletin 106 we shall hereafter call Earliest of All (which see). The name seems to be applied to a number of varieties, no one of which has any definite right to it. We have Satsuma under the name of Yosobe.

Correspondents are asking what varieties of Japanese plums I recommend. In reply I will say that I never recommend varieties of any fruit for anyone to plant. The merit of a variety must be measured by the uses to which it is to be applied and by the tastes of the planter, quite as much as by its intrinsic characters. The correspondent rarely specifies whether he wants a red plum or a yellow one, an early or a late, for dessert or for market. It is like asking a man at a distance what fence a questioner shall put in his back lot, without saying whether it is to be a pig fence, hen fence, sheep fence, cow fence, or a fence merely to mark off his premises from his neighbor's. I can state what varieties I might plant for myself, but my selection might not be such as would please my neighbor. For myself, I should still adhere to my list of four varieties of two years ago—Red June, Abundance, Burbank, Chabot. I should place as second choice Douglas, Berckmans, Satsuma, Hale and Wickson, and should expect that the last two would rise, upon further acquaintance, to a place in the first rank. If I wanted a yellow plum, I should take Georgeson, with Ogon for early. If I wanted the earliest varieties, without respect to size or quality, I should choose Berger, Engre, Earliest of All and Willard.

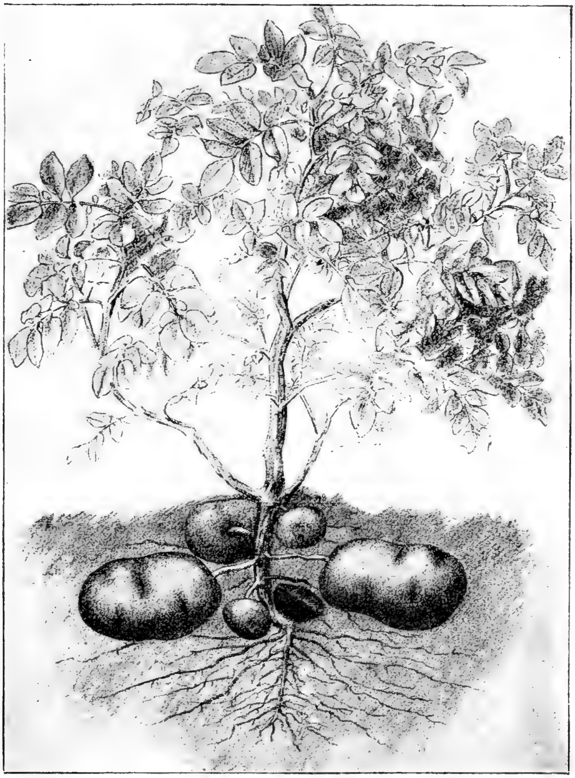
L. H. BAILEY.

Bulletin 140. **November, 1897.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

Second Report on Potato Culture.



By I. P. ROBERTS and L. A. CLINTON.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1897.

ORGANIZATION.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, the following persons have been appointed investigators and instructors in the College of Agriculture of Cornell University to serve throughout the state according to the needs of the several localities for a portion or all of the year.

J. W. SPENCER, B. M. DUGGAR, A. L. KNISELY,
G. T. POWELL, J. L. STONE, Miss M. F. ROGERS.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in western New York.
125. A Disease of Currant Canes.
126. The Currant-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums for western New York.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.

SECOND REPORT ON POTATO CULTURE.

In Bulletin 130 of this station was published the results of experiments in potato culture for 1895 and 1896. Those two years were remarkable in that the potato crop was an enormous one, the supply being far greater than the demand. Farmers were unable to dispose of all of them at satisfactory prices, and many bushels were fed to stock or allowed to go to waste. With these conditions prevailing, it was not remarkable that a bulletin telling how to increase the yield of potatoes should not awaken great interest on the part of the farmers. They felt that already too many potatoes were being grown, and that information as to how the yield could be increased was not necessary.

During the present year the conditions have radically changed. Owing to the ravages of the potato blight over nearly the entire state it was found upon harvesting the potato crop that in certain localities from 50 to 75 per cent. had rotted. The effect of this upon the market has been very decided. The prevailing price, instead of being from 10 to 25 cents, is from 50 to 75 cents per bushel.

In spite of adverse conditions, the potato crop on the station grounds was one of the best grown during the three years' trials. While the average crop of the state this year was only from 50 to 65 bushels per acre, the yield on the station ground was over 300 bushels per acre. This yield was obtained not by the liberal use of fertilizer or manure, as two forage crops and one corn crop have previously been removed from the land since the application of any manure or fertilizer. The soil, instead of being naturally more fertile than ordinary soils, has been found by analysis to be carrying only about one-half the total amount of plant food carried by the average soil (see Bulletin 130). The satisfactory results obtained can only be ascribed to the culture and treatment given as described in this bulletin and in the former bulletin, No. 130.

PREPARATION OF THE LAND.

After the removal of the 1896 crop the land was plowed and sown to oats and peas as a cover crop. This cover crop prevented loss of plant food during the fall and winter and returned some organic matter to the soil. Owing to the gravelly nature of the land, this cover crop is considered of some importance. Besides preventing waste of plant food by leaching, it restores humus to the soil, and assists materially in conserving moisture and in keeping the soil in proper physical condition.

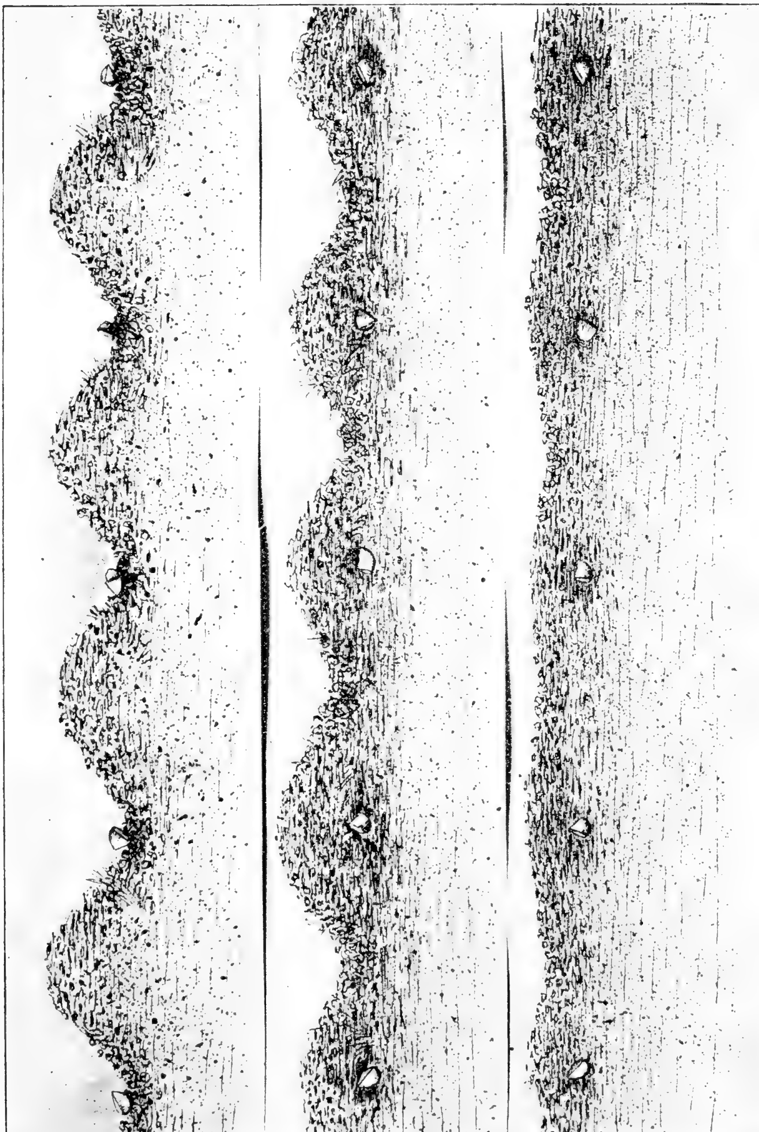
The plowing was done April 2 and 3, as early in the spring as the conditions of the soil would permit. Before planting, the Acme harrow was used frequently, the soil being in this way brought to a superior condition of tilth. It should be noticed that the land was plowed early, and was thereafter frequently stirred until the time of planting. The Acme harrow kept the surface loose and thus established a soil mulch which prevented the stores of moisture from being wasted by evaporation (see Cornell Bulletin 120).

PLANTING THE POTATOES.

All plats were planted May 7. The rows were marked off at distances of 40 inches, and opened to a depth of about 4 inches with a double moldboard plow. The seed was dropped one piece in a place, and at distances of 14 inches in the row. The potatoes selected for seed were large marketable ones, free from scab, and in every respect as perfect as could be secured. In cutting, care was taken to have one or two strong eyes to each piece and to have each piece of good size. While some growers have made use of parings, or have simply removed the eye or bud of the tubers for seed, and others have used, for the same purpose, small potatoes year after year, neither practice can be recommended. The potato is naturally a perennial, and the parent plant stores up in the tubers the readily available food which is designed to start the young plant of next season's growth. If then the eyes or parings simply are used the plants are hampered at the outset, and, unless the season is favorable, are never able to overcome the effects of the unfavorable conditions under which they were started. The seed should be cut into pieces of good size and each piece should contain from one to two strong buds or eyes. On the experimental grounds, to be sure that the same amount of covering was given to each plat, the covering was done by hand. But in ordinary farm practice the work should be done by machinery. The following plan is recommended: Open the rows deeply and wide with a double moldboard plow or a shovel plow. If commercial fertilizer is to be applied, distribute it in the bottom of the furrow and thoroughly incorporate it with the soil. This thorough mixing with the soil is of importance, for should the seed be put directly upon the fertilizer it is possible the bud would be weakened, if not killed. Drop the seed in the bottom of the furrow, one piece in a place and pieces 12 to 15 inches apart in the row. Cover by means of the double moldboard plow or the shovel plow, breaking open the middle of the space between rows and covering the potatoes deeply. This will leave the land in ridges with the furrows between the rows of potatoes. In from five to six days after planting, with a smoothing or spike tooth harrow, level the surface of the ground (see figure 122).

This thorough stirring of the soil by means of plow and harrow does much toward bringing it into good physical condition. One reason why many farmers find it necessary to hill their potatoes is because the ground has not been made thoroughly mellow, and the potatoes in expanding naturally find their way toward the direction of least resistance. This is toward the surface, and the hilling operation is resorted to because of the failure to properly fit the land previous to planting. The harrowing of the land before the potatoes are up does much toward putting the surface soil in excellent condition. The spring rains which usually follow potato planting pack the soil and form more or less of a crust on the surface. The harrow breaks this crust, destroys any weeds which may be appearing, draws the clods and stones which may be directly over the row into the furrow between rows. Frequently two or three harrowings may be given before the potatoes are up, and where the planting has been done in drills so that the after tillage can be given in only one direction, much labor may be saved if the weeds are destroyed by means of the harrow.

The after tillage should be frequent and with implements which will leave the land as nearly level as possible. Best results have been secured by stirring the soil with a fine toothed implement every ten to twelve days and continuing the operation until the vines have so grown as to render further culture harmful. It will be found that the



122.—*Land prepared for potatoes, showing respectively the furrows opened, the seed covered, and condition after harrowing.*

vines have then formed a complete shade for the ground, so the necessity for further cultivation has largely ceased.

The following tables show the result of the experiments with potatoes for the years 1895, 1896 and 1897:

RECORD OF POTATO PLATS FOR 1895.

1895.	Number of cultures.	Yield per acre. Bushels.
Plat No. 21	13	378
Plat No. 22	9	415
Plat No. 23	13	319
Plat No. 24	9	414
Plat No. 25	13	304
Plat No. 26	9	311
Plat No. 27	13	350
Plat No. 28	9	330

RECORD OF POTATO PLATS FOR 1896.

Plat No.	Date of planting.	No. of cultivations.	Date of digging.	Yield per acre. Bushels.	REMARKS.
6	May 9	7	Oct. 9	318.2	Fertilized with 200 lbs. muriate of potash and 300 lbs. of acid phosphate.
7	"	7	"	310.5	Fertilized with 200 lbs. sulphate of potash and 300 lbs. of acid phosphate.
8	"	7	"	350.3	} Comparable.
9	"	11	"	338.1	
10	"	3	"	280.	
11	"	3	"	299.7	} Comparable.
12	"	7	"	341.6	
13	"	7	"	334.	Variety test.
29	"	7	"	360.6	Fertilized with 200 lbs. of muriate of potash and 300 lbs. of acid phosphate.
30	"	7	"	333.5	Fertilized with 200 lbs. of sulphate of potash and 300 lbs. of acid phosphate.
31	"	7	"	346.5	} Comparable.
32	"	11	"	339.	
33	"	3	"	245.8	

Those marked "comparable" are to be studied for the effect of tillage only.

RECORD OF POTATO PLATS FOR 1897

Plat No.	Variety.	No. of cultivations.	No. of times sprayed with Bordeaux and Paris Green.	Total yield per acre. Bushels.
{ 34	Carman No. 3	8 Level	4 Times	{ 384
{ 35	" "	"	"	{ 357
{ 36	" "	5 Level	"	{ 349
{ 37	" "	"	"	{ 325
{ 38	" "	5 Hilled	"	{ 288
{ 39	Rural New Yorker No. 2...........	5 Level	No Times	{ 234
{ 40	" "	"	4 Times	{ 305
{ 41	" "	7 Level	"	{ 347
{ 42	Rose of Sharon....................	"	"	{ 320
{ 43	" "	5 Level	"	{ 311

The reader is requested to make a careful study of the tables and of the results obtained from the different plats. Plat No. 34 grew spurry in 1896 and the crop was plowed under. The spurry reseeded itself and was plowed under the second time. It reseeded again, and was allowed to remain as the cover crop during the winter of 1896-7. No crop was removed from the plat in 1896. Upon all the other plats forage crops were grown in 1896 (see Cornell Bulletin 135.) Plat 34 responded to the better treatment by producing a total of 384 bushels per acre.

Attention is called to the results on plats 37 and 38. These two plats were treated alike in every way, except that at the last time of cultivating plat 37 was left level and plat 38 was hilled. The result shows a yield of 37 bushels more per acre on the plat left level than on the plat hilled. If in any season the hilling would have shown good results it should have been during the present season. Rain was abundant, and at no time during growth was it apparent that the plants were suffering because of lack of moisture. The reason ordinarily given for hilling potatoes is that it is done to keep tubers from growing out of the ground and becoming sunburned. If the land be properly fitted and the planting properly done the potatoes will not grow out of the ground. On the plat where level culture was given no potatoes were thrown out because of sun burning. The potato loves a moderately cool, moist soil, and the hilling process is not adapted to produce these conditions. In the case of the two plats mentioned above, the falling off in yield of potatoes on the plat receiving hill culture means the present season a loss of $24 per acre, as the potatoes were sold direct from the field for 65 cents per bushel.

The general results, with culture, verify the results obtained in 1896, *i. e.*, that in the ordinary season about seven to nine cultivations with a fine toothed implement are likely to give best results. As the vines of the potatoes spread so as to cover a portion of the space between the rows, the cultivating implement should be made narrower so that it will not come into too close contact with the plants.

Insect Enemies of the Potato.

Leaf Flea Beetle (*Crepidodera cucumeris*).

In this section the first insect which attacks the foliage of the potatoes is the little flea-beetle. In case of a dry spring their depredations are much worse than doing wet weather. They appear soon after the potatoes are above ground and begin their work upon the leaves, and their presence may not be noted except by the careful observer until they have seriously damaged the foliage. If the vines are disturbed, the beetles will immediately hop off. Their work is evidenced by light colored spots which appear on the foliage soon after it has been injured. Unless measures are taken to prevent or check the work of this beetle, the plants may become seriously weakened.

While no practical method has been determined for killing these beetles, yet for two seasons in succession they have been largely driven from the potatoes by the timely use of Bordeaux mixture. (Directions for making this mixture are given on page 69.) While this mixture does not kill the insects, it seems to be obnoxious to them in some way and causes them to migrate to other feeding grounds. The use of the Bordeaux mixture thus early in the season will serve as a preventive of the early blight. By using Paris green in conjunction with the Bordeaux mixture that great insect enemy of the potato crop the

Colorado Potato-Beetle (*Dorypnora decemlineata*)

may be destroyed if any have made their appearance thus early.

In treating the potatoes for this pest, timeliness is an important consideration. When the grubs are small, four ounces of Paris green to the barrel (50 gallons) of water will be effective. If, however, they are allowed to become half to two-thirds grown, the quantity of Paris green must be increased to six or even eight ounces to 50 gallons of water. The Paris green can be applied with the Bordeaux mixture nearly as easily as it can be applied with clear water or with plaster. During the early part of the season and until the potato-beetles have ceased their work, when it is found necessary to apply Paris green it should be combined with Bordeaux mixture, which serves to prevent ravages of blight and the flea-beetle, and when Bordeaux mixture is applied as a prevention of blight and to drive away the flea-beetles, Paris green should be mixed with it to destroy at the same time the Colorado potato-beetles. Thus by judicious work several enemies may be destroyed by one application.

It is always important in using Paris green to know that the quality is good. It may be tested easily in the following manner. Put a small quantity of Paris green to be tested into some common household ammonia or hartshorn. If the Paris green is good, it will all dissolve, leaving no sediment. If it is impure there will be more or less sediment remaining. It is always well to apply this simple test before treating a large area, as but a few minutes are required to make the test, and much valuable time may be saved, as Paris green is not always true to name.

BLIGHT.

The prevailing difficulty during the present year has been the late blight and the resulting potato rot. Nearly every farmer has acquired the habit of treating potatoes for the Colorado potato-beetle, but previous to the present season comparatively few have been impressed with the necessity of treating potatoes for the blight. In the case of the beetles it is clearly evident when the ravages begin, and then the remedy may be applied. In case of the blight and the flea-beetle the remedy is largely preventive and should be applied before the necessity for treatment is apparent, for once blight gets started it is difficult to hold in check. There is no subject relating to potato culture which is now of more importance than the blight. It is probable that it has come to stay, and while its ravages may be much greater some years than others, and it may at times be confined to certain localities, yet without doubt this is one of the enemies to the potato crop which must hereafter be taken into consideration and remedial measures adopted in order to insure the success of the potato crop.

Two kinds of blight, designated respectively as early and late, prey upon potatoes, and as they differ essentially in their characteristics will be described separately.

Early Blight (*Macrosporium solani*).

As the name indicates, this usually makes its appearance early in the season and upon early varieties of potatoes. Hot, dry weather favors its growth, and it is usually most severe in its attacks where the potatoes are planted on dry soils. It will, however, make its appearance when the weather is moderately cool. Whenever the potato foliage has been injured by the flea-beetles it seems to be predisposed to attacks of the early blight, the spores finding a favorable resting spot on the injured places of the leaf. Any condition or treatment which has produced a weakening of the plant causes it to be more likely to attacks of blight. Strong, healthy, growing plants may be entirely free from attack, while plants which have for any reason been checked in their growth fall an easy prey to the disease. While this early blight does not cause the potatoes to rot, it so injures the foliage that the growth is checked long before maturity, and instead of the potatoes being full grown they are undersized and immature. It is very possible for the early blight to attack a field of potatoes and its presence never be recognized by the farmer, it being mistaken for a case of early maturity. This may be the reason the early blight fails to attract as much attention as the late blight, and it no doubt does far more damage than is generally accredited to it.

It is difficult to describe its characteristics definitely, as so many variations occur, and as it frequently is confounded with the late blight, it being sometimes scarcely possible to recognize the difference without the aid of a glass. It usually makes its appearance during the latter part of June or during July, and may even appear as late as August.

The parts of the foliage first attacked are likely to be the edges of the leaves, the disease manifesting itself in several places on the same leaf, the affected area at first being circular in outline. The color of the foliage changes from a green to a russet or dark brown, or even black, and the edges curl as the tissue dies. A distinguishing characteristic of the early blight is the general appearance of the tissue of the leaf beyond the most seriously affected portions. Instead of retaining the green color of healthy foliage, it assumes a yellowish appearance similar to that of matured plants, this premature ripening probably being caused by the general weakening of the plant. This appearance, no doubt, is the cause of the general supposition that when potatoes are affected with the early blight the death of the vines is due to natural causes, and is simply a case of early ripening, when in reality it is premature and due to the blight.

One remedy for early blight will have been suggested by what has been said regarding the predisposing causes. It attacks plants which have been for some cause weakened or injured. Treatment, then, should begin with the preparation of the land. Deep plowing to furnish an adequate feeding ground and a reservoir for moisture, seed cut in pieces of good size, the surface soil crust broken with a harrow before plants are up, and then thorough tillage and protection from both the flea-beetles and the Colorado beetles. If the plants are kept in vigorous growth they will largely possess immunity to the early blight.

Bordeaux mixture is the standard remedy for this as well as other fungous diseases. If it has been used in early spring in combating the flea-beetles, and if Paris green is used to kill the Colorado potato-beetles, it is applied in Bordeaux mixture, there is but slight chance that the early blight will appear. The treatment in the manner above described serves a double purpose. The foliage is kept vigorous and healthy, free from attacks of the insect pests, and this alone lessens the liability of attack by the blight as the Bordeaux mixture forms a coating of copper over the foliage thus protecting it.

Late Blight (*Phytophthora infestans*).

This is a fungous disease which is responsible for the potato rot of the present season in New York State. Its appearance is well known, and it has attracted far more attention than has the early blight. The widespread famine in Ireland in 1846 was largely due to the fact that the potato crop was destroyed by the late blight. At the present time another famine is threatening in Ireland and due to the same cause. In our own country, while the disaster is not so great, yet the loss this year has been enormous, and it is a loss which might have been prevented.

This disease in an aggravated form is not difficult to recognize, as it may be perceived both by its appearance and disagreeable odor which comes at first from the foliage and later from the decayed tubers.

The fungus causing the common potato rot is an old offender. It was undoubtedly introduced into Europe with some of the early importations of the potato, and has in certain years proved so destructive that famines have resulted from the entire loss of the potato crop. Such occurrences eventually lead to thorough study of the organism. As early as 1846, the fungus causing the trouble was very carefully described in an English publication,* and since that time other observers have given the disease much attention. It has spread to many regions in which potatoes are extensively grown, so that both scientists and farmers are very familiar with many of its characteristics.

The most interesting feature connected with the fungus is undoubtedly the wonderful energy which it exhibits, under favorable conditions, in the destruction of the potato plants. It sometimes spreads with such rapidity that a crop may be ruined in one or two days; and unfavorable conditions, or the total destruction of the plants, formerly appeared to be the only effectual agents in preventing or checking the spread of the dreaded disease. This rapid decay of both the foliage and tubers is perhaps the most distinctive of those characters which are commonly brought forward for the identification of the disease. It is almost invariably accompanied by a strong, disagreeable odor which is easily recognized by all who have once experienced it. When large fields have been attacked, the smell is particularly strong; it then arises entirely from the foliage, and is not produced by the tubers.

The conditions which favor such rapid decay are, as a rule, not generally present throughout this state. The fungus makes its most rapid growth in a temperature of 70 degrees Farhenheit when much moisture is present in the atmosphere. Cloudy days, with occa-

---

* Rev. M. J. Berkeley, *Journal of the Royal Horticultural Society*, Vol. I.

sional showers, and a close damp air are especially favorable to its growth; and if such periods occur during August and September, the disease may appear at any time. But, on the contrary, if the season is dry and hot, the fungus is unable to develop, and little or no injury of this nature can appear. It is for this reason that the potato rot is not a regular visitor in most parts of the state, but is more generally confined to certain localities. These are found in the more northern potato districts, in the regions near the sea coast, and in some parts which have a high altitude. In such places the fungus may develop regularly every year, and the severity of the attack will be modified chiefly by abnormal atmospheric conditions.

The manner in which the germ tube of a spore penetrates the tissues is interesting. It is now generally believed that the ends of the tube secrete a ferment which has the power of dissolving the walls of the cells comprising the outer layer of leaf tissue. "When such an opening has been made, the small thread of the parasite passes through the outer layer, enters an intercellular space, and then rapidly extends its thread-like growth between neighboring cells, drawing its nourishment by means of minute suckers which penetrate the cell walls."* The entire destruction of the leaf may be accomplished. A stoma or breathing pore may also serve as a point of entrance.

The rapidity with which the fungus advances within the leaf tissues depends very largely upon external conditions, and the appearance of the affected parts is also modified to a very considerable extent. Unfavorable conditions frequently render the identification of the parasite a difficult matter without the aid of a glass, but under such circumstances the disease may be fairly widespread, and still cause little injury. In serious attacks, however, many characteristic symptoms may be easily recognized.

The figure represents a leaf which has been entered in several places by the fungus, causing late blight or potato rot. The growth of the parasite has been rapid, and the illustration may be considered as a typical example in which the normal development of the disease has taken place. The following points should be noted:

The diseased areas are of considerable extent, and may be started

---

* B. M. Duggar.

in any part of the leaf, but the edges appear to suffer more from new infection than the more central portions of the leaflets. This is probably due to the fact that in the case of rains these portions remain moist for a longer period than the center, since the water drains to the lower parts of the leaflets, and collects there in the form of drops of greater or less size. It is to be expected that under such conditions a fungus could gain an entrance more easily than in drier places. The decayed portions are inclined to droop; this is especially true in cases of rapid invasions, for at such times the parts do not dry so fast as the parasite advances. The rapid decay also prevents the edges of the leaflets from curling, although this takes place when the air becomes warm and dry.

The distribution of colors over the affected leaf is very suggestive. Under normal conditions, the unaffected parts retain a deep green color, while the diseased area may be yellowish brown, dark brown, or nearly black. But whatever the color each area is sharply outlined. There is no gradual merging of one into the other, but a distinct change of color marks the progress of the disease. Occasionally another peculiarity may be noticed. If the leaves are closely examined it will be found that the green and the brown areas are not directly in contact with each other; they are separated by a narrow strip in which the green has been destroyed, and the brown has not yet appeared. It consists of a colorless or at most a very pale yellow line in which the growth of the fungus is probably very active. But during periods which are unfavorable to the development of the parasite this line cannot be discerned, and the green and brown tissues are apparently in contact. Under such circumstances the identification of the disease without the aid of a microscope is an exceedingly difficult matter. Let us suppose that the fungus has succeeded in gaining an entrance, and that it has advanced a limited distance in the leaf tissues. If at this time the weather should turn dry and hot, the development of the parasite would be checked, and the result would be the formation of a small brown spot or area, perhaps near the edge of the leaflet, and if several such spots exist the injury might be ascribed, without careful examination, to what is commonly known as the early blight fungus.

The name "downy mildew" has been given to the potato rot disease trom the fact that there appears, under favorable circumstances, a downy or mouldy growth upon the under surface of the leaves. This is white in color and may be of considerable density. The upper surface of the foliage does not show it, but whenever this frost-like growth appears on the under side, it is almost certain that the potato rot fungus is present, especially if the other conditions mentioned above are also present. This external growth consists of spores and of the parts bearing them. The spores, or conidia mature very quickly, and have the power of immediately propagating the fungus. They are small and light, and may be carried long distances by winds. It is largely owing to these bodies that the progress of this potato disease is so rapid. They are produced in countless numbers and are very energetic in attacking healthy tissue. It appears to be very probable, also, that these conidia, or summer spores, are the cause of the rotting of the tubers. After maturing upon the leaf, some fall to the ground, and by means of water and other mechanical agents they are brought in contact with the tubers growing underneath the surface of the soil. Here they germinate and effect an entrance in the same manner as occurs above ground. The color of the affected tubers also changes, a brown, dry rot taking the place of the normal white color. The more slowly the tubers decay, the less is the amount of moisture present; the contrary is also true. The decay does not take place in a uniform manner, but its progress varies in different tubers. In some it is mostly the parts near the surface that are affected, while in others the disease may advance rapidly towards the center of the tuber, causing the exterior to show much smaller amount of disease than is actually present. The discoloration, however, generally presents a uniform appearance. Athough it is by no means impossible for the mycelium to reach the tubers from the leaves by means of the stems, still it is the generally accepted opinion that infection does not take place in this manner. This belief was held many years ago, for in some of the earlier writings recommendations may be found in which very high hilling is advocated so that the spores may be washed past the tubers and away from them, and not through the soil directly to them.

"There is still another feature of the late blight which it is well to bear in mind. The disease generally appears during August and September, although earlier and later attacks are not very rare. Coming so late in the season, all the earlier varieties are comparatively free from attack, but the later ones are especially subject to the disease. This, however, is not necessarily due to the foliage of such varieties being more susceptible, but rather to the habits of the fungus. I have not observed that the age of the potato plants has a marked influence upon the spread of the disease; nor that the young foliage of the plants is less subject to the disease. It appears as if the parasite is able to thrive upon all potato foliage which is in a healthy condition at the time of the germination of the spores, and that old and young foliage or plants suffer practically to an equal extent."*

"Acceptable evidence of a resting stage or oosporic form of this fungus is lacking, and many believe that the fungus threads survive the winter in the partially diseased tubers."†

The important question and the question which concerns every potato raiser is, "Is there any practical remedy or preventive for the potato blight?" Fortunately there is, and there is no more reason now for a farmer to permit his potatoes to be destroyed by the blight than to permit them to be destroyed by the potato-beetle. The standard preventive is the Bordeaux mixture. This, if properly made (see page 69) and properly applied, will protect potatoes from the late blight and the consequent potato rot. Had this treatment been generally practiced in New York state this year it would have meant the saving of thousands of dollars to the farmers. Had the Irish peasants been properly instructed upon the use of Bordeaux mixture, and had they followed faithfully the instructions given, the threatening famine in Ireland might have been averted.

As has been stated, the treatment for blight consists in preventive measures, and this is, without doubt, the reason why potatoes are often neglected, as the necessity for treatment may not be apparent until too late.

The record of spraying on the experimental plats this year is as follows:

June 18, sprayed with Bordeaux mixture and Paris green.
July 6, " " " " " " "
July 21, " " " " " " "
August 12, " " " "

---

* E. G. Lodeman, Cornell Bulletin 113.

† B. M. Duggar.

123.—*Potato leaf affected with early blight (adapted from Galloway).*

124.—*Potato leaf affected with late blight.*

This spraying was given to all plats except No. 39, which was left as a check. On this plat no treatment was given except for the potato beetle, the Paris green applied being mixed with plaster. By reference to the table on page 56 it will be seen that on plat 39 the yield of potatoes was only 234 bushels per acre, while on the adjacent plat, No. 40, treated exactly the same as plat 39, except the spraying, the yield of potatoes was 305 bushels per acre. In this case the sprayed plat gave an increase of 71 bushels per acre over the plat not sprayed. The average total yield of all plats sprayed and given level culture was 337 bushels per acre and of the plat receiving no spraying 234 bushels. The only reason we can ascribe as the cause of the low yield on the plat not sprayed is that owing to the attack of the blight the vines died three weeks earlier than did those on the sprayed plats.

The necessity for thorough work should be emphasized. The foliage must be thoroughly covered with a coating of the Bordeaux mixture so that spores of the blight will not readily find a lodging place. If the spraying is done in a careless manner it may nearly as well not be done at all, as it will not accomplish the purpose. Even with the potatoes on the experimental ground where the spraying had been thoroughly done the blight struck them about the 1st of September, and no doubt lessened the yield somewhat. It was, however, so late in appearing that no opportunity was offered for the disease to attack the tubers and produce the rot. Had another spraying been given about August 25, it is probable the time of growth would have been lengthened and more satisfactory results obtained. There appears to be a difference in the ability of different varieties to withstand attacks. With us the Carman No. 3 possessed the greatest power of resistance, and the Rose of Sharon was most susceptible to the disease. In all cases the seed used should be from stock not attacked by blight, as it is possible the disease may be carried over in affected tubers.

ONE ACRE POTATO FIELD.

In addition to the series of experimental plats which have been described, one acre of potatoes was planted on the land where 314 bushels of potatoes had been harvested in 1896. Previous to 1896 this land had been subjected to a regular four years' rotation of wheat, meadow, corn and oats. In the fall of 1895 a light application of strawy manure was applied, and then the straw was all raked off in the spring before plowing the land for potatoes. The yield in 1896 was 314 bushels. Without any additional manure or fertilizer the land was again planted to potatoes in 1897, and a yield of 273 bushels obtained from the acre. Five cultivations and four sprayings were given, the first three sprayings being with Bordeaux mixture and Paris green, and the last spraying being with Bordeaux mixture alone. This field was somewhat neglected, owing to the wet August, and the weeds were permitted to grow. While it was late in the season when the weeds were allowed to grow, there is no question but that the yield of potatoes was materially decreased by them. To see what effect weeding would have, four rows were cleaned of the large weeds by hand, and it was found upon harvesting that the weeding had increased the yield at the rate of 30 bushels per acre. The whole potato field should have been kept perfectly clean of weeds until the time of harvesting. A source of material loss to the potato crop is frequently due to the fact that in late summer and early fall the weeds are allowed to grow.

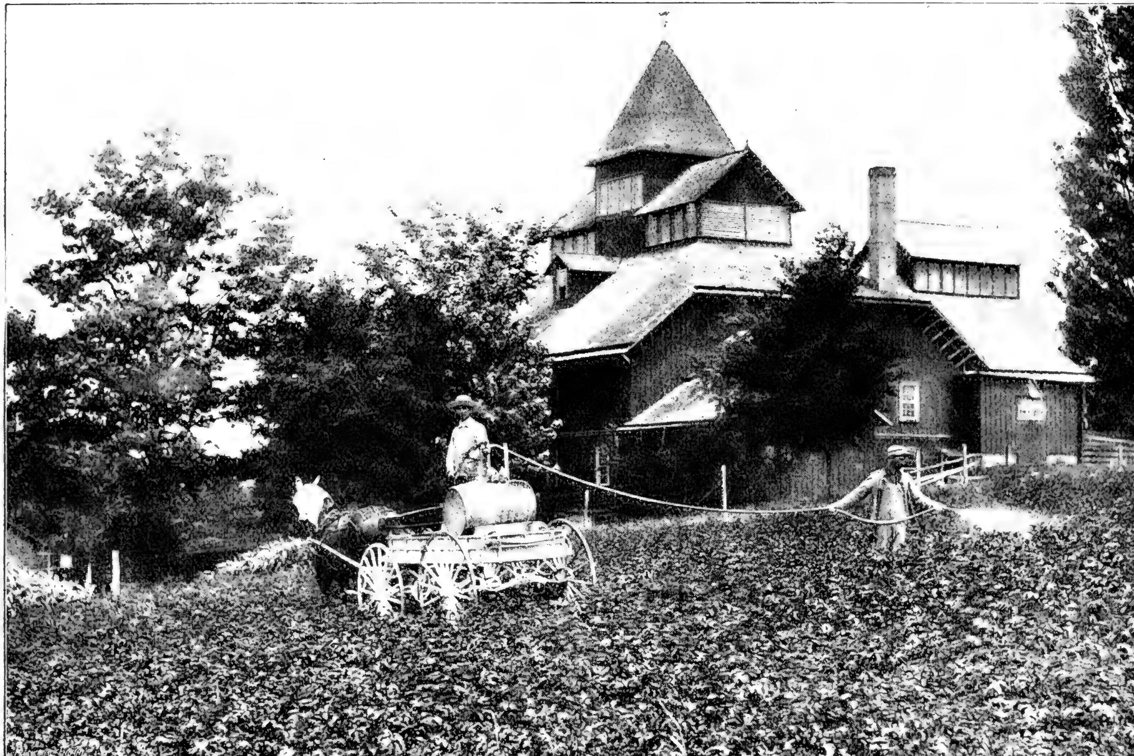
BORDEAUX MIXTURE.

No doubt failure to secure satisfactory results from the use of Bordeaux mixture is often due to the fact that the mixture is not properly prepared. While its preparation is very simple, it is possible the very simplicity has caused some to think no great care need be exercised in its preparation. This is a mistake, for the success of the application depends upon its being made properly.

The standard formula for Bordeaux mixture is

Copper sulfate........................	6 pounds.
Lime..................................	4 "
Water.................................	45 gallons.

Potatoes will require from two to six barrels of the mixture per acre according to the size of the vines. In case a large area is to be sprayed, it may be well to make up a stock solution of copper sulfate. The following directions for making up the solution may be found helpful. Into a barrel containing 40 gallons of water suspend in a bag or gunny sack 40 pounds of copper sulfate or blue vitriol. It is important that this be suspended near the surface as the solution has a greater specific gravity than water. If it should be put in the bottom of the barrel a



125.—*Spraying Potatoes on the Experimental Plats.*

saturated solution would soon be formed there, when no more of the copper would be dissolved. If the barrel be covered tightly this stock solution will keep good for an indefinite length of time.

The lime used should be fresh burned, caustic and not air slaked. The most convenient receptacle in which to slake the lime is a somewhat shallow, long, water tight box To make up say four barrels of the Bordeaux mixture, put into this box 16 pounds of lime and add sufficient water to thoroughly slake. The lime should be kept well stirred during slaking that the water may come in contact with all parts. If it is desired to keep the lime for some days after slaking, it may be simply covered over with water so that the air will be excluded. When it is desired to use it, stir thoroughly and put one fourth the contents of the box into a keg or other receptacle and dilute with 20 gallons of water. If more than four barrels of Bordeaux mixture are likely to be wanted, two slaking boxes would better be provided so that the lime will be ready for use when required

Into the barrel from which it is to be pumped put six gallons of the contents of the barrel containing the dissolved copper sulfate. It seems hardly necessary to state that before doing this the copper sulfate solution should be thoroughly stirred. Fill the spray barrel half full of water and add the lime which has been diluted with 20 gallons of water. All of this material should be run through a sieve or strainer so that no sediment will clog the action of the pump.

If Paris green is to be used to kill the potato "bugs" put it in the mixture at this time, four ounces if the grubs are small, six ounces if they are half grown. A paste should be made of the Paris green by mixing it with a small amount of water before putting it in the spray barrel. Fill the barrel with water and the Bordeaux mixture is ready for use to protect potatoes from the flea-beetles, the blight and the Colorado potato beetles. A strong force pump is best, as then every part of the foliage can be covered by the liquid. During the operation of spraying the liquid should be frequently stirred, otherwise the ingredients will not be evenly distributed through the mixture.

Numerous inquiries have been received not only from New York state but from many states and foreign countries asking how the success achieved by the station with potatoes was accomplished. While the yield was fair, yet it was in no way remarkable, and was not in excess of what should be realized by every potato raiser should the proper methods be practiced. In ordinary farm practice barn manures and commercial fertilizers are frequently used, while on the station grounds no manures or fertilizers have been used for four years. If use had been made of them it is probable that better results could have been shown. The purpose of the experiment, however, has been to show what could have been accomplished by better methods of tillage and better care of foliage than is ordinarily given. Should one-third of the land be planted to potatoes which is ordinarily planted, and this lessened number of acres be given better tillage and better care, the results would be far more satisfactory.

The question is frequently asked, "Will these better methods pay?" While this question cannot be answered definitely, yet it is recommended that a careful study be made of the results obtained during the three years in which the trials have been made. If it appears that these results are better than are ordinarily obtained by the farmer, then the study should be continued to determine how these results were obtained.

While we cannot guarantee that the same increase of labor will in all cases give the same satisfactory results, yet we recommend that it is worthy of a trial by all who are interested in securing better returns for the labor expended.

I. P. ROBERTS.
L. A. CLINTON.

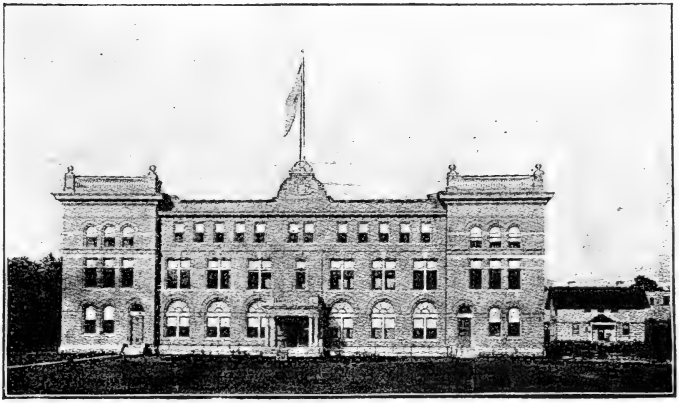
Bulletin 141. November, 1897.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

VETERINARY DIVISION.

POWDERED SOAP AS A CAUSE OF DEATH AMONG SWILL-FED HOGS.



NEW YORK STATE VETERINARY COLLEGE.

By VERANUS A. MOORE.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1897.

ORGANIZATION.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, the following persons have been appointed investigators and instructors in the College of Agriculture of Cornell University to serve throughout the state according to the needs of the several localities for a portion or all of the year:

J. W. SPENCER, B. M. DUGGAR, A. L. KNISELY,
G. T. POWELL, J. L. STONE, MISS M. F. ROGERS.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in western New York.
125. A Disease of Currant Canes.
126. The Current-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums for western New York.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report on Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.

POWDERED SOAP AS A CAUSE OF DEATH AMONG SWILL-FED HOGS.

It is a common experience of those who are engaged in the investigation ot animal diseases to occasionally find outbreaks of a peculiar nature among swill-fed hogs. By these are meant herds of greater or less size, usually kept near or within the outskirts of our villages or small cities, and which are fed upon the kitchen refuse, often including the dish water, collected from hotels, boarding houses and private dwellings. The cause of death in these outbreaks is, in this state, at least, usually attributed to hog cholera. The basis for this popular diagnosis seems to be in the similarity of certain of the symptoms manifested by these animals to those of hog cholera, such, for example, as diarrhœa and partial paralysis, and the fact that a majority of those attacked die. The course of the disease is irregular, deaths occurring in from a few hours to several days after the symptoms appear.

During the past year I have had occasion to make investigations into the nature of several of these outbreaks of a supposedly infectious disease. In a few of these epizootics hog cholera or swine plague was easily demonstrated. In certain others, however, these or other infectious diseases could not be found. The animals were usually fed the kitchen slops collected from hotels and boarding houses. The tissue changes in the animals examined were atypical of any known disease, and notwithstanding the bacteriological examinations which were made, together with animal inoculations with pieces of the diseased organs, the cause of death remained undetermined. The post mortem examinations showed in nearly all of these animals enlarged and dark colored lymphatic glands, especially those of the mesentery. The blood vessels of the mesentery were very much distended with blood. The liver and kidneys were usually not affected, but occasionally these organs were involved. Where there had been marked nervous symptoms the brain was much congested. Occasionally the lungs contained areas of collapse. The intestines were, as a rule, pale and the mucous membrane seemed to be abnormally shiny.

The negative outcome of these investigations suggested that possibly our methods had been faulty or that some unknown conditions existed which had obscured the cause of death, and that after all the popular diagnosis of an infectious disease was right. Against this theory was the fact that the disease did not spread from the affected herds to others, although, as a rule, precautions were not taken to prevent its dissemination, and in some instances the neighboring herds were most favorably situated for contracting the disease if it had been contagious. In certain of the outbreaks the exceedingly filthy condition in which the pens and yards were kept suggested, in the absence of a knowledge of definite, specific agents, that the animals had died as a result of their unsanitary surroundings and unwholesome food, a hypothesis which in some instances is still entertained as being highly probable. However, we were still confronted with the problem that in many outbreaks neither a specific infectious disease could be found nor the exciting cause of death pointed out.

Although it was apparent that the cause of the deaths was to be found in the food, the feeders of this kind of swill failed to see why they should discontinue its use. Naturally they felt that if we could not find or demonstrate the presence of the destructive agent in the swill the cause of death must be something else, probably hog cholera, for thousands of hogs are annually raised upon this kind of food. Further, the plea that such garbage was not a suitable or even wholesome food for their animals availed nothing, for the reply was, that usually their pigs thrived upon it.

Early in the summer, in conversation on this subject with Mr. W. F. Davey, an enterprising farmer living near Brewerton, N. Y., he related the circumstances concerning an outbreak of this kind in which he had traced the cause of the trouble to the soap used in washing the dishes. The swill, including the dish water, was collected from three small hotels and fed to a herd of swine. In a short time the animals began to sicken and many of them died. Upon inquiry it was found that in the hotels large quantities of powdered soap were used in washing the dishes. This was stopped and no more animals died. Later in the season Dr. J. A. McCrank, of Plattsburg, told me of an outbreak of an apparently infectious disease among swine which had come under his observation and in which he could not make a positive diagnosis. In the investigation of its cause he found that the hogs were being fed the swill, including the dish water, from a hotel. Upon inquiry he found that powdered soap was being used in large quantities. The swill from this place was stopped and the disease disappeared.

In following up the line of inquiry which these experiences suggested, it was found that there is among the more enterprising farmers a quite general belief that these soaps, when given in considerable quantities, are injurious and even fatal to hogs. The consensus of opinion on this subject, together with the more definite observations of Mr. Davey and Dr. McCrank, appeared to be so conclusive that it seemed important to determine by careful experiment to what extent, if at all, powdered soaps can be considered as the cause of death in this class of outbreaks. To this end the experiment about to be described was carried out. It shows that when certain of the powdered soaps sold in the market are present in the food in relatively large quantities a considerable percentage of the animals will sicken and many of them will die. When, however, the soaps are added to the food in small quantities (a dessert spoonful in the food for three pigs, twice daily) no bad effects seem to follow. The cause of death, when it does occur, is probably due, as shown by the chemical analyses, to the free alkali, sodium carbonate or washing soda, which they contain.

EXPERIMENT IN FEEDING POWDERED SOAPS TO PIGS.

In the experiment three of the commonly used powdered soaps were selected. They are here designated as soaps A, B and C. Nine pigs weighing about 20 pounds each were taken. They were given their regular food, grain mixed in water and some separator milk. To this was added a definite quantity of the soaps, which were dissolved and thoroughly mixed in the food twice daily.

SOAP A.

July 10. Pigs Nos. 1, 2 and 3 were placed in pen No. 1. They were given, night and morning, regular rations as previously described, to which were added two ounces of Soap A.

July 14. Pigs well. Quantity of soap given increased to four ounces.

July 18. Pig No. 1 has profuse diarrhœa; others well.

July 20. Pig No. 1 has diarrhœa; at times it runs about the pen in apparently a dazed condition.

July 24. Pigs Nos. 1 and 2 have had diarrhœa. Quantity of soap given reduced to one ounce.

Aug. 1. Pigs appear to be well.

Aug. 7. Quantity of soap increased to five ounces.

Aug. 8. Pigs sick, all have diarrhœa, do not eat. Have some difficulty in walking.

Aug. 9. Pigs appear to be no better.

Aug. 11. Pigs still sick. Have eaten very little. Soap stopped.

Aug. 12. Pigs slightly better.

Aug. 15. The condition of the pigs much improved.

Aug. 18. Animals apparently well.

The feeding of this soap was repeated on these animals some weeks later with a similar result.

Soap B.

July 10. Pigs Nos. 4, 5 and 6 were placed in pen No. 2. They were fed the regular rations, to which were added, morning and evening, two ounces of Soap B.

July 14. Pig No. 4 has a bad diarrhœa. Others well. Quantity of soap given increased to four ounces.

July 15. All three have diarrhœa.

July 19. Pig No. 4 found dead. No. 5 very sick, unable to stand, refuses food.

July 20. Pig No. 5 cannot stand, limbs constantly jerking. There seems to be paralysis. It dies late in the afternoon. Pig No. 6 has suffered from diarrhœa, but otherwise seems to be well, although it eats very little. Quantity of soap reduced to one-half ounce.

July 22. Pig No. 6 better.

Aug. 1. Pig No. 6 much improved. Soap discontinued.

Soap C.

July 10. Pigs Nos. 7, 8 and 9 were placed in pen No. 3. They were fed the same as the others. Night and morning two ounces of soap C were mixed with their food.

July 13. All the pigs have diarrhœa, eat very little.

July 14. Quantity of soap reduced to one ounce.

July 16. Pigs very sick. Eat very little, heads jerk constantly, limbs tremble, temperature 103.5, 104, 103.8° F.

July 18. Pig No. 7 dies suddenly to-day. Others still sick. No. 8 has much difficulty in standing. Lies with feet extended. Legs and head are constantly jerking. No. 9 has diarrhœa, eats little, but otherwise appears to be well.

July 19. Pig No. 8 found dead this morning. No. 9 seems to be better.

July 20. Pig No. 9 eats heartily. Appears to be quite well.

Three other pigs, Nos. 10, 11 and 12, from the same lot were placed in pen No. 3 with pig No. 9. They were given half an ounce of soap C thoroughly mixed with their food twice daily.

July 25. Pigs apparently well.

Aug. 1. Pigs apparently well.

Aug. 17. Pigs apparently well. The quantity of soap increased to four ounces at each feeding.

Aug. 18. Pig No. 10 sick.

Aug. 20. Pigs all sick, refuse food. They ate sparingly of some corn given them.

Aug. 21. No appreciable change.

Aug. 23. Pig No. 10 very sick. The muscles of the head and legs constantly jerking. Eats very little of the regular food, but partakes sparingly of corn.

Aug. 25. No change.

Aug. 27. Pigs very sick, have refused food containing soap for two days. Eat sparingly of corn. Soap discontinued.

The pigs which recovered from the immediate effect of the soap did not become thrifty for some weeks. It was late in September before they began to show signs of growth.

POST MORTEM EXAMINATION.

Pig No. 4. The skin over the ventral part of the body and between the thighs of a pinkish color. Kidneys very pale. Spleen normal. The blood vessels of the mesentery much congested. The mesenteric glands enlarged and œdematous. Many of them are congested. Areas of the mucous membrane of the intestines, especially the ileum, were of a dark reddish color. The lungs and heart were not changed. The brain was deeply congested.

Pig No. 5. This pig showed lesions very similar to those exhibited by No. 4. The essential difference was an increase in the intestinal congestion.

Pig No. 7. The skin between the thighs and about the nose was of a bright pinkish color. The liver was small, exceedingly firm and friable. The mesenteric blood vessels were injected and the mesenteric glands were enlarged and œdematous, and many of them deeply reddened. A few were hemorrhagic. Spleen normal. The cortex of the kidneys very pale, but the papillæ were abnormally dark. The mucous membrane of the intestines was congested in a few irregular areas. The mucosa of the stomach covered with a thick layer of mucus. The heart and lungs were normal in appearance. The brain was very much congested.

Pig No. 8. The tissue changes in this animal were similar to those found in Pig No. 7, with the exception that the kidneys were much congested.

A careful bacteriological examination was made of the liver, spleen, kidneys and blood of each animal that died. In nearly every instance (all but two) the tubes of culture media (agar and bouillon) inoculated remained clear. The two exceptions contained saprophytic bacteria and were probably contaminations from the air. This examination shows that the alkali had not favored the migration of the bacteria from the intestines to the various organs of the body.

In order to check the results, several pigs from the same litters as those used in the experiment were kept in adjacent pens, and given the same kind of food. They all remained well. This fact, in addition to the negative results from the bacteriological examination, and the peculiar nature of the lesions, are sufficient evidence that the sickness and the fatalities among the pigs in the experiment were due to the soap administered.

It is important to note that the lesions found in the pigs which died in the experiment were similar to those found in the pigs in certain of the outbreaks mentioned among swill-fed hogs. Considering the facts as they appear, it seems highly probable that the cause of death of the animals in certain of the outbreaks mentioned was the presence of the free alkali in the swill. This hypothesis is supported by the experiences of Mr. Davey and Dr. McCrank.

CHEMICAL ANALYSIS OF THE SOAP POWDERS USED.

In order to ascertain the chemical nature of these soaps they were submitted to Mr. Geo. W. Cavanaugh, Assistant Chemist of the Agricultural Experiment Station for analysis. The following report was received:

"The soap powders used in the above experiment are mixtures of ordinary hard soap that has been powdered or in some way reduced to a fine condition, and sodium carbonate. Sodium carbonate is known in commerce as Sal Soda, Washing Soda or Soda. In water it forms a caustic solution which is the lye used in making the old-fashioned hard soaps.

Analysis.

Soap A	49.60 per cent.
Soap B	55.42 per cent.
Soap C	55.44 per cent.

(Signed) GEO. W. CAVANAUGH, Asst. Chemist."

A careful inquiry has been made to ascertain the quantity of these soaps commonly used in washing dishes. This has revealed the fact that while the amount used by different individuals varies, the quantity is large, usually far in excess of the amount prescribed by the manufacturers. Thus I have been told, by thoroughly reliable people, of dish washers who would use one-third of a box in cleansing the dishes after a single meal. While this is extreme, it is said to happen not infrequently, and it is easy to understand that the swill from these kitchens would contain far more of the alkali than we found necessary to produce fatal results. Should such excess in the use of these cleaning agents be indulged in for several days in succession, we have, in the light of the foregoing experiment, a cause for many fatalities among the hogs fed upon the dish water.

In view of this danger it seems better to abandon altogether the habit of giving dish water to hogs. Although the feeding of garbage is generally condemned, the scraps of vegetables and table refuse could, perhaps, if properly collected, be used with safety. But certainly pure water is a much more wholesome drink, even for swine, than dirty dish water. When the subject of "swill feeding" as a business is studied and the conditions, as they exist, are understood, the wonder is, not that some of the hogs die, but rather, that any of them live.

It is not presumed that the poisoning by carbonate of sodium is the only cause of death among swill-fed hogs. Other destructive agencies are liable to be found in the decomposing garbage. The results of the investigation, which the necessity of good farm hygiene demands, will very likely disclose the specific nature of many of them. Another fact worthy of consideration is that the investigation of the last year shows that nearly all of the outbreaks of hog cholera and swine plague which came to our attention started among herds of swine fed upon garbage and swill collected from the sources above mentioned. This is significant, and it points to the undesirableness of feeding garbage to animals. In fact, if the total losses it occasions are counted, it is questionable if anything is gained in this attempt to save waste products. It is stated in the official reports of the U. S. Department of Agriculture that in 1896 12 per cent. (which amounts to 5,440,176) of the hogs in this country died from disease.

Again, it has long been recognized that the feeding of garbage to hogs furnishes one of the most favorable channels for the introduction of hog cholera and swine plague bacteria. As a rule, wherever we find hogs in clean, well ventilated pens and fed upon wholesome food, we find thrift and health, and, conversely, where these animals are surrounded with disgusting filth, and fed upon decomposing slops or other unwholesome food, we expect to and often do find disease.

It is unfortunately becoming a too prevalent habit among our farmers to assume, as soon as one or two pigs die, that some infectious disease, such as hog cholera, is among them. It is further most unfortunate that they frequently entertain the fatalistic notion that a remedy is beyond their reach. Fully 25 per cent. of the outbreaks of reported hog cholera which we have investigated during the past year have not been hog cholera or any other known infectious disease. While it is true that when hog cholera becomes well established in a herd there is great danger that the majority of the animals will die, it is equally true that if the disease is not a genuinely infectious one that a majority of the animals can, by proper treatment, be saved. When a pig sickens and dies the thing to do is to examine, or have it carefully examined, to find out if possible what the cause of death is, in order that the best methods known for preventing the further spread of the disease may be promptly adopted.

If the examination shows the disease to be hog cholera, swine plague, or any other infectious disease like anthrax or tuberculosis, the as yet uninfected and apparently well animals should be placed in other pens and the old ones disinfected. The animals should be given easily digested and nourishing food, plenty of sunlight and pure air. If others should become affected, the well ones should again be separated from the sick. The channel or way by which the specific cause of the disease got into the herd should be diligently sought for. As the most common way is through the food, it is always a safe precaution to change the diet.

It is certainly not desirable to acquire the reputation of having an infectious disease among one's animals when the real trouble is due to poor hygiene, to some irregularity in their care, or to an accidental poisoning.

If the diagnosis cannot be positively made, it is best to put the apparently well hogs in a separate pen, provide them with good ventilation, wholesome food and cleanliness. *It is important that the food should be changed.* By carefully observing the method of *strict isolation*, disinfection, healthful surroundings and nourishing diet, many epizootics of infectious diseases have been checked, and it is safe to presume that if such precautions were rigidly adhered to, nearly all of the losses now sustained from dietary causes would be saved. The observance of the rules necessary for the promotion of good health among mankind applies with equal force to the lower animals.

CONCLUSIONS.

From the foregoing the following conclusions seem to be warranted:

1. The greatest amount of loss sustained from swine diseases in this state is among hogs fed upon the swill collected from hotels, boarding houses, and other large institutions.

2. The cause of death in certain outbreaks of disease among swill-fed hogs is the direct poisoning of the animals by the excess of free alkali (washing soda) in the swill. These alkalies come from the powdered soaps used in washing dishes.

3. It appears that small quantities of the powdered soaps do not produce immediate bad results. It is presumable that they can be used in quantities sufficient for the needs of cleanliness with perfect safety, but, owing to the danger involved in their use, it is safer not to give the water containing them to animals.

4. In addition to the unwholsomeness of garbage and kitchen slops for animal food, and in addition to the losses sustained from the immediate effect of such kinds of food, hogs fed upon it are very liable to contract specific infectious diseases, such as hog cholera, swine plague and tuberculosis.

5. The enormous amount of loss among garbage fed hogs, which in this state alone aggregates thousands of dollars annually, suggests the desirability of urging the discontinuing of the practice of collecting swill for such purposes. Certainly if the refuse material is to be used for feeding swine, it should be collected and fed while fresh and sweet. When possible, it should be kept dry, and by all means free from alkaline dish water. It is advisable to cook all kitchen or table refuse before feeding in order to remove the danger of infection from specific diseases. The only suitable channel for the disposal of dish water is the sewer.

New York State Veterinary College,
Cornell University, Ithaca, N. Y., October 20, 1897.

SECOND EDITION, ISSUED JULY 25, 1898.

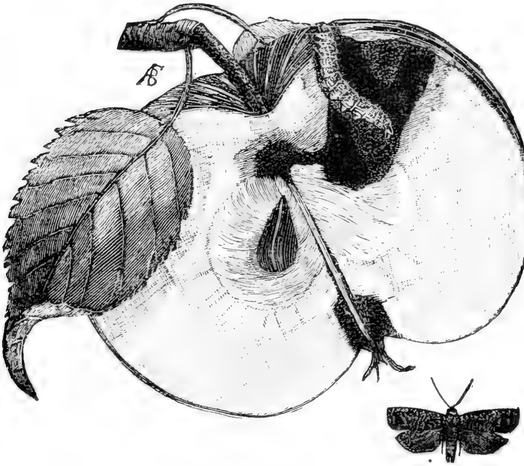
Bulletin 142. **January, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

The Codling-Moth.



(*Picture from Lodeman's "The Spraying of Plants," by permission of The Macmillan Co.*)

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION

BOARD OF CONTROL:
THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE, - - - Trustee of the University.
Hon. B. F. TRACY, - - President State Agricultural Society.
Professor I. P. ROBERTS, - - - - Agriculture.
Professor G. C. CALDWELL, - - - - Chemistry.
Professor JAMES LAW, - - - - Veterinary Science.
Professor J. H. COMSTOCK, - - - - Entomology.
Professor L. H. BAILEY, - - - - Horticulture.
Professor H. H. WING, - - - Dairy Husbandry.
Professor G. F. ATKINSON, - - - - Botany.

M. V. SLINGERLAND, - - - - Entomology.
G. W. CAVANAUGH, - - - Chemistry.
L. A. CLINTON, - - - - Agriculture.
B. M. DUGGAR, - - - - - Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS, - - - - - - Director.
E. L. WILLIAMS, - - - - - Treasurer.
EDWARD A. BUTLER, - - - - - Clerk.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, the following persons have been appointed investigators and instructors in the College of Agriculture of Cornell University to serve throughout the state according to the needs of the several localities for a portion or all of the year.

J. W. SPENCER, B. M. DUGGAR,
G. T. POWELL, Miss M. F. ROGERS.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1898.

142. The Codling-Moth.

THE CODLING-MOTH.

Carpocapsa pomonella Linn.

Order LEPIDOPTERA; family GRAPHOLITHIDÆ.

Almost every lover of fruits has seen a "wormy apple," and most people understand that, as our little two-year-old daughter puts it, "a naughty old worm did it." The time is soon coming when these little observers of nature will not be content with this meagre information, and fathers and mothers will be called upon to tell more of the story of the life of this "naughty old worm." How few of us know this story!

This apple-worm is one of the most serious drawbacks to the profitable growing of apples by the average fruit-grower. From one-fourth to one-half of the apple crop in the United States is usually ruined annually by this insect; it thus exacts millions of dollars of tribute yearly from our fruit-growers. As many of our more progressive orchardists have already learned, the number of wormy fruits can be largely reduced by the intelligent application of modern methods. In spite of the fact that this insect usually causes a greater monetary loss to the apple-grower than all the other insect foes of the apple combined, yet it can be often more easily controlled than the apple-borer, the canker-worms, and several other orchard pests. We wish that every apple-grower could be induced to read, from Nature's book if possible, the life-story of this insect, and then put to practical use the knowledge thus obtained. For we are hopeful that then it would not be necessary to look over a bushel of apples in our city markets to find half a dozen that were not wormy; and besides the apple-grower would then be prepared to introduce a very interesting bit of nature-study into the home whenever the little ones chanced upon the work of the "naughty old worm." It has come to be a well-established fact in our experience among fruit-growers, that those who combat their insect foes with the least trouble, the most successfully, and get the most fun out of it—they are the ones who like Hiawatha have

> "Learned their names and all their secrets,
> How they built their nests in summer,
> Where they hide themselves in winter,
> Talked with them whene'er he met them."*

Naturally much has been written about an insect of such great economic importance, and yet the literature embraces but comparatively few approximately exhaustive and comprehensive accounts of it; none of these are now easily accessible to the fruit-grower. By far the best account, written by Dr. L. O. Howard, was published in 1888, and no similar attempt has been made by American writers since. Although many reports, comprising thousands of pages of printed matter, have been made on the insects of New York State, it is a surprising fact that everything therein pertaining to this most important of all orchard pests would occupy little more than half a dozen printed pages. We began a critical study of the insect in the spring of 1896, and for nearly two years have devoted much time to careful observations of its habits in all stages. Considerable time has also been spent in ransacking all of the foreign, as well as American, literature that could be bought or borrowed; several interesting facts have been gleaned from this search through many quaint and musty records which make up the history of this insect.

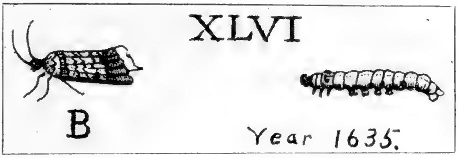
The above facts, we believe, fully warrant the somewhat exhaustive discussion of this pest which follows.

SOME GENERAL HISTORICAL NOTES.

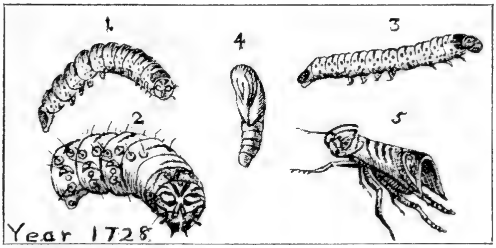
First account of the codling-moth ever published.—"These grubs have their origin in the interior of the sugar pears, where they have their home and find all their necessary food. It disposes itself for transforma-

* As some inquisitive mind may wonder why it is necessary that man should be tormented with this little worm whose palace is the wormy apple, we submit the only attempt at an explanation that we have seen: "Or were they created, solitary preachers on each little globe of fruit, which falls like manna from above, to teach us some great moral lesson? Come they into our very faces to remind us how 'dearly we pay for the primal fall?' Do they inhabit the finest specimens of that fruit by which our first mother was tempted, in order to bid us taste the viands of Eden, and make us feel 'that the trail of the serpent hangs over them all?'"

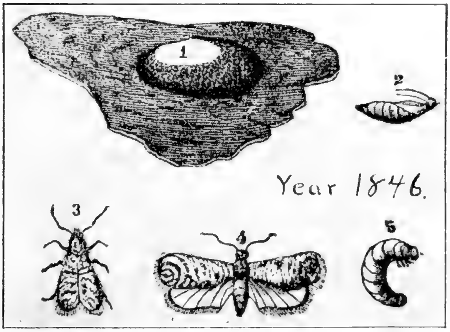
tion on the 3d of August and on the 2d of July of the following year the moth is so far advanced as is indicated at B; thus it has lain as if dead in its process of transformation for eleven months. I name it from its food



the *Pear-eater*." (Translated from Goedaerdt's quaint Dutch volume, *Metamorphosis Naturalis.*)

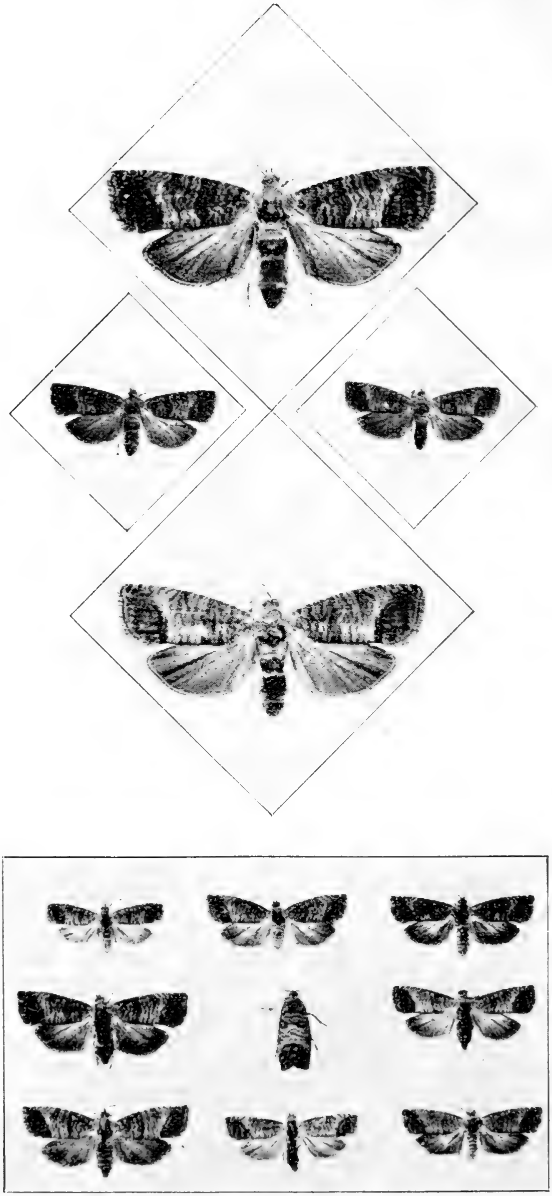


A GROTESQUE OLD GERMAN PICTURE (FROM FRISCH).



THE FIRST AMERICAN PICTURE.

126.—*Some historical pictures of the Codling-Moth.*



128.—*Pictures of the Codling-Moth, showing its variations. All natural size, except the two large ones, which are enlarged twice.*

131.—*Some pictures of the egg of the codling-moth; natural size on the apples at* a, b, b, *and enlarged at* e, es, es, h; o *shows the end of the ovipositor of the female.*

It is said that Cato speaks of "wormy apples" in his treatise on Agriculture, written nearly two hundred years before the Christian era. In the first century, A. D., both Columella and Pliny doubtless refer to this insect in their writings. Pliny says: "The fruits themselves, independently of the tree, are very much worm-eaten in some years, the apple, pear, medler, and pomegranate, for instance." While the apple-growers of these ancient times were doubtless familiar with the work of this worm, yet the real history of the insect itself apparently begins in 1635, or almost with the beginning of purely entomological literature. A translation, with a reproduction of the pictures, of this first quaint Dutch account is given in figure 126. Nearly a century seems to have elapsed before we again find the insect discussed by entomologists. In 1728, Frisch, a German writer, gave us the first detailed descriptions of the insect; his grotesque pictures of the different stages are reproduced in figure 126. Before the middle of the 18th century, two other especially noteworthy accounts were published. In 1736, Reaumur, a Frenchman, added some accurate details, with good figures, of its habits in the fruit, and in preparing for transformation. Ten years later, Roesel, a German writer, devoted several pages of his wonderfully interesting "Insect Recreations" to a very good account of the habits and life of the insect based upon original observations; the hand-painted pictures illustrating this have never been excelled in color since. The next year, 1747, apparently the first English account, by Wilkes, appeared. He compiled briefly from Roesel, but rendered his account especially noteworthy, since he then gave to the insect the common name by which it is to-day recognized by all the English-speaking peoples.

During the next century and a quarter much was written of the insect in Europe, and considerable was added to our knowledge of some of the details of its habits and life. The most noteworthy German discussions during this period, from 1750 to 1875, were those of Schmidberger, Ratzeburg and Nördlinger. The excellent discussions by "Rusticus" (1833) and by Westwood (1838) still remain in the best English literature. Among the best discussions in the French literature are those of Goreau (1861) and Boisduval (1867).

Although the insect had been introduced into America many years before (its introduction and spread in America is discussed later on), it seems to have been first noticed in American literature in 1819. Mr. Joseph Tufts, of Charlestown, Mass., then published an account of rearing a moth, instead of the plum curculio, which had been previously thought to be the sole cause of wormy apples in America. Thatcher had made the same discovery when he wrote the second edition of his "American

Orchardist" in 1825. This is apparently the first notice of the insect in any horticultural book, and although Europeans had been writing of it for nearly two hundred years, it is a curious fact that, so far as we can glean from the literature, it remained for this American writer to make the first suggestion for controlling the insect. Apparently it was not realized until 1832, when Dr. Harris called attention to the fact, that the insect which caused wormy apples in America was the same as the well-known European insect. Only two noteworthy discussions of the insect appeared in American literature during the next thirty years. In 1841, Dr. Harris gave a very good account in his "Insects of Massachusetts;" and in 1846, Miss Morris published in the *American Agriculturist* some original observations, accompanied by the first American picture of the insect. This picture is reproduced in figure 126.

The American literature of this pest since 1864 is doubtless nearly as voluminous as that of all other countries combined. During this period the following Americans have made notable additions to our knowledge of the insect and how to combat it: Trimble (1865), Walsh (1868), Riley (1868, 1873), Le Baron (1873), Cook (1875, 1888), Cooke (1881), Chapin (1883), Atkins (1884), Goff (1886), Forbes (1886, 1887), Wickson (1887), Howard (1888), Gillette (1889, 1891), Popenoe (1889), Washburn (1891, 1893), Koebele (1890), Munson (1892), Lodeman (1892, 1893), Marlatt (1894, 1895), Smith (1894, 1897) and Card (1897). The best and most comprehensive discussions of the insect are those by Le Baron, Cook (1875), Cooke (1883), Howard (1888), Gillette (1891) and Washburn (1893).

GEOGRAPHICAL DISTRIBUTION OF THE INSECT.

The native home of this insect, like that of its principal food, the apple, was doubtless southeastern Europe. It is now a cosmopolitan pest, occurring in nearly every corner of the globe where apples are cultivated. It is especially destructive in Europe, the United States and Canada, and in the English colonies of South Africa, Australia, Tasmania and New Zealand. It is said to have been seen in Victoria about 1855, in Tasmania at least as early as 1861, in New Zealand in 1874, and in South Australia and South Africa about 1885. It has been a serious pest in Canada for many years, but it seems to have not yet gained a foothold in British Columbia. In 1871, Zeller reported having received it from Brazil.

Its introduction and spread in the United States.—It was probably introduced into the United States from Europe in packages containing apples or pears. Just when the insect arrived in America will doubtless never be known. It may not have been until about the middle of the last century, for we find no references to "wormy apples" until after the plum curculio began to be discussed in the literature. For many years the cause of wormy apples in America was thought to be the plum curculio. Apparently it was not until 1819 that this mistake was discovered by breeding a moth from the supposed grubs of the curculio. At that time wormy apples and pears were common near Boston. By 1840, the insect had become a serious pest in the New England States and was common in central New York. A few hints here and there in the literature give us some idea of its westward progress. It is said to have been unknown in Illinois in 1849, and to have not invaded Iowa until about 1860. During the next decade its westward progress must have been rapid, for it reached Utah soon after 1870 and appeared in California in the spring of 1874.

The insect is now recognized as a pest in nearly every section of the United States where there are bearing apple-orchards.

How it is spread.—As the worm often goes into the barrel or other packing-case with the fruit when it is picked, and as it finds therein a suitable place to spin and undergo its further transformations, it is thus often transported for longer or shorter distances. This is doubtless the principal method by which the insect has been distributed, whether from one state to another or from one continent to another. When these receptacles are emptied of their fruit at its destination they are often thrown one side without a thought that adhering to the sides and tucked away in the cracks there may be a dozen, or even a hundred, of the little worms in their snug cocoons, only awaiting the proper season to develop into the parent insects, which usually have little trouble in finding a suitable place in which to start their progeny.

ESTIMATED LOSSES FROM ITS RAVAGES.

Evidently this insect has been noticeably destructive in orchards, that is, it has ranked as an insect pest since the earliest times; for Pliny wrote in the first century of the Christian era that apples and pears "are very much worm-eaten in some years." Judging from recent reports, the percentage of wormy fruits is at the present time nearly as large in many parts of Europe as it is in America. Conservative estimates put the annual loss from its ravages, in all countries where it is noticeably destructive and but little is done to check it, at from 25 to 75 per cent. of the crop of apples; but with pears the loss is usually considerably less. Where modern methods of combating the insect are practiced this percentage is often reduced one half or more.

We have seen but two estimates of how many dollars this pest may cost fruit-growers annually. In 1887, Professor Forbes, after making careful experiments and observations, and making all allowances for modifying circumstances, reached the conclusion that the annual loss due to the apple-worm in the state of Illinois must reach the enormous total of $2,375,000, or one-half the value of the average apple crop. In 1892, the insect is said to have caused a loss of $2,000,000 to the apple-growers of Nebraska.

Through the kindness of the *American Agriculturist* in furnishing us with the statistics, we will hazard an estimate at the annual tribute which our New York apple growers pay for the ravages of this pest. The average annual crop of apples in New York now amounts to about 5,000,000 barrels; as $1.50 per barrel would seem a fair average valuation, the total valuation of the annual crop may be estimated at $7,500,000. Although many New York fruit-growers are fighting this insect with modern methods, we think that the wormy apples would constitute at least one-third of the total crop. That is, New York fruit-growers yearly furnish $2,500,000 worth of apples to feed this insect; and there must be added to this at least $500,000 worth of pears (certainly a low estimate for New York) which the same insect renders worthless. This makes a tax of $3,000,000 which a single insect levies and collects each year from the fruit-growers of our state.

ITS FOOD.

The insect feeds mostly upon fruits, and is, above all, an apple pest. It has also worked in pears from the earliest times; in fact, it was first named a "pear-eater" in 1635 (see this quaint account in figure 126). Sometimes the insect works in pears as freely as in apples, but usually the percentage of wormy pears is considerably less. Wild haws, crab apples, and quinces are also quite freely eaten by the worms. Sometimes the insect works in the stone fruits. In 1868, Saunders reported it as quite destructive to plums in Canada, and it has recently been found in plums in New Mexico. About 1870, it was found to have acquired a taste for peaches in this country, and a little later it was bred from apricots. In 1893, Koebele found it infesting cherries in California. It has also been found in Europe in nearly all of these fruits.

There are several European records of the occurrence of the insect in walnuts and oak-galls. These reports were carefully sifted by Dr. Howard in 1887, and the conclusion reached that the evidence was not sufficient to definitely prove that the insect does sometimes feed upon walnuts or oak-galls. We have seen no further conclusive evidence on this point. In 1869, Dr. Riley recorded having a specimen of the moth which had been bred from the sweetish pulp of a species of screw-bean (*Strombocarpa monoica*) which grows in pods, and which was obtained from the Rocky Mountains.* In 1894, Bruner, of Nebraska, reported that perhaps the insect fed upon the seed-buds of roses.

ITS NAME.

Popular name.—When the insect was first discussed in 1635, it was named the "pear-eater." It was next called the "fruit-worm in pears and apples" in 1728; and from this has come the common names, "apple and pear-worm or moth, fruit-worm, fruit-moth," and others, under which the insect is now discussed in nearly all publications except those in the English language. While the very appropriate name of "apple-worm" is also often used by English and American writers, they usually discuss the pest under the perhaps less suggestive name of "codling-moth."

This name was first given to the insect in 1747 by Wilkes, an English writer; as he figures a codling-tree (the name then applied to a kind of apple-tree), in connection with his account, this doubtless suggested the name. The word "codling" is doubtless a corruption

* One instance is recorded where the insect apparently took an inclination to literature and mutilated some books to a considerable extent. Apples had been stored near a library and the worms upon leaving the fruit and seeking a place to transform, gnawed their way into some of the books and there spun their cocoons. We also encountered this literary habit of the insect when infested apples were left near books on the office table where this is being written.

of the old English word "querdlyng," meaning at first (in the fifteenth century) any immature or half-grown apple, then in the seventeenth century being applied to a variety suitable to be cooked while still unripe, but the peculiar codling-shape seems to have determined its modern application to certain varieties of apples. At the present time, most horticulturists and some entomologists are spelling the name "codlin"; and sometimes the form "coddling" appears. Neither of these forms or variations have any etymological evidence to support them, and the name of the insect should be spelled "codling-moth," as originally given in 1747.*

---

* The form "codlin" was used as early as 1715 in connection with a kind of apple, but seems not to have been used in speaking of the insect until a century or more later. Nearly all prominent horticulturists and most English and Australasian writers now use the form "codlin-moth," but nearly all American entomologists still spell it "codling-moth." While the shorter form thus has the sanction of good usage, its only excuse for existence, so far as we can learn from those who use it, is that it is shorter and thus saves time in writing. The shortening makes it a different word, both in form and pronunciation. The encyclopedias offer contradictory and unreliable evidence. The dictionaries are our most reliable sources of information on such questions, and although both forms are given in most of them, we find that "codlin" is considered by the Century Dictionary as practically obsolete, and by the Standard Dictionary is recognized simply as a variant. Still stronger evidence in favor of the incorrectness of "codlin" is the fact that the original word is made up of "cod" and the old English diminutive suffix "ling"; and it is manifestly an inexcusable violation of etymological rules to drop the "g" of the "ng" of this suffix, thus making practically a new word, simply for the sake of brevity in writing, not in speaking. The most reliable authorities on compounding words also use the hyphen in the name, thus, "codling-moth."

As to the form "coddling-moth," noted etymological authorities (the Century and Murray's New English Dictionaries) agree that there is doubtless no connection between the verb "coddle" and "codling," meaning an unripe apple; the resemblance is purely accidental, the verb appeared later, and there is no required precedent form of "coddling-apple."

Scientific name.—The name by which this insect is recognized by scientists the world over was given to it by Linnæus in 1758. This great naturalist named it *pomonella*, and his description of it consists of only six words: "Alis nebulosis postice macularubra aurea." *

As our knowledge of the world's insect fauna advanced, the generic position of this insect was changed from the *Tinea* of Linnæus through *Pyralis*, *Tortrix*, etc., until now all scientists agree in calling it by the generic name (which corresponds somewhat to our sirname) of *Carpocapsa*, which was proposed in 1830. This name comes from two Greek words meaning, "I eat fruit greedily." The specific name comes from the Latin word for apple. The scientific name of the insect, *Carpocapsa pomonella*, thus aptly expresses its characteristic habits.

HOW THE INSECT LOOKS.

Who has not, in biting or cutting into an apple, unceremoniously disturbed a little flesh-colored caterpillar in its home, the familiar worm-eaten interior? † When full-grown, this apple-worm is about three-fourths of an inch long, and varies in color from whitish, through flesh-color, to sometimes quite a distinct pink. Some have thought that this variation in color may be due to the different varieties of apples infested. The general characteristics of

127.—*The apple-worm, enlarged about three times.*

* In 1775, Fabricius gave it the name of *pomana*, and a year later it was named *pomonana* by Schiffenmüller. It is a curious and, to us, an unexplainable fact that nearly all continental European writers on economic entomology should still use this name—*pomonana*. The fact that the same insect was described and named by Linnæus as *pomonella* eighteen years before, and thus has priority, seems never to have been questioned. Why *pomonana* should still be used seems a mystery.

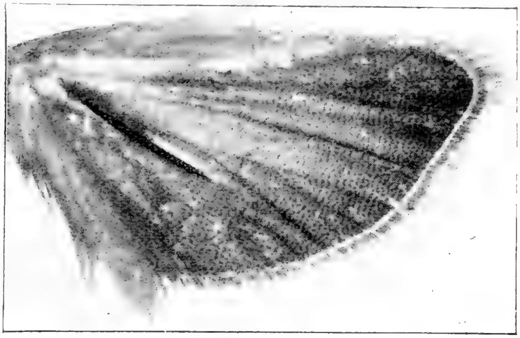
† This is well shown in the picture used as a frontispiece.

the worm are shown in the enlarged figure 127. It can always be distinguished from the grubs of the plum curculio, which are often found in apples, by the presence of distinct legs, three pairs of true legs and five pairs of false or pro-legs. The head is brown in color, and the first thoracic and anal segments each bear a similarly colored shield. The body bears a few short hairs arising from small, often indistinct, blackish spots. These piliferous spots are often very distinct on the young worms, as is shown in figure 132.

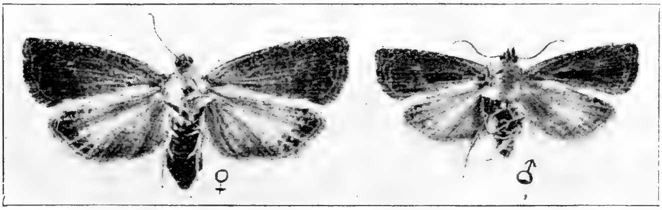
The adult insect or codling-moth.—If no mishap occurs, each of these little caterpillars just described develops into the adult insect—a moth. Although such an exceedingly common and important insect pest, there is doubtless not one fruit-grower in ten who has ever seen the parent insect—the moth. It is a beautiful little creature whose front wings, when seen at a little distance, have somewhat the appearance of brown watered silk; when closely examined, they will be seen to be crossed by numerous gray and brown lines of scales, scalloped something like the plumage of a bird. Near the hind angle of each front wing there is a large dark brown spot marked with streaks of bronze or gold. The hind wings are of a lighter greyish brown color, darker toward the outer margin. The pictures of this moth (all of which are natural size, except two which are twice natural size) in figure 128 give one but a faint idea of the artistic beauty of this pretty creature. An artist who once painted for us a picture of this moth thoroughly appreciated the beautiful coloring with which nature has endowed it. As is shown in the lower group of figure 128, the moth varies considerably in size and general coloring; the moth in the center of this part of the figure is represented at rest, and shows how nicely the markings on the front wings match when the wings are folded, thus giving the insect quite a different appearance. The peculiar coloring and especially the habits (discussed further on) of these pretty little moths, largely explain why our fruit-growers are not familiar with the parents of one of their worst insect foes.

How the male and female moths may be distinguished.—There are at least two characteristics by which the sexes of the adult insect may be quite readily distinguished. One of these was discovered by Zeller in 1870, and is shown, much enlarged, in figure 129. It consists of a narrow pencil of rather long black hairs situated in a slight furrow on the upper surface of each hind wing of the males only. Sometimes this distinguishing mark is not easily seen, except with a lens.

We have in our collection at the University over a hundred bred specimens of the codling-moth, and while separating the sexes of these by the aid of the character just mentioned, we accidentally discovered that the male bore another much more conspicuous, yet constant and peculiar mark. In figure 130 are shown a male (on the right) and a female moth, twice natural size, as seen from beneath. It requires but a glance to see that on the underside of each front wing in the male there is a distinct, narrow, elongate, blackish spot, which is entirely lacking on the female. The spots consist simply of a group of blackish scales. The spot extends nearly to the base of the wing, and is more distinct on some specimens, but in our experience it has always been distinct enough to render it an easy matter to distinguish the males at a glance, no lens being necessary. We cannot understand how this



129.—*Hind wing of male moth, showing narrow black pencil of hairs, much enlarged.*



130.—*Male (on the right) and female moth, twice natural size, as seen from beneath. Note characteristic black spots on front wings of male only.*

sexual marking could have escaped the notice of entomologists for a couple of centuries. Doubtless others have seen these spots, but we have not been able to find the slightest hint that they might be a sexual characteristic either in systematic or economic discussions of the insect.

THE STORY OF THE LIFE OF THE CODLING-MOTH.

Perhaps the biography of no other insect pest has been written so often as that of the codling-moth. Begun by Goedaerdt in 1635, and considerably extended by Reaumur in 1736, it was fairly well understood by Roesel as early as 1746. Since then the insect has been studied under many varying conditions in nearly all climes, and naturally different observers have been able to add many interesting details in regard to variations in its habits and life-history. Yet there are many interesting things to be learned about this common insect pest before its complete biography can be written. Our story of its life which follows is the result of a critical study of all the biographies available, supplemented by many personal observations on the insect in all its stages. This story may very properly begin with that stage in which life begins for the insect.

The Egg.

It is a curious and striking fact that it is only within the past few years that anything definite has been recorded about the egg itself, in which so common and important an insect pest begins its life. Recent observations in this connection have brought out some facts which are of vital importance to the fruit-grower.

Historical notes.—By whom or when the eggs were first seen, we have been unable to determine. In spite of the fact that nearly every account since Roesel's, in 1746, contains definite statements regarding where they are laid, and as early as 1855 we find it stated that they are said to be of a pale, yellowish-red color, yet there is no definite evidence to show that the eggs were ever seen on an apple before 1870, and perhaps not until nearly twenty years later. The eggs have often been taken from the body of the moth, and Riley's description of them as "tiny yellow eggs" (1869), and Fernald's brief description in Bull. 12 of Mass. Expt. Sta. (1891) were undoubtedly made from eggs thus obtained. If Cook saw numbers of the eggs, as he states, in 1874, *on* or *in* the calyx of the young fruit, it seems strange that he has never given us a hint as to how they looked, and that no other observer since has ever found them *on* or *in*, although sometimes *near* the calyx. In 1881 Cooke saw eggs which a codling-moth had deposited in a vial, and in 1882, Miss Walton states that some of the moths laid a lot of eggs in her cyanide bottle, but her description does not apply to any of the eggs we have ever seen.

The eggs were undoubtedly seen on the fruit by Kœbele and Wier in California in 1889 (Insect Life, II., 84), and by Wight in New Zealand in 1891 (Insect Life, III., 394). But none of these writers tell us how the eggs looked. It is a notable fact that, after ravaging apple orchards for centuries, and after undergoing the closest scrutiny by many competent observers, the first picture and accurate description of the egg should not have appeared in the literature until 1893. In 1892, Mr. F. L. Washburn made the first careful observations upon the eggs, and his results were published in 1893, in Bulletin 25 from the Oregon Expt. Station. His picture of the egg is not quite accurate, but we cannot understand why such important observations should have been almost entirely overlooked by later writers. In 1895, the eggs were described and poorly figured by Gœthe in Germany. He built a cage over a small tree, and introducing some of the moths, soon got eggs and recorded their development. In 1896, the writer, and in 1897, Mr. F. W. Card, in Nebraska, recorded further observations, quite at variance with the commonly accepted ideas regarding the egg-laying habits of this insect.

How the egg looks.—Fortunately we were able to get some life-like photographs of the eggs of the codling-moth and these are reproduced in figure 131. The small whitish spots on the apples at *a* and *b*, *b* in the figure represent the eggs natural size, just as they were laid on the fruit by the moth. At *e* is shown one of the eggs much magnified, and *es* and *es* are pictures of the egg-shell, greatly enlarged. These pictures give a good idea of the shape, size and general appearance of the egg. They have been aptly characterized as resembling a minute drop of milk adhering to the skin of the fruit.

The egg is a thin, scale-like object, not quite so large as the head of a common pin (it measures from .96 to .99 mm. by 1.17 to 1.32 mm.), and is of a semi-transparent, whitish color, often with a yellowish tinge, which is sometimes quite pronounced. Unless one has seen the eggs, they could not be readily discovered on an apple; those on the apples at *a* and *b*, *b* in the figure, were unnaturally whitened to bring them out in the reproduction. After one has become familiar with the eggs, it is a comparatively easy matter to find them by turning the fruits around; when the light strikes the egg just right it can be quite readily seen. As the pictures in figure 131 show, the whole surface of the shell, when viewed under a microscope, is quite rough and is marked with an irregular net-work of fine ridges extending from the edge over about one-half of the surface, but not over all of the surface, as represented in Washburn's picture.

Where and when the eggs are laid.—In the light of recent observations, it seems remarkable how the notion, that the eggs of this insect are laid *on* or *in* the so-called calyx or blossom-end of the fruit, has clung to the literature for nearly a century and a half.

Rœsel was apparently the first one to make any definite statement regarding oviposition. He said in 1746: "The female places her impregnated eggs singly either below at the stem-end or above at the blossom-end of the fruit." In 1833, "Rusticus" wrote that the moth lays its eggs "in the eyes, one only in each, by introducing its long ovipositor between the leaves of the calyx, which form a tent above it that effectually shields it from any casualty." In 1855, Nördlinger wrote that "according to some, the moth deposits its eggs upon the fruit itself, according to others, usually upon the calyx or between the calyx lobes or in the stem cavity. Undoubtedly all of these views are correct." The fact that the worms do often enter at the blossom-end, and sometimes near the stem or even on the side of the fruit, was apparently the only foundation for the common notion that the eggs must have been laid at these points.

However in 1889 and 1891, observers in California and New Zealand noticed that the eggs were laid almost anywhere else on the fruit than in or on the calyx; some were even seen on the stems of pears. In 1892, Washburn found the eggs "placed on both the sides and the top of the fruit." In the spring of 1896, we saw the egg of the codling-moth for the first time; a moth had been induced to lay it on an apple in one of our cages. A little later we had no trouble in finding many eggs in orchards. In confinement, we found that the moths laid their eggs almost anywhere it happened, on the sides of the cage, on the leaves or bark of branches placed in the cage, and sometimes several eggs were laid in a cluster, overlapping each other; Gœthe had a similar experience in Germany in 1895.

During the past two years we have seen hundreds of the eggs on apples in New York orchards and have never yet seen one *on* or *down in* between the calyx lobes on the so-called blossom-end. We have seen eggs *near* the calyx, in old curculio scars, near the stem, and have found what appeared to be codling-moth eggs even on the leaves of the tree. Most of the eggs we found were glued to the skin apparently without much choice as to location, on the smooth surface of the fruit, as shown at *a* and *b*, *b* in figure 131.

During the past year Mr. Card has found the eggs in Nebraska. He states that "instead of being laid in the calyx, we find that the eggs are laid almost exclusively on the upper surface of the leaves, in the orchard, though in confinement they may be laid anywhere. They are usually found on leaves of a cluster associated with an apple."

In the light of these definite facts, the old stereotyped notion that the eggs are usually laid *in* the calyx must be discarded. The eggs may be glued anywhere it happens, to the surface of the fruit, to the stem, or even on the adjacent leaves. A glance at the ovipositor of the moth, represented at *o* in figure 131, shows that it is only adapted for laying eggs on the surface of the fruit or leaf. It is quite flat and hoof-like in appearance, and strongly beset with hairs. The eggs of the second or more broods, wherever such occur, are probably laid in similar situations; Koebele found them in California in August, 1889, on the stem, on the fruit near the stem, on the upper half and near the calyx of pears.

It seems that there has been considerable difference of opinion on the important question of *when* the eggs are laid; that is, at what stage in the development of the fruit they are laid. The records on this point vary from "just before the petals fall" to "nearly a month after the blossoms dropped." The common notion has been that the eggs were laid soon after the blossom fell, but apparently with no definite evidence to support it. When Koebele and Wier first found the eggs in California, the fruit was about an inch in diameter. In 1889, Gillette noted in Iowa that no worms hatched until nearly a month after the blossoms fell, and the apples were then an inch in diameter. Both in 1896 and 1897, we were unable to find any eggs on either early or late varieties of apples in orchards at Ithaca, N. Y., until the fruit had reached the size shown at *a*, *b*, *b* in figure 131; this was during the last week in May, and the blossoms had been off for a week or more, and the calyx lobes had drawn together. Furthermore, moths did not begin to emerge in our cages in any numbers until a few days before we found eggs in the field, or not until after the blossoms had fallen even from later varieties. Mr. Card's careful observations in Nebraska in 1897 add corroborative evidence to the above. He found the first eggs on June 3 and the first worm on June 12, while the petals had fallen from most varieties by May 10.

Thus from the only definite evidence we have, one cannot escape the conclusion that, in the northern half of the United States at least, most of the eggs of the codling-moth are not laid until a week or more after the petals of the blossoms have fallen from most varieties of apples;* or usually during the latter part of May and the first half of June.

The date of the falling of the blossoms varies considerably in different years, depending upon the weather conditions, which may cause spring to open early or late. As these same conditions affect the date of the emergence of the moths in general, the above statement regarding the egg-laying of the insect will hold good.

The observations of Goethe in Germany show that most of the eggs are laid at night, when the moths are the most active.

The number of eggs and the egg-laying period.—Several guesses have been made of how many eggs one codling-moth may lay, and the estimates vary from two dozen to two or three hundred. There seems to be no definite observations upon this point, except what has been learned from examination of the ovaries of the female. In 1873, Le Baron recorded that he found from 40 to 50 tolerably developed eggs and a considerable number of undeveloped ova; that is, he found eggs in all stages of development in the ovaries. This shows that the egg-laying period must last for several days. Cooke records having a vial containing 85 eggs laid by one moth. Thus the number which one female lays may reach nearly a hundred.

As to how long after the emergence of the moth in the spring before egg-laying begins, accounts differ from forty-eight hours (Cooke) to six or eight days (Washburn).

Another stereotyped notion which has been handed down in the literature for more than a century is the statement that "the codling-moth has the wise instinct to lay but one egg on the same apple, and what is still more remarkable, she must have the instinct to avoid those apples which have been already appropriated to this purpose; since,

---

* In the Rept. of the Gov. Entomologist of the Cape of Good Hope, South Africa, for 1896, which has just come to hand, Mr. Lounsbury records (p. 11) the following in regard to this phase of the codling-moth: "The insects were ovipositing at the time of my visit (in October). Not many eggs were found, but, curiously enough, few of these at the blossom-end of the fruit, where they are said to be usually placed. At this time (October 20) some fruit was fully an inch in diameter and already contained the caterpillars, while unopened fruit buds were yet common on the trees, and many of the insects had not yet emerged from their cocoons. Such irregularity in the appearance of moth and in the setting of the blossoms make repeated applications of insecticides necessary."

otherwise, we should oftener find more than one worm in the same apple" (Le Baron). We have often seen two eggs on an apple no larger than the one shown at *a* in figure 131, and in one case we found five egg shells, or, perhaps, sterile eggs (as we found no worms in the fruit) on such an apple. Koebele counted 11 eggs on a pear in California in August.

Mortality among the eggs.—Our observations agree with those of Washburn, Goethe and Card that many apparently sterile eggs are laid by codling-moths.

Duration of the egg-stage.—Roesel stated in 1746 that the eggs hatched in eight days. Later observers record a variation of from four to ten days. The eggs under our observation hatched in about a week, and this is doubtless about the usual duration of this stage.

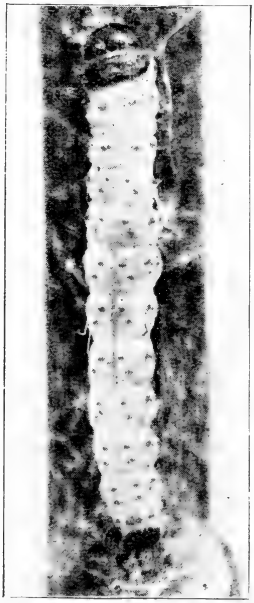
A day or two after the egg is laid, a narrow whitish or yellowish ring can be plainly seen through the shell. A day or so later this ring takes on a decided reddish tinge; it is visible in the picture of an egg at *e* in figure 131. Soon after this the black head of the developing caterpillar and the outline of its body can be plainly seen. At *h* in figure 131 is shown an egg with the little caterpillar almost ready to emerge.

The Young Apple-worm and its Habits.

How it gets out of the egg and its characteristics.—Roesel tells us in 1746 that the little caterpillar "comes out of that part of the egg where it lies on the fruit, so that the very small opening may not be observed, because it is yet covered by the egg-shell which still adheres." We find no other hint in the literature on this point until Washburn observed in 1892 that the young worms "broke or ate their way through the shell and entered the apple somewhere else than at the spot occupied by the egg." A caterpillar which we saw emerge, came out of the egg near the edge at one end. In the picture of an egg-shell at *es* and *es* in figure 131, one can see at the upper end a small black spot, and extending from this to the right is an irregular, whitish line, which was the crack made by the worm when it pushed its way out.

A newly-hatched apple-worm measures scarcely a sixteenth of an inch in length, and is of a semi-transparent whitish color, with a shiny black head and blackish thoracic and anal shields. Usually the body is marked with many quite distinct blackish spots, regularly arranged and each bearing a short hair. In figure 132 is represented an apple-worm only a few days old, much enlarged, upon which these spots were very distinct.

The first meal of the little apple-worm.—We have seen some of the newly-hatched caterpillars eating their first meal. After emerging from the egg those we saw wandered about on the surface of the apple until they found some angular place like the point where the calyx lobes join the skin of the fruit, or near the stem, or in an old curculio scar, or where a leaf or another apple touched the one upon which the worm hatched; often they simply crowded in between two of the calyx lobes and got their first meal within the little cavity at the blossom-end. In short, our observations agree with those of Koebele and Washburn that the young caterpillar enters the fruit somewhere else than at the point where the egg is laid.



132. — *Young apple-worm only a few days old. Note the distinct spots on the body. Much enlarged.*

When a suitable place was found, the worm often tunneled its way through the skin and went directly toward the core. Where a leaf or another apple touched, the worm sometimes ate away the skin for a space about as large as a pin's head before burrowing in; in this case the entrance-hole was closed with a network of silken threads in which bits of apple were intermingled. In one instance a worm ate little holes through the skin near the stem in three or four places before it finally began its journey toward the core; other writers have noted this same habit of the young worms in first entering a fruit. Thus the young caterpillar may get its first meal at almost any place on the apple, but usually this meal, or any subsequent meal for that matter, includes only a very small portion of the outer surface of the fruit. As has long been noted by writers, most of the young worms enter the fruit in the spring or early summer at the blossom-end. They either crawl between the calyx lobes or tunnel into the calyx cavity at the point where the lobes join the surface of the fruit. Thus more often the young apple-worm takes its first meal out of sight in the calyx cavity and is protected by the tightly closed calyx lobes.

We have noted above that Mr. Card found most of the eggs of the codling-moth laid upon the leaves instead of on the fruit in Nebraska. In confinement, he found that the young worms sometimes fed for twenty-four hours on the leaves where they hatched, and ate out quite large pieces, usually eating away one skin of the leaf and the inner tissue, leaving the other skin intact. Whether they fed upon the leaves to any extent in the orchard was not determined.

Where it spends the first few days of its life.—Apparently the newly-hatched apple-worm spends but a few hours of its life on the skin of the fruit. Whenever it enters at any other point than at the calyx, it usually soon begins to tunnel toward the core. However, 75 per cent. or more of the young worms enter the fruit at the blossom-end, and our observations indicate that they spend several days feeding around in the calyx cavity. When the worms hatch, the blossoms have been off for two weeks or more, and the calyx lobes have drawn tightly together (compare figure 146 and *a* and *b* in figure 131) forming a covered cavity in the blossom-end of the apple; this does not happen in the case of the pear, as the central picture in figure 146 shows. This is a very important phase in the habits of the apple-worm, as we shall see when we come to discuss "remedies."

133.—*A wormy apple, showing the familiar mass of brown particles thrown out at the blossom-end by the young worm.*

All are familiar with the first indications that the apple-worm has begun work; the masses of little brown particles which it thrusts out of the calyx are quite conspicuous, as shown in figure 133. These first few days of the apple-worm's life, which are usually spent in feeding in the blossom-end of the fruit, have proved to be the most vulnerable phase of the life of the insect. It is during this time that we kill it with a poison spray; just how this is done is discussed later on.

Habits and Growth of the Apple-worm Inside the Fruit.

The apple-worm's objective point soon after it enters the fruit seems to be the core. It usually reaches the core in about a week, and there begins its destructive work on the seeds, of which it seems to be especially fond, and on the surrounding flesh. It feeds in or near the core during the greater part of the remainder of its life in the fruit. As it feeds, it increases in size, and has to shed its skin from time to time to accommodate itself to this growth; it is said that this caterpillar sheds its skin four times while feeding in the fruit. As the worm increases in size, its head and thoracic and anal shields change in color from black to brown, and the small, blackish, piliferous spots, so distinct in the young worms, as shown in figure 132, usually become quite indistinct; we have, however, seen nearly full-grown apple-worms on which these spots were still very distinct. The body of the worm also acquired a distinct pinkish or flesh color, sometimes even when the worms are only half-grown.

While at work in the blossom-end or in tunneling to the core from any point on the fruit, the young worms apparently try to keep their home clean by throwing their excrement out at the entrance hole. Once fairly at work in the core, however, little or no trouble is taken to remove the grains of excrement; they are often found in the worm-cavity fastened together by silken threads.*

Preparations for leaving the fruit.—Several days before the apple-worm gets full-grown, it proceeds to eat a passage way, usually by the shortest route, toward the exterior. This exit tunnel often follows the entrance burrow, and thus often opens at the blossom-end, but usually the external opening or, familiar "worm-hole," occurs in the side of the fruit. When the worm reaches the surface with its exit tunnel, it uses the opening as a door out of which

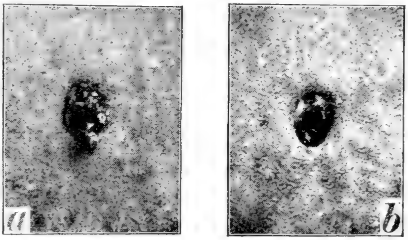
---

* Reaumur thought this was purposely done by the worm to prevent the pellets from being thrown about in the cavity by the motions of the fruit. This may be true, or it may be more probable that, like many other caterpillars, this apple-worm spins a thread wherever it goes around in its home, and the pellets simply get entangled in these threads.

it throws its excrement; it apparently keeps the hole closed with a net work of silken threads in which are mingled particles of apple bitten off by the worm and with grains of excrement. An exit hole thus stopped up is shown, enlarged, at *a* in figure 134. This "worm-hole" often remains in this condition for several days, the caterpillar evidently feeding inside and making further preparations to leave the fruit forever.

The codling-moth usually spends from twenty to thirty days of its life as a caterpillar feeding inside the fruit.

Are two or more fruits ever attacked by the same worm?—Roesel believed that the worms often went from one apple to another, even though the apple fell to the ground and the worm had to climb the tree again. Later observers have only seen indications of where a worm has left one fruit and entered another touching it while the fruits were still on the tree. There is no authentic evidence to show that more than two apples are ever entered by the same worm. Usually the apple-worm gets its growth in the same fruit where it got its first meal.



134.—*The "worm-hole" or exit hole of the apple-worm; enlarged.* a, *before the worm has left the fruit, and* b, *after it has emerged and pushed away the plug.*

The number of worms in a single fruit.—Usually but one apple-worm occurs in a fruit, but several instances are recorded where two, three, or even four worms have been found in one fruit. Out of 201 apples examined by Atkins, in Maine, in 1882, nine had been penetrated by three worms each, and 47 by two worms each; in no case did a worm gnaw through into the burrow of another. When two or more worms are found in the same fruit, they are usually quite different in size, and may belong to different broods.

Effect of their work on the fruit.—Usually fruit in which the apple-worm is at work shows signs of a premature ripening. This is especially true of early varieties, and "windfalls" are often the final result. In the case of late varieties, however, the infested fruit often remains on the tree and ripens naturally with the others, the worms thus having but little effect on the fruit, except to render it unattractive to buyers and eaters. Usually "wormy" fruit is practically worthless for almost any purpose, but much of it is often fed to stock or to us in the form of sweet cider.

How and When the Worms Leave the Fruit.

When the caterpillar is ready to leave the fruit, it pushes away the plug of pellets, described above and shown at *a* in figure 134, and crawls out, leaving a round, blackish-looking "worm-hole" as shown at *b* in the same figure. When this exit-hole is found, one can easily tell whether a fruit still contains the worm or not by the presence or absence of the plug of pellets. It is said that the worms leave the fruit mostly at night.

If the fruit has already fallen to the ground, the caterpillar proceeds to crawl to some secure and suitable place in which to begin its preparations for becoming a moth. Those worms which leave the fruit on the tree were seen by LeBaron in the orchard by lamp-light to either let themselves down to the ground by a silken thread, which they spun as they went, and then crawl back to the trunk; or they crawled from the apple onto the branch, and thence down to the trunk. Cook, from some experiments made in 1875, thought that the worms seldom, if ever, dropped from the tree to the ground; and that at least one-half of them did not descend to the ground at all. Trimble records collecting a number of worms and putting them on the ground in the vicinity of an apple-tree. They crept about at random for a little while, but, if not too far off, most of them were soon seen going in the direction of the tree.

The date when the worms which enter the fruit in the spring, get full-grown and leave, cannot be stated definitely. For the irregularity in the appearance of the moths at that time is so great that oftentimes some of the earliest worms will be ready to leave when others hatched from later eggs will be just entering the fruit. In the latitude of St. Louis, Riley records finding full grown worms as early as the 5th to the 10th of June. Usually, however, the early summer brood of worms in the latitude of New York do not mature until July and later. From the 1st of July until winter sets in, one can usually find at any time worms of all sizes in the fruit; and large numbers of them do not leave the fruit until it has been barreled or stored for winter.

The Cocoon.

Where it is made.—After leaving the fruit, the apple-worm next devotes its energies to finding a suitable place for its cocoon, in which to undergo its further transformation. Many of them find their way to the trunk, larger branches, or into the crotch of the tree, where they crawl into any crevice they can find under the rough, loose bark. Other worms find suitable quarters on near-by fences or trees, in piles of rubbish, under boards or chips, in stumps, in fact, almost anywhere, except in the ground or among the grasses or weeds.* In November, 1875, Beal made a very careful examination of several square feet of soil and grass under different trees which had borne or had had wormy apples sorted under them; no trace of the insect was found.

If the worms are carried into the store-rooms or barreled with the fruit when it is picked, upon leaving the apples they spin their cocoons in the crevices and angles of the barrels, or anywhere in the store-room, especially in any rags, papers, or clothes that may be lying about.

How it is made.—Having found a suitable place, the apple-worm first usually hollows out with its jaws a little oval cavity, and then begins its cocoon. The cocoon is rather thin but quite tough and is made largely of silk in which are mixed bits of the substance on which it is being made. It is lined with a thin layer of white silk, and on the outside it is usually covered, and often thickened at some point, with more loosely bound together particles of the surrounding substance; this renders the cocoon quite inconspicuous. Several cocoons are shown, natural size, in figure 135,

---

* Mr. Crawford records an instance in Australia where the worms took refuge in the pith of old raspberry canes growing under apple trees; 20 worms were found in one of these canes. In 1896, several raspberry canes which had been badly infested with the cane-borer, were sent us from Ohio. In the pith we found several apple-worms snugly tucked away in their cocoons. In this case, the worms had evidently found an easy entrance to the canes through the large hole made by the borer when it emerged as a beetle. While breeding the insect here in the insectary, we have had the worms burrow into pieces of cork and work their way into books to spin their cocoons. Cooke says the cocoons are often found in California from one to six inches below the ground on the base and roots of the smooth-barked trees.

just as they appeared on the piece of bark when it was removed from the tree. Figure 136 shows some cocoons enlarged, and it well illustrates their method of construction. In shape, the cocoons are adapted to the shape of the place in which they are built. Anyone can soon find these cocoons on old rough-barked apple-trees after a little search at almost any time from August 1 until spring opens. Cooke states that a worm completes its cocoon in twenty-four hours. It is said that the cocoons made by the worms late in the season, and in which they expect to pass the winter, are tougher, thicker and darker colored than those made earlier, from which the moths soon issue.

135.—*Cocoons of the codling-moth as they were found attached to a piece of loose bark, natural size.*

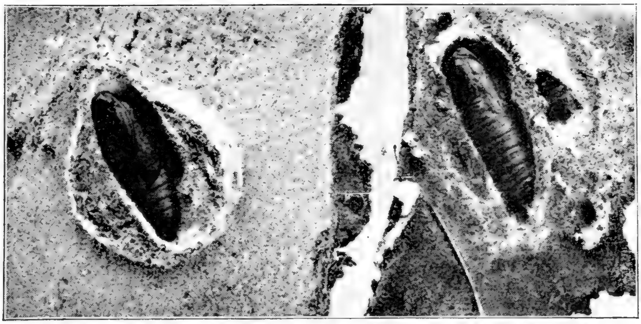
How Long and in What Condition the Insect Lives in Its Cocoon.

Usually when the cocoon is made during or after August, the insect may be found therein as a caterpillar until the next spring. If the cocoon is made before August 1, its maker, the caterpillar, may change within three days to a very different looking object known as the *pupa*. Cocoons containing these pupæ are shown, natural size, in figure 135, and enlarged in figure 136. The insect usually spends but two or three weeks, sometimes less, in the pupa state, whether the change to a pupa takes place in July or not until the next spring. Thus the insect may spend less than three weeks of its life as a pupa in the cocoon, or it may occupy it as a caterpillar for ten months, and then as a pupa for two or three weeks longer. The reason for this seemingly great variation in the life-history of the codling-moth will appear in the discussion of the next and very important phase of the subject.

The Number of Broods of the Insect.

For more than a century the statements which have been made regarding the number of broods of the codling-moth during the course of a year, have differed widely. Some writers record only one brood, others two, and some as many as three or more in a year. This variation has been the subject of considerable discussion in Germany, and more recently in the United States.

Beginning with Goedart's first account in 1635, the European records indicate but one brood north of latitude 50 degrees, that is, in



136.—*Pupæ of the codling-moth in cocoons, enlarged.*

England, Holland, Germany (except possibly the southwestern portion), and the more northern countries. The evidence from Reaumur, Pissot, and Schmidtberger indicate two broods in France and Austria or south of latitude 50 degrees; recent evidence from Italy indicates three broods there.

In America the evidence thus far submitted, shows a similar, and in some instances a more striking variation in the number of broods of the insect. The observations of Atkins, Harvey, and Munson in Maine, indicate one regular or full brood and a partial, in some years possibly nearly a full, second brood in that state. This statement will doubtless also apply to most of the New England States, and so far as our observations indicate, it is also true of the state of New York.

In 1871, Mr. Chapin, of East Bloomfield, N. Y., found that by caging some of the insects in July a second brood of the moths appeared in

August (*Country Gentleman*, January 25, 1871). We have bred moths in August here at Ithaca from cocoons spun in July, and our observations indicate that in New York the number of worms of the first brood which develop into moths the same season depends largely upon the weather conditions which affect the earliness or lateness of the opening of spring. In 1896, for instance, spring opened earlier than usual in New York, and everything was very favorable for the development of insect life for several weeks, with the result that there was evidently nearly if not quite a full second brood of the codling-moth, for a much larger percentage of the apples than usual were injured late in the season. We believe that there is always a partial second brood of the insect in New York, and in some years probably a full second brood in many parts of the state.

There is conclusive evidence of two full broods of the insect in Illinois, Iowa, Missouri, Kansas, Nebraska and Colorado, with indications of a partial third brood in southern Illinois and in Nebraska and Colorado. In the higher altitudes of California there are apparently but two broods (Bull. 22, U. S. Div. of Ent., p. 89), while three broods appear in other parts of the state. Observations in Oregon and New Mexico indicate three broods there also.

The evidence submitted from New Jersey indicates some peculiar variations in the life of the insect in that state. In 1865 Trimble recorded that he found pupæ under some of his bands at Newark, N. J., on August 10, and on August 20 and 23 he found that "about one in five of the worms had transformed to moths"; thus demonstrating at least a partial second brood in that part of the state. In 1894, Smith recorded some experiments extending over three years, from which he recently concludes that "near New Brunswick there is positively a single annual brood only." But he admits that "south of Burlington county there is at least a partial second brood." In the same paragraph he also states that the moths emerge earlier at New Brunswick than Card records them in Nebraska, where there are at least two broods of the insect. It seems strange that there should be such a difference in the life of this insect within a distance of less than thirty miles in the same state. But there seems to be something peculiar about the conditions near New Brunswick, N. J., for Smith finds that other insects, notably the elm leaf-beetle, lead a different life there than they do only a comparatively short distance either to the north or south.

In 1895 Fletcher reported that "careful observations made during the last ten years convince me that in this part of Canada (Ottawa) there is only one regular brood of this insect in the year. This is, I believe, the case as far west as Toronto. In the fruit growing districts of West Ontario there are two broods, the second brood being invariably the most destructive."

From the above evidence we conclude that there is one well-defined brood and usually a more or less complete second brood of the codling-moth yearly in the New England States, New York, most of New Jersey, and part of Canada. Two well-defined annual broods occur in Michigan, Illinois, Iowa, Missouri, Kansas, Nebraska, Western Ontario, and Colorado, with sometimes a partial third brood in some localities and seasons. In California, Oregon, New Mexico, and in the South there seems to be three broods annually. We should have more definite observations on this point in many states. It is not possible to define these different regions by parallels of latitude, for the variations in the number of broods depends upon differences in climate, temperature, and latitude.*

Whenever the first brood of worms transforms into moths the same season, this usually occurs late in July and during August, and the second brood of worms work from August on, many of them even completing their growth after the fruit is stored. In those parts of Europe where the insect is single-brooded, the moths do not appear from the winter cocoons until the middle of June and in July. The second brood is usually more destructive than the first, as it is more numerous and works in the later and more valuable varieties of fruit. In some years the partial second brood which works in New York spoils many more apples than the first brood.

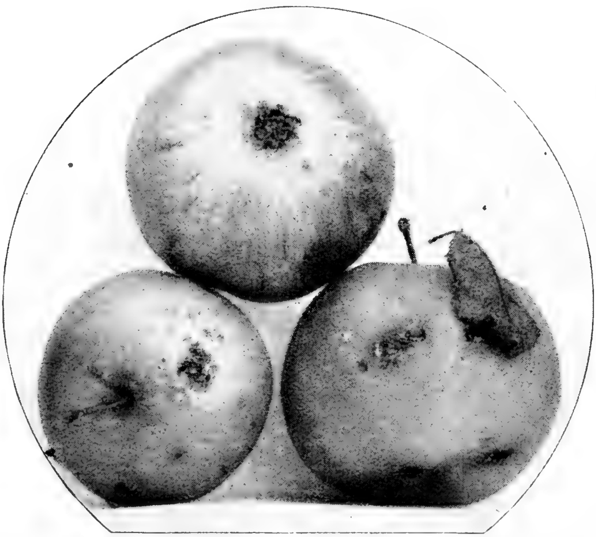
This question of the number of broods of this pest is of great practical importance in connection with the methods of combating it. We have learned how quite successfully to control it where there is one and a partial second brood, or even two broods annually, but where there are more than two broods we are not so successful.

---

* Mr. Marlatt suggests (Proc. Ent. Soc. of Wash., III., p. 228) that "Dr. Merriam's map showing the distribution of the total quantity of heat during the season of growth and reproductive activity, presents an interesting agreement in its zones with the available records in regard to the number of broods of this insect. * * * At least, a good basis is furnished for future observations." He thinks that the data thus far submitted indicates one annual brood in Dr. Merriam's transitional zone; two annual broods may be expected in the upper austral life-zone, and three annual broods in the lower austral zone.

How the Second Brood Works.

Doubtless the eggs of the second brood, like those of the first, are laid anywhere it happens on the fruit or possibly on the leaves, but not so many of the young worms enter the fruit at the blossom-end, many of them entering at other points. Instead of making their way to the core soon after entering, many of the worms of the second brood seem to feed for some little time in the flesh just beneath the skin near the point where they entered, forming there a shallow mine. This results in a large wormy spot which greatly disfigures the fruit, as shown on the two lower apples in figure 137; often a leaf may be fastened down to the fruit over the spot, as shown on one of the apples. In 1896 there was much complaint from New York apple-growers on account of so much of their fruit having these wormy spots on them late in the season; most growers did not realize that it was the work of their old enemy, the codling-moth. Perhaps the more common method of work of this second brood, however, in many localities, is shown on the upper apple in figure 137. That is, the worm enters the blossom-end, but instead of soon making its way to the core it extends its feeding grounds out into the fruit around the calyx, forming a shallow mine just under the skin. Sometimes the flesh is thus mined out for a distance of half an inch from the



137.—*Wormy spots made by the second brood of apple-worms, half natural size.*

calyx, the worms often attaining their full growth there. Harvey records that in Maine, in 1888, three-fourths of the apples from some localities showed this work of the second brood of worms around the calyx. Whether the second brood often works in this peculiar manner in other parts of the country, especially where there is a third brood, we cannot say. It is probable that many of the worms which are hatched late in the season, of whatever brood, work in this manner.

How the Insect Passes the Winter.

Almost invariably the codling-moth winters as a caterpillar in its cocoon. Differences in latitude, climate, or altitude seem to cause no variation from this rule.* Often some of the worms go into winter quarters in August. As worms of all sizes may be found in the fruit late in the fall, doubtless many of the young ones perish, unless they are lucky enough to be carried into the store-room where they may continue feeding and finish their growth.

One can readily find these hibernating worms in the winter or early spring, snugly curled up in their cocoons, by carefully examining the loose bark on almost any old apple-tree which bore much fruit the previous season. It is interesting to watch the caterpillars when their cocoons have been torn open, even in the winter. They soon bestir themselves and proceed to repair the damage at once. If removed from the cocoon each will spin another. We have had a worm make two or three new and complete cocoons after being removed very early in the spring from the one in which it hibernated.

When the Moths Appear in the Spring.

Those hibernating worms which escape the birds during the winter, change to brown pupæ, shown in figure 136, in the spring, and in from two to three weeks the moths emerge. The date of the emergence of the moths depends much upon the place where the worms hibernated, and upon the weather conditions prevailing in the spring. Oftentimes the cocoons are spun in temporary storerooms in the fall, where the

* Mr. Howard records an apparent exception to this rule. Specimens of the insect were received at the Dept. of Agr. from Kansas, on November 15, were in the pupa state when sent three days before. They were kept in a warm room and the moths issued in January.

subsequent temperature is so warm as to cause the insect to transform considerably sooner than it naturally would on the trunk of a tree; or if the wormy apples are placed in a cool cellar, the transformation of the worm may be unnaturally prolonged. The recorded appearances of the moths vary from March and the first half of April in California, through May and the early part of June for most localities in the northern half of the United States, and some moths have not emerged from cellars or storerooms until July 13 or later.

During the past two years we have made many visits to orchards early in the spring, and have collected and examined hundreds of cocoons. These were placed in cages and the worms allowed to transform into moths, the date of emergence of the latter being noted. In 1896, we began collecting April 8, and found only caterpillars in the cocoons until April 28, when one or two pupæ were seen. In 1897, the first pupa was found April 27, and by the 7th of May only about one-fourth had pupated in the cocoons on the trees. The following table gives the dates of the emergence of the moths (with the number for each day) from cocoons collected in April, 1896 and 1897:

1896.				1897.	
Date.	Number of Moths.	Date.	Number of Moths.	Date.	Number of Moths.
May 3......	1	June 1......	8	May 24.....	4
" 4......	1	" 2......	6	" 26.....	4
" 5......	2	" 3......	7	" 28.....	5
" 7......	4	" 4......	6	" 29.....	3
" 10......	4	" 5......	9	" 30.....	8
" 11......	5	" 6......	4	" 31.....	6
" 17......	5	" 7......	5	June 2.....	6
" 25......	5	" 8......	6	" 3.....	9
" 26......	4	" 9......	9	" 4.....	7
" 28......	5	" 10......	1	" 6.....	6
" 29......	4	" 11......	1	" 7.....	6
" 30......	2	" 12......	5		
" 31......	3	" 13......	4		
		" 18......	1		
		" 21......	2		
		" 22......	2		

The above table shows that the moths may emerge over an unusually long period in the spring in central New York; that is, from May 3 until June 22, or over a month and a half. Apparently a majority of them emerged in 1896 and 1897 during the last week in May and the first week in June. We found the first eggs in the orchard on May 28 in 1896, and recently-laid eggs, evidently of the first brood, were seen as late as June 27.

Compared with the blossoming period of apples.—The date of the opening of apple-blossoms varies considerably in the same localities in different years, depending upon the earliness or lateness of the opening of spring.

At Ithaca in 1896, the petals had fallen from most varieties by May 10, and by May 28 the fruit was as large as shown at *a* and *b* in figure 131. In 1897, however, early varieties of apples were not in full bloom until May 11, and the petals had not fallen from the later varieties until May 20. In the same locality in 1892, Lodeman found that the petals were not off until June 6; in 1893, he found that the first blossoms opened on May 19, and a few blossoms remained on June 8. In 1892 the blossoms were off by May 20 in Pennsylvania. It is recorded that at Benzonia, Mich., the season was so late in 1888 that there were no apple blossoms for Decoration Day, May 30; while the same year in California, the apples were in bloom March 17. In 1889, the petals had fallen in Iowa by May 15, and in 1891, Munson records that the last blossoms were falling in Maine on June 11. In New Hampshire, the blossoms had fallen by June 9 in 1894. In 1897, Card reports that the season was later than usual in Nebraska and the petals fell about May 8. In 1888, a calendar was kept of the date of blooming of different varieties of apples in Kansas (First Rept. Kan. Expt. Station); the calendar shows less than a week's difference in time of blooming of the earliest and latest varieties, most of them being in full bloom about April 21.

The above evidence in regard to the blossoming time of apples as compared with the dates of the emergence of the codling-moths, indicates that the moths may begin to emerge about the time the apple-trees are in bloom. But our breeding experiments and what little definite evidence there is on this point, indicate that the majority of the moths do not emerge until several days after the petals have fallen. Then allowing a few days for the preparation for oviposition, we should not expect, and, in fact, do not find eggs until a week or more after the petals drop. Another week must elapse before the eggs hatch, so that theoretically, we should find but few worms until after the blossoms have been off for two weeks or more on most varieties; and this agrees with our observations and with the definite evidence recorded by Atkins, Gillette, Washburn and Card. There is no definite evidence that eggs have been seen on apples on the tree until the fruit has reached nearly the size shown at *a* and *b* in figure 131, or until it is from one-half to three fourths of an inch in diameter.

We have gone into some detail to bring out the above facts, not only because they correct some old stereotyped notions, but because they have a very important bearing on the question as to when it is necessary to apply the spray to reach the worms most successfully. As will be brought out more fully, with illustrations, in our discussion of the time to spray, it is necessary for fruit growers to watch the blossoming of their trees and especially the development of the young fruit, for therein lies an easy and sure method of determining just when the spray can be applied to do the most good.

Habits of the Moth.

It has long been known that the adult insect was nocturnal in its habits, usually remaining hidden during the day. The fact that the moth closely mimics the bark in its coloring, and its habits of moving about only at night, account for the fact that but few fruit-growers have ever seen it. Kœbele gives the following account of their habits in California: "On a hot and sunny day, while walking through an old apple orchard at 10 A. M., moths started up either from the trunk or lower leaves of nearly every tree and settled down again, generally higher up and on the upper sides of the leaves exposed to the sun. From May 25 until the end of June there could be seen at dusk from 25 to 50 on each tree. The place is situated on the east side of the hills. About half an hour after the sun disappeared behind the mountains, and while it was yet visible for nearly that length of time on the opposite hill, the moths began to appear, flying with quick movements around the trees, chiefly near the tops, and settling down again upon the leaves or fruit from time to time. This was kept up until towards dark when they became less numerous. During this time both sexes may be readily collected with a long butterfly-net. I have taken many near the ground on the lower leaves and often distant from fruit trees. By their peculiar flight they are easily distinguished from any other species of moth." Gœthe found in his experiments in Germany that the moths were the most active about 9 P. M. Most of the eggs are thus doubtless laid in the evening.

Unlike many other moths, the codling moth is not attracted to lights. This has been demonstrated several times by careful experiments with trap-lanterns in orchards.

The moth has a slender, pointed tongue, with which it sometimes sips or sucks up sweet substances. LeBaron saw the moths feed freely upon lumps of moist sugar and slices of sweet apple which he placed in their cage. McMillan records that they willingly feed upon sweetened water, and that he has "seen those of the second brood feeding upon the yellow flowers of an autumnal composite (*Grindelia squarrosa*) in the dusk of evening" in Nebraska. The weight of evidence from careful experiments indicate that the moths are not easily attracted to alluring baits of any kind.*

How long a codling-moth lives is not definitely known. In confinement, most observers record that they all die in about a week. Washburn concluded from his observations that the life of the moths was from ten to fifteen days. One moth lived for seventeen days in one of our cages.

Brief Résumé of the Life-history.

The codling-moth appears in the spring about the time the blossoms are falling from apple trees, and after a few days glues its tiny scale-like eggs (see figure 131) onto the skin of the young fruit or even the adjacent leaves, where they hatch in about a week. The little apple-worm usually finds its way into the blossom-end, where it takes its first meal, and where it remains feeding for several days, finally eating its way to the core. In about three weeks it gets nearly full-grown and makes an exit-tunnel to the surface, closing the outside opening of the tunnel for a few days while it feeds inside. Emerging from the fruit, it usually makes its way to the trunk of the tree, where

* A Connecticut correspondent states in the *Rural New Yorker* for January 9, 1897, that "happening to pass a sweet-bough apple-tree one evening in August, where a number of apples, half eaten by the chickens, were lying scattered about, I noticed a kitten busily trying to catch some small object. On investigation, I discovered that the half-eaten apples were covered with codling-moths. There were thousands of them, apparently feeding on the fruit. They were very active when disturbed. I procured a lot of old newspapers, and for half an hour or more I kept several fires burning brightly, while the kitten and I stirred them up. I don't think I succeeded in burning as many as the kitten caught. They carefully avoided the fires."

it soon spins a cocoon (figure 135) under the loose bark. Usually the first worms to thus spin in June or July, soon transform to pupæ (figure 136), from which the adult insect emerges in about two weeks, and eggs are soon laid from which a second brood of the worms hatch. In most of the more northern portions of the United States, only a part of the worms of the first brood pupate or transform to moths the same season, but in the central, western and southern portions there is a complete second brood, and in some portions even a third brood of the worms annually. In the fall all the worms spin cocoons wherever they may be, either in the orchard or in storerooms, and remain curled up in them as caterpillars until spring opens, when they transform, through the pupa, to the moth, thus completing their yearly life cycle.

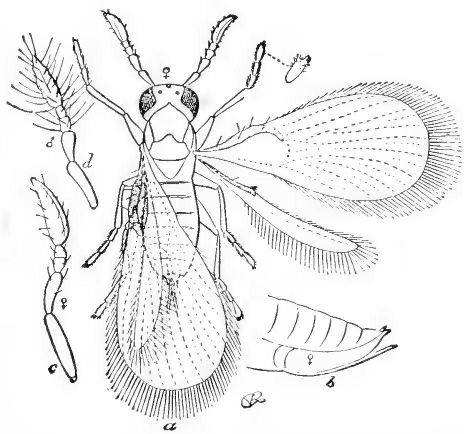
THE NATURAL ENEMIES OF THE CODLING-MOTH.

At no period of its existence does the codling-moth seem to be secure from the attacks of its enemies; even the tiny eggs and the moth do not escape their relentless jaws.

Koebele records that in California a " most efficient destroyer of the insect is a small bat which is always in search of the moth, appearing somewhat later than the latter, but keeping up its chase until dark, when apparently the moths cease their flight and the bats go off in search of other food. Every night during June as many as six of these bats were to be seen flying around an isolated apple-tree upon which there were a large number of the moths, not only taking the codling-moth on the wing, but very often darting at a leaf to get the resting moth."

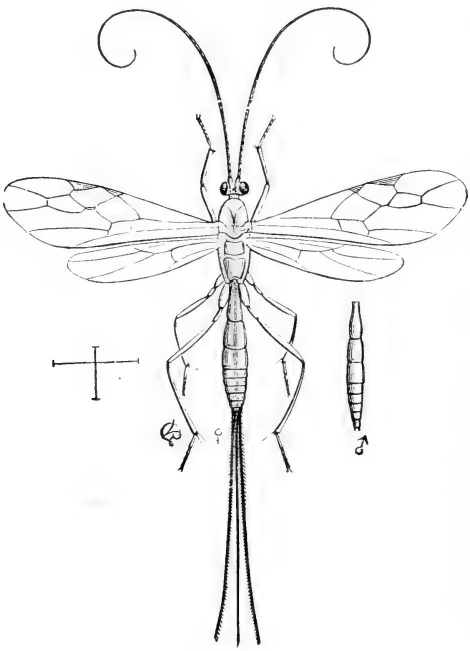
It would seem that the codling-moth's egg, not quite so large as a common pin's head, would escape the eye of the enemy, but many of them do not. In June, 1896, we were surprised to find that quite a number of the eggs we saw had a peculiar black appearance. These were placed in cages, and a few days later the mystery was explained. For, instead of little apple-worms hatching from them, there appeared fully developed adult insects, the surprising number of four coming from a single tiny egg in some cases. It is wonderful to think of four perfect animals having been born in, and having obtained sufficient sustenance to develop into perfect insects from the contents of such a tiny thing as the egg of a codling-moth. In figure 138 is shown a greatly enlarged picture of this pretty little parasite, which is, of course, an exceeding small creature, yet it is easily visible to the naked eye. Dr. L. O. Howard determines these little parasites as probably the same insect, *Trichogramma pretiosa*, which infests the eggs of the cotton worm to a large extent in the South. In 1889, Koebele found many parasitized eggs of the codling-moth in California; the parasite he reared is either the same as, or first cousin to, the one working in the egg in New York.

Even after the apple-worms get out of sight in the fruit, they are not safe from their enemies. In California a wasp (*Sphecius nevadensis*) is reported to frequent pear trees, and is described as pulling the worms out of the fruit with its "fore foot." In 1890, Mr. Webster reported (Insect Life, III., 348) that two observers in Indiana had seen downy woodpeckers deftly extracting the worms from the blossom-ends of young apples without injuring the fruit. In 1873, Dr. Riley found that an Ichneumon fly, which he called the "delicate long-sting," "probably pierced the unfortunate apple-worm while yet in the fruit, as it always succumbs soon after forming its cocoon, and before changing to a pupa." Riley's picture of this graceful, pale honey-yellow parasite is given in figure 139; the lines at the left show its natural size. While examining wild haws in 1890 for apple-worms, we were surprised to find in a few fruits nearly full-grown worms whose life was being sucked out by small maggot-like creatures which had attached themselves to the body of their host, one to each apple worm. We did not succeed in rearing the adult insect from this external parasitic grub. It may have been the same parasite which Popenoe found in



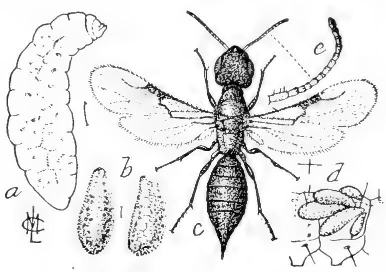
138.—*Trichogramma pretiosa. Egg-parasite of the codling-moth, greatly enlarged.* (From Riley, 4th Rept. Ent. Com., U. S. Dept. of Agr.)

Kansas in 1889, but he does not state whether the apple-worm was attacked while in the fruit or not. A picture of this Kansas parasite, which Dr. Howard writes us is probably a species of *Goniozus*, is shown greatly enlarged in figure 140. In 1872, Mr. Foster, of Babylon, N.Y., reported (*Gardner's Monthly*), the discovery of a very curious and strange case of parasitism. He had found a species of the well-known hair-snakes imbedded in one of the codling-moth caterpillars in the center of a large pear. Since then several observers have found these hair-snakes in apple-worms or coiled in the core of wormy apples. Hair-snakes are often found in ground-inhabiting insects like grasshoppers, but how they ever get into apple-worms inside the fruits on the tree is yet a mystery. A German writer suggests that a heavy dew may moisten the trunks of trees sufficiently to enable the hair-worms to ascend them. The apple-worm is also infested by a hair-snake in Europe.

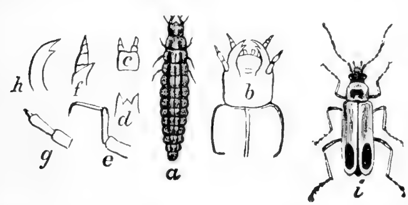


139 —*The delicate long-sting parasite* (*Macrocentrus delicatus*. (From Riley).

After the apple-worm leaves the fruit, it has to run the gauntlet of many other enemies. The larva (*a* in figure 141) of the Pennsylvania soldier-beetle (*Chauliognathus pennsylvanicus*) often devours the apple-worm while it is getting ready to spin, and possibly sometimes before it leaves the fruit. The adult form—the beetle—(*i* in figure 141) of this predaceous enemy is a very common yellowish beetle, which feeds only on the pollen of flowers. It is probable that the larva of the margined soldier-beetle (*C. marginata* also even enters the fruit to feed upon the apple worm. The larva of the two lined soldier-beetle (*Telephorus bilineatus*) is also reported as preying upon apple worms. Still another predaceous beetle larva, which has been found feeding on the apple-worm, and the pupæ also, in many parts of the United States, is shown at work at *a* in figure 142. We have seen many of these larvæ at work in our search for apple-worms on the trunks of trees in early spring. With the exception of the birds, it seems to be the most efficient enemy of the codling-moth in New York. Its first cousin, *Trogosita laticollis*, also has the same habit. In California, the larva of a Raphidian (a Neuropterous insect occurring only in the far west) is a most effective enemy of the apple-worm. An attempt has been made to introduce this insect into Australia to help in keeping this pest in check there. A Tachinid fly (*Hypostena variabilis*) is recorded as having the apple-worm for its host (Bull. 7, Tech. Ser. U. S. Div. of Entomology, p. 17). Besides these predaceous enemies, there is a parasitic Ichneumon-fly which attacks the apple-worm after it leaves the fruit. This black parasitic fly is shown much enlarged in figure 143. It is known as the ring-legged Pimpla (*Pimpla annulipes*). The grubs of this fly live within the body of the apple-worm or the pupa, and the adult fly escapes by eating its way through the pupa skin and cocoon of its host.



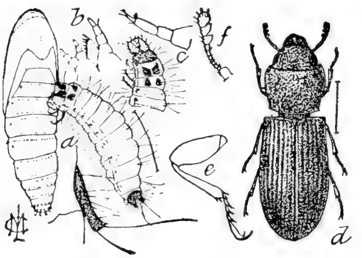
140.—*Goniozus sp. externally parasitic on apple-worms.* (From Popenoe.)



141. — *The Pennsylvania Soldier-beetle (Chauliognathus pennsylvanicus).* (From Riley.)

In Europe three parasites are recorded as attacking the codling-moth; they are *Campoplex pomorum*, *Pachymerus vulnerator*, and *Phygadeuon brevis*.

By far the most efficient aids to man in controlling the codling-moth are the birds. Nearly all writers since Roesel's time, 1746, have referred to the effective work done by the birds. Anyone who tries to collect the apple-worm on the trunks of the trees in early spring, will be surprised to find how many empty cocoons there will be. Usually, however, a tell-tale hole through the bark into the cocoon, explains the absence of its occupant. Our observations lead us to fully agree with Riley and Walsh that "almost all the cocoons of the moth that have been constructed in the autumn on the trunks and limbs of apple trees, are gutted of their living tenants by hungry birds, long before the spring opens." In our experience, it was almost impossible to find anything but empty cocoons on any part of the tree in the spring, except on the trunk at the surface of the ground and for a distance of from six inches to a foot above. One finds such an astonishingly large number of empty cocoons, that it would seem as though the birds must get the larger percentage of the worms which go into hibernation in the fall. Among the birds which thus include the apple-worm in their menu are the downy woodpecker, nuthatch, black-capped titmouse, bluebird, crow blackbird, kingbird, swallows, sparrows, wrens, chick-a-dee, and jays. It is probable that most of the birds which winter in any locality, include the apple worm in their dietary.



142 — *Trogosita corticalis. Note the predaceous larva at work on a codling-moth pupa.* (From Popenoe.)

Recent reports have appeared in horticultural papers that the fruit-growers of Oregon and Washington were trying to arrange for the importation of a German bird which is said to be a natural enemy of the codling-moth. Our advice to a correspondent, who wrote us from Washington in regard to the scheme, was "do not try it." There are too many risks to run. In the first place, it is very doubtful if there is any German bird

143 — *The ring-legged Pimpla parasite.* (*Pimpla annulipes.*) (From Riley, An. Report Sec. of Agr for 1897.)

which gets as many apple-worms to eat in its native home as do some of our own native birds in our orchards. As the *Rural New Yorker* puts it: "This foreigner should furnish a certificate of good moral character before being allowed to land." The English sparrow was introduced into the United States to destroy canker-worms, and to-day it is an unmitigated pest, while the canker-worms were never more numerous and destructive than now. Dr. L. O. Howard, in a recent address (Proc. Am. As. Ad. Sci. for 1897) has well said: "We have thus had sufficient experience with intentional importations to enable us to conclude that, while they may often be beneficial in a high degree, they form a very dangerous class of experiments and should never be undertaken without the fullest understanding of the life-history and habits of the species. Even then there may be danger as, with a new environment, habits frequently change in a marked degree."

And yet, in spite of the above array of enemies, enough codling-moths succeed in running the gauntlet every year to allow it to take rank as the most destructive apple pest in nearly all parts of the world.

HOW TO FIGHT THE CODLING-MOTH.

The codling-moth seems to have ravaged orchards for twenty centuries before anyone accorded any suggestions by which it might be checked.* During the past seventy-five years, however, so many schemes have been devised that it would require volumes to contain all that has been said pro and con concerning them. Believing that oftentimes it is just as valuable to a fruit grower to know *what not to do* as it is *what to do*, and that one method may be more applicable or practicable under certain conditions than another method, we have thought it advisable to briefly discuss all of the so-called "remedies" that we have seen suggested.

---

* Of interest, historically, is the fact that, so far as we can discover, the first one to even hint at any remedial measure was an American, a Mr. Thatcher. In the second edition of his *American Orchardist*, he shrewdly reasons that as the worms are said to spend the winter on the trunks of the trees, it would be well to scrape off all lose bark and apply Forsyth's wash (consisting of soap-suds, lime and cow-dung); this would certainly help in reducing the number of the pest.

In devising any method for combating an insect foe, the first thing that should be considered is, in what stage or when is it the most vulnerable to attack? Recommendations for fighting the codling-moth include schemes for reaching it in all stages and under all sorts of conditions. Most writers have considered that the insect is not so easily gotten at in either of the shorter stages of its life, that is, in the moth, egg, or pupal stages, therefore most of the remedial suggestions are directed toward the destruction of it in the caterpillar stage, in which it spends the greater part of its life.

What Can be Done Against the Moths?

"Rusticus" said in 1833 that one could drive away the moths in June by making a smoking fire of weeds under valuable trees. This is possible, but hardly probable, and not often practicable. In 1839 Freyer suggested that the best way is to hunt out the moths on the trunk and leaves and kill them. He must have been joking, for we have never yet been able to get sight of the moth on a tree. Ratzeburg condemned the method the next year.

The insect-catching properties of the flowers of the different species of *Physianthus* have long been known, and there has been considerable discussion over the claim made by some that many codling-moths were caught in these flowers. It was proposed to train these vines up the trunks of apple-trees, surmising that the flowers by capturing the moths would thus protect the crop. Conclusive evidence has been recorded to show that these flowers have no attractions for codling-moths.

The fact that many different kinds of moths are often attracted to lights or to alluring baits in large numbers has led many to believe that the codling-moth could also be lured in sufficient numbers to make it pay to build fires or to place trap-lanterns in an orchard, or to hang sweetened or other baits of various kinds in the trees. Many experiments have been tried along this line by such reliable observers as Riley, Cook and Atkins, and so few codling-moths were captured as to conclusively show the entire futility of attempting to check the pest in this way. Many collectors of insects also report very few captures of the moth at their lures or at lights. Most of the reported captures of the insect in large numbers at baits or traps are the results of mistaken identity.*

There is one suggestion of considerable importance to be made in this connection. Many of the worms are carried with the fruit into store-rooms in the fall, where they spin their cocoons, consequently the moths often emerge in the spring in considerable numbers and escape through the windows and doors. It would be a simple matter to put screens or mosquito netting over all openings during May, June and July, thus effectually trapping the moths which would otherwise find their way to orchards and start a numerous progeny. The number of the moths which sometimes emerge in these fruit-rooms is surprising. Hundreds of cocoons have been found in a single apple barrel, and in one instance in California the openings in a fruit-room were screened, and nearly 16,000 codling-moths were thus trapped and killed between the middle of April and the end of August, nearly 1,000 being caught in a single day, June 15. It would not be necessary to go to the trouble of catching all the moths in a room thus screened, for they would soon die a natural death.

Can We Kill the Eggs?

It is only recently that anyone has suggested the possibility of reaching the codling-moth in its egg stage. Mr. Card reported from Nebraska in August, 1897, that "the eggs are very easily accessible, being laid, as they are, on the upper surface of the leaf. In a limited way, in laboratory experiments, we have found that kerosene emulsion will destroy these, but we are not yet able to say whether a strength that may be safely used will prove effective in field work." Mr. Washburn seems to have been the only one to try any other experiments against the eggs. In 1892 he allowed a few apples, upon which eggs occurred, to remain in a solution of one pound of IXL (a mixture of lime, salt and sulphur), about one pound of whale oil soap, and about an ounce of Paris green, in sixteen gallons of water; subsequently these eggs hatched.

---

* The use of baits has recently received considerable attention in Germany and in *Der Praktische Ratgeber*, for 1895, is recorded an account of an experiment with glasses of apple jelly hung in the trees. We glean from the report that quite a number of codling-moths were thus captured, about half of them being females.

Apple-trees have been sprayed with similar substances. In 1878 Cook sprayed an apple-tree weekly from May 15 till the last of June with a strong solution of soft soap, with the results that not a single apple was wormy, while an unsprayed tree had nearly three-fourths of its fruit infested. Whether the strong smell of the soap kept the moths away, whether the eggs were killed, or how the solution affected the insect, is not suggested. Goff has sprayed apple-trees with kerosene emulsion once (June 11) and with McDougall's Sheep Dip twice (May 25 and 30), but with little or no effect on the codling-moth.

It may be possible to reach the eggs with a spray in Nebraska where they seem to be laid on the leaves, but our experience in trying to kill the eggs of insects leads us to fear that it will take a stronger mixture than the plant will stand to accomplish the desired result. Whether the eggs can be reached as readily when they are laid on the fruit, can be determined only by experiment. On the whole, we doubt if the codling-moth can ever be combated in its egg stage nearly so successfully and easily as at some other time.

Can We Reach the Pupæ?

As the pupal period lasts only about two weeks, and is passed in the cocoon hidden in some crevice of the bark or in store-rooms, it offers but little opportunity for attack. Many pupæ are killed during the summer when the "banding" system (to be discussed later) is thoroughly carried out. Many of them could also be killed in the spring in store-rooms by fumigating the room, as suggested by Wier of California, with carbon bisulphide or hydrocyanic acid gas. But the insect can be just as effectually gotten at while it is yet a caterpillar, or in the fruit room, even after the moths have emerged; so that, although the pupæ can be reached to a limited extent and killed, we can fight the insect more easily and more successfully at some other time.

How to Kill the Apple-worm or Caterpillar.

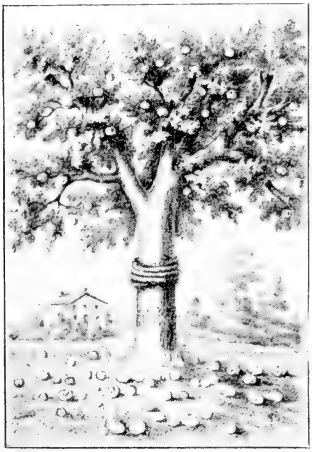
Having discussed the possible chances of reaching the insect in its moth, egg, and pupal stages, we now turn our attention to combating it in its more vulnerable stage, as an apple-worm. From the time the caterpillar leaves the egg until it is snugly ensconced in its cocoon, it can be reached in several different ways, none of which, however, are a complete success.

Jarring or picking infested fruit from the trees.—The fact that one can often easily detect the wormy fruit soon after the insect has begun work, by the pile of brown excrement thrown out at the blossom-end (as shown in figure 133) led several orchardists about 1870 to adopt the practice of jarring or picking off such fruits and destroying them. In 1871, Mr. Chapin, of East Bloomfield, N. Y., reported that by this means he was able to preserve the fruit in an orchard of 100 acres, at the rate of about an acre an hour, with two men and a boy. The men would knock off the wormy fruit with poles about as fast as the boy could gather them into baskets. This simple expedient would be practicable nowadays in the case of a few trees in a door-yard, but even there equally as successful results can be secured with less labor by other methods.

The destruction of the "windfalls."—Among the earliest recommendations made for the destruction of the codling-moth, both in Europe and in this country, was to destroy all "windfalls" as fast as they fell. Careful experiments by Forbes and Munson have shown that about 82 per cent. of these "windfalls" are caused by the codling-moth; the observations of LeBaron, Beal and Cook led them to conclude that about one-half of the wormy apples which fell still contained the worms; many have also observed that the worms do not remain long in "windfalls." From these facts one can readily see that the prompt destruction of the "windfalls" would considerably lessen the numbers of the pest, but it could be only partially effective since about half of the worms leave the fruits before they fall. Many have reported good results from pasturing hogs or sheep in orchards to eat the "windfalls," and wherever this is practicable, it would prove a valuable addition to other methods of warfare. In the case of a few choice trees in a door-yard, it would be a good, practicable plan to gather the "windfalls" by hand every few days and destroy them or feed them out to stock.

At best, however, the destruction of "windfalls" can be only partially effective against the codling-moth.

Trapping the worms on the tree trunk, or the "banding" method.—Upon leaving the fruit, the apple-worm preferably seeks the shelter of the crevices and loose bark of the trunk of the tree before spinning its cocoon. This fact was known as early as 1746, but it was not until nearly a century later that Burrelle, of Massachusetts, discovered that thousands of the insects may be obtained "by winding round or hanging any old cloth in the crotch of the trees, from the time they begin to leave the apple till the time the fruit is gathered. I think at present the best remedy would be this: In the fall, when the insect has crept into the cloth for winter quarters, take the cloth from the trees and put it into an oven hot enough to destroy them." Other orchardists soon recorded similar operations, and finally, as a natural outgrowth of Burrelle's recommendation, Dr. Trimble, after a series of experiments with various "bands" in 1864, devised his famous "hay-rope band." A reduced copy of Dr. Trimble's picture of his hay-rope band in operation is shown in figure 144. In forming an ideal place for the apple-worms in or under which to spin their cocoons this hay-rope band is equal to anything yet devised.



144.—*The hay-rope band in operation.* (Reduced from Dr. Trimble's picture.)

This "banding system" thus thoroughly inaugurated by Dr. Trimble soon became the principal and most successful method of warfare against this pest. It was largely practiced during the decade between 1870 and 1880 in many parts of the United States, especially in Michigan, where it is said to have brought about a noticeable improvement in the apples from that state. Extensive experiments have been made since 1869 with bands of various kinds by Riley, LeBaron, Cook, Beal, Chapin, Wickson, Popenoe, Washburn and Card; and within the past three or four years the banding system has received considerable attention in Germany by Schilling. These experimenters differed in their conclusions as to what was the best band to use. Among those found the most practical and successful may be mentioned common straw wrapping paper, 18x30, folded lengthwise thrice upon itself; rags of any kind; a very effective but rather expensive one was formed by lining one side of an old piece of sacking, four inches wide, with strips of lath; strips of old carpet; woolen cloths; old grain sacks cut into strips; felt paper sold for carpet lining; and strips of heavy express paper cut on a slight curvature and folded together once; while Trimble's hay-rope band was found equally effective, it was not nearly so convenient to make or use, and was thus early discarded.* Any of the above bands are easily made and quickly applied by placing them around the tree and either putting a tack through the overlapping ends and into the tree or else by simply tying a cord around the middle of the band. To work the most successfully, the tree should be scraped quite smooth where the band is applied; the band should be arranged to present one or more folds, in which the worms like to spin their cocoons; and two bands should be put on each tree, one near the crotch and the other near the base, thus offering convenient places for the worms which may come down from the apples on the tree, and also for those which may go up from the "windfalls." The bands should be put on in June or about the month after the blossoms have fallen, and they should be kept on until the fruit is gathered. They must be removed and examined every ten days until the latter part of August, when it will not be necessary to examine them again until late in the fall, except where more than two broods of the pest occur. All of the cocoons with their living contents must be destroyed at each examination; this can be done either by burning the cheap paper bands and putting on new ones each time, or, in the case of cloth bands,by putting them in hot water or by running them through a wringer. The necessity for this frequent examination of the bands arises from the fact that some of the worms will be changing to pupæ and the moths would soon escape, thus defeating the whole object of the use of the bands. All those who have expressed an opinion after using the bands extensively, state that the expense during the season need not exceed four cents per tree, or that they can be used with decided profit.

* In 1870 or 1871 there was patented and put on the market what was known as "Wier's shingle trap." It consisted of three shingles, separated for a slight distance and held together by a large screw through their center, by which they were also fastened to the side of a tree. The idea was that the worms in seeking a place to spin upon the trunk of the tree would be allured to these shingles. The trap could be easily detached from the tree and by turning the shingles the insects between them could be quickly crushed. This trap aroused considerable interest at the time, but careful comparative tests by Riley and LeBaron soon showed that it was not nearly so effective as almost any kind of a band which went completely around the tree; and Wier's shingle trap was soon discarded.

In 1887 Wickson carried on an experiment to get at the exact proportion between the worms on a tree and the number caught by bands during the season. He bandaged 457 apple and pear trees at the California Experiment Station, and caught only 1,188 worms while 2,704 fruits were found from which the worms had escaped; the bands had thus captured only 44 per cent. of the worms. The trees were quite smooth, and only one band was used. Doubtless better results would have been obtained by the use of two bands. However, 44 per cent. is a good showing, and, as Mr. Wickson well says, "the destruction of this proportion of fully fed and healthy larvæ must be considered very satisfactory;" and it will be seen that this old method of treatment is still one of the most effective that can be employed." The next year a similar experiment was made at the Kansas Experiment Station, but in this case all of the trees were also sprayed with poisons, thus somewhat complicating matters. The record shows that the bands captured only about 8.5 per cent. (238,000 infested apples and only 20,398 insects) of the insects which had done the injury; one band was used, and it seems as though there must have been some conditions not mentioned in the record which might explain the great difference between these results and those obtained in California. Yet, with even this small per cent. of worms captured, it was considered that the bands could be used with profit in Kansas.

It is surprising how many of the worms can be captured sometimes under these bands. In 1873, Beal thus entrapped on 211 trees bearing light crops 6,884 of the insects during the season, the largest catch being 1,450 on July 18, and the smallest 210 on August 15.

Previous to the discovery of the spraying method for combating the codling-moth, this banding system was the most successful method suggested, and as the above facts show, it has been demonstrated that much can be done with bands to reduce the numbers of the pest. Yet, under the most favorable circumstances, apparently, we cannot hope to capture more than half of the full-grown worms with the bands, and then not until they have done their destructive work. In short, with the bands we simply help to reduce the numbers of the succeeding generations of the insect, and thus at the best it is only a partial remedy. However, all who have tested it, claim that the method can be practiced with profit, and it is evident that where there are two full broods or more of the insect, we must devise something to supplement or take the place of the poison spray. Thus, under such circumstances, doubtless the best method of combating the pest, so far as our present knowledge goes, would be to combine the band treatment with that of the poison spray, to be discussed next. Forbes arrived at the same conclusion in his experiments in Illinois in 1885 and 1886, as also did Popenoe, Marlatt and Mason in their Kansas experiments in 1888, and experiments now in progress in Nebraska and New Mexico are along these lines.

Spraying for the Codling-Moth.

Apparently the first suggestion to spray apple-trees to check the codling-moth was recorded in 1850 by Mr. Simpson, of Massachusetts (Downing's Horticulturist, IV., 567). By placing a thin plate of beeswax over the "eyes" of a number of apples, he found that he saved them from attack by the apple-worm. He then reasoned: "But the plan for practical purposes is to syringe the fruit with whitewash; this will fill the eye and thus prevent the moth from laying her egg."

About thirty years later the same idea seems to have been conceived by Dr. Hull, of Illinois. He recommended dusting air-slaked lime over the trees just after the blossoms fell, especially when the dew was on. In 1885, Forbes sprayed some apple-trees eight times with fresh air-slaked lime mixed in water; the results indicated "the uselessness of this substance against the codling-moth." In 1889, Gillette mixed some carbolic acid with plaster and threw this on the trees when the dew was on; two applications were made "with an apparent saving of 34 per cent. of the fruit that would have been wormy." He states that as it simply repells the moths from laying eggs and does not kill the insect, it could hardly be recommended, even if it gave much better results.

Spraying with poisons.—In 1872, Le Baron recommended fruit-growers to spray their trees with Paris green to check the canker-worms, and this method was soon adopted by many orchardists, some of them using white arsenic instead of Paris green. In 1878, a practical fruit-grower accidentally discovered that when he sprayed his trees with Paris green, he "not only rid the orchard of canker-worms, but that the apples on the sprayed part were much less eaten by codling-moths." *

---

* This fact seems to have been first discovered by Mr. E. P. Haynes, then living near Hess Road, Niagara Co., N. Y. Mr. J. S. Woodward had advised him to use the poison for the canker-worms, and in January, 1879, this discovery was reported to the meeting of the Western N. Y. Hort. Society by Mr. Woodward. It seems that the Hon. J. M. Dixon, and others, had also

The first careful experiments by an entomologist with the poison spray were made in Michigan in 1880 by Cook, who had learned through Mr. Woodward of its successful use in western New York. Cook sprayed twice with London purple and reported the following results in December of the same year: "The trees were loaded with fruit, but careful examination, made August 19, discovered not a single injured apple. Other apple trees, only a few rods distant, which were not treated with the poisonous liquid, are bearing fruit one-fourth to one-half of which is 'wormy.'" Notices of the successful use of the poison spray appeared in most of the leading agricultural papers, yet comparatively few adopted the method for the destruction of the codling-moth during the next few years. Entomologists were somewhat afraid to recommend it, and orchardists seemed to hesitate in applying poison for this pest, although it was quite freely used for canker-worms. A very few of the most progressive men adopted the method, and with apparently successful results.

In 1885 and 1886 Forbes and Goff made careful and extensive experiments with poison sprays, and the results indicated that at least 70 per cent. of the loss commonly suffered by the fruit-grower from the ravages of the codling-moth could be prevented by thoroughly applying the Paris green once or twice in the spring. Similar results were obtained in California by Wickson in 1887. After the establishment of the State Experiment Stations in 1888, a new impetus was given to the adoption of the arsenical sprays, for nearly every station, sooner or later, reported the results of careful and successful spraying experiments against the codling-moth. Not only has the practicability and effectiveness of the poison spray been demonstrated during the past ten years by the most carefully conducted experiments at nearly every experiment station in the United States, but the thousands of practical fruit-growers who have thoroughly tried it are unanimous in their testimony that from 50 to even 90 per cent., in some cases, of the fruit that would otherwise be ruined by the insect can be saved at a comparatively slight expense. To ensure success it is necessary to

---

used white arsenic and Paris green for canker-worms in Iowa as early as 1875, but we can find no indications in the contemporaneous horticultural literature that Mr. Dixon realized he had at the same time checked the codling-moth until 1880 (Trans. Iowa Hort. Soc.) or after Mr. Woodward had reported his success, and it had been confirmed by the careful experiments of Cook in Michigan. It thus seems that to Mr. Haynes and Mr. Woodward belong the credit of this pioneer work, in the discovery of what has proved to be the most successful method of combating the pest yet devised.

understand some of the essential facts in regard to the "whys and wherefores" of the operation which have been brought out at one time and another by the various experimenters during the past ten years.

What poison to use.—Many comparative experiments have been made with the different arsenical poisons (Paris green, London purple, white arsenic, arsenite of lead, etc.), to determine which is the most effective against the codling-moth. In nearly every case the recorded results show a decided advantage in favor of Paris green over all other poisons. At the present time hundreds of tons of it are used in the United States in combating the codling-moth alone. It is less variable in its composition than London purple, and the latter is more liable to injure the foliage, but its cheapness and lightness causes many to use it in preference to Paris green.*

Paris green should be used at the rate of one pound in from 160 to 200 gallons of water, or it can be used even a little stronger when mixed with the fungicide, Bordeaux mixture. Careful experiments by Lodeman, Craig and others have demonstrated that the poison is just as effective against the codling-moth when used in combination with the fungicide as when used alone. When used alone there should be added to the Paris green, but more especially to London purple, about twice as much freshly-slaked lime, to prevent any caustic action on the foliage resulting from the presence of soluble arsenic in the poisons; the lime already in the Bordeaux mixture does this. It is, therefore, now a common practice among fruit-growers to use the poison (for the codling-moth) in combination with the Bordeaux mixture (for the apple scab fungus), thus "killing two birds with one stone." In mixing Paris green or London purple, it is always best to first wet it in a small quantity of water, making a sort of thin paste; if the dry poison is thrown directly into a large quantity of water it cannot be mixed so quickly nor as satisfactorily.

When to spray for the codling-moth.—The commonly accepted notion that the eggs of the insect were laid in or on the calyx of the fruit soon after the blossom fell, and the fact that a large percentage of the worms

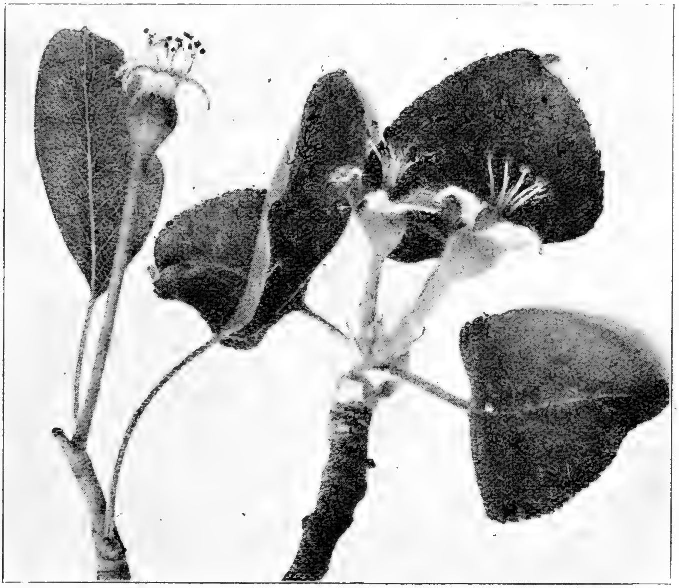
---

* A "Zoektein Poison" was tested by Goff in 1888 and 1889, and "Climax Insect Poison" in Kansas in 1888, but neither these nor other poisons which have been tested have proved equal to Paris green in effectiveness.

enter at this point, led to the recommendation to spray just after the blossoms fell. The experience of those who have sprayed has confirmed this conclusion, and it is now the universal practice to try and make the first application at this time. As Mr. Lodeman has put it: "The falling of the apple blossoms is the signal for the use of arsenites in the destruction of the codling-moth." Our observations would indicate that a safe rule will be to spray the fruit at any time within a week after the blossoms fall; if it rains within a few days repeat the spray at once. The reason why and the great importance of spraying at this time is discussed under the next heading. Where there are both early and late varieties in an orchard, it may be necessary to spray some trees before others; usually there is not enough difference in time between the dropping of the blossoms from late and early varieties but that all trees can be sprayed the same day. Although experiments demonstrated that it was necessary to spray at this time to secure the best results, yet but few really understood the "why" of it; that is, just how it did or could affect the insect when applied at this time.

How the poison affects the codling-moth.—Those who critically examine the literature will be surprised to find how few definite statements there are regarding this very important phase of the question of combating this insect. It seems to have been the current notion for some time that the poison spray not only killed some of the insects, but that it also acted as a preventive in some way. It was in consequence of the repeated requests of Mr. Lodeman for information on this point that we began studying this old enemy, about which most of us have thought there was nothing new to be learned. We were surprised to find several times that our observations would not agree with the stereotyped notions regarding the life and habits of the insect at the time when fruit-growers were spraying to kill it. Our first surprise was to find that the moths did not begin to emerge in considerable numbers until several days after the blossoms had fallen, and consequently we were unable to find any eggs until the blossoms had been off for a week or more.

Meanwhile, we had been watching the development of the young fruit and had seen something of great importance to fruit-growers and which seems to have escaped the notice of most experimenters; we have seen no mention of it except by Gillette and Munson. Just after the petals fell, we found the blossom-ends of both apples and pears in the condition shown in figure 145; that is, the calyx lobes were spread widely open, forming a saucer-like cavity. As several complaints had reached us that the codling-moth was not so easily reached on pears as on apples, we watched the developing pears also. The fruit at the left in figure 145, is a pear, and the only difference we could see at the time between it and an apple was that the latter was covered with a coating of fine hairs. At the time we theorized that possibly the Paris green would stick to these



145.—*Just right to spray. A pear and two apples from which the petals have recently fallen. Note that the calyx lobes are widely spread.*

"fuzzy" apples better than to the smooth pears, and the worms thus be more liable to get some of the poison on the apple, but this theory was soon exploded by further observations. About a week after the petals fell, we found that the blossom-ends of apples and pears looked like those shown in figure 146; the center fruit is a pear. The calyx lobes on the apples had begun to draw together, and within the next few days the apples presented the appearance shown at *a* and *b* in figure 131; that is, the calyx lobes had drawn completely together forming a tight cover over the calyx cavity. In the case of the pears, however, the calyx lobes drew together but very little. How this fact may affect the effectiveness of the poison spray for the insect on pears will be discussed later. On most varieties of apples we found the calyx cavity closed within two weeks after the petals fell. Mr. Card found it closed in about ten days in Nebraska in 1897, but in the case of some varieties of apples it never closed. Munson records that the calyx lobes on the Baldwin closed in about two weeks. The time doubtless varies a few days with different varieties.

146.—*Almost too late to spray apples effectively. Note that the calyx lobes are drawn nearly together on the two apples, while on the pear in the center, the calyx cavity is open.*

Now, of what importance to the fruit-grower are these facts regarding the closing of the calyx lobes? Anticipating a little, it means that *the closing of the calyx lobes is the signal that it is too late to get in your most effective blow against the codling-moth with a poison spray.*

Returning to our observations upon the insect, we found no eggs until the calyx lobes had closed, or nearly so, as shown at *a* and *b* in figure 131. And as the worms would not hatch until a week later, we were in a quandary to explain how a Paris green spray, applied according to the prescribed rule of "just after the blossoms have fallen," could possibly affect a worm appearing on the apple ten days or two weeks later. Our observations on the development of the young fruit, as just described, led us to theorize that the poison must have lodged in the open calyx cup (see figure 145) and, no rain intervening to wash it out, remained there while Nature proceeded to draw a protecting roof over it (see figure 146) and finally left it securely hidden in the calyx cavity. Here it was found by a young apple-worm a week or so later.

We soon found, as have other observers, that from 75 to 85 per cent. of the worms which hatch in the spring enter the apples through the blossom-end; and we found, also, that these young worms got their first and several subsequent meals in this calyx cavity. It then only remained to prove the possibility of there being poison therein which had been left there when the trees were sprayed two weeks before. Fortunately, about the time the worms were hatching, we found some apples which had been sprayed with Paris green and Bordeaux mixture just after the blossoms fell. A careful examination of the calyx cavity with a lens revealed particles of a bluish color. Were these particles of Bordeaux mixtures with their attendant bits of poison? Only the chemist could tell this. We at once carefully removed the calyx lobes and surrounding skin from about 50 of these apples, and then submitted only that portion of the apples containing the calyx cup to our chemist, Mr. Cavanaugh. He soon reported traces of arsenic. The quantity found was scarcely enough to weigh, and it seemed as though it were not enough to kill the little apple-worms. But when one remembers that only four or five gallons of the spray are usually applied to a whole tree, and when this is divided up among the millions of leaves and the thousands of apples on that tree, it is easy to see that the amount of arsenic which a single fruit would get, or even 50 of them, would be exceedingly small. Would it be enough to kill the young apple-worms? Careful experiments have shown that it takes much less poison to kill caterpillars when they are small; and as the young apple-worms are scarcely a sixteenth of an inch in length when they begin feeding in the calyx cavity, it would take only an infinitesimally small amount of arsenic to kill them.*

* Munson has figured out how much poison would be liable to stay on one apple, allowing two sprayings of two gallons each to a tree. His figures show that the amount of poison per fruit would be less then 3-1000 of a grain.

Others have made chemical analyses of the blossom-ends of apples, and report no traces of arsenic, but their material was not taken until several weeks after the spraying was done (and it may not have been done when the calyx cup was open), hence could be of little value to determine the point in question.

The above facts and observations lead us to believe that in applying a poisonous spray soon after the blossoms fall, we deposit some arsenic in the calyx cavity, where Nature kindly takes care of it for us until ten days or two weeks later, when the little apple-worm includes it in the menu of his first few meals. Furthermore, this poisoning of these young worms, which enter the developing fruit in the spring, seems to be the only way and the only time that the insect is or can be most successfully reached with the spray; as the worms sometimes eat through into the calyx cavity from the outside at the base of the lobes, and as some of the poison often lodges here, possibly a few of them get enough poison to kill them at this point. Not enough of the spray can be made to stay on the surface of the fruits then or at any subsequent time to reach one in a hundred of the worms which enter elsewhere than at the blossom-end. Put in another way, the above facts mean that we can hope to reach with a poison spray only those apple-worms which enter the blossom-ends of the forming fruits in the spring. To do this, the application must be made soon after the blossoms fall, when the calyx is open, as shown in figure 145. If we wait a few days until the fruit has reached the condition shown in figure 146, or still later as at *a* and *b* in figure 131, it will be too late. We can conceive of no possible way in which a majority of the 15 or 20 per cent. of the worms which enter the fruit at some other point in the spring, and all of the worms of the subsequent broods, can be effectively reached with the poison spray.

Thus, while the spraying method is very effective, it can never prove a perfect panacea, especially where there are two full broods or more of the insect in a season. However, it is a great improvement over the old banding method, for with the spray we kill the worms before they fairly begin their destructive work, thus saving the fruit they would otherwise ruin with an ugly worm-hole. Our observations indicate that the little worms do no feeding on the outside of the fruit except just enough to make a tiny entrance-hole into the flesh or into the calyx cavity. If it were not for their habit of feeding in this blossom cavity for a few days, it is doubtful if spraying would be nearly so effective as it is. It is thus a remarkable fact how much of our success with a poison spray depends upon this habit of the little worms.*

* We have never found any dead worms in the calyx cavity, and thus have no absolute proof that they are killed by the poison there, but Munson has

Never spray a fruit tree when it is in blossom.—You can reach the insect and fungous enemies just as effectively, and in some cases more so, either just before or just after the trees bloom.

How many applications to make.—As has just been shown under a preceding topic, it is necessary to success to get a dose of poison into the blossom-end of the young fruit soon after the petals fall, and before the calyx lobes have drawn together. If no rains occur between the time of spraying and the closing of the calyx lobes, this one application will be just as effective, we believe, if it is thoroughly done, as half a dozen later applications. The sole aim of the fruit-grower should be to have a dose of Paris green in that calyx cup when it is covered by Nature. If rains wash out one application, then spray again if there be still time before the blossom cavity is covered. Usually the recommendation is to spray trees twice, once just after the petals fall and again in a week or ten days, to catch the last worms which hatch.

Many extensive experiments have been made to determine the number of applications it is necessary or profitable to make. In 1885, Forbes made seven and eight applications, and the next year only one and two. His results were equally as satisfactory from the lesser number of sprayings. This is also the conclusion reached by Lodeman and others who have made comparative tests. These results are what we should expect from the life-history and habits of the insect. When the second brood of the worms hatch, the calyx cavity is securely closed and the apples have turned down, so there is scarcely any chance to lodge the poison where the little worms would be liable to get it before they get into the fruit out of harm's way. Yet some experiments

---

recorded an experiment in Maine which strongly indicates that this is the case. He found that out of 346 wormy fruits borne on sprayed trees, only 133 had been entered by the worms at the calyx, while 213 worms had entered at the side or base; and out of 449 wormy fruits on unsprayed trees, 252 had been entered at the calyx, while only 197 worms had entered at the side or base. Thus the relative number entering the calyx was more than doubled in the case of the unsprayed tree. "The only plausible explanation would seem to be that the poison lodging in the calyx had destroyed the larvæ attempting to enter at that end, while those entering the side or base escaped. The larvæ of the second brood were also exempt."

in Oregon indicate that a few of the worms of these later broods can be reached with the spray, and apparently enough of them to lead the experimenter to conclude that even six or seven applications can be made with profit. However, it is the unanimous conclusion of experimenters here in the eastern portion of the United States, where there are only two broods or less of the insect in a year, that two applications are sufficient, one just after the petals fall and a second a week later. No definite date can be set for spraying for the pest, as the falling of the blossoms will vary from year to year in the same orchard.

The important thing for the fruit-grower to do is to watch the blossoming of his trees and the developing of the young fruit, and not depend on anything or anybody else. Simply see to it that there is a good dose of poison put into each blossom-end, and that it is not washed out by rains before nature gets it protected with the closed calyx lobes.

How to spray for codling-moth.—Thousands of fruit-growers annually go through the operation of spraying their orchards, and yet many of them simply waste their time and money, for they only half do it. Every one who sprays, or is thinking about doing so, should read and re-read Professor Bailey's "Notions about the Spraying of Trees" (Bulletin 101 of this Station).

As most of those who have sprayed for this insect have not thoroughly understood the necessity for filling the blossom-end with the poison, there is but little definite evidence as to just how this can best be done. Mr. Card, in Nebraska, has recorded the following pertinent suggestions on this point: "By following the sprayer, I found that ordinarily we do not get the calyx thoroughly drenched. For this reason the spray was made coarser than heretofore, and this seemed to work better, particularly when applied with considerable force. It appeared to be easier to get the poison into the cavity when the lobes were wide open (see figure 145) than when they had begun to close (see figure 146), making a vase-formed receptacle. The leaves increase in size very rapidly after the blossoms fall, so on this account the sooner the spraying is done the more thorough it is likely to be. Were there no danger that the poison would be washed out by rains, the best time to apply it would be immediately after the blossoms fall. The later the poison is applied while the calyx is still open the better."

The expense, or will it pay to spray for the codling-moth?—Your neighbor who has been spraying his orchard for a year or more can the most effectively answer this question for you. In Bulletin 84 of the Station was recorded the testimony of several fruit-growers on this point. It not only pays to spray thoroughly, but it is a positive necessity in many cases. Read Professor Bailey's remarks on this point in Bulletin 101 just mentioned. The cost per tree is a trifling matter, and will not exceed from five to ten cents for the season, depending upon facilities, rains, etc.

It will be necessary to spray for the codling-moth every year that there is a setting of fruit, for several reasons. Usually there are less enterprising neighbors who do not spray and who thus breed a crop of the moths annually, some of which will find their way into your orchard. The insect breeds readily in wild haws, pears, and some other fruits, so that even when there are no apples in a locality some years, the codling-moth does not lack for food. And especially must one remember that we cannot hope to reach with the poison spray the 15 or 20 per cent. or more of the worms which do not enter the fruit at the blossom-end, and these are sufficient to develop a large crop for the next season, where there are two or more broods of the insect in a year.

Is there any danger of poisoning the fruit with the spray, or the stock pastured in sprayed orchards?—No. For several years after the introduction of spraying for the codling-moth, this notion prevented its coming into general use. But to-day one scarcely ever hears the question considered seriously. In 1889 Cook made some experiments in Michigan which effectually settled the question that there is no danger from pasturing stock in sprayed orchards.

He drenched some apple trees with London purple, used twice as strong as recommended. All the poison which dripped off was caught on a paper and the amount of arsenic on this paper then determined by the chemist. In one case, it amounted to .4 of a grain and in another to 2.2 grains. Although these analyses showed that there was little or no danger, the matter was more fully tested by thoroughly spraying other trees under which was growing some bright and tender grass. All of the grass was cut close to the ground, and Professor Cook fed it to his horse;

and no injury resulted. The experiment was repeated later with the same result. Next three sheep were kept till hungry, and then put in a pen made under another tree which had just been sprayed. All of the grass was eaten with no injurious results. This experiment was twice repeated with the same result. Thus practical experiments confirm the conclusions of the chemist.

As no poison is usually sprayed on the fruit after it is half grown, the rain and wind would naturally remove the last particle of it before the fruit was picked. Chemical analyses have shown that there was not the slightest trace of arsenic on the mature apples which had been sprayed several times when they were small.

Why the spray may not be so effective on pears.—Several fruit-growers have asked us to explain why they were unable to control the codling-moth on pears as effectively as they do on apples. We can only offer the following suggestions on this point. Our observations on the young pears after the blossoms fall show that the calyx lobes never draw together as they do on most varieties of apples (see figures 145 and 146). While it would thus be just as easy to lodge some poison in the blossom-end of pears, the fact that the calyx cavity remains open or unprotected would permit the poison to be easily washed out by rains or blown out by winds. Whether the recently-hatched apple-worm has similar habits when born on a pear as it does on an apple, we cannot say from observation. Possibly, however, the fact that the calyx cavity is open, may cause the worms to enter the fruit at once, thus taking but few if any meals in the blossom-end. Thus the fact that it will doubtless be more difficult to keep a dose of poison on pears, owing to the open calyx, may partially explain why it may be more difficult to control the insect on this fruit.

In 1874, Riley recorded that experiments in Illinois had shown that pears were mostly injured by the second brood of the apple-worms. Washburn recently reached a similar conclusion from his observations in Oregon. As it has been shown that we can reach but few of the worms of the second brood on apples with a poison spray, it is evident that a similar treatment on pears would have little effect, providing that most of the injury to pears is done by the second brood of worms. Perhaps we have been spraying too early for the insect on pears. Wherever it does serious injury to pears, it would be well to make some careful experiments with the poison sprays.

Briefly stated, no panacea for the codling-moth has yet been found, but by thorough work with a Paris green spray, we can often save at least 75 per cent. of the apples that would otherwise be ruined by the worms. Where more than two broods of the insect occur during the season, as in Kansas, Nebraska, Oregon, New Mexico, and neighboring localities in the West, and in the South, the poison spray is not so effective, for although 75 per cent. of the first brood of worms may be killed by the spray, the few worms left will form a sufficient nucleus for a large and very destructive second or third brood; in these localities the best that can be advised at present is to supplement the poison spray by the old banding system.

To use the poison spray the most effectively, one must understand that it is necessary to fill the blossom-end of each apple with poison within a week after the blossoms fall, for this is where the little apple-worm gets its first few meals, and it is practically our only chance to kill it with a spray. Watch the developing fruit after the petals fall, and be sure to apply the poison before the calyx lobes close (as at *a* and *b* in figure 131), for while *the falling of the blossoms is the signal to begin spraying, the closing of these calyx lobes a week or two later is the signal to stop spraying.*

While we thus have no new methods to offer, and doubt if anything better than the poison spray will be found for combating this insect, we believe that a better understanding of the "whys and wherefores" of the methods already in use will insure still greater success with them.

MARK VERNON SLINGERLAND.

BIBLIOGRAPHY OF MOST OF THE MORE IMPORTANT CONTRIBUTIONS TO THE ECONOMIC LITERATURE OF THE CODLING-MOTH.

1635. Goedaerdt. Metamorphosis Naturalis, Vol. I., p. 98, figure 46. Apparently the first published account of the insect. It seems to have escaped notice until 1864, when Werneburg referred to it in his "Beiträge zur Schmetterlingskunde." Lister added nothing of importance in his Latin edition of Goedaerdt, published in 1685.

1728. Frisch. Beschreibung von Allerley Insecten in Teutschland, part 7, pp. 16-17, pl. 10, figures 1-5. Grotesque and yet quite accurate descriptions of moth and larva; believed it preferred to work in unhealthy or injured fruits. No definite data on life-history.

1736. Reaumur. Mem. pour servir a L'Histoire des Insects, Vol. II., pp. 484, 496-499, pl. 38, figures 11, 12, and pl. 40, figures 1-10. Good account of work of larva in fruit, and in making its cocoon. Two broods indicated.

1746. Roesel. Insecten-Belustigung, Vol. I., part 6, No. 13, pp. 33-37, pl. 13, figures 1-5. In accuracy of detail and coloring, the hand-painted figures equal, if not excel, any colored pictures of the insect published since. Good account of original observations upon its life-history; thought the newly-hatched larva sometimes entered the fruit beneath the egg-shell, and that the worms sometimes left one apple and went to another fresh one. One brood indicated. All stages, except the egg, well described.

1747. Wilkes. The English Moths and Butterflies, book I., class 1, p. 5, No. 9, pl. 65 (copies of Roesel's figures). Probably the first English account; brief compilation from Roesel. Gave to the insect its name of "Codling-Moth," from the Codling-Tree, which is also figured.

1758. Linné. Systema Naturæ. Ed. X., p. 538, No. 270. *Tinea pomonella*, "Alis nebulosis postice macula rubra aurea." Original description of the insect, when it received its first scientific name.

1791. Brahm. Insektenkalender, Vol. II., p. 465. Brief account, with many early references. Common and sometimes destructive in orchards, and records its habits in fruit-rooms.

1802. DeTigny. Historie Nat. des Insectes, Vol. IX., p. 256. Largely a compilation from Reaumur and Roesel. Says eggs are laid on fruit before petals fall.

1805. Bechstein and Scharfenberg. Natur. der Schäd. Forstinsekten, Part III., pp. 753-755. Mostly a compilation from Roesel and Brahm.

1819. Tufts. Massachusetts Agricultural Repository and Journal, Vol. V., 364-367. Apparently the first account of the insect in American literature. Previous American writers had credited the plum curculio with the cause of "wormy apples." Records some original breeding experiments by which he was led to conclude that the cause of most of the wormy apples in Massachusetts was a moth, and not a beetle or curculio.

1825. Thatcher. American Orchardist, second edition, p. 116. Records finding the worms on the trunks of the trees, and therefore advises scraping off the rough bark and washing trunks with Forsyth's composition. Apparently the first notice of the insect in horticultural books, and the first one to make any recommendations for controlling the insect.

1830. Treitschke. Die Schmetterlinge von Europa, Vol. VIII., pp. 161-163. Many references to early literature. Descriptions. Brief compiled account of life-history.

1832. Harris. Discourse before the Mass. Hort. Soc., p. 42. Brief remarks. Article not seen.

1833. "Rusticus." Entomological Magazine, Vol. I., pp. 144-146. A very good detailed account of the life-habits of the insect. Eggs laid *in* the calyx-cup. One brood. Apparently the first important article in the English literature.

1833. Bouché. Garten-Insekten, pp. 113-114. Brief compiled descriptions and account of habits. All that can be done to control it is to collect and feed out all wormy fruit as fast as it falls.

1837. Schmidberger. In Kollar's Naturg. der schäd. Insecten. (For English translation see Loudon and Westwood's edition of Kollar, pp. 229-232, date 1840). Good general account. Two broods indicated. (He published an earlier and more complete account in his Natur. der Obst. schäd. Insecten, to which we have not had access.)

1838. Westwood. Gardiner's Magazine, Vol. XIV., pp. 234-239. Mostly a good compilation from the accounts by Reaumur and "Rusticus." One brood indicated.

1840. Ratzeburg. Die Forst-Insecten, Vol. II., pp. 234-236, pl. 14, figure 7. Very good general account. Believes there is but one brood in North Germany, and doubts Schmidberger's account of two broods in South Germany.

1840. Burrelle. New England Farmer, Vol. XVIII., No. 48, June 3, p. 398. "On the Curculio." Records breeding the moth. One brood only. Apparently the first one to suggest the famous "banding" method.

1841. Harris. Insects of Massachusetts, pp. 351-355. (In the editions of 1852 and 1862 no change occurs.) Very good general account. Only one brood indicated.

1843. Gaylord. Trans. N. Y. State Agr. Soc., p. 158. Brief account with Westwood's figure. Recommends allowing swine to run in orchard. Insect then common in New England, but very rare in the Middle States.

1844. Löw. Schädliche Insecten, pp. 239-241. Largely a compilation from Roesel, with good discussion of remedies.

1845. Downing. Fruits and Fruit-trees, p. 66. Brief account.

1846. Morris, Miss. ("Old Lady"). American Agriculturist, Vol. V., February, pp. 65-66. Good account, with original observations, and illustrated by what is probably the first original figure of the insect to appear in American literature.

1849. Cole. American Fruit Book, p. 89. Brief account. Reports it numerous in New England and along the seaboard, and becoming more common in the Middle States.

1850. Simpson. The Horticulturist, Vol. IV., p. 567. Brief account of breeding experiments. Two or three broods indicated. Discovered that a cloth in the crotch enticed many worms, and after experiments with wax, recommends that trees be sprayed with whitewash to fill blossom-end of fruits and thus prevent egg-laying at this point.

1855. Nördlinger. Kleinen Feinde der Landwirthschaft, pp. 339-346. One of the best and most complete accounts which have appeared in the German literature. Very good discussion of remedies. Believes it is single-brooded in Germany.

1859. Jaeger. The Life of N. Am. Insects, pp. 179-181. Brief, quaint account.

1861. Goreau. Insects Nuis. aux Arbres Fruiters, pp. 118-121. Very good general account. One brood in France.

1865. Trimble. Treatise on the Insect Enemies of Fruit and Fruit Trees, pp. 103-139. Three full-page colored plates. One of the best accounts in the American literature. Detailed notes on birds as enemies of the insect; "hay-bands" devised and experiments recorded. Bred two broods at Newark, N. J.

1867. Boisduval. Essai sur L'Entomologie Horticole, pp. 560-563. Fairly good general account. One brood.

1868. Walsh. Report on Insects of Illinois, pp. 27-29. Arguments for two broods in Illinois.

1868. Walsh and Riley. American Entomologist, Vol. I., pp. 3-6. Evidence in favor of allowing hogs to run in orchards.

1869. Walsh and Riley. American Entomologist, Vol. I., pp. 112-114. Very good general account, illustrated by Riley's well-known figures. Two broods.

1869. Riley. First Missouri Rept. on Insects, pp. 62-67. Good general account. Two broods.

1870. Riley. American Entomologist, Vol. II., pp. 321-322. Records experimental proof of two broods in latitude of St. Louis, and discusses hay-bands vs. rags for trapping the worms.

1871. Taschenberg. Ent für Gärtner und Gartenfreunde, pp. 310-313. Good general account. Admits but one generation in Germany. (The same account occurs in his Prak. Insektenkunde, III., pp. 228-231, date, 1880)

1872. Riley. Fourth Missouri Report, pp. 22-30. Good discussion of bands, Wier's Trap, lights, jarring, and the enemies of the insect.

1873. Riley. Fifth Missouri Report, pp. 46-52. Records careful experiments with different traps on trunk, and the discovery of two parasites.

1873. LeBaron. Third Rept. on Insects of Ill., pp. 167-185. One of the best accounts in the American literature; based largely upon original observations.

1875. Cook, A. J. Rept. Mich. Pomol. Soc. for 1874, pp. 152-160. One of the best accounts in American literature, largely based upon original observations. Records seeing the eggs but does not describe them.

1875. Saunders. Rept. Ont. Ent. Soc. for 1874, pp. 43-50. Good general account, largely compiled from LeBaron and Riley's writings. Two broods in Canada.

1879. Woodward. *Rural New-Yorker*, Feb. 8 (Proc. West. N. Y. Hort. Soc. for 1879, p. 20). First published account of successful use of poisons (Paris green) against the codling-moth.

1880. Cook. American Entomologist, Vol. III., p. 263. Also published in 1881 in Proc. Am. As. Ad. Sci. for 1880, p. 669; and in Rept. Mich. Hort. Soc. for 1880, p. 136. Records the successful use of London purple to destroy the insect; first test of poisons made by entomologists.

1881. Cooke. Insects Inj. to Cal. Fruit and Fruit Trees, pp. 13-19. One of the best discussions of the habits and methods of fighting it in our literature. (Practically the same account was published by the author in 1879, and again in 1883 in his book on "Injurious Insects," pp. 102-108.) Three broods indicated.

1881. Schmidt-Göbel. Die Schäd. und Nütz. Insecten, pp. 121-122. Brief general account.

1883. Walton, Miss. Report Iowa Hort. Soc. for 1882, pp. 199-203. Good general account, with some valuable breeding experiments.

1883. Chapin. Rept. 2d An. Conv. of Cal. Fruit Growers, pp. 17-25. Detailed account of an extensive experiment with bands, and gathering infested fruit; over 15,000 moths caught in a fruit-room in one season.

1883. Saunders. Insects Injurious to Fruits, pp. 127-133. Very good general discussion.

1884. Atkins. Rept. Maine Bd. of Agriculture for 1883, pp. 356-363. One of the most important contributions to the American literature; it is based entirely upon original observations. One full brood and a partial second one indicated.

1885. Girard. Traité, D'Entomologie, Vol. III., pp. 714-716. Good general account. One brood.

1886. Goff. Fourth Rept. of N. Y. Agr. Expt. Station, 1885, pp. 246-248. Records one of the first carefully conducted experiments with Paris green.

1886. Forbes. Trans. Ill. Dept. of Agr. for 1885, Appendix, pp. 26-45. Records one of the first and most carefully and scientifically conducted experiments with poison and lime against the insect. Eight applications made.

1886. Whitehead. Rept. on Insects, prepared for Agr. Dept. of Great Britain, pp. 62-67. Good general account.

1886. Crawford. Rept. on Insect Pests in S. Australia, pp. 32-39. Good general account.

1887. Forbes. Bulletin No. 1, Office of State Ent. of Ill., 26 pages. Results of scientific experiments with Paris green, London purple, and arsenic in 1886. Comparison of 1, 2 and 3 applications. Three broods indicated.

1887. Wickson. Bull. 75, Cal. Agr. Expt. Station. Careful comparative experiments with bands and spraying.

1888. Howard. Report U. S. Dept. of Agr. for 1887, pp. 88-115. The best and most exhaustive discussion of the insect in the literature; and from it have been compiled most subsequent discussions of habits and life-history. Colored plate.

1888. Cook. Bull. 39, Mich. Expt. Station, pp. 1-4. Results from 1, 2, and 3 sprayings, and general conclusions from 8 years' experimenting with poisons.

1888. McMillan. Bull. 2, Nebraska Expt. Station, pp. 68-77. Very good general discussion of habits and especially of remedies.

1889. Pissot. Le Naturaliste, p. 60. Notes on metamorphosis, with detailed account of cocoon. Two broods indicated.

1889. Gillette. Bull. 7, Iowa Expt. Station, pp. 270-280. Very important and careful experiments with poisons and carbolic acid. Two broods.

1889. Popenoe, Marlatt and Mason. First Rept. Kansas Expt. Station, pp. 165-193. Valuable record of careful experiments with poisons and bands, including tables giving dates of blossoming of many varieties of apples.

1889. Tryon. Rept. on Insects and Fungous Pests (Queensland, Australia), No. 1, pp. 43-49. Very good general account.

1890. Bos. Tierische Schäd. und Nüz., pp. 526-527. Brief account.

1890. Cook. Rept. Mich. Bd. of Agr. for 1889, p. 320. Experiments to show that grass under sprayed trees may be safely fed to stock.

1890. Ormerod. Manual of Injurious Insects, pp. 286-290. Brief general account.

1890. Olliff. Agr. Gazette of New South Wales, Vol. I., pp. 3-10. Very good general account.

1890. Koebele. Bull. 22, Div. of Entomology, U. S. Dept. of Agr., pp. 89-93. New and important observations upon the habits of the moth, the eggs, and the enemies of the different stages of the insect.

1891. French. Handbook of Dest. Insects of Victoria, part 1, pp. 45-55. Excellent general account; colored plate.

1891. Gillette. Bull. 15, Colorado Expt. Station, pp. 4-18. One of the best and most accurate general discussions of habits and remedies.

1891. Washburn. Bull. 10, Oregon Expt. Station, pp. 1-16. Valuable record of careful experiments with poisons and bands.

1891. Beckwith. Bull. 12, Delaware Expt. Station, pp, 16-23. Comparative test of Paris green and London purple, showing slight advantage for the former.

1892. Munson. Rept. Maine Expt. Station for 1891, pp. 99-109. Careful experiments with poisons and important deductions therefrom.

1892. Lodeman. Bull. 48, Cornell Expt. Station, pp. 268-274. Results of careful experiments with combinations of poisons and Bordeaux mixture.

1892. Thompson. Handbook to the Insect Pests of Farm and Orchard, (Tasmania), part I., pp. 34-54. Excellent general account; two broods.

1892. Kellogg. Common Injurious Insects of Kansas, pp. 78-80. Good general account.

1892. Treat. Injurious Insects, pp. 161-163. Brief general account.

1893. Washburn. Bull. 25, Oregon Expt. Station, pp. 1-8. Record of original observations which form one of the most important and accurate contributions to the literature of the habits of this insect yet made. The egg figured for the first time.

1893. Lodeman. Bull. 60, Cornell Expt. Station, pp. 265, 273-275. Experiments to show that usually two applications of poisons are all that are necessary or profitable in New York.

1893. Riley. Bull. 23, Maryland Expt. Station, pp. 71-77. Very good general account of habits, remedies, and especially of its enemies.

1893. Lintner. Ninth Rept. on Insects of N. Y., pp. 338-342. Detailed account of the work of the second brood of larvæ in N. Y.; and a discussion of the prevalent ideas regarding the egg-laying habits of the insect.

1893. Coquillett. Bull. 30, Div. of Ent. of U. S. Dept. of Agr., pp. 30-33. Notes on life-history, supposed enemies, and methods of combating the insect in California.

1894. Smith. Entomological News, Vol. V., pp. 284-286. Records breeding experiments which indicate but one brood of the insect at New Brunswick, N. J.

1894. Marlatt. Insect Life, Vol. VII., pp. 248-251. Evidence from various sources to show that insect is usually double-brooded.

1894. Schilling. Der Praktische Ratgeber, Vol. 9, pp. 121-123; 133-135; 141-143. The best discussion of the insect from a practical and economical standpoint in the German literature. One brood.

1894. Sempers. Injurious Insects, pp. 57-59. Brief general account.

1895. Marlatt. Proc. Ent. Soc. of Wash., Vol. III., pp. 228-229. Suggests that Merriam's life-zones may explain and determine the variation in and number of broods of the insect.

1895. Goethe. Bericht d. Kgl. Lehr. für Obst. Wein. und Gartenbau, pp. 22-25. Records original observations (from breeding-cage experiment) on the egg and on the habits of the young larvæ, with illustrations and descriptions. First definite account of these phases of the insect to appear in any foreign literature.

1895. Weed. Insects and Insecticides, Second Edition, pp. 88-89. Brief general account.

1896. Lounsbury. Rept. Gov. Ent. for Cape of Good Hope, for 1895, pp. 33-36. Brief account.

1896. Bos. Tijdschrift over Plantenziekten, Vol. XII., pp. 52-74. Very good account compiled from the writings of Schilling and Goethe.

1896. Slingerland. Michigan Fruit Grower, Vol. V., p. 8. Paper read before Mich. State Hort. Soc. Detailed account of original observa-

tions on oviposition and the habits of the young larvæ, resulting in the discovery of some new and important economic facts. (The paper also appears in Rept. Mich. Hort. Soc. for 1896, and that portion of it relating to the codling-moth in the *Rural New Yorker* for Jan. 30, 1897, p. 67; and in the Proc. West. N. Y. Hort. Soc. for 1897, pp. 28-30.)

1896. Lodeman. The Spraying of Plants, pp. 252-255. Good general account.

1896. Smith. Economic Entomology, pp. 322-323. Good general account.

1897. Card. Garden and Forest, Vol. X., pp. 302-303. Detailed account of original observations on egg-laying and the habits of the young larvæ in Nebraska. Eggs laid mostly on the leaves, and two broods, at least, indicated.

1897. Smith. Garden and Forest, Vol. X., p. 334. Notes peculiar differences in habits of the insect in N. J. and especially at New Brunswick, N. J.

1897. Del Guercio. Bulletino della Soc Ent. Italiana, pp. 12-17. Very good general account.

1897. Card. Bull. 51, Nebraska Experiment Station, 39 pages. Interesting, original observations on the eggs and habits of the young larvæ with record of experiments against all stages of the insect.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar-Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.
150. Tuberculosis in Cattle and its Control.

Bulletin 143. February, 1898.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

Agricultural and Chemical Divisions.

Sugar Beet Investigations.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1898.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	Trustee of the University.
Hon. B. F. TRACY,	President State Agricultural Society.
Professor I. P. ROBERTS,	Agriculture.
Professor G. C. CALDWELL,	Chemistry.
Professor JAMES LAW,	Veterinary Science.
Professor J. H. COMSTOCK,	Entomology.
Professor L. H. BAILEY,	Horticulture.
Professor H. H. WING,	Dairy Husbandry.
Professor G. F. ATKINSON,	Botany.
M. V. SLINGERLAND,	Entomology.
G. W. CAVANAUGH,	Chemistry.
L. A. CLINTON,	Agriculture.
B. M. DUGGAR,	Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	Director.
E. L. WILLIAMS,	Treasurer.
EDWARD A. BUTLER,	Clerk.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.

Cornell University, Ithaca, N. Y., February 12, 1898.

The Honorable Commissioner of Agriculture, Albany, N. Y.

Sir: This account of the investigations carried on throughout the state and at Ithaca in the cultivation of the sugar beet, together with the results of more than four hundred analyses of beets from nearly as many plats, is submitted for publication under Chapter 128 of the Laws of 1897.

In the spring of 1893, seventy packages of sugar beet seed were sent to as many farmers with the view of making a preliminary test of soil and climate in various parts of the state. By this means it was hoped that some information might be secured which would be of value should the culture of sugar beets be introduced. Thirty-one farmers who received the seed responded by sending samples of beets for analyses, and some data as to yield, growth and soil.

The average weight of beets sent for analyses was 830 grammes, and the average per cent. of sugar 12.9. The typical sugar beet should weigh about 600 grammes and contain not less than 14 per cent. of sugar. Notwithstanding the large size of the beets, due without doubt to too thin seeding, the sugar content was equal to the average of many European sugar beet districts. It should be stated that many of these test plats of beets were in localities where the soil was not well adapted to their growth.

In 1894 another attempt was made to carry forward the work, but there was so little interest in beet culture it was decided to temporarily drop the work.

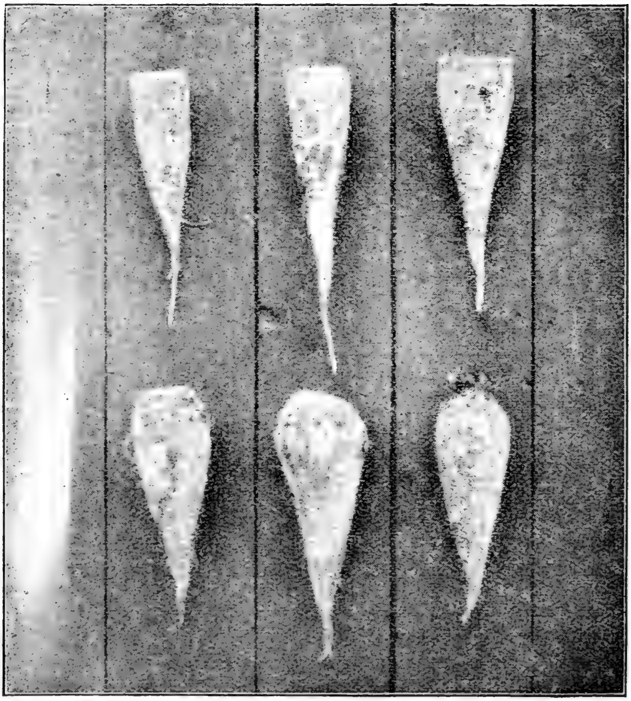
During the winter of 1896-97 the subject of sugar beet culture was again brought up and discussed, and it was decided to resume our investigations. The Department of Agriculture, at Washington, gave its hearty support to the work and sent to the Station five hundred pounds of Kleinwanzlebener beet seed and appointed the Director of the Station special agent in sugar beet investigation.

We found the farmers ready to undertake the work of testing the soil and climate by planting small plats of beets, and to follow the printed instructions which were sent with the seed. Some public spirited farmers bought, and in some cases distributed to their neighbors, packages of seeds. The beets from these plats, when sent to us, were also analyzed. While some data as to soil and tillage accompanied these beets, the information secured could not be as accurate as was that secured by members of our staff who visited the plats under our control and helped to harvest the beets, measure the land and select samples for analyses.

This bulletin, which has cost so much thought and labor, is written in two parts: Part I. treats of soils, tillage and character of beets; Part II. gives somewhat in detail the results of the analyses of beets and some of the by-products of the factory, together with notes related thereto.

It is not the purpose to express any opinion as to the wisdom of encouraging the sugar industry in this state by granting a small bounty to the producers of beets. But if it is deemed wise to grant such bounty, it should be based on the per cent. of sugar which the beets are found to contain when delivered at the factory, thereby securing a double benefit—increase in production and improvement of quality. A competent chemist for each factory should be appointed by the state to determine the per cent. of sugar of each consignment of beets, and his report to his superiors should be final.

I. P. Roberts, Director.



147.—*Properly trimmed beets in upper row, improperly trimmed in the lower row*
See page 177.

SUGAR BEET INVESTIGATIONS.

PART I. FIELD WORK.

1. General Remarks on Sugar Beet Cultivation.

By J. L. Stone.

The successful manufacturing of sugar from the beet root in America is no longer in doubt. That question has passed the experimental stage. It has been thoroughly demonstrated that American enterprise can secure the necessary skill and machinery either by importation or home production, to successfully manufacture from beets a high grade of sugar.

A beet sugar factory, however, without an abundant supply of good beets is sure to be a financial failure. No matter how well planned, nor how carefully constructed the factory is, nor how thoroughly informed and skillful in all the intricate processes of sugar making the management may be, if the farmers cannot or will not produce the beets to profitably employ the machinery and skill provided, the enterprise must languish. Early efforts to introduce the beet sugar industry into America failed for want of beets rather than for want of knowledge and skill in the manufacture of sugar. A number of the factories now in successful operation in this country passed through several "campaigns" before the farmers had become sufficiently interested and skillful to produce a sufficient quantity of good beets to enable the factories to be operated at a profit. At the present time these same factories are unable to handle all the beets that the farmers of their localities desire to grow. It has been demonstrated that beets sufficiently rich in sugar for profitable manufacture can be produced in large quantities in a number of our western states. That the yield per acre is sufficiently large to make the growing of the beets profitable at the price paid, is proven by the fact that the older factories, in some cases, find it necessary to limit the area the farmers are permitted to grow. The farmers in the vicinity of these factories have been prosperous through the recent hard times and land values have advanced, while over the country in general land has declined.

Investigations conducted in New York by this Station during the past season (1897) seem to indicate that the state is not behind any of the western states in adaptation of soil and climate to the production of sugar beets.

Examinations of 495 samples of sugar beets grown in 24 counties in the state were made this season. The result shows a juice averaging 16.91 per cent. sugar and 83.5 quotient of purity. A portion of each of 272 plats was carefully measured and the product weighed, the result indicating an average yield of 16.95 tons of trimmed beets per acre. See figure 147, p. 162, also table p. 198.

For purposes of comparison, results obtained in other states are given. The Chino factory, Cal., reports as an average of five years' operation, a crop of 9.33 tons per acre, containing 14.2 per cent. sugar. The Lehi factory, Utah, reports for the same period an average yield of 9.56 tons per acre, 12.1 per cent. sugar in beets and 80.2 quotient purity (see Bulletin 55, Wisconsin, p. 12). In Nebraska about 10,000 analyses show an average of something over 14 per cent. sugar, while ordinary yields are from 10 to 12 tons per acre. (Myrick's Sugar, p. 54.)

In each of these states the industry is successfully established. Other states that are not producing sugar have studied the adaptation of soil and climate to sugar beet growing, and some of the results are added. Ohio reports that beets grown on 49 farms in 19 counties, juice averaged 12.95 per cent. sugar and 72.2 quotient of purity.*

Wisconsin reports that beets grown on 517 farms in 59 counties in 1890–1892 averaged 12.44 per cent. sugar in juice and 76 quotient of purity.†

Washington State reports that 1,544 analyses of sugar beets showed an average of over 15 per cent. sugar in juice and 84 quotient of purity.‡

The French "Journal of Sugar Manufacturers" states that the average yield of beets in Germany is 15 tons and in France 11.13 tons

* Ohio Bulletin 75, p. 18.

† Wisconsin Bulletin 55, p. 20.

‡ Washington Bulletin 26, p. 5.

NOTE.—The figures given for California, Utah and Nebraska are percentages of sugar in beets and are not strictly comparable with the others, which are percentages of sugar in juice. To make the figures comparable, divide the percentages of sugar in the beets by .95, and the quotient will be the percentage of sugar in the juice.

per acre. Many more cases might be added, but these are sufficient for comparison.

The question at once arises whether the results obtained on our experimental plats this season represent approximately what the farmers of the state may expect to do when growing a commercial crop. All very well know that it is easy to select a small piece of rich land and by giving it extra care to grow a crop that will far exceed in yield what can be obtained on larger areas.

It is not believed that the results obtained need be discounted on account of these considerations. In the first place, the farmers were inexperienced with the crop and did not know the conditions most favorable to its growth. Brief instructions were sent out from this office, but more than half of the farmers either did not receive them or paid no attention to them. Some of the plats were on well selected land, the beets grown at appropriate distances and given good culture; but in more cases one or more of these conditions were wrong. Many plats were planted the same as potatoes, three feet or more between rows. Necessarily the result was either a low yield of beets or a larger yield of overgrown beets with a lower percentage of sugar. (See page 241.) In August and the first part of September members of the Station staff visited and inspected 249 of the experimental plats and found a large proportion of them needing cultivation and weeding. The rainfall in July was excessive (see page 241), and for several weeks, just when the farmers should have been actively engaged cultivating their crops, they were not able to get on the land. The weeds grew apace, and when the soil was fit to till the farmers were so pressed with their regular work that the beets, being a side issue, were very generally neglected.

The wet July was followed by a severe drought in September and October; the soil baked very hard and conditions were unfavorable. Notwithstanding these seemingly adverse conditions the average yield as given above is very satisfactory. Again in October agents of the Station went to many of the farms and helped to harvest and weigh beets from 178 plats. The beets were washed and trimmed, as required by the factories, before weighing, so it is known that the estimated yields, in these cases at least, were correctly made. Instructions for harvesting and estimating yields were sent to those farmers who it was found impracticable to reach in person. So there scarcely can be any over estimate as to the yields actually obtained on the experimental plats.

The percentage of sugar and the quotient of purity are also unexpectedly high. It is known that some seasons are more favorable to a high quality of beets than others, and perhaps the past season, notably dry in August, September and October, produced beets of more than normal richness. It will not be surprising, then, if the high quality of beets secured this season is not maintained in the future with different weather conditions while beets are maturing, but it is believed that the falling off will not be sufficient to reduce the quality below the point of profitable manufacture.

So far as soil and climate are concerned it seems to be settled, then, that the state of New York is well adapted to the commercial growing of sugar beets. The question of greater importance remaining for discussion is, Will the farmers of the Empire State grow the beets in sufficient quantities, and send them to the factories in such condition as to make the manufacture of sugar profitable ?

Agriculture has shared in the general depression of recent years, and farmers are anxiously asking what crop can be grown with a fair chance of profit. The present interest in the sugar industry, therefore, seems to be opportune, and farmers are much more likely to put forth the necessary effort to become skillful in the production of sugar beets than if other crops were paying well.

The sugar beet is an exacting crop, and persons unfamiliar with the best methods of growing it have much to learn, and will make many mistakes that will cut down the profits. With a view of helping those who are thinking of growing beets for the factories the following simple instructions have been prepared. These instructions are based partly on our own investigations and partly on the statements of others who have had large experience both as experimenters and practical growers.

Soil.—Sugar beets can be grown successfully on quite a variety of soils—gravelly loam, sandy loam, loam and clay loam—though a sandy loam is usually considered best suited to the crop. Any soil that is well adapted to potatoes will raise sugar beets. While the industry is in its infancy in the state, it is wise to select only those soils that are believed to be well adapted, and that are in a high state of fertility, and, so far as possible, are free from foul weeds.

So many things are to be learned regarding the growing of the crop that it is well to encounter as few difficulties as possible at first and take up the more difficult cases later.

Subsoil.—Sugar beets should have a deep soil, with a moderately porous subsoil. A shallow soil with a hard or water soaked subsoil is fatal to the crop. If the soil is not right in these respects it may often be made so by thorough drainage and subsoil plowing. In fact, land that is naturally quite unsuited to beet growing may, by these means, coupled with the growing of deep rooted plants, like the clovers, have its character so changed in a few seasons as to become excellent beet land.

Preparation of the soil.—The necessity of deep plowing cannot be emphasized too much in this connection. The sugar beet should bury itself in the soil the same as a parsnip, and it will do so if the soil conditions are right. If, however, the subsurface soil is hard or saturated with water the tap root cannot penetrate into it, or if it does get down fairly well, it cannot expand freely in the hard soil, but expands in the direction of least resistance, which being upwards the result is a short root, a considerable portion of which grows above the surface of the soil. This form of beet is objectionable not only because the yield is necessarily less than with long, well formed roots, but the beets are very much less valuable for sugar making.

It is found that the upper portion of the beet, especially that part that grows above ground, is less rich in sugar than the part growing well in the soil, while this same part is highly charged with impurities that interfere seriously with the manufacture of sugar.

The factory people aim to keep the impurities down by requiring that the portion of the beet growing above the surface of the ground be cut off. The aim should be to so prepare the land that the root can bury itself well in the soil. Thus will be secured not only a larger yield, but a smaller percentage of waste in the crown removed (see figures 148 and 149). Deep plowing is, therefore, essential, and except where the subsoil is very porous it should be loosened with a subsoil plow. In those localities where sugar beet growing is established the practice of subsoiling has become general.

It is best to plow the land deeply in the autumn, setting the plow to turn up an inch or two of new soil. The action of the winter's frosts will ameliorate this soil and render it fit for crop growing. Follow the ordinary plow with a subsoil plow, breaking up, but not throwing

148.—*Thirty-three per cent. waste in trimming. Result of growing beets in improperly prepared soil.*

149.—*Fifteen per cent. waste in trimming. Grown in properly prepared soil.*

on top, several inches more of the hard soil. The earth should thus be stirred to a depth of twelve to fifteen inches. This fall treatment is desirable on several accounts. It permits the turning up of more new soil than would be safe in the spring. It secures the more complete decomposition of any coarse vegetation that may be on the land. It breaks up the compactness of the soil so that it can receive the winter's rain and store it for the next season's crop. Opportunity is given for the re-establishment of the capillary action in the soil which was disturbed by deep plowing, enabling the plant to draw from the deeper reservoirs of moisture during the dry season.

It is not advised to plant sod land to beets, but if necessary to do so, it should be fall plowed to give time for the decomposition of the sod, the settling of the soil and the re-establishment of capillary action. It should be plowed deep so as to have plenty of loose earth for a seed bed without disturbing the decaying sod. Sod land will probably suffer more from drought than other, but with plenty of moisture it will grow large crops of beets, which, however, may be low in sugar and in purity on account of too much organic matter in the soil. For the same reasons it is best to apply barn manure to the preceding crop rather than to the beets, but if used on the beet land it should be applied in the fall and plowed under. The influence on the quality of beets of an application of manure applied to the land the same season the crop is grown, as compared with the same applied the previous year, is shown in the following table, which includes all the plats thus reported:

QUALITY AS AFFECTED BY BARN MANURE APPLIED IN 1896 AND 1897.

	No. of plats.	Average per cent. of sugar in juice.	Average quotient of purity.
Manured in 1896	45	17.37	83.96
Manured in 1897	59	16.62	82.94

Another effect of the direct application of barn manure is the tendency to produce ill-formed beets, as shown in figures 152 and 153, page 176.

Commercial fertilizers may be applied in the spring, but they should be thoroughly incorporated with the soil. Observations made this summer lead to the belief that commercial fertilizers applied on the surface have a tendency, like recenly applied barn manure, to cause the development of "fingers and toes," as the ill-shaped sprangly roots are called. It is reasonable to suppose that the plant finding its food near the surface would throw out branches at this point. No doubt this tendency would be most marked in very poor soils and in dry seasons.

If the land is not plowed in the fall, then plow deeply in early spring, taking care not to turn up much new soil. In the Western States experience has taught that subsoil plowing in the spring is an unsafe practice. If abundant rains do not come after the plowing is done, to compact the soil and re-establish capillary action, the crop may suffer more from drought than it will be benefited by the loosening of the subsoil. It would seem that in this state there would scarcely occur a season when there would not be sufficient rainfall after *early* plowing to properly compact the soil before the dry weather of summer sets in. As early in the spring as the land is fit it should be harrowed and left for a week or ten days that the weeds may have a chance to start, when they will be easily killed by another working. If this operation can be repeated several times before seeding, the crop will be kept clean during the season with much less labor.

The seed bed should be thoroughly prepared. The subsurface should be fairly well compacted; the surface fine, level and free from obstructions to cultivation. It is very important that a good stand of plants should be secured, and this is much facilitated by a properly prepared seed bed, but just what tools to use and how much to use them will depend upon the character of the soil and the season.

Seed.—It is of prime importance that first-class seed be used. The modern sugar beet is the result of a vast amount of painstaking care and labor in its selection and growth, and is a highly artificial product. It therefore quickly deteriorates when the conditions favorable to the maintenance of its high qualities are wanting.

In Europe the production of high class seed is relegated to skillful seedsmen who have made the industry a life study. Little effort has been made in America as yet for the production of seed, our supplies being drawn largely from Germany and France. The matter of selecting the varieties and importing the seed is usually left in the hands of factory management. There are a large number of varieties possessing somewhat different characteristics and adapted to different classes of soils. Some are noted for their high percentage of sugar, but are light croppers, and are best suited for those localities where the tendency is to grow too large a crop of coarse beets low in sugar. Others are better croppers but not so high in sugar, and are adapted to soils where the tendency is to produce too light a crop of very rich beets. The Vilmorin and the Dervaux are among the very rich varieties but are rather light croppers; the Kleinwanzlebener, the Dippe and the Metta Kleinwanzlebener are among the medium croppers with a good percentage of sugar, while the Deprez and the Eloir are heavy croppers but rather low in sugar. The Kleinwanzlebener and the Vilmorin have been most grown in this country, and seem to be best adapted to our soil and conditions.

Seeding.—For good results it is very necessary to get a good stand. Without it the yield will be unsatisfactory and many of the beets, having too much room, will be overgrown, resulting in a low percentage of sugar and purity.

It is customary to sow about twenty pounds of seed per acre, though if it all grows this is many times more than is needed. If dry weather follows the planting, only the best of the seed will germinate; if a crust is formed before the plants are up, they help one another to break through, hence the chances are much better for getting a good stand with heavy than with light seeding.

A machine that will drop with accuracy three or four seeds in a place at such distances apart as experience shows is best for different soils, will not only save seed, but will tend to secure an even spacing of the plants in the row and greatly reduce the labor of thinning and weeding. In heavy or damp soils the seed should not be covered more than one-half to three-fourths of an inch, in light dry soils one to two inches. The soil should be firmed over the seed, the degree to be determined by its character, light soils requiring more compacting than heavy ones. On most soils best results are obtained by planting in rows from 18–22 inches apart. If the rows are much farther apart than this the beets cannot use all the space and the yield is lessened, or if a good yield is secured it is by growing large beets at the expense of quality.

Such narrow rows, however, are difficult to cultivate except for those accustomed to the work and having machinery especially designed for it. When the ordinary implements of tillage are to be used it would seem wise to allow more room for working between the rows, say 24–27 inches, and leave the plants a little closer in the rows. Those who expect to till considerable areas of beets will do well to provide themselves with special seeders and cultivators. These seeders are made to sow either two or four rows at a time, and they may be adjusted to sow 16, 18 or 20 inches apart, spacing them very accurately. The cultivators work either two or four rows at a time and are accurately adjusted to follow the seeder, the workman confining his attention to one row while the machinery adjusts itself to the others. Of course such a cultivator can only be used to work rows that are accurately spaced by a special seeder.

Those who have both the special seeders and special cultivators may find it advantageous to adjust the machines so as to sow two rows at either side 16–18 inches apart and leaving a space of 24 or more inches at the center in which the horse can travel easily while cultivating—the cultivator being adjusted the same as the seeder.

Tillage.—Under certain conditions of soil and weather a weeder can be used with very great satisfaction for the first working of the land after seeding, but those conditions are not always present. Should a heavy rain cause a crust to be formed and the soil again get dry enough to work before the seeds have thrown out many sprouts, the weeder can be used with great benefit to break the crust and destroy small weeds that start more quickly than the beet seed. Again, on rather light land that is quite free from small stones and other impediments to tillage, if the plants have come up quite thickly the weeder can be used very advantageously to stir the soil in the rows, thin the beets somewhat, and destroy many small weeds.

Regular cultivation should begin as soon as the rows can be followed, and repeated as often as necessary to keep the surface loose and prevent weeds from gaining a foothold. Under ordinary circumstances tilling fortnightly will probably give as good results as tilling weekly, but whenever a crust has been formed by rains it should be broken up as soon as the condition of the soil will permit. The weeds will be kept in subjection more economically by frequent light tillage than by fewer cultures which will permit them to get a foothold and require more labor in their destruction.

Thinning.—This is the most difficult and expensive operation in beet growing and upon its proper execution the success of the crop largely depends. The distance between the beets in the row should depend upon the quality of the soil, as on a rich, moist soil they will thrive if left much thicker than on a poor, dry soil. If planted in extra wide rows to facilitate horse culture, they may be left closer in the rows than otherwise. If the rows are 18–20 inches apart the beets should ordinarily be thinned to 8–10 inches in the rows. The first operation of thinning is done with a common hoe having a blade 5–7 inches wide, according to the distance apart it is desired to have the beets stand when the work is complete. When the beets are well started, and usually immediately after the second cultivation, pass along the rows and with the hoe strike out portions the width of the hoe blade, leaving bunches of two or three inches containing several plants. This operation is called bunching and results in the removal of the weeds in the row and the stirring of the soil as well as the removal of most of the surplus plants. Shortly after the bunching the plants remaining are reduced to one in a place and all weeds removed by hand pulling. As this work is usually done by cheap help it is necessary to watch very closely to see that it is well done. One plant, and that the strongest, should be left from each bunch, all the weeds should be *pulled*, not broken off, and if the soil is displaced about the young plant by the removal of the others it must be returned but not packed down hard. The thinning should be done as soon as the plants have four well formed leaves and it is better to employ extra help rather than to delay this work. If the thinning is delayed the beets entwine about one another so that the roots of those left are injured by the removal of the others, and if the tap root is broken the plant will never produce a well formed beet.

Since the soil will become considerably compacted by tramping of the workmen during the thinning it should be immediately loosened by horse cultivation, followed by a thorough hand hoeing. This working should stir the soil three inches deep and leave the crop free from weeds. Under favorable conditions of soil and season the handhoeing just after thinning may be the only one necessary for the crop, but if the weeds begin to start close to the rows it will be advisable to handhoe once before thinning. Again, if rains interfere with the frequent use of the cultivator after thinning and weeds begin to show themselves in the rows another handhoeing must be given.

It is impossible to say just how much tillage may be required for best results, but probably one to three handhoeings and four to six cultivations will be sufficient.

Some effort was made to determine the effect of very frequent cultivation in comparison with good ordinary tillage. Mr. J. W. Gilmore, a senior in the College of Agriculture, conducted experiments with a series of eight plats, four of which were cultivated seven times and four of them five times, with results as shown in the following table :

MR. GILMORE'S CULTURE EXPERIMENTS.

	Tons per acre.	Sugar in juice.	Quotient of purity.
		Per cent.	
Average of four plats cultivated seven times	19.65	14.26	78.2
Average of four plats cultivated five times	21.68	13.83	75.95

This experiment is given in full on page 185. The averages as given here indicate no gain by seven over five cultivations.

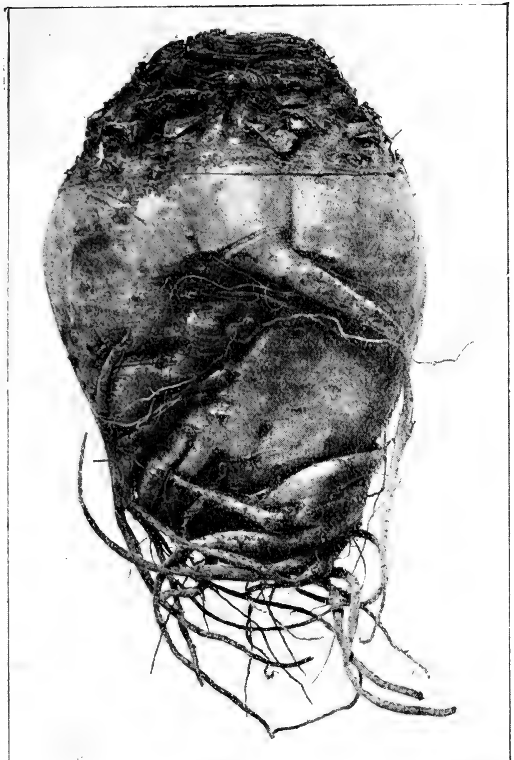
Messrs. D. M. and A. S. Green, Adams, Jefferson Co., conducted cultural experiments on four plats, two of which were cultivated weekly from June 1 to September 5, and two were cultivated fortnightly for the same period. The results are shown in the following table :

MESSRS. GREEN'S CULTURE EXPERIMENTS.

	Tons per acre.	Sugar in juice.	Quotient of purity.
		Per cent.	
Average of two plats cultivated weekly	16.00	16.52	84.15
Average of two plats cultivated fortnightly	15.90	16.38	85.39

150.—*An Ideal Sugar Beet—grown in good soil with a porous subsoil.*

151.—*A less desirable form of beet. Subsoil so hard or other conditions so unfavorable that the root has grown mostly near or above the surface of the ground.*



152.—*A very large beet grown in rich soil and well tilled, but subsoil too hard and beets allowed too much room.*

153.—*"Fingers and Toes"—Result of transplanting.*

No appreciable gain is seen here as the result of weekly cultivation.

The harvest usually begins the first part of October, though with early planting it may begin a few weeks before, and it should be completed before hard freezing occurs. There are machines for pulling the beets which are said to work very satisfactorily, doing the work as fast as a team will travel. Manufacturers are also making a beet topper with fair prospects of ultimate success, but this has not yet passed the experimental stage.

As few farmers are likely to be provided with this special harvesting machinery for several years, a subsoil plow, or a common plow with the mould board removed, may be used to loosen the roots. Pull them by hand, throwing into piles and topping with a knife. This knife should be heavy enough so that the crown can be removed at the earth line by a single well directed blow.

It is important that farmers should understand how to properly trim the beets, for if too much of the crown is left on, carrying with it its large percentage of impurities, the value of the beet for the manufacturer is much reduced. When on a visit to the sugar factory at Rome, N. Y., the past autumn, a dozen men were found at work in the yard removing the crowns from improperly trimmed beets that had been delivered by the farmers. The factory people found it to be better economy to employ men to remove the crowns, rather than to work the beets with the crowns on and suffer the loss of sugar that would not crystallize in consequence. The farmer gains nothing by sending to the factory improperly trimmed beets, or those loaded with dirt, as the state weigher samples each load, washes, and, if necessary, trims the sample, and determines the percentage of dockage. The farmer not only gets nothing for the crown at the factory, but loses its value on the farm as stock food and fertilizer. Figure 147 on page 162 shows beets properly and improperly trimmed. Where a large portion of the beet grows out of the ground, or is ill-formed on account of the soil having been badly prepared, the percentage of waste is very much increased (see figures 148 and 149, p. 168).

If the beets are not needed at the factory as fast as harvested they may be pitted or siloed in the field the same as potatoes, and drawn or shipped to the factory later when the pressure of farm work is not so great. In pitting it is essential that the beets shall be quite mature before harvesting, and that they be secured before freezing occurs, as immature or frosted beets will not keep well.

2. RESULTS OF FERTILIZER EXPERIMENTS WITH SUGAR BEETS AT CORNELL UNIVERSITY EXPERIMENT STATION, 1897.

By L. A. Clinton.

The experiments with sugar beets at this Station in 1897 were for the purpose of determining what effect, if any, different fertilizers would have upon the yield and quality of the beets produced.

In experiments with fertilizers a frequent source of error lies in the fact that the soils of the different plats lack uniformity, and hence the fertilizers applied do not have equal opportunity for each to exercise its full effect. To obviate this difficulty the plats upon which the beets were grown were prepared in the following manner: The soil selected was gravelly loam and had been cropped heavily for three years without the application of any fertilizer or manure. In the spring of 1897 a space was measured off for fourteen plats, each, 4 x 5 feet in size. The soil of this whole area was then removed to a depth of twenty-four inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the eight inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were filled, each layer of soil after having been thoroughly mixed was returned to its original position.

The fertilizers were applied at the time of planting, being put in the bottom of the drill and thoroughly incorporated with the soil before the seed was planted. All the fertilizers were applied in this way except the lime on plat 13 which was applied as a top dressing after the seed was covered.

The fertilizers and the rate per acre applied to each plat were as follows:

Plat 3	Sulfate of potash	554	pounds.
Plat 4	Superphosphate	554	"
Plat 5	Sulfate of potash	277	"
	Nitrate of soda	277	"
Plat 6	Nitrate of soda	554	"
Plat 7	No fertilizer.		
Plat 8	No fertilizer.		
Plat 9	Sulfate of potash	277	"
	Superphosphate	277	"
Plat 10	Nitrate of soda	277	"
	Superphosphate	277	"
Plat 11	Sulfate of potash	184 2-3	"
	Nitrate of soda	184 2-3	"
	Superphosphate	184 2-3	"
Plat 12	Muriate of potash	554	"
Plat 13	Quick lime	1089	"
Plat 14	Ground phosphate rock	1089	"

All plats were planted to beets May 19, the variety being the Kleinwanzlebener. Germination was good, and the beets on all plats were finally thinned down to 28 plants to the plat.

Samples were taken for analysis from the various plats October 4, 9 and 20, November 6 and 27. The results of these analyses at the different dates are shown in the following tables:

RESULTS ON PLAT 3—1897.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	16.70	18.5	90.3
October 9..	16.65	18.5	90 0
October 20..	17.65	20.6	85.7
November 6..	19.30	20.8	92.8
November 27..	19.50	21.9	89.0
Average	17.96	20.08	87.56

RESULTS ON PLAT 4—1897.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	16.15	18.1	89.2
October 9..	18.70	21.0	89.0
October 20..	18.10	20.8	87.0
November 6..	17.95	19.0	94.5
November 27..	20.00	21.7	92.1
Average	18.18	20.12	90.36

RESULTS ON PLAT 5.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	15.00	17.2	87.2
October 9..	14.55	16 9	86.1
October 20..	18.25	20 8	87.7
November 6..	18.45	19.0	97.1
November 27..	19.15	21.4	89.5
Average	17.06	19.66	89.52

RESULTS ON PLAT 6.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	17.55	19.7	89.1
October 9..	15.75	18.18	83.7
October 20..	17.35	19.9	87.2
November 6..	18 90	19.4	97.4
November 27..	18.40	20.3	90 6
Average	17.59	19.496	88.4

RESULTS ON PLAT 7.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	16.55	18 5	89.4
October 9..	14.30	17.2	83.1
October 20..	18.25	20.3	89.9
November 6..	17.70	18.8	94.1
November 27..	19.95	22.3	89.5
Average	17.35	19.42	89.2

RESULTS ON PLAT 8.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	13.90	16.5	84.2
October 9	14.80	17.2	86.0
October 20..	18.70	20.6	90.7
November 6..	18.25	19.9	91.7
November 27..	19.80	21 9	90.4
Average	17.09	19.22	88.6

RESULTS ON PLAT 9.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	15 40	17.9	86.0
October 9..	17.50	19.7	88.8
October 20..	17.90	19.2	93.2
November 6.	17.95	18.3	98.1
November 27..	18.70	20.6	90.8
Average	17.49	19.14	91.38

RESULTS ON PLAT 10.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	15.40	18.5	83.2
October 9..	17.40	19.2	90.6
October 20	19.75	21.7	91.0
November 6..	18.00	18.8	95.7
November 27..	18.65	21.0	88.8
Average	17.84	19.84	89.86

RESULTS ON PLAT 11.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	16.95	19.4	87.4
October 9..	17.30	19.2	90.1
October 20..	20.00	21.2	94.3
November 6..	18.00	19.2	93.7
November 27..	19.40	21.4	90.6
Average	18.35	20.08	91.22

RESULTS ON PLAT 12.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	17.00	19.4	87.6
October 9..	16.70	18.8	88.8
October 20..	21.10	22.5	93.8
November 6..	18.05	20.6	87.6
November 27..	20.50	22.3	91.9
Average	18.67	20.72	89.94

RESULTS ON PLAT 13.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	14.90	17.6	84.6
October 9.	15.50	19.0	80.2
October 20..	19.00	19.7	96.4
November 6..	18.15	20.1	90.3
November 27..	19.25	20.1	95.7
Average	17.36	19.3	89.44

RESULTS ON PLAT 14.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	14.25	16.5	86.4
October 9..	16.05	18.3	87.7
October 20..	17.95	19.7	91.1
November 6..	17.55	20.1	87.3
November 27..	19.40	20.8	93.2
Average	17.04	19.08	89.14

ALL PLATS.

AVERAGE RESULTS AT DIFFERENT DATES.

	Per cent. sugar in juice.	Per cent. solids in juice.	Quotient of purity.
October 4..	15.81	18.15	87.05
October 9..	16.26	18.60	87.00
October 20..	18.66	20.6	90.7
November 6..	18.18	19.5	93.36
November 27..	19.40	21.56	91.00

COMBINED RESULTS OF ALL PLATS.

Plat	Fertilizer rate per acre.	Pounds of beets with crowns.	Per cent. sugar in juice.	Per cent. solids.	Quotient of purity.
3	554 pounds Sulfate Potash	19.2	17.96	20.08	87.56
4	554 pounds Superphosphate ...	18.3	18.18	20.12	90.36
5	277 pounds Sulfate Potash .... 277 pounds Nitrate Soda.......	21.6	17.06	19.06	89.5
6	554 pounds Nitrate Soda	19.9	17.59	19.49	88.4
7	No Fertilizer	17.3	17.35	19.42	89.2
8	No Fertilizer	19.7	17.09	19.22	88.6
9	277 pounds Sulfate Potash .... 277 pounds Superphosphate ...	18.6	17.49	19.14	91.38
10	277 pounds Nitrate Soda....... 277 pounds Superphosphate ...	21.1	17.84	19.84	89.86
11	184⅔ pounds Sulfate Potash ... 184⅔ pounds Nitrate Soda ..... 184⅔ pounds Superphosphate ..	18.3	18.35	20.08	91.22
12	554 pounds Muriate Potash....	19.7	18.67	20.72	89.94
13	1089 pounds Quick Lime	19.5	17.36	19.3	89.44
14	1089 pounds Ground Phosphate Rock	21.9	17.04	19.08	89.14

While the yield was somewhat low, yet this can be accounted for by the fact that the subsoil has been so thoroughly loosened somewhat late in the spring that capillary action was not fully restored and hence the beets failed to make as large a growth as would have been the case had the conditions been more favorable.

The effect of the fertilizer is not marked. The largest yield was on Plat 14 where the untreated phosphate rock was applied. The highest quotient of purity was found on Plat 11 where the complete fertilizer was applied. The results from the fertilizer are not marked enough to warrant the drawing of conclusions. There was evidently all the plant food in the soil that could be utilized with the amount of moisture present. The experiment will be continued to see if more definite results can be reached.

Mr. J. W. Gilmore, conducted culture and fertilizer experiments with sugar beets on eight plats of one-eightieth of an acre each. The land selected upon which to conduct these experiments was a portion of the regular mangold field which had been liberally fertilized with barn manures in previous years and brought to a high state of cultivation. The variety of beets was Kleinwanzlebener, planted in rows two feet apart and thinned to about eight inches in the row. The fertilizer was applied in the drill at the time of planting. Part of the plats received cultivation five times and others were cultivated seven times. The following table shows results:

Plat	No. times cultivated.	Fertilizer applied per acre. Pounds.	Tons per acre with crown.	Tons per acre without crown.	Per cent. sugar in juice	Quotient of purity.
1	7	160 lbs. Muriate Potash	19.63	14.86	14.48	79.04
2	5	320 lbs. Superphosphate	21.70	16.38	14.63	76.85
3	7	160 lbs. Nitrate Soda	19.02	14.36	14.80	80.00
4	5	320 lbs. Superphosphate	19 95	15.06	14.14	76.00
5	7	160 lbs. Sulfate Potash	21.82	16.48	13.40	76.19
6	5	320 lbs. Superphosphate	23.31	17.60	13.67	76.76
7	7	160 lbs. Nitrate Soda	18.12	13.68	14.34	77.60
8	5	160 lbs. Sulphate Potash	21.74	16.41	12.88	74.20

The results shown here from the use of the commercial fertilizer are not much more decided than in the former case. While the tonnage per acre is very satisfactory, yet the per cent. of sugar and the quotient of purity run somewhat low. This is probably due to the fact that barn manures have been used liberally on the land, and to the same cause may be ascribed the failure of the fertilizers to give any marked results. It is generally stated that sugar beets are especially benefited by the application of potash and phosphoric acid, and that the form of the sulfate of potash is preferable. So far as our experiments with fertilizers this year go we have not verified the truth of this statement.

PART II. THE WORK OF THE CHEMICAL DIVISION.

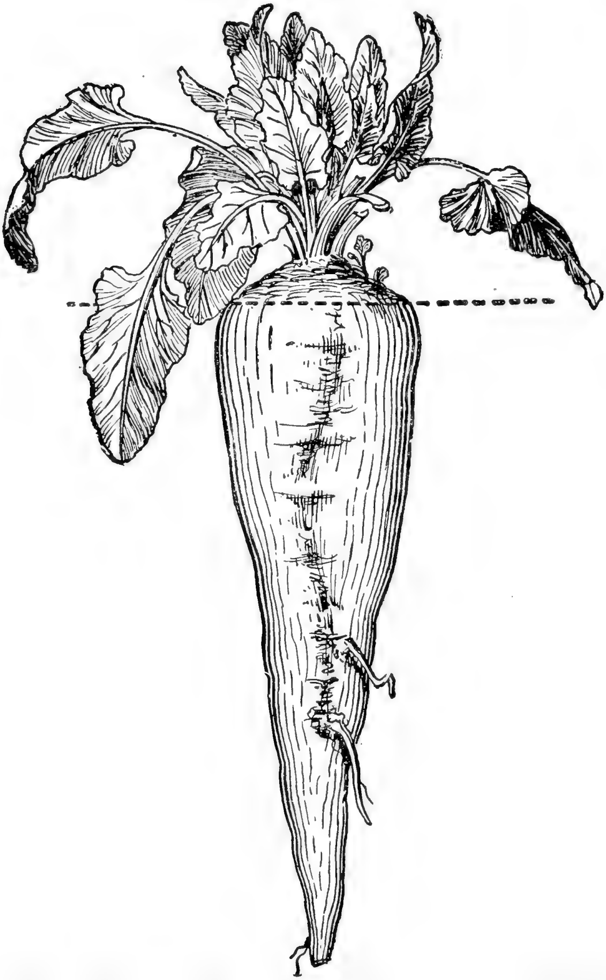
By G. W. Cavanaugh and A. L. Knisely, assisted by C. W. Mudge, under the direction of G. C. Caldwell, Chemist.

In order that the work of the chemical department, in connection with the sugar beet investigations, might be of real and permanent value, it was necessary to secure not only representative samples of the beets grown, but also accurate and carefully recorded data relative to their culture. With this end in view the co-operation of intelligent farmers who have already given evidence of an active interest in educational and experimental work was sought. The instructions in grape growing and orcharding which had been carried on for two previous years had eminently fitted a goodly number of farmers to take up the work of sugar beet culture in an intelligent way.

The circular on page 188, which was sent out at the close of the season, was filled out with far more painstaking care than is usual in such cases. These reports give unmistakable evidence that the work already done by the Station staff had been of great value. In fact, it had trained a large number of farmers far enough to make them intelligent observers and willing to take some pains to record their observations. Much care has been taken to put down all the data in detail, and while these tables may be of little interest to the general reader, it is hoped that the data recorded will be of value for reference as the work goes on.

We desire to thank all those who have co-operated with so much care in the field work. The work in the laboratory, which has been very extended, would be of comparatively little value if we did not feel that the notes and observations of the farmers were reliable.

CIRCULAR NO. 11.



154, WILEY, Bulletin 52, Division of Chemistry, United States Department of Agriculture.

CORNELL UNIVERSITY,
AGRICULTURAL EXPERIMENT STATION,

Ithaca, N. Y., September 15, 1897.

SIR:

We inclose herewith circular giving directions for taking samples of beets for analysis, blank for describing samples (Form A), and MODEL (Form B), showing how blank for description should be filled in, with envelope and return shipping tag for sending samples by express.

Circular of directions, blank for describing samples with envelope, return-addressed shipping tag, and model for filling in descriptive blank, comprise the necessary documents for sending samples.

Your special attention is called to the fact that the value of the analytical data depends on the fidelity with which you follow the inclosed directions.

I. P. ROBERTS Director.

DIRECTIONS FOR TAKING SAMPLES OF SUGAR BEETS FOR ANALYSIS.

When the beets appear to be mature (September 20 to November 20, according to latitude and time of planting) and before any second growth takes place, select any average row or rows, and gather every plant along a distance which should vary as follows, according to the width between the rows:

From	rows	16	inches	apart	take	75	feet	in	length.
"	"	18	"	"	"	66	"	"	"
"	"	20	"	"	"	59	"	"	"
"	"	22	"	"	"	54.8	"	"	"
"	"	24	"	"	"	50	"	"	"
"	"	28	"	"	"	42.9	"	"	"
"	"	32	"	"	"	37.5	"	"	"
"	"	36	"	"	"	33	"	"	"

Where the row is not long enough to meet the above conditions, take enough from the adjacent row or rows to make up the required length. Rows of average excellence must be selected; avoid the best or poorest. Count all the beets in the length of the row taken. Remove the tops, leaving about one inch of the stem, wash free from all dirt and wipe dry. Select two average beets, being careful not to select the largest or the smallest.

From all the rest of the beets *except these two* the necks are removed with a sharp knife, at the point indicated by the dotted line in the figure. The beets, including the two saved as a sample, are then weighed.

The number of beets harvested multiplied by 435.6 will give the total number per acre. The total weight of beets harvested multiplied by 435.6 will give the yield per acre.

Wrap the two sample beets carefully in soft paper and write your name legibly thereon. The beets must be perfectly dry. Fill out blank describing beets, place in the envelope, and enclose beets. Sew the beets up in a cotton bag or wrap in strong paper, attach the enclosed shipping tag thereto and send by U. S. mail.

No beets will be analyzed which are not sampled as described above and properly identified. Miscellaneous analyses of samples without accurate description are of no value.

A model showing how blanks should be filled out is inclosed.

Model (Form B).

MODEL FOR DESCRIBING SAMPLE OF SUGAR BEETS.

Variety. . . . . *Klein Wanzlebener.*

Date planted . . . . *May* 3, 1897.

Date thinned . . . . *June* 3, 1897.

Date harvested . . . . *November* 5, 1897.

Character of soil . . . . *loam ; in cultivation for* 20 *years, chiefly in corn ; level, tile-drained ; last crop, oats ; no fertilizer was used ; barn-yard manure applied in* 1895.

Character of cultivation (dates, implements, etc.) . . . . *Plowed November*, 1896, *eight inches deep, subsoiled, six inches; harrowed with disk harrow May*, 1, 1897 *; rolled ; seed planted with hand drill one-half inch deep ; plants up May* 16 *; stand excellent ; hoed by hand May* 22 : *plowed with horse hoe May* 28 *and June* 8, 16, 24, *July* 3, 10 *and* 17.

Length of row harvested (feet) 66

Width between rows (inches) 18

Number of beets harvested 88

Total weight of beets, less necks and tops (pounds) 88

. . . .

Weather for each month . . . . *May, dry ; June, copious rains ; July, fine growing weather ; August, hot and dry ; September, dry until the* 24*th, when a heavy rain fell.*

. . . .

. . . .

State . . . . *New York.*

Post office . . . . *Ithaca, Tompkins Co.*

Date . . . . *October* 1, 1897.

Name . . . . *Robert Simpson.*

NOTE.—Beets will not be analyzed unless accompanied with description as above.

(Form A.)

DESCRIPTION OF SAMPLE OF SUGAR BEETS.

Variety .... *Klein Wanzlebener.*

Date Planted .... *May* 7, 1897.

Date thinned .... *June* 10, 1897.

Date harvested .... *October* 18, 1897.

Character of soil........................ *clay loam; in cultivation* 65 *years. Used* 30 *years for garden level. Tile drained. Barn manure in* '92. *Hen manure used occasionally. Last in fall* '96.

Character of cultivation (dates, implements, etc.)...... *plowed May* 1*st*, 9 *inches deep; harrowed* 3 *times. Seed sown by hand. Up May* 16*th*, *stand excellent; horse cultivated* 3 *times; hand-hoed twice.*

....

Length of row harvested (feet) 42.9

Width between rows (inches) 28

Number of beets harvested 60

Total weight of beets harvested, less necks and tops (pounds) 95

Weather for each month ....

....

....

....

State .... *N. Y.*

Post-office .... *Riga.*

Date .... *October* 18, 1897.

Name .... *Arnold A. Palmer.*

NOTE.—Samples of beets will not be analyzed unless accompanied with this blank filled out as indicated in model B.

G. C. CALDWELL, Chemist.
G. W. CAVANAUGH, Ass't Chemist.

The first question that arises is this: In what condition did the samples for analysis arrive at the Experiment Station? With but few exceptions they arrived in very good condition, well wrapped and securely tied. The majority of them were received in from one to three days after being harvested and in good condition for analysis.

The fairness of the samples.—Were the beets sent to the Station for analysis of good average size and did they fairly represent the beets harvested? In the data sent in the circulars, we have the *number of beets harvested* and also *the total weight* of beets harvested, less necks and tops, in pounds. From these we obtain the average size, or weight, of each crownless beet harvested.

The whole sample received was weighed after removing crowns and the average weight of each beet obtained. Now by comparing the *average weight harvested* with the *average weight of beets in the sample analyzed*, we can see with what degree of accuracy the samples were taken.

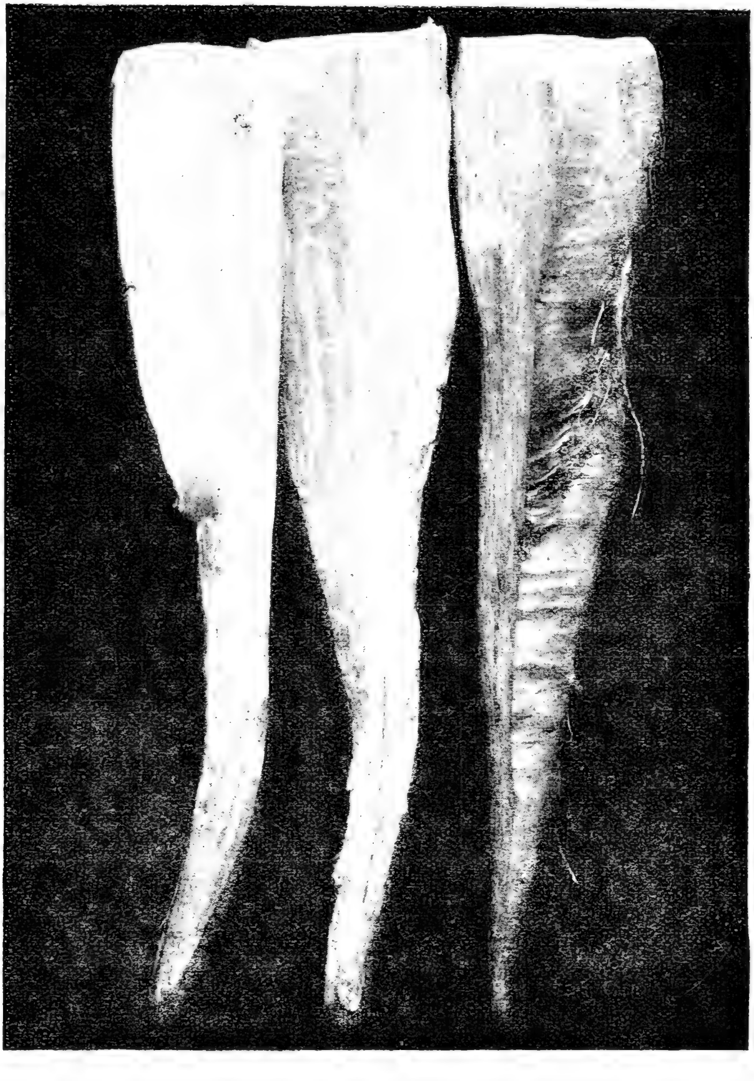
In 296 cases the average weight of the individual beets harvested was 1.18 *pounds each.* In the same 296 cases the average weight of the beets sent for analysis averaged 1.18 *pounds each.* So it will be seen that, on the whole, the sampling of beets was very well done.

Preparation of the sample for analysis.—Each sample was weighed *before* and *after* removing the crown in order to ascertain the loss or waste that the beet sustains while being prepared for the sugar factory.

The sample thus prepared was reduced to a fine pulp by means of a grater. If the sample was small all of it was pulped for analysis; if of medium size half of each beet was analyzed; in some cases only a quarter of each beet was taken. In all cases where the whole beet was not used, a longitudinal section the entire length of it was taken for analysis as shown in figure 155 (next page). The pulp was at once put into a piece of strong canvass and the juice pressed out by means of a press capable of exerting a pressure of 2,000 pounds or more.

The necessity of taking a longitudinal section the entire length of the beet would seem to be proved by the results of the following five experiments.

Five samples consisting of three beets each (*without crowns*) were cut in two, crosswise, so that the upper and lower halves of each sample



155.—*Methods of sampling large beets for analysis.*

could be examined separately. These halves were analyzed with the following results:

Case.	Upper half.		Lower half.	
	Per cent. sugar.	Per cent. purity.	Per cent. sugar.	Per cent. purity.
1............	13.95	77.1	13.60	79.1
2............	14.45	83.0	14.20	87.1
3............	13.25	78.4	13.00	81.2
4............	13.05	77.2	12.95	81.9
5............	17.25	89.8	17.00	89.5

In these five cases the sugar and purity were not equally distributed. The upper halves being richer in sugar whilst the purity was considerably higher in the lower halves except in No. 5.

In obtaining juice for analysis it is necessary to express as much as possible from the pulp, because that which *first runs from the press* is not so rich in sugar as that which is obtained toward the *end* of the operation. Thus in five cases tried the per cent. of sugar and per cent. of purity were as follows:

Juice first running from press.		Juice last running from press.	
Per cent. sugar.	Per cent. purity.	Per cent. sugar.	Per cent. purity.
Case 1...............13.55	82.1	14.00	82.8
" 2...............15.20	76.4	15.75	76.5
" 3...............18.45	87.9	18.45	87.9
" 4...............12.85	71.8	13.95	74.2
" 5...............19.35	89.1	19.50	96.0

Method of Analysis.

When al. the juice was pressed out that could be obtained it was thoroughly mixed and its *density* ascertained by means of an areometer (Brix) specially constructed for this purpose and from that the total solids of the juice found; corrections were made for variations in temperature when necessary.

Next, 52,096 grams of the juice were weighed and transferred to a 100 c. c. flask; 10 c. c. of a solution of sub-acetate of lead, made as directed in Wiley Agr. Anal. III., p. 101, were added; after shaking the mixture it was made up to 100 c. c. with distilled water and again thoroughly shaken. Then the entire contents of the flask were poured on a ribbed filter, the first part of filtrate being poured a second time through the same filter; the filtrate was thoroughly mixed and the sugar in it determined by means of a "double compensating shadow polariscope" now in general use for this purpose, using a 200 mm. tube. This reading divided by two gives the per cent. of *sugar in the juice.*

Explanation of Tables

In the following tables we have given in the first three columns: 1st, degree Brix or per cent. of total solids in the juice; 2d, per cent. of sugar in the juice; and 3d, per cent. of purity of the juice. We will consider:

First: The Degree Brix or per cent. total solids in the juice.—Beet juice consists of water and solid matter consisting of sugar, mineral salts, coloring matter, nitrogenous compounds, etc. The first beet juice in the tables reads "19.9° Brix." This means that 19.9 per cent. of that juice is solid matter and the remaining 80.1 per cent. is water; or, in other words, in 100 pounds of such a juice there are 19.9 pounds solid matter and 80.1 pounds of water.

Second: The per cent. of sugar in the juice.—This per cent. is determined by the polariscope. The first beet juice in the tables analyzed 17.25 per cent. of sugar. This means that in 100 pounds of that juice there are 17.25 pounds of sugar.

Third: Purity per cent.—This term is often called the coefficient of purity, or, better still, the quotient of purity. It expresses the ratio between the *per cent. of total solids in the juice* and the *per cent. of sugar in that same juice.* That is, in any particular juice the *purity* expresses what proportion of the total solids is sugar. Thus, in the juice first analyzed, in the following tables there is given, "*Purity per cent.*, 86.6." This means that if such a juice were evaporated to dryness and the total solid matter obtained, then of the solids thus obtained 86.6 per cent. would be sugar and the remaining 13.4 per cent. would be impurities not sugar; or stated in another way, in every 100 lbs. of the solid matter obtained by evaporating the juice, 86.6 lbs. would be sugar and the remaining 13.4 lbs. would be impurities and not sugar.

In any given case the *purity* is obtained by dividing the *per cent. of sugar* in the juice times 100 by the *per cent. of total solids* in that same juice. Thus in sample No. 1 of the following tables $\frac{17.25 \times 100}{19.9}=86.6$ per cent. purity. The term *purity* is not an indication of the quality of a *juice*, but of the quality of the *total solids* in the juice; that is, it tells *how many parts are sugar in every 100 parts of the total solids.*

Per cent. of sugar in beets without crowns.—It has been stated upon good authority (Wiley, Agr. Anal., III., p. 242) that 95 per cent. of the beet consists of *juice* and 5 per cent. *marc*, or that which is left after all the juice has been extracted. That is, each 100 pounds of beets prepared for the factory yields 95 pounds of juice and 5 pounds of marc. Having given the per cent. of sugar in each sample of *juice* we multiply it by $\frac{95}{100}$ and have the per cent. of sugar in the *beet.* The column headed *per cent. sugar in the beet* was obtained in each case by this multiplication and the result was recorded as per cent. of sugar in the beet.

Thus in first analysis of tables $17.25 \times \frac{95}{100} = 16.39$, the per cent. sugar in the beet.

Pounds of sugar per ton of beets.—In each case we multiply the per cent. of sugar in the beet, or the number of pounds in 100 pounds of beets by 20, a ton being 20 times 100 pounds, and record the result as pounds of sugar per ton of beets, discarding decimals. Thus in first analysis 16.39x20=328 pounds, approximately, of sugar per ton.

Pounds of sugar per acre.—In cases where yields have been given, we multiply the pounds of sugar per ton by the number of tons yield per acre. Thus 7.84x328 pounds=2,572 pounds per acre (discarding decimals.)

Kind of soil.—L=loam.

When plowed and depth, inches.—In this column, F=fall plowed; S=spring plowed. The numeral indicates depth in inches.

The remainder of the tables is self-explanatory with the exception of "*Distance between beets in rows*" and "*Average weight of beets.*" From data sent to the Station, the *length of the rows* and the whole *number of beets* harvested were given, and from these the average distance between each beet in the rows was calculated. From the recorded total weight and number of the beets harvested the average weight of the beets *less crowns and tops* was ascertained.

Each sample of beets sent for analysis was weighed and thus the average weight of beets analyzed was found.

The variety of beets analyzed.—In each case the variety of sugar beet analyzed was the *Kleinwanzlebener*, except toward the end of the tables, where special mention is made of other varieties.

We believe that these tables will be of enough value and interest to warrant their publication. They are not published with the thought or idea of having established either a *maximum* or *minimum* of results in the growing of sugar beets, but are given as showing *what the farmers have done this present season* (summer of 1897).

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Albany.							
1	W. D. Veeder	Guilderl'd.	19.9	17.25	86.6	16.39	328	7.84	2572
		Broome.							
2	A. S. Bartlett	Bingh'ton	20.6	17.85	86.6	16.96	339	*19.69	6675
3	David Smith	"	19.5	16.20	83.1	15.39	308	*18.91	5824
4	E. A. Lawrence....	"	21.2	18.10	85.4	17.19	344	*21.88	7527
5	A. R Park	"	21.9	18.65	85.2	17.72	354	*16.90	5983
6	Geo. A. Lusk......	"	22.2	19.00	85.6	18.05	361	8.49	3065
7	W. S. Stone	"	20.6	17.10	83.0	16.25	325	*16.03	5210
8	J. E. Rogers	"	21.5	18.20	84.7	17.29	346	*14.98	5183
9	G. E. Larraber	"	17.0	12.45	73.2	11.83	237	*13.80	3271
10	C. Rogers	"	21.5	18.00	83.7	17.10	342	*34.33	11741
11	W. S. Weed	"	20.4	16.65	81.6	15.82	316	*13.28	4196
12	C. E. Lee	"	20.6	17.00	82.5	16.15	323	*25.78	8327
13	R. W. Wright.....	"	19.1	15.50	81.2	14.73	295	*14.29	4216
14	Geo. F. Lyon......	"	17.0	13.10	77.1	12.45	249	*14.29	3558
15	David Smith, Jr...	"	20.2	16.50	81.7	15.68	314	*19.51	6126
16	A. Hamilton	"	19.3	15.55	80.6	14.77	295	*20.74	6118
17	H. S. Martin	"	22.8	19.25	84.4	18.29	366	*23.18	8484
18	C. Constable	"	18.1	14.50	80.1	13.78	275	*20.21	5578
19	J. M. Price........	"	17.2	13.45	78.2	12.78	256	*13.94	3569
20	E. C. Rogers	"	19.0	14.15	74.4	13.44	269	*19.86	5342
21	C. J. Knapp.......	"	20.8	16.50	79.3	15.68	314	*24.00	7536
22	C. P. Knapp.......	Deposit ...	16.3	12.00	73.6	11.40	228	*22.88	5217
23	C. H. Wells	Pt.Dickson	19.7	17.15	87.0	16.29	326	*17.07	5565
24	Alton Gray........	Hooper....	19.3	14.20	73.6	13.49	270	*24.74	6680
25	Abram Davis......	Langdon ..	21.2	17.85	84.2	16.96	339	*12.76	4326
26	R. W. Evans	Riverside .	20.1	16.40	81.5	15.58	312	*16.98	5298
27	J. E. Croffutt......	W. Colesv.	20.3	17.00	83.7	16.15	323	*23.00	7429
28	D. E. Pease	Windsor ..	20.6	16.80	81.5	15.96	319	*25.09	8004
29	H. W. Humiston ..	"	19.2	15.45	80.5	14.68	294	*27.18	7991

* Through the courtesy of Mr. J. E. Rogers, of Binghamton, the Station has received most of the Broome county samples of beets. The yields reported in cases "starred" included crowns; therefore in each of the cases the yield has been reduced one-fifth to allow for the weight lost in removing crowns.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Sandy	40	Carrots	....	F.&S.8	3	Jun 18	Jul 27	Oct 30	36	14.5	1.00	1.00
Clay. L	..	....	....	S	4	M'y 22	Jun 18	Oct 23	20	9.0	1.42	.96
" "	..	....	....	"	4	" 18	" 16	" 22	18	9.0	1.27	1.24
Sandy "	..	....	....	"	3	Jun 2	" 30	" 21	18	9.0	1.36	.89
" "	..	....	'96	"	5	M'y 10	" 15	" 20	20	9.0	1.21	.73
Gravel "	..	....	....	....	3	" 26	" 23	" 20	36	9.0	.87	1.51
Sandy "	..	....	....	....	3	" 19	" 23	" 20	18	9.0	1.15	1.34
" "	..	....	....	....	4	" 19	" 16	" 18	18	9.5	1.05	1.45
Clay "	..	....	....	....	5	" 7	" 4	" 17		.....	....	1.50
Sandy "	..	....	....	....	3	" 15	" 20	" 19	24	6.0	1.91	1.63
Sod..........	..	....	....	....	5	" 25	" 26	" 18	36	6.0	....	1.49
Clay L	..	....	....	....	3	" 22	" 6	" 19	18	10.0	1.87	1.60
Sandy "	..	....	....	....	3	" 28	" 22	" 20	36	8.5	1.78	1.73
Gravel "	..	....	....	....	4	" 12	" 26	" 19	36	9.5	2.00	1.60
Clay "	..	....	....	....	4	" 16	" 22	" 29	18	11.0	1.56	1.70
Sandy "	..	....	....	....	5	Jun 2	" 23	" 23	20	9.0	1.29	1.46
Black "	..	Garden.....	....	....	3	" 3	Jul 2	" 29	12	9.5	1.58	1.70
Clay "	..	....	....	....	4	M'y 28	Jun 15	" 28	18	9.0	1.33	1.54
Sandy "	..	....	'96	F. & S.	5	" 13	" 24	Nov. 8	36	7.0	1.48	1.27
Loam........	..	Garden.....	'97	S., 8..	..	" 20	Jul 15	Oct 21	24	8.5	1.61	1.68
"	..	....	....	....	..	Jun 2	Jun 29	" 28	..	.....	....	.86
Sandy L	..	....	....	....	..	M'y 20	" 16	" 15	18	10.0	1.95	1.73
Clay "	..	....	....	....	..	" 18	" 20	" 19	36	7.0	1.69	1.19
" "	..	....	'96	S	..	" 11	" 20	" 29	24	8.5	2.03	1.07
" "	..	....	....	....	4	Jun 2	" 26	Nov 3	36	8.5	.77	1.05
Sandy "	..	....	....	....	4	M'y 25	" 17	" 3	20	12.5	1.54	1.58
Clay "	..	....	....	....	3	Jun 28	Jul 16	" 2	18	8.5	1.45	1.30
Sandy "	..	....	....	....	2	" 17	" 10	Oct 18	18	8.0	1.50	.88
" "	..	....	....	....	3	" 2	" 1	Sep 18	18	8.0	1.39	.71

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
		Catta'gus.							
30	W. B. Smith	Cottage ...	20.6	18.55	90.0	17.62	352	28.75	10120
31	L. L. Palmer	S. Dayton.	21.5	18.40	85.6	17.48	350	13.06	4571
32	D. Achley..........	Gowanda .	21.1	18.55	87.9	17.62	352	13.83	4868
33	Clay Torrence.....	"	19.9	17.10	85.9	16.25	325	......	......
34	"	"	19.4	16.20	83.5	15.39	308	......	......
35	"	"	19.9	16.85	84.6	16.01	320	......	......
36	"	"	20.2	17.60	87.1	16.72	334	......	......
37	Jerome Kennedy ..	Versailles .	19.2	15.30	79.7	14.54	291	......	.....
38	Peter Pierce.......	"	14.7	10.85	73.8	10.31	206	......	......
39	Eli Pierce..........	"	17.4	12.90	74.1	12.26	245	......	......
40	H. H. Thomas.....	Farmerv'le	19.7	16.65	84.5	15.82	316	......	......
41	John Hall..........	W. P'rrysb	23.9	21.50	90.0	20.43	409	9.80	4008
42	Clayton Gates.....	Conew'goV	20.6	17.60	85.4	16.72	334	15.46	5164
43	E. F. Davis	Hinsdale ..	21.0	18.40	87.6	17.48	350	......	......
44	"	" ..	20.1	17.65	87.8	16.77	335	......	......
		Cayuga.							
45	Sam. Searing......	Poplar R..	20.1	18.10	90.0	17.20	344	14.16	4871
46	I. P. Hazard	" ..	19.5	15.25	78.2	14.49	290	11.43	3315
47	Thomas Mitchell ..	" ..	19.5	15.95	81.8	15.15	303	14.37	4354
48	E. Cook...........	" ..	21.7	18.95	87.3	18.00	360	14.37	5173
49	Nathan Bacon.....	Westbury .	21.0	18.65	88.8	17.72	354	15.86	5614
50	J. N. Shotwell.....	"	20.8	17.15	82.4	16.29	326	18.86	6148
51	Dan. Olmstead	"	19.7	16.40	83.2	15.58	312	......	......
52	W. F. Searing.....	Sherwood .	22.5	19.80	88.0	18.81	376	6.21	2335
53	D. Duryea.........	Auburn ...	19.9	16.10	80.9	15.30	306	......	......
54	J. Brinkerhoff.....	" ...	19.0	14.85	78.2	14.11	282	......	......
55	H. A. Lamphere...	Weedsport.	20.6	17.05	82.7	16.20	324	47.75	15471

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Gravel L					4	M'y 26		Oct 23	32	7.5	2.20	1.43
Clay "				S., 7	3	" 25	Jun 25	" 16	28	10.0	1.20	1.46
Sandy "	70	Corn	'95	" 5		Jun 8	" 24	" 18	24	6.5	.71	1.56
Bottom L'd												1.61
" "												2.16
" "												1.95
" "												2.03
" "						M'y 20	" 20	" 20				.79
Clay L						" 26	" 20	" 20				1.43
						Jun 21	Jul 10	" 20				1.46
												1.19
Black L		Oats		S.,		M'y 25	Jun 24	" 26	36	9.0	1.07	1.74
Gravel "		Hay		" 6	7	" 30	" 29	Nov 3	24	8.5	1.00	1.17
Loam	20	Cabbage		" 8		" 10		" 18	20			1.39
												1.00
Sandy L		Oats	'96	S., 8	4	M'y 18	Jul 2	Nov 6	42	7.0	1.30	1.40
Loam					1	" 15	" 6	Oct 21	30	8.0	1.17	1.17
Clay L		Oats	'97	" 7	3	" 20	" 2	" 19	32	9.5	1.37	1.20
Loam			'97		7	" 25	" 15	" 25	36	9.0	1.50	1.49
Clay L	75	Sod		" 6	5	" 20	" 25	" 13	36	6.5	1.22	.91
Sandy "	75		'96	"	3	" 12	Aug	" 13	15	6.0	.56	.55
" "	50		'97	" 6	6	" 12	" 20	" 12	14	6.0	1.59	1.42
Loam	100		'97	" 8	9	" 15	Jul 6	Nov 6	35	12.0	.85	.92
												.61
Gravel L						Jun 1		" 15	24			1.42
Sandy "	50		'97	" 8	3	M'y 15	Jun 10	" 15	22	6.0	2.00	1.65

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau'qua.							
56	L. Newton	Irving	19.7	17.60	89.3	16.72	334	30.92	10327
57	R. L. Newton	"	19.2	16.50	85.9	15.68	314	26.00	8164
58	Frank Newton	"	17.5	13.40	76.6	12.73	255	31.36	7997
59	James Duffy.......	"	19.7	16.15	82.0	15.34	307	......	......
60	"	"	19.7	16.30	82.7	15.49	310	33.32	10329
61	"	"	17.4	14.20	81.6	13.49	270	......	......
62	D. Burmaster	"	21.2	18.00	84.9	17.10	342	......	......
63	A. D. Burmaster ..	"	20.6	17.25	83.7	16.39	328	......	......
64	" ..	"	20.8	16.80	80.8	15.96	319	......	......
65	" ..	"	19.7	16.50	83.8	15.68	314	31.36	9847
66	C. A. Burmaster...	"	19.7	16.40	83.2	15.58	312	31.80	9922
67	" ...	"	19.2	16.40	85.4	15.58	312	31.80	9922
68	Wm. Hull.........	"	18.5	15.55	84.0	14.77	295	26.00	7670
69	"	"	16.0	12.15	75.9	11.54	231	......	......
70	"	"	17.9	14.45	80.7	13.73	275	28.75	7906
71	H. E. Goodell	"	23.2	20.40	88.5	19.38	388	......	......
72	L. Newton	"	21.0	18.25	86.9	17.34	347	......	......
73	R. L. Newton	"	22.1	19.00	86.0	18.05	361	......	......
74	Israel Mott.........	"	18.8	14.50	77.1	13.78	275	......	......
75	Jas. J. Mott	"	18.5	14.70	79.5	13.97	279	29.18	8141
76	"	"	21.5	15.50	72.1	14.73	295	......	......
77	D. G. Smith	"	17.7	15.00	84.7	14.25	285	18.00	5130
78	W. B. Horton	"	18.1	14.60	80.7	13.87	277	21.00	5817
79	H. M. Goodell.....	"	20.8	17.45	83.9	16.58	332	......	......
80	"	"	22.5	18.65	82.9	17.72	354	......	......
81	"	"	18.3	13.50	73.8	12.83	256	......	......
82	I. J. Mott	"	17.0	12.50	73.5	11.88	238	9.76	2323
83	R. L. Newton	"	20.2	17.20	85.1	16.34	327	17.36	5677
84	Jas. Duffy	"	18.6	14.65	78.8	13.92	278	33.35	9271
85	B. Barker	"	18.3	13.90	76.0	13.21	264	......	......
86	G. S. Stevins	"	20.2	17.35	85.9	16.48	330	29.29	9666

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Bottom L'd	30			S.	4	Jun 14	Jul 14	Oct 13	18	9.0	1.61	1.23
"	20					" 14	" 1	" 13				1.32
"				" 8	4	M'y 27	Jun 10	" 6	18	9.5	1.75	.97
"						" 14	" 10	" 20				1.37
"	35		'95	"	4	Jun 12	Jul 1	" 20	16	10.0	1.68	1.46
Loam						M'y 28	" 25	Nov 27	16			2.67
						" 24	Jun 16	Oct 20				1.44
												1.29
												.50
Bottom L'd	30			S&F 10	3	" 27	" 15	" 6	18	8.0	1.41	1.05
"	30				4	Jun 3	" 26	" 13	18	9.0	1.62	.85
"					4	" 3	" 26	" 13	18	9.0	1.62	.74
"	20			S.	4	M'y 26	" 10	" 13				1.20
"				"		" 26	" 10	" 13				.78
"	15			" 8	5	" 25	" 4	" 6	18	9.0	1.50	.94
						Jun 20		Nov 20	16			.66
						" 14	" 30	Oct 20				1.15
Bottom L'd	20					" 14	Jul 1	" 13				.80
Alluvial L.						" 10	" 1	" 20				.75
"						" 10	" 3	" 20	18	8.0	1.40	2.64
"						" 2	" 3	Nov 23				.94
Clay L.				" 8	2	Apr 20	M'y 4	" 6				1.19
Gravel "	30			" 8	4	M'y 24	Jun 10	" 6				1.26
Loam						Jun 20	Jul 20	" 20	16			.75
"						" ..	" ..	" ..				1.04
"												1.21
Alluvial L.						" 1		Oct 20	18	8.5	1.44	1.57
"				"		" 14	" 7	" 20	16	9.0	.81	1.14
"				" 9	2	" 14		" 20	16	9.0	1.57	1.31
Sandy L.				" 6	6	M'y 15	M'y 30	" 15				1.37
"	60	Vegetables.		" 7	3	Jun 23	Jul 12	" 15	20	8.0	1.50	1.14

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau., C'td							
87	M. Sackett	Irving	20.4	15.85	77.7	15.06	301	26.79	8064
88	R. L. Newton	"	18.8	14.90	79.3	14.16	283	26.24	7426
89	A. D. Burmaster	"	19.2	15.95	83.1	15.15	303	23.85	7227
90	Det. Dye	Forestville	20.3	17.35	85.4	16.48	330	......	......
91	E. J. Cole	"	21.1	17.25	81.7	16.39	328	......	......
92	Chas. Barnes	"	21.7	19.40	89.4	18.43	369	11.76	4339
93	E. H. Keyes	"	20.4	16.65	81.6	15.82	316	......	......
94	F. A. Gron	Jamestown	17.0	13.60	80.0	12.92	258	......	......
95	A. A. Van Vlick	"	22.3	19.60	87.9	18.62	372	13.07	4862
96	B. W. Hayward	"	19.9	15.80	79.4	15.01	300	......	......
97	Oscar Briggs	Silver Cr'k	22.2	19.60	88.3	18.62	372	18.00	6696
98	H. B. Clothier	"	20.8	18.00	86.5	17.10	342	......	......
99	Wm. H. Jacobs	"	19.4	15.00	77.3	14.25	285	15.12	4309
100	E. Thomas	"	20.2	17.00	84.1	16.15	323	......	......
101	"	"	20.2	17.40	86.1	16.53	331	......	......
102	J. A. Kaiser	"	18.1	14.45	79.8	13.73	275	......	......
103	"	"	19.0	15.35	80.8	14.58	292	......	......
104	H. D. Wilson	"	23.4	21.10	90.2	20.05	401	......	......
105	O. L. Swift	"	18.8	15.20	80.8	14.44	289	......	......
106	"	"	20.4	17.00	83.3	16.15	323	......	......
107	W. T. Christy	"	21.7	19.50	89.8	18.53	371	25.92	9616
108	M. J. Sackett	"	19.2	16.45	85.7	15.63	313	......	......
109	R. S. Arnold	Prospect	22.5	20.40	90.7	19.38	388	19.70	7644
110	"	"	19.2	15.40	80.2	14.63	293	......	......
111	Mrs. B. B. Lord	Sinclairv	19.0	15.70	82.6	14.92	298	......	......
112	A. B. Hawkins	Ripley	19.4	15.70	80.9	14.92	298	......	......
113	C. G. Brown	"	18.1	14.10	77.9	13.40	268	22.11	5925
114	Mrs. M. Langworthy	Dunkirk	20.8	16.25	78.1	15.44	309	14.59	4508
115	"	"	21.4	17.35	81.1	16.48	330	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Sandy L.	..	Potatoes ...	'95	S., 6..	3	M'y 20	Jun 7	Oct 15	18	15.0	1.77	1.40
"	75	Vineyard ...	....	" 7..	2	Jun 14	Jul 20	" 14	18	8.0	1.23	1.17
"	70	Corn	....	" 7..	2	M'y 24	Jun 15	" 14	18	7.0	.96	1.35
"	..	....	....	" ...	2	" 23	" 22	Dec 2	..	.....	....	1.32
Gravel L.	..	Corn	'96	" 6..	..	" 15	......	Nov 16	..	.....	....	....
"	50	Potatoes ...	'95	" 7..	8	Jun 4	Jun 18	Oct 13	20	7.5	.55	1.00
"	..	" ...	....	" 8..	..	M'y 1	Never	" 13	12	.....	....	1.12
Loam	20	....	....	....	..	Jun 1	Jun 20	" 13	..	.....	....	2.92
Gravel L.	..	....	....	" 8..	7	M'y 26	......	" 30	36	7.0	1.09	1.37
....	..	....	....	" ...	..	......	......	......	..	.....	....	1.72
"	..	....	....	....	..	" 2	" 10	Nov 13	..	.....	....	.77
"	..	....	....	....	..	" 5	" 5	" 13	..	.....	....	1.20
Sandy L.	..	Potatoes ...	'97	" 8..	2	Jun 19	Aug 6	" 5	18	6.0	.53	.76
Clay "	..	....	....	" 8..	2	" 1	......	Oct 22	..	.....	....	1.27
"	..	....	....	" 8..	2	" 1	......	" 22	..	.....	....	1.40
Loam	25	....	....	" ...	..	M'y 6	Jun 8	" 26	16	.....	....	2.25
....	..	....	....	....	..	......	......	......	..	.....	....	2.09
Clay L.	..	....	....	....	..	M'y 25	......	" 29	..	.....	....	.94
"	..	....	....	....	..	......	......	......	..	.....	....	1.90
....	..	....	....	....	..	......	......	......	..	.....	....	2.43
Gravel	60	Potatoes ...	'97	" 7..	11	" 8	M'y 18	" 14	24	7.5	1.48	1.46
Muck L.	..	....	....	" 7..	..	Jun 27	......	" 22	..	.....	....	1.19
Clay "	..	Garden	....	....	..	" 15	Jul 28	Nov 30	18	10.0	1.14	.89
Muck "	..	....	....	....	..	......	......	......	..	.....	....	.81
....	..	....	....	....	..	......	......	......	..	.....	....	1.29
Dark "	..	Grapes	....	....	..	" 1	" 10	Dec 4	..	.....	....	1.56
Muck "	20	Potatoes ...	'96	" 8..	2	" 1	" 1	Oct 9	24	8.0	1.37	1.71
Dark "	..	....	....	....	5	M'y 28	" 17	Nov 20	36	4.0	2.03	1.29
....	..	....	....	....	..	......	......	......	..	.....	....	1.14

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
		Chau., C'td							
116	R. T. Rolph	Dunkirk ..	20.3	17.15	84.4	16.29	326	......	......
117	"	" ..	21.9	18.85	86.1	17.91	358	......	......
118	M. M. Fenner	Fredonia ..	21.7	19.10	88.0	18.15	363	54.56	19805
119	"	" ..	21.2	19.50	91.9	18.53	370	......	......
120	H. D. Pangborn...	" ..	20.1	17.65	87.8	16.77	335	......	......
121	" ...	" ..	21.0	18.75	89.3	17.81	356	......	......
122	F. W. Howard	" ..	21.4	18.50	86.4	17.58	351	......	......
123	C. E. Edmunds....	" ..	19.1	16.87	88.5	16.03	321	16.99	5454
124	S. S. Crissey	" ..	20.4	16.70	81.9	15.87	317	19.82	6283
125	Thos. Moran	" ..	23.7	20.65	87.2	19.62	392	13.29	5210
126	John Thies.........	" ..	19.7	16.60	84.3	15.77	315	20.91	6587
127	J. J. Parker.......	" ..	19.5	15.65	80.3	14.87	297	22.32	6629
128	M. M. Fenner	" ..	18.5	16.35	88.3	15.53	311	......	......
129	"	" ..	18.5	17.00	91.9	16.15	223	......	......
130	P. M. Elmer........	Stockton ..	22.3	18.70	83.9	17.77	355	......	......
131	"	" ..	23.2	19.05	82.1	18.10	362	11.13	4029
132	A. J. Swart	Sherman ..	21.2	18.20	85.9	17.29	346	16.99	5879
133	R. E. Bliss	" ..	17.9	13.50	75.4	12.83	256	......	......
134	F. A. Kelsey........	Westfield..	21.7	19.85	91.5	18.86	377	30.49	11497
135	Thomas Craigg	" ..	19.7	15.00	76.1	14.25	285	20.77	5919
136	V. E. Saunders	" ..	24.3	21.00	86.4	19.95	399	18.08	7214
137	S. G. McEwen.....	" ..	18.3	13.10	71.5	12.45	249	12.63	3145
138	Harlon Munsen....	" ..	20.1	15.60	77.6	14.82	296	14.81	4384
139	A. N. Munsen	" ..	21.4	18.45	86.2	17.53	351	12.13	4258
140	"	" ..	20.6	17.10	83.0	16.25	325	......	......
141	Sam Craft..........	" ..	21.0	17.30	82.4	16.44	329	24.39	8024
142	J. H. Damm.......	" ..	21.7	18.00	82.9	17.10	342	13.42	4590
143	W. H. Beedle......	" ..	19.3	16.67	86.3	15.84	317	13.07	4143
144	T. E. Denison	" ..	22.1	20.45	92.5	19.43	389	10.07	3917
145	A. Kelsey...........	" ..	18.5	13.60	73.4	12.92	258	12.94	3339
146	J. LaFlamboy.....	" ..	19.8	17.25	87.1	16.39	328	28.23	9259

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Sandy L....	..	....	....	F. & S.	..	Jun 20	......	Nov 12	..	.....	....	2.07
....	..	....	....	....	..	......	......	......	..	.....	....	1.14
Black " ..	21	Oats	....	....	5	" 4	Jul 2	" 5	30	.....	....	1.84
....	..	....	....	....	..	......	......	......	..	.....	....	1.23
Clay " ..	..	Potatoes ...	'96	....	..	M'y 15	......	" 13	..	.....	....	3.37
....	..	....	....	....	..	......	......	......	..	.....	....	1.18
....	..	....	....	....	..	......	......	......	..	.....	....	1.18
Loam........	15	....	'97	S	5	Jun 1	" 7	" 12	36	7.0	1.41	1.02
Sandy L ..	40	Cabbage ...	....	" 6..	6	M'y 27	Jun 16	Oct 13	30	7.5	1.44	1.72
Gravel " ..	40	Carrots	'95	" ...	3	" 25	" 20	" 12	20	8.5	.73	.84
Sandy " ..	40	Sweet Corn.	'95	" 7..	6	Jun 1	" 22	" 13	24	7.0	1.13	1.24
Clay " ..	70	Onions.....	'95	" 9..	5	M'y 8	M'y 25	" 13	28	9.0	1.83	1.70
....	..	....	....	....	..	......	......	......	..	.....	....	3.41
....	..	....	....	....	..	......	......	......	..	.....	....	1.43
....	..	....	....	....	..	......	......	......	..	.....	....	1.02
Clay " ..	..	Garden.....	'96	" ...	4	M'y 19	Jun 12	" 25	20	14.5	1.04	1.42
" " ..	..	....	'97	....	..	" 10	Jul 23	Nov 20	18	11.0	1.08	.79
" " ..	..	....	'97	....	..	Jun 20	" 21	" 6	..	.....	....	.99
Gravel " ..	..	....	....	....	..	M'y 16	July	" 17	24	6.5	1.50	1.32
" " ..	..	....	....	....	..	" 5	" 15	" 18	22	9.0	1.34	1.33
Sandy " ..	..	....	....	....	4	" 10	" 22	" 18	22	.....	....	1.13
Dark " ..	..	....	....	....	..	" 10	" 14	" 10	36	5.5	.81	2.10
Gravel " ..	..	Mangolds ..	....	....	..	" 16	" 22	" 20	36	8.0	1.42	1.96
" " ..	..	Garden.....	....	....	3	" 16	" 22	" 20	30	7.0	.84	1.61
....	..	....	....	....	..	......	......	......	..	7.0	....	1.59
" " ..	..	Corn	....	....	..	" 5	" 18	" 20	36	8.0	2·28	1.00
" " ..	..	....	....	....	..	" 18	" 23	" 15	18	10.0	.80	.79
Clay " ..	21	....	....	....	1	Jun 16	" 17	" 12	36	10.0	1.50	.99
" " ..	..	....	'97	F.&S.9	1	" 5	" 17	" 10	30	24.0	1.36	.63
Muck........	..	....	....	....	..	Jul. 1	Aug 1	" 8	36	6.0	.90	1.43
Clay L....	..	....	'97	....	..	Jun 3	Jul 15	" 5	30	.....	....	1.33

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau., C'td							
147	Ottaway Bros	Westfield .	22.2	19.20	86.5	18.24	365	17.99	6566
148	H. Shaw	"	20.6	17.65	85.7	16.77	335	26.13	8754
149	O. Freeling	"	20.3	16.28	80.1	15.47	302	22.87	6907
150	S. M. Hosier	"	21.7	19.55	90.3	18.57	371	11.33	4203
151	D. W. Hall........	"	19.0	15.35	80.8	14.58	292	12.26	3580
152	Wm. Schrader	"	21.9	18.95	86.5	18.00	360	27.88	10037
153	F. W. Foster......	"	21.2	17.15	80.9	16.29	326	16.73	5454
154	P. G. Phillips	"	22.2	17.75	80.0	16.86	337	13.29	4479
155	F. R. Thompson...	"	17.0	13.30	78.2	12.64	253	26.46	6694
156	J. W. Spencer.....	"	22.2	18.35	82.7	17.43	349	......	......
157	E. Saunders.......	"	23.3	19.00	81.5	18.05	361	11.16	4029
158	F. A. Hall.........	"	18.8	14.50	77.1	13.78	376	......	......
159	C. R. Colburn.....	"	19.4	16.45	84.8	15.63	313	22.43	7021
160	H. L. Kent	"	20.3	18.00	88.7	17.10	342	19.60	6703
161	"	"	19.2	15.65	81.5	14.87	297	......	......
162	F. L. Monfort	Portland ..	21.0	17.50	83.3	16.63	332	7.18	2384
163	D. W. Douglas....	"	18.5	13.30	86.2	12.64	253	......	......
164	"	"	21.7	16.60	83.0	15.77	315	......	......
165	F. McGinnis.......	"	18.6	14.80	79.6	14.06	281	......	......
166	R. D. Burhans.....	"	20.4	16.85	82.6	16.01	320	4.85	1552
167	R. F. Sternburg ...	Frewsburg	19.5	16.05	82.3	15.25	305	18.51	5646
168	S. Townsend	"	22.3	19.40	87.0	18.43	369	13.07	4823
169	W. Judd	Hamlet ...	17.2	13.10	76.2	12.45	249	10.35	2577
170	"	" ...	15.9	11.75	73.4	11.16	223	......	......
171	C. A. Weaver	D'Wittv'lle	22.2	19.00	85.6	18.05	361	12.89	4653
172	M. P. Nevins	Smith's M.	19.7	16.10	81.7	15.30	306	20.26	6200
173	T. H. Roberts	"	21.9	19.50	89.0	18.53	371	......	......
174	E. R. Howard.....	"	21.7	18.05	83.2	17.15	343	12.94	4438
175	J. Overhiser	"	21.2	18.30	86.3	17.39	348	......	......
176	A. P. Stone	"	23.2	21.00	90.5	19.95	399	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Loam........	..	Turnips....	'97	....	6	Jun 4	Jul 20	Nov 17	20	6.5	.76	.70
Gravel L....	..	....	'97	....	4	" 5	" 15	" 15	18	8.0	1.22	1.32
" "....	..	Mangolds ..	'97	....	5	" 8	" 15	" 12	24	7.5	1.31	1.09
Dark "....	..	Hay........	....	S., 7..	2	" 4	" 20	" 15	36	12.0	1.53	1.39
Clay "....	..	Potatoes ...	'97	....	..	" 5	......	" 18	22	7.5	.61	1.29
Gravel "....	..	Corn.......	'97	....	6	" 10	" 25	" 12	30	5.0	1.33	2.06
Sandy "....	..	....	'97	....	..	" 4	" 15	" 15	24	10.05	1.24	2.25
Clay "....	60	Potatoes ...	'97	F	5	" 1	Jun 21	Oct 11	34	6.0	.87	1.31
" "....	..	Sod	'95	S., 8..	3	" 5	" 18	" 9	24	8.0	1.66	1.82
Sandy "....	..	....	....	....	2	" 1	" 17	" 9	..	......	....	1.14
Gravel "....	..	Vegetables .	'94	S., 6..	2	" 1	" 28	" 11	24	5.0	.44	.68
Clay "....	..	....	....	....	4	" 10	" 25	" 23	..	......	....	2.43
Alluvial......	..	Oats	'97	....	5	" 10	Jul 10	Nov 10	30	9.0	1.84	1.46
Gravel L....	..	....	....	" ..	3	" 2	" 10	......	30	6.5	1.25	1.63
....	..	....	....	....	..	......	......	......	..	......	....	1.27
Gravel "....	..	....	....	" ..	2	M'y 20	" 23	" 10	18	19.0	.80	1.24
Loam "....	50	Carrots	'94	" ..	3	Jun 14	" 26	" 13	18	.....	1.04	1.75
....	..	....	....	....	..	.....	......	......	..	......	....	1.04
Clay "....	..	....	'97	....	..	Jun 10	" 15	" 5	30	8.5	....	1.87
"	..	....	....	" ..	4	M'y 25	Jun 20	Oct 1	36	8.0	.44	.43
Yellow "....	25	Turnips....	'97	S., 10..	4	" 25	" 20	Nov 1	36	6.5	1.42	1.26
Gravel "....	..	Corn.......	'96	" 7..	3	Jun 7	Jul 20	Oct 30	36	7.5	1.15	1.42
Loam	..	Corn.......	'97	....	..	" 1	" 1	" 6	18	9.0	.53	.86
....	..	....	....	....	..	......	......	......	..	......	....	4.94
Sandy L....	..	....	....	....	5	Apr 20	Jun 28	" 9	21	......	....	1.46
Clay "....	60	Potatoes ...	'95	S., 8..	6	M'y 24	" 9	" 14	24	10.5	1.63	1.33
Gravel	..	....	....	....	..	" 25	......	......	..	......	....	1.14
Sandy "....	..	Sod	....	" 9..	3	Jun 5	......	" 22	28	8.0	.91	.99
Clay "....	..	....	....	....	..	M'y 25	......	" 22	..	......	....	.71
Dark "....	..	....	....	" 7..	2	" 25	......	" 22	..	......	....	.83

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau., C'td							
177	E. B. Tolles	Sheridan	19.2	16.15	84.1	15.34	307	14.15	4344
178	M. J. Tooke	"	19.2	16.05	83.6	15.25	305	......	......
179	Wm. Wallert	"	19.2	15.80	82.3	15.01	300	37.95	11385
180	E. E. Hamlet	"	20.8	17.90	86.1	17.01	340	19.82	6739
181	L. Harmon	Brockton	20.0	17.90	89.5	17.01	340	......	......
182	A. M. Gardner	"	20.0	16.85	84.3	16.01	320	18.79	6013
183	D. G. Smith	Hanover	19.3	16.30	84.4	15.49	310	......	......
184	J. P. Clark	Falconer	21.5	18.00	83.7	17.10	342	16.90	5780
185	J. E. Bonney	Irwin	20.4	16.50	80.9	15.68	314	......	......
		Erie.							
186	J. Buzenburg*	Brant	18.1	15.00	82.9	14.25	285	11.87	3383
187	E. G. Fenton*	Fenton	16.5	13.00	78.8	12.35	257	28.75	7389
188	M. J. Brown*	"	22.3	20.15	90.4	19.14	383	19.00	7277
189	J. Russell*	"	22.5	19.50	86.7	18.53	371	......	......
190	Benj. Fenton*	"	22.8	20.85	91.5	19.81	396	16.55	6554
191	"	"	20.1	18.10	90.0	17.20	344	16.55	5693
192	Jas. Bufton*	"	22.5	20.35	90.4	19.33	387	......	......
193	J. A. Fenton*	"	22.2	19.55	88.0	18.57	371	......	......
194	"	"	21.7	18.75	86.6	17.81	356	37.46	13336
195	E. G. Fenton*	"	17.2	13.50	75.8	12.83	257	......	......
196	"	"	17.6	13.75	78.1	13.06	261	......	......
197	Wm. Krull*	"	19.1	15.80	82.7	15.01	300	27.01	8103
198	M. J. Brown*	"	20.4	18.05	88.5	17.15	343	20.04	6874
199	"	"	22.0	19.85	90.2	18.86	377	......	......
200	"	"	20.4	18.50	90.7	17.58	352	......	......
201	"	"	21.9	20.85	95.2	19.81	396	15.25	6039
202	"	"	20.6	18.75	91.0	17.81	356	......	......
203	Geo. J. Martin*	"	20.6	17.60	85.4	16.72	334	19.20	6413
204	P. Privater*	"	23.7	21.50	90.7	20.43	409	15.68	6413

* Through the courtesy of Mr. C. M. Fenton, of the Erie Preserving Co., the Station has received samples of beets for analysis from the above "starred" parties.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Gravel L....	85	Sod	'95	S., 6..	4	M'y 25	Jun 10	Oct 13	24	9.5	1.05	1.07
" "....	85	Potatoes	....	....	..	" 26	Never	" 13	..	....	....	.75
Clay "....	30	Onions....	'97	" 7..	..	Jun 15	Jul 10	Nov 9	18	7.5	1.63	1.47
Gravel "....	75	....	....	....	2	" 2	....	" 5	21	6.5	.84	1.17
Sandy "....	..	....	....	....	..	M'y 26	Jul 19	" 12	..	....	....	1.36
Clay "....	40	Potatoes	'95	" 5..	4	" 25	Jun 16	" 12	36	8.0	1.67	1.47
Gravel	..	....	....	"	..	....	....	Oct 29	..	....	....	.70
Sandy "....	..	Garden....	....	" 8..	3	Jun 5	Jul 10	" 9	24	7.0	.86	.55
Alluv'l "....	..	....	....	....	1	" 22	....	" 23	..	....	....	1.14
Sandy L....	50	Cabbage	....	S ..	4	M'y 15	Jun 8	Oct 16	36	8.0	1.14	.67
Sandy "....	..	....	'97	" ..	7	Apr 16	M'y 25	" 21	30	9.0	2.54	2.31
" "....	..	Beans....	....	" 7..	2	" 15	" 20	" 27	16	....	....	.92
Clay "....	..	....	....	....	..	Jun 1	Jul 1	" 25	..	....	....	1.13
" "....	20	....	....	" 8..	..	M'y 25	Jun 10	" 13	18	9.0	.84	.79
" "....	20	....	....	" 8..	..	" 25	" 10	" 13	18	9.0	.84	.55
Sandy "....	..	....	....	....	..	" 20	" 15	" 20	..	....	....	1.05
Clay "....	..	....	....	....	..	" 25	....	....	..	....	....	.65
" "....	15	Peas, Beans.	....	" 8..	..	" 25	" 15	" 5	18	8.0	1.76	1.09
....	..	....	....	....	..	....	....	....	..	....	....	2.72
....	..	....	....	....	..	....	....	....	..	....	....	5.46
Clay "....	30	....	....	" 8..	5	" 8	M'y 20	" 6	18	9.0	1.28	1.34
" "....	15	Peas	....	" 8..	..	Jun 3	Jun 20	Sep 26	18	7.5	.87	1.76
....	..	....	....	....	..	....	....	....	..	....	....	1.17
....	..	....	....	....	..	....	....	....	..	....	....	1.10
Clay "....	..	Peas	'96	" 8..	3	M'y 25	" 20	Oct 12	18	8.0	.72	.69
" "....	..	....	....	....	..	" 25	" 20	Nov 1	..	....	....	1.16
Sandy "....	..	....	....	" 8..	2	Jun 2	" 24	Oct 18	..	....	....	.91
Clay "....	22	Cereals	....	" 8..	..	M'y 27	" 26	" 13	18	8.5	.75	.57

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Erie, C'td.							
205	Emery Coffram*...	Fenton....	22.6	19.65	87.0	18.67	373	14.00	5222
206	W. Taft*..........	"	21.0	17.45	83.1	16.58	332	14.00	4648
207	J. H. Bragg	S. Wales ..	21.5	18.65	86.7	17.72	354	5.36	1897
208	Chas. Benson......	" ..	21.5	19.00	88.6	18.05	361	......	......
209	A. Wade, Jr.......	Farnham..	21.5	18.90	87.9	17.96	359	......	......
210	Chas. N. Cook*....	" ..	21.9	19.65	89.7	18.67	373	16.55	6173
211	Chas. Crawford* ..	" ..	19.5	16.15	82.8	15.34	307	21.33	6548
212	Wm. Thuerk*	" ..	22.3	19.95	89.5	18.95	379	8.45	3203
213	Chas. Nertling* ...	" ..	20.6	17.25	83.7	16.39	328	......	......
214	J. C. Winters*	Brant.....	20.2	18.90	93.6	17.96	359	17.04	6117
215	David George*	"	18.6	13.60	73.1	12.92	258	......	......
216	J. Buzenburg*	"	20.8	18.50	88.9	17.58	352	18.00	63.36
217	" ...	"	20.8	18.80	90.4	17.86	357	18.00	6426
218	Mrs. F. Poodry*...	"	20.3	15 85	78.1	15.06	301	......	......
219	J. C. Winters*	"	21.2	19.05	89.9	18.10	362	9.58	3468
220	S. A. Parker*	"	19.9	16.90	84.9	16.06	321	18.00	5778
221	E. H. Babcock	Eden Cen .	19.3	16.50	85.5	15.68	314	......	......
222	G. E. Kister.......	" .	19.3	15.65	81.1	14.87	297	26.68	7924
223	Wm. Taft	N. Collins.	19.5	15.40	79.0	14.63	293	14.60	4278
224	F. J. Quigley	Collins....	21.2	18.45	87.0	17.53	351	......	......
225	A. Cervis*	Orchard P.	20.8	18.05	86.8	17.15	343	14.16	4857
		Genesee.							
226	D. L. Graham	Batavia...	19.1	15.60	81.7	14.82	296	10.34	3061
227	M. W. Oderkirk...	" ...	16.5	14.25	83.4	13.54	271	16.95	4598
228	John Moore	" ...	19.5	14.94	76.7	14.20	284	14.71	4178
229	W. R. Bigelow	" ...	22.2	19.00	85.6	18.05	361	8.06	2910
230	Pratt Bros	" ...	22.8	20.00	87.7	19.00	380	8.49	3226

* Through the courtesy of Mr. C. M. Fenton of the Erie Preserving Co., the Station has received samples of beets for analysis from the above "starred" parties.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Clay L....	..	Hay	....	S	6	M'y 20	Jun 20	Oct 12	..	.....	....	.75
" "...	..	.....	....	.....	..	" 25	" 28	" 13	..	.....	....	1.27
Muck "...	12	Turnips	'97	"	3	" 18	" 24	" 28	36	7.0	.42	.64
" "...	50	.....	'97	S., 7..	3	Jun 15	Jul 20	Nov 20	16	5.0	....	.60
Clay	..	.....	....	.....	2	" 6	" 1	Oct 13	18	.....	....	.89
Bottom L....	15	.....	....	" 8..	..	M'y 17	" 1	" 12	18	12.5	1.19	1.20
Sandy "...	20	.....	....	" 8..	3	" 27	" 18	Nov 6	18	9.0	1.08	1.21
" "...	..	.....	....	" ..	3	Jun 10	" 10	" 12	22	16.0	.94	.75
Clay "...	..	.....	....	.....	..	M'y 23	Jun 10	Oct 20	..	.....	....	1.43
Sandy "...	30	Corn	'95	" 6..	4	" 20	" 16	" 16	24	7.5	.98	.93
.....	..	.....	....	.....	..	Jun 10	Jul 1	" 20	..	.....	....	1.15
.....	..	.....	....	.....	..	M'y 26	Jun 20	" 13	..	.....	....	.92
.....	..	.....	....	.....	..	" 26	" 20	" 13	..	.....	....	.68
.....	..	.....	....	.....	..	Jun 25	Jul 17	" 20	..	.....	....	.72
.....	..	.....	....	" 6..	3	M'y 15	Jun 10	" 13	18	15.0	.83	.82
.....	..	.....	....	.....	..	" 20	" 25	" 13	..	.....	....	.60
Sandy L....	40	Strawberr's	....	" 5..	1	Jul 1	Jul 18	" 19	..	.....	....	1.10
" "...	60	Corn	'96	Fall 5.	4	Jun 4	Jun 27	" 19	24	8.0	1.66	1.43
Heavy "...	..	Potatoes ...	'97	S., 6..	2	M'y 20	Aug 10	" 21	30	.....	1.26	1.33
.....	..	.....	....	.....	..	.....	.....	.....	..	.....	....	.37
Sandy "...	40	Garden	'97	" 4..	4	" 20	Jul 7	Nov 15	18	8.0	.66	.66
Dark L....	..	Beets	'97	S	5	Jun 1	Jul 27	Oct 9	28	9.0	.83	1.00
Sandy "...	..	.....	'97	S., 8..	5	M'y 24	Jun 27	" 13	18	8.0	.73	1.09
" "...	..	.....	....	.....	1	Jun 3	Jul 29	Nov 18	19	14.0	1.27	.96
Clay	50	Sod	....	" 8..	8	M'y 20	Jun 25	Oct 16	36	11.5	1.09	.70
"	..	Alfalfa	....	" 8..	3	" 27	.....	" 9	18	11.0	.54	.50

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Gen., Ct'd							
231	O. Marsh	Batavia	20.0	16.00	80.0	15.20	304	13.83	4204
232	Mrs. K. Slager	"	17.4	14.60	83.9	13.87	277	......	.....
233	E. Hirsch	"	18.6	14.85	79.9	14.11	282	11.41	3218
234	L. O. Campbell	"	21.5	17.20	80.0	16.34	327	15.43	5046
235	H. Huntington	"	19.7	16.15	82.0	15.34	307	11.47	3521
236	A. Prole	"	19.7	15.35	77.9	14.58	292	7.29	2129
237	H. Putnam	"	17.7	14.00	79.1	13.30	266	16.06	4272
238	C. Brumsted	"	19.5	16.20	83.0	15.39	308	11.94	3678
239	J. G. Fargo	"	19.7	15.60	78.6	14.82	296	15.63	4626
240	W. N. Torrence	"	17.9	14.00	78.2	13.30	266	9.80	2607
241	H. L. Foster	"	19.3	16.20	83.9	15.39	308	11.81	3637
242	C. Pratt	"	23.7	19.40	80.0	18.43	369	13.07	4823
243	C. L. Gillett	"	17.2	13.35	77.6	12.68	254	15.85	4026
244	O. Harris	"	19.3	15.15	78.5	14.39	288	20.88	6013
245	A. G. Collins	"	18.6	14.90	80.1	14.16	283	7.26	2055
246	L. Scoville	"	19.5	16.70	85.7	15.86	317	4.19	1328
247	E. O. Bratt	"	20.2	17.05	84.4	16.20	324	12.03	3898
248	J. F. Post	"	20.6	17.90	86.9	17.00	340	10.97	3730
249	W. Tyrell	"	19.3	16.05	83.1	15.25	305	3.32	1013
250	G. Hayden	"	20.0	17.60	88.0	16.72	334	7.20	2405
251	W. S. Spink	"	17.9	14.90	83.2	14.16	283	......	......
252	W. H. Uphill	W. Batavia	19.3	16.30	84.5	15.49	310	15.30	4743
253	Wm. Heywood	Stafford	20.0	17.00	85.0	16.15	323	10.78	3482
254	"	"	19.5	15.90	81.6	15.11	302	10.78	3256
255	J. S. Combs	"	20.9	17.55	84.9	16.68	334	14.59	4873
256	J. F. Stutterd	"	19.1	15.10	79.1	14.35	287	11.43	3280
257	R. Call	"	20.0	16.90	84.5	16.06	321	11.11	3566
258	Jas. Linsler	"	19.8	16.40	82.8	15.58	312	12.41	3872
259	John Heywood, Jr.	"	20.8	17.55	86.3	16.68	334	6.64	2218
260	J. Lathrop	Morganv'le	21.9	18.15	82.9	17.24	345	20.24	6983

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Marl	..		'95	S	5	M'y 20	Jun 16	Oct 23	30	7.5	.99	1.52
Bl'k Muck	..				3	Jun 1	" 15	" 23	..			1.51
Sandy L.	..	Potatoes	'96	" ...	2	M'y 15	" 28	" 8	20	10.5	.77	1.36
" "	..			" 8..	3	" 10	" 10	" 9	22	7.5	.82	1.30
" "	..	Potatoes		" ...	6	" 28	" 29	" 8	28	11.0	1.11	1.21
Gravel "	..				2	Jun 1	Aug 1	" 9	28	7.0	.51	.66
Loam	..				4	M'y 13	Jul 3	" 6	28	10.0	1.44	1.76
Gravel L.	..				6	" 2	Jun 25	" 8	20	13.5	1.05	1 31
Sandy "	75	Nurs'ry Stk	'95	" 9..	5	Jun 2	" 14	" 8	32	7.0	1.14	1.56
" "	45	Grass		" 7..	6	M'y 25	Jul 12	" 8	36	11.5	1.32	1.37
" "	..	Corn	'97	" 7..	3	" 20	" 10	" 8	18	8.5	.54	.93
Gravel "	..			" ...	2	Jun 1	" 7	" 5	30	8.0	.97	.94
Alluv. "	10		'97		6	M'y 1	" 3	" 5	36	8.0	1.49	1.57
Sandy "	9		'97		5	" 10	" 10	" 6	28	8.5	1.60	1.45
Alluv. "	..	Sod	'97		6	Jun 15	" 25	" 5	30	11.5	.81	1.29
Muck "	..				1	" 1	Late .	" 4	18	8.5	.20	.20
Sandy "	..				3	M'y 15	Jul 3	" 4	24	7.0	.63	.60
Gravel "	30		'97		4	" 20	" 10	" 5	36	8.0	1.03	1.06
Sandy "	..				7	" 25	" ..	" 5	30	17.0	.54	.75
Dark "	..				..			" 5	36	9.0	.78	.69
" "	..				..			" 6				.65
Gravel "	..	Beets			..	Jun 10	" 3	" 26	24	9.0	1.06	1.23
Loam	..			" ...	2			" 11	28	8.5	.81	1.07
"	..			" ...	2	" 5		" 11	28	9.0	.85	.95
Sandy L.	..	Beets	'97	" ...	..			" 12	24	6.5	.74	1.04
" "	100	Oats, Peas	'97	" ...	5	M'y 20	Jun 28	" 12	36	9.0	1.19	1.13
Dark "	..			" ...	3	" 27		" 12	28	8·5	.85	.96
Sandy "	..	Beets	'97	" 8..	8	" 20	" 16	" 8	32	6.0	.79	1.13
" "	..		'97	" ...	4	Jun 15	Jul 15	" 11	32	12.5	.85	.89
Clay "	80			" ...	6	" 10	Aug 1	" 12	18	6.5	.76	.77

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Gen., C'td.							
261	H. Radley..........	Morganv'le	18.8	16.50	87.8	15.68	314	11.03	3463
262	J. W. Bater	"	19.2	16.10	83.8	15.30	306	16.60	5080
263	J. Simmons	"	21.3	17.50	82.2	16.62	332	......	......
264	T. O. Parminter ...	"	21.7	18.80	86.6	17.86	357	16.99	6065
265	Thos. Marsh	Byron.....	23.0	19.60	85.2	18.62	372	12.93	4810
266	W. A. Walker	"	20.4	17.50	85.8	16.62	332	12.20	4050
267	I. W. White........	"	20.4	18.00	88.2	17.10	342	23.52	8044
268	H. C. Norton......	"	18.5	14.50	78.4	13.77	275	15.40	4235
269	W. J. Tyler	S. Byron..	19.3	15.15	78.5	14.39	288	18.08	5207
270	I. Durfee..........	" ..	18.6	14.60	78.5	13.87	277	12.75	3532
271	J. R. Norton	Davis	17.2	13.80	80.2	13.11	262	13.39	3508
272	A. H. Olmstead ...	LeRoy	18.6	14.05	75.5	13.35	267	12.96	3460
273	Jas. Forsyth	New Kirk .	20.9	17.65	84.4	16.77	335	13.61	4559
274	J. R. Fotch	"	20.4	17.10	83.8	16.25	325	5.93	1927
275	D. G. Frazer	Alexander.	18.8	14.65	77.9	13.92	278	11.39	3166
276	T. W. Fansen	Bergen....	21.0	18.80	89.5	17.86	357	17.26	6162
277	J. C. O'Brien......	"	22.2	19.55	88.0	18.57	371	13.30	4934
278	C. W. Maybeck....	N. Bergen.	22.3	18.95	85.0	18.00	360	8.17	2941
279	B. D. Harkness....	Elba	20.6	17.85	86.6	16.96	339	12.20	4136
280	E. M. Vail	E. Oakfield	21.5	17.75	82.6	16.86	337	......	......
281	J. Cleveland	E.P'mbr'ke	21.0	18.40	87.6	17.48	350	16.39	5737
282	L. Mallory	"	22.5	19.35	86.0	18.38	368	17.26	6352
283	L. F. Lyman	"	18.8	15.35	81.6	14.58	292	14.48	4228
284	H. Beckwith	N. "	19.7	15.85	80.5	15.06	301	16.83	5066
285	T. Harding........	Bethany ..	23.0	19.80	86.1	18.81	376	17.04	6407
286	W. M. Crawford...	W. B'th'ny	22.1	18.60	84.1	17.67	353	11.33	3999
287	E. C. Norton	"	19.9	17.05	85.6	16.20	324	16.67	5401
		Herkimer.							
288	Wm. McKerrow ...	Middleville	17.5	13.85	79.2	13.16	263	16.77	4411

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Gravel L....	..	Clover	'95	S., 6..	4	M'y 25	Jun 25	Oct 13	34	10.0	1.17	1.16
Sandy "....	..	....	'97	" ...	2	" 28	Jul 10	" 13	18	9.0	.88	1.18
Lime rock ...	..	....	....	......	..	......	......	" 20	..	.....	....	1.19
Sandy L....	..	....	....	" ...	1	Jun 3	......	" 12	24	3.0	.42	.63
Loam	..	....	....	" ...	2	" 5	" 15	" 15	24	7.0	.68	1.04
Dark L....	..	Corn	'96	" 7..	2	M'y 13	" 6	" 15	24	8.5	.81	1.15
Gravel "....	..	Celery	....	S	3	" 19	Jun 25	" 15	24	6.0	1.06	1.29
Dark "....	..	....	'97	S., 8..	9	" 20	......	" 15	36	12.0	2.13	1.30
Gravel "....	..	....	'95	" 9..	4	Jun 15	Jul 15	" 13	34	10.0	1.94	1.73
Stiff "....	14	....	'97	" 9..	9	M'y 14	Jun 10	" 13	36	12.0	1.75	1.28
Black "....	..	Mangolds ..	'96	" ...	2	" 20	" 25	" 5	2	5.0	.44	.99
Loam.......	..	....	....	S	5	" 25	Jul 10	" 7	28	9.0	1.04	1.18
Gravel L....	20	Beets	'94	S., 8..	4	" 1	M'y 20	" 5	32	8.0	1.12	1.74
Clay "....	70	Pasture	....	" ...	6	" 14	Jul 10	" 5	32	6.5	.40	1.02
Stiff "....	..	....	....	" 7..	6	Jun 12	" 12	" 6	28	10.0	1.00	.91
Dark "....	..	Mangolds ..	'96	" 8..	8	......	......	......	22	10.0	1.52	1.08
Clay "....	..	....	'97	" 8..	5	M'y 15	Jun 15	" 14	28	7.5	.91	1.07
Sandy "....	..	....	'95	" 8..	4	" 15	......	" 16	30	5.0	.38	.47
" "....	40	Cabbage ...	....	" 7..	3	" 19	Jul 12	" 20	28	.....	....	.92
....	..	....	....	......	..	......	" 5	" 20	24	.....	1.00	1.14
Sandy "....	..	....		......	..	Jun 1	" 15	" 23	20	11.0	1.21	1.30
Loam.......	65	T. Hay.....	....	" 8..	3	M'y 29	Jun 28	" 27	36	6.5	1.32	1.26
Sandy L....	20	Mangolds ..	....	" 7..	4	" 20	" 30	" 19	30	10.0	1.41	1.34
" "....	..	Corn	'95	" 8..	5	" 20	Jul 10	" 21	36	8.0	1.57	1.03
Clay "....	3	Beets	....	" 8..	3	Jun 6	" 20	" 26	32	6.5	1.11	1.16
" "....	..	Orchard....	'96	" ...	..	M'y 29	" 1	Nov 5	36	9.0	1.14	1.13
Dark "....	3	Corn	'97	" 8..	..	Jun 5	......	Nov 10	18	6.0	.58	.60
Gravel "....	..	Corn.......	....	S., 9..	6	M'y 28	Jun 30	Oct 6	36	11	1.08	1.75

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Jefferson.							
289	W. J. Tilley.......	Plessis	22.0	18.65	84.8	17.72	354	......	......
290	Frank Favery.....	Chaumont.	18.1	13.03	72.0	12.38	248	......	......
291	Geo. B. McMullin .	E.Hounds'f	19.5	16.80	86.2	15.96	319	21.78	6948
292	D. M. Greene......	Adams	21.5	18.65	86.8	17.72	354	......	......
293	"	"	19.5	16.85	86.4	16.01	320	15.95	5104
294	"	"	16.5	13.00	78.8	12.35	247	......	......
295	"	"	17.7	14.50	81.9	13.78	276	......	......
296	"	"	18.3	15.00	82.0	14.25	285	......	......
297	"	"	19.5	16.35	83.8	15.53	311	......	......
298	"	"	19.9	17.40	87.4	16.53	331	......	......
299	"	"	18.8	16.25	86.4	15.44	309	.....	......
300	"	"	18.3	15.00	82.0	14.25	285	......	......
301	"	"	18.3	15.65	85.5	14.87	297	......	......
302	"	"	17.0	14 55	85,6	13.82	276	......	......
303	"	"	20.9	17.90	85.7	17.01	340	......	......
304	"	"	19.9	17.00	85.4	16.15	323	......	......
		Livingston							
305	C. D. Edwards	N. Sparta .	22.5	19.25	85.6	18.29	365	10.45	3824
		Monroe.							
306	F. W. Brower	Churchv'le	19.7	18.45	93.6	17.53	351	......	......
307	J. M. Carver	"	21.7	19.10	88.0	18.15	363	12.41	4505
308	H. P. Dusinberry..	"	19.4	16.55	85.3	15.72	314	12.35	3878
309	Jas. Easton	"	19.9	16.65	83.7	15.82	316	7.97	2519
310	G. A. Young.......	"	19.5	15.85	81.3	15.07	301	14.95	4500
311	S. L. Payne	"	20.4	17.95	88.0	17.05	341	6.67	2274
312	J. L. Bangs	"	18.3	15.55	85.0	14.77	295	13.94	4112
313	F. D. Palmer......	"	21.9	19.95	91.1	18.98	380	12 63	4799
314	A. McIntosh.......	"	19.7	16.00	81.2	15.20	304	8.93	2715
315	C. W. Banister	"	20.6	18.30	88.8	17.39	348	6.53	2272

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Muck........	..	Clover	....	F	6	Jun 12	......	Oct 11	..	.....	....	1.34
Clay	..	....	....	......	3	" 15	Jul 28	" 28	16	.....	....	1.31
Sand	..	Sod	....	" 7....	3	M'y 21	Jun 10	" 26	18	4.0	1.04	.81
....	..	....	....	....	15	......	......	Nov 3	..	.....	....	.68
Gravel L	..	Beans	....	F. & S.	15	" 13	......	Oct 4	..	.....	1.89	1.54
" "	..	"	....	"	15	" 13	......	" 4	..	.....	....	1.56
" "	..	"	....	"	15	" 13	......	" 4		.....	....	1.49
" "	..	"	....	"	15	" 13	......	" 4	..	.....	....	1.79
" "	..	"	....	"	15	" 13	......	" 4	..	.....	....	1.37
" "	..	"	....	"	8	" 13	......	" 4	..	.....	1.84	1.43
" "	..	"	....	"	8	" 13	......	" 4	..	.....	....	1.25
" "	..	"	....	"	8	" 13	......	" 4		.....	....	1.88
" "	..	"	....	"	8	" 13	......	" 4	..	.....	....	1.62
" "	..	"	....	"	8	" 13	......	" 4	..	.....	....	1.09
" "	..	"	....	"	15	" 13	......	" 4	..	.....	1.80	1.42
" "	..	"	....	"	8	" 13	......	" 4	.	.....	1.63	1.50
Clay "	40	Oats, Peas..	'97	S., 6..	1	" 18	Jun 26	Oct 21	24	9.0	.73	.54
Sandy L	40	Corn	'95	S., 8..	1	Jun 1	Aug 4	Oct 14	..	.....	....	.52
Clay "	60	Cabbage ...	'97	" 6..	3	M'y 18	Jul 20	" 15	28	10.0	1.11	.89
" "	65	Corn	'96	" 8..	8	" 19	Jun 16	" 15	30	8.0	.95	1.18
" "	50	Potatoes ..	'96	" 6..	5	Jun 3	Jul 5	" 18	36	10.0	.82	.75
Sandy "	..	....	....	" ...	2	" 1	......	" 18	28	6.0	.84	1.06
" "	..	....	....	" ...	5	M'y 18	Jul 15	" 18	36	8.0	.61	.77
Gravel "	60	....	....	" 10..	6	" 8	" 10	" 15	30	9.0	1.20	1.02
Clay "	60	Cabbage ...	'96	" 7..	3	" 13	" 25	" 16	24	15.0	1.21	.97
" "	65	Garden	'96	" 8..	8	" 4	Jun 10	" 15	30	7.0	.61	.98
" "	65	....	....	" 5..	7	" 18	Jul 5	" 14	32	8.0	.64	.90

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Mon., C'td.							
316	Geo. Savage........	Churchv'le	20.4	17.30	84.8	16.44	329	26.48	8712
317	Hiram Sage	"	21.2	17.05	80.4	16.20	324	21.13	6846
318	Wm. Bailey	"	21.9	19.65	89.7	18.67	373	15.03	5606
319	Spencer Day	"	23.0	20.40	88.7	19.38	388	19.27	7477
320	C. M. Emery	"	20.6	17.60	85.4	16.72	334	12.58	4202
321	J. Robertson	"	22.6	18.90	83.6	17.96	359	12.20	4380
322	H. J. May..........	"	22.0	18.40	83.6	17.48	350	11.94	4179
323	L. D. Bangs........	"	21.3	17.25	81.0	16.39	328	17.26	5661
324	Henry Dewey	"	20.6	17.10	83.0	16.25	325	17.42	5662
325	E. S. Parnell......	"	17.2	12.85	74.7	12.21	244	......	......
326	"	"	17.0	12.90	75.9	12.26	245	......	......
327	"	"	19.3	16.15	83.7	15.34	307	......	......
328	Jas. Wilson	"	20.8	17.85	85.8	16.96	339	13.96	4732
329	F. T. Kurtz	"	19.7	15.75	80.0	14.96	299	15.79	4721
330	T. Perry	"	20.8	18.50	88.9	17.58	351	9.47	3324
331	W. Lehman	"	20.6	18.45	89.6	17.53	351	19.11	6708
332	Geo. Brodie	"	21.5	18.40	85.6	17.48	350	7.19	2517
333	Thos. Dick	"	18.6	17.50	94.1	16.63	323	12.52	4044
334	Geo. Stewart.......	"	17.0	13.95	82.1	13.25	265	7.94	2104
335	C. Schneiter	"	21.7	18.20	86.9	17.29	346	14.15	4896
336	H. W. Davis	"	21.3	18.70	87.8	17.77	355	22.32	7924
337	A. Bebee	Riga......	20.0	14.40	72.2	13.68	274	10.45	2863
338	Wm. Bell	"	21.9	18.85	86.1	17.91	358	14.54	5205
339	Chas. Lear	"	23.9	20.10	84.1	19.10	382	13.47	5146
340	J. A. Moule	"	19.5	15.20	78.0	14.44	289	11.68	3376
341	John Amesbury ...	"	21.9	16.75	76.5	15.91	318	......	......
342	John Brodie........	"	19.7	16.45	83.5	15.63	313	14.32	4482
343	A. A. Palmer......	"	21.0	7.35	82.6	16.48	330	20.69	6828

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Clay L....	65	Mangolds ..	'96	S., 9..	3	M'y 10	Jun 21	Oct 16	18	10.5	1.54	1.23
" "....	70	....	'96	" 8..	3	" 18	" 20	" 19	16	6.5	.69	1.07
" "....	65	Cabbage ...	'96	" 8..	6	" 7	" 16	" 19	24	9.0	1.07	1.07
Sandy "....	65	Potatoes ...	....	" 8..	4	" 11	" 12	" 16	16	6.0	.62	.76
Black M'rl...	25	" ...	'96	" 7..	3	" 20	Jul 19	" 16	16	10.0	.66	.63
Clay L....	70	....	....	" 8..	6	" 10	Jun 25	" 19	32	9.0	1.08	1.17
" "....	70	Cabbage ...	....	" 11..	5	" 12	" 10	" 14	32	6.5	.73	1.12
" "....	65	Potatoes ...	'92	" 9..	3	" 21	" 20	" 14	28	7.5	1.14	1.05
" "....	20	....	....	" 8..	5	" 16	" 12	" 14	28	12.5	1.95	1.46
" "....	20	....	'96	" 6..	1	" 18	" 22	" 19	..	......	....	1.74
Sandy "....	20	....	....	" 6..	1	" 18	" 22	" 19	..	......	....	.95
Black "....	15	Oats	'97	" 8..	..	" 18	Jul 19	" 19	..	......	....	1.02
Clay "....	..	....	....	" 6..	8	" 16	Jun 20	" 18	36	5.0	.84	1.12
Light "....	65	Cabbage ...	'95	" 7..	5	" 5	" 12	" 19	30	7.5	1.12	1.06
" "....	60	Grass	'96	" 7..	4	" 15	Jul 10	" 16	28	15.0	1.28	.98
Clay "....	50	Potatoes ...	'97	" 7..	5	" 20	Jun 20	" 16	28	9.5	1.62	1.03
" "....	65	Corn	'96	" 7..	6	" 20	Jul 6	" 15	28	10.0	.65	.91
Loam.......	..	....	'96	S.&F.8	4	" 21	" 1	" 14	30	7.5	.90	1.00
Clay L....	50	Mangolds ..	....	S., 8..	4	" 4	" 3	" 19	33	12.5	1.12	.85
" "....	65	Hay	....	" 7..	6	" 20	Jun 30	" 19	32	10.5	1.54	1.07
Lime St	..	....	'94	" 10..	3	" 14	......	" 14	18	7.5	.95	.97
Clay L....	65	....	'92	" 7..	7	" 24	Jul 2	" 18	36	9.5	1.17	.99
"	..	....	....	" ...	7	" 15	......	" 19	24	7.5	.82	.92
Muck "....	..	....	....	" ...	5	" 24	......	" 14	30	7.0	.87	.84
" "....	30	....	....	" 8..	3	Jun 3	" 15	" 19	28	14.0	1.45	1.21
Clay "....	65	Corn	'93	" 8..	8	M'y 15	Jun 16	" 18	..	......	....	.80
Stiff "....	..	....	'97	" ...	6	" 21	......	" 19	30	8.0	1.08	1.22
Clay "....	65	....	'92	" 9..	5	" 7	" 10	" 18	28	8.0	1.58	1.34

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
		Mon., C'td.							
344	D. D. Church	Riga	19.7	16.60	81.2	15.20	304	19.06	5794
345	C. F. Apthorp	"	19.2	15.70	81.8	14.92	298	15.19	4527
346	John Atwater	"	20.4	17.30	84.8	16.44	329	......	......
347	Geo. A. Johnson ...	"	20.4	16.15	79.1	15.34	307	19.82	6085
348	Geo. McConell	"	21.0	17.00	81.0	16.15	323	15.66	5058
349	R. Garrison	Brockport.	20.5	17.15	83.6	16.29	326	10.67	3478
350	G. W. Sime	"	20.9	17.80	85.2	16.91	338	18.73	6331
351	W. H. Dobbin	Fairport ..	......	15.35	76.0	14.58	292	......	......
352	A. W. Lumdell	Rochester.	......	18.90	90.9	17.96	359	......	......
353	Brown Bros. Co ...	"	18.8	15.55	82.7	14.77	295	......	......
354	M. B. Batcheller ...	Webster ..	21.7	18.00	82.9	17.10	342	23.96	8194
355	H. S. Curtis	Ridgeland.	18.1	13.75	75.9	13.06	261	9.37	2446
356	J. B. Johnston	Chili Sta..	23.3	18.10	81.9	17.19	344	14.48	4981
357	G. Denel	N. Chili...	19.9	17.10	85.9	16.25	325	24.83	8070
358	A. Fairbanks	"	20.4	17.45	85.5	16.58	332	13.45	4465
359	M. H. Cusick	Clarkson..	26.3	21.70	82.5	20.62	412	15.90	6551
360	Mrs. L. Patterson .	"	18.8	14.80	78.7	14.06	281	21.78	6120
361	Ara Wilkinson	"	21.1	17.70	83.9	16.82	336	17.64	5927
362	"	"	21.1	17.75	84.1	16.86	337	13.61	4587
363	Geo. P. Hill	Ogden	18.6	15.75	84.7	14.96	299	21.78	6512
364	J. C. E. Hill	"	18.5	17.00	91.9	16.15	323	15.48	5000
365	H. D. Scribner	"	21.7	19.10	88.0	18.15	363	23.74	8[illegible]18
		M'tgomery							
366	A. Van Alstine	Canajoharie	17.2	12.90	75.0	12.26	245	......	......
367	J. W. Shults	"	20.0	16.85	84.3	16.01	320	......	......
368	E. Countryman	"	19.7	15.50	78.7	14.73	295	......	......
		Niagara.							
369	Lockner & Delaney	Lockport..	20.4	15.80	77.5	15.01	300	......	......
370	R. Bewley	" ..	21.9	18.20	83.1	17.29	346	27.00	9342

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Clay L....	70	....	'95	S., 9..	6	M'y 26	Jul 1	Oct 16	28	9.0	1.56	1.02
Alluvial "....	..	....	....	" 8..	4	" 10	Jun 16	" 16	28	6.0	.75	1.34
Clay "....	..	....	....	" ...	6	" 10	......	" 15	..	.....	....	1.36
" "....	..	....	....	" 8..	7	" 15	Jun 15	" 14	28	7.0	1.32	1.39
" "....	..	....	....	" 8..	5	" 16	......	" 19	30	8.0	1.24	1.34
" "....	75	Grass	'96	" 9..	10	" 25	" 26	" 11	28	10.0	.94	.98
Gravel "....	..	Beans......	'96	" 7..	6	Jun 2	Jul 3	" 12	24	9.0	1.28	.96
....	..	....	....	......	..	......	......	......	..	.....	....	1.82
....	..	....	....	......	..	......	......	......	..	.....	....	1.63
....	..	....	....	......	..	......	......	......	..	.....	....	1.65
Sandy L....	20	Garden	'97	" 4..	4	M'y 15	Jun 15	Nov 5	20	9.0	1.37	1.24
Black "....	..	Onions.....	....	......	7	Jun 11	Jul 28	Oct 21	30	8.0	.72	.76
Clay "....	..	Corn	'94	F.&S..7	6	M'y 7	Jun 10	" 5	24	8.0	.85	.94
Dark "....	18	Carrots	'95	S., 8..	5	" 10	" 14	" 14	28	7.0	1.52	1.64
Clay "....	60	Hog yard ..	....	" 8..	8	" 10	Jul 12	" 16	30	9.5	1.26	1.12
" "....	65	Beets	'96	" 8..	7	" 8	M'y 24	" 13	20	9.5	.99	1.11
" "....	80	....	'97	" 6..	11	" 25	Jun 25	" 10	24	8.5	1.43	1.52
" "....	75	Beans	....	" 7..	4	" 3	" 9	" 10	36	10.0	2.02	1.33
Black "....	75	Cabbage ...	....	" 7..	3	" 3	" 9	" 10	24	8.0	.83	.85
Sandy "....	..	Potatoes ...	....	......	..	" 10	......	" 21	24	7.0	1.16	.97
" "....	..	....	....	......	..	" 8	......	Nov. 3	18	5.5	.48	.65
" "....	..	....	'97	....	..	" 5	......	Oct 22	18	11.0	1.51	1.24
....	..	....	....	......	..	......	......	......	..	.....	....	1.31
....	..	....	....	......	..	......	......	......	..	.....	....	.74
....	..	....	....	......	..	......	......	......	..	.....	....	1.41
Sandy L....	10	Beans......	....	S	2	Jun 5	Jul 10	Oct 10	30	12.0	....	1.62
Clay "....	22	....	'97	S., 9..	8	M'y 14	Jun 15	" 18	30	9.5	2.50	2.00

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
		Niag., C'td.							
371	Peter Faling	Gasport ...	21.1	18.35	87.0	17.43	349	42.14	14707
372	C. H. Whitcomb...	W.Sum'rs't	19.9	17.70	89.9	16.82	336	18.07	6072
373	A. M. Bennet......	Barkers ...	19.5	16.50	84.6	15.68	314	......	......
374	E. L. Ellis	" ...	21.3	16.90	79.3	16.06	321	37.73	12111
375	J. T. Mellirt	" ...	21.2	17.70	83.5	16.81	336	......	......
		Oneida.							
376	Geo. W. Brown ...	Vernon C..	19.7	16.85	85.5	16.01	320	5.23	1674
377	C. Gleason	Clinton ...	21.9	19.65	89.7	18.67	373	31.00	11563
		Onondaga.							
378	W. H. Ellison	Baldwinsv.	20.1	17.40	86.6	16.53	331	13.07	4326
		Orleans.							
379	W. J. Strickland ..	Albion	20.8	20.00	96.1	19.00	380	16.34	6209
380	" ..	"	19.4	16.20	83.5	15.39	308	......	......
381	Briggs Applin	Waterport.	20.0	15.75	78.7	14.96	299	......	......
		Oswego.							
382	N. W. Adams......	Bundys C .	19.0	14.45	76.1	13.73	275	18.56	5104
		Saratoga.							
383	John Randall	Corinth ...	23.4	20.25	86.6	19.24	385	16.38	6306
		Schuyler.							
384	B. Stephens	Beaverd'ms	20.0	15.50	77.5	14.73	295	15.29	4511
385	Mrs. C. Stephens ..	"	20.8	17.05	81.9	16.20	324	26.14	8469
		Seneca.							
386	John Anderson	Magee	18.1	14.10	77.9	13.40	268	12.63	3385
387	John Dickerson....	Farmer ...	19.7	16.40	83.2	15.58	312	21.34	6658
388	Dr. A. Alleman	McDougals	20.8	17.58	84.5	16.70	334	......	......
389	"	"	21.0	17.50	83.3	16.63	323	......	......
390	Joe Jennings	Romulus ..	19.9	17.35	87.2	16.48	330	12.09	3990
		Steuben.							
391	Oscar Wheeler	Hornellsv .	19.2	16.55	86.2	15.72	314	21.13	6635
392	Frank Marley	"	18.6	16.10	86.5	15.30	306	35.06	10728

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Gravel L....	..	....	'97	S. & F.	..	M'y 10	Jun 12	Oct 18	28	5.5	2.00	1.12
Sandy "….	30	Corn	'96	S., 10..	9	" 27	" 12	" 25	28	9.0	1.43	1.31
Heavy....	..	....	....	....	..	Jun 15	Jul 10	" 23	16	....	....	1.64
Muck L....	..	....	....	F	5	" 6	" 8	" 19	18	9.0	2.00	1.02
Sandy "….	..	....	....	....	6	" 5	" 3	" 16	18	7.0	....	.78
Clay "….	..	....	....	....	..	" 5	....	" 22	..	....	....	.74
Black "….	..	....	....	....	..	M'y 20	Jun 25	" 13	..	....	....	.98
Clay "….	..	....	'96	S	3	Jun 8	Jul 10	" 18	30	12.0	.73	1.53
Gravel "….	50	Corn	....	F. & S.	..	" 11	Jun 20	Nov 4	30	9.0	1.41	1.52
....	..	....	....	....	..	....	....	....	..	....	....	1.46
....	..	....	....	....	..	....	....	....	..	....	....	1.13
Clay "….	..	Cabbage	'95	S....	6	Jun 8	Jul 5	Nov 18	24	6.0	.87	1.44
Sandy "….	..	....	....	S., 8..	6	M'y 14	" 6	Oct 22	16	7.0	.56	.54
Shale....	40	Strawberr's.	....	"	2	" 15	Jun 10	" 7	30	6.0	.87	.97
Clay L....	40	Potatoes	'96	" 5..	2	" 28	" 25	" 28	16	7.5	1.50	1.11
" "….	70	Garden....	'95	" 8..	8	" 18	" 30	" 21	36	8.0	1.18	1.28
" "….	7	Beets	'97	F., 8..	4	" 16	" 15	" 20	18	7.5	.90	.84
" "….	80	Potatoes	'95	....	4	" 15	Jul 15	Nov 5	..	....	....	....
" "….	..	"	'95	....	7	" 15	" 15	" 5	..	....	....	....
Muck....	..	....	....	S....	5	" 19	Jun 20	Oct 10	36	7.0	.96	.85
Sandy L....	..	....	....	....	2	" 18	....	" 23	36	10.5	2.62	.88
Loam....	..	Carrots	....	S....	..	" 14	Jun 15	" 7	18	7.0	1.40	1.17

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Steub. C'td							
393	Pomeroy Smith....	Coopers P.	20.4	16.20	79.4	15.39	308	14.59	4494
394	Mrs. C. Harrison ..	Canisteo ..	20.8	18.50	88.9	17.58	352	11.97	4213
395	A. L. Ryndirs	Cohocton..	19.9	17.20	86.4	16.34	327	......	......
396	Casper Shults	"	19.0	14.20	74.7	13.49	270	......	......
397	H. P. Wilcox......	"	18.3	14.70	80.3	13.97	279	......	......
398	R. W. Milly.......	"	19.2	14.95	77.8	14.20	284	......	......
399	C. Merz	"	20.6	17.15	83.2	16.29	326	......	......
400	S. W. Newman	"	23.0	19.80	86.1	18.81	376	......	......
401	Jas. Stanton	"	17.4	15.35	88.2	14.58	292	......	......
402	M. Wager	"	21.5	17.75	82.5	16.86	337	......	......
403	A. P. Rocher	"	18.6	13.50	72.5	12.83	257	......	......
404	W. Courtney	"	21.9	19.00	86.7	18.05	361	......	......
405	F. A. Tobias.......	"	21.5	19.45	90.4	18.48	370	......	......
406	Webster Edmunds.	"	18.1	14.00	77.3	13.30	266	......	......
407	W. L. Rowe.......	"	18.3	15.60	85.2	14.82	296	......	......
408	E. W. Bentley	"	17.4	13.60	78.2	12.92	258	......	......
409	Phil. Sich	"	19.5	15.20	78.0	14.44	289	......	......
410	J. G. Stirble.......	"	18.8	14.65	77.9	13.92	278	......	......
411	Chris. Miller	"	20.6	17.10	83.0	16.25	325	......	......
412	Wm. Craigg.......	"	18.3	14.35	78.4	13.63	273	......	......
413	A. H. Wilcox......	"	18.1	16.80	92.8	15.96	319	......	......
414	M. H. Wilcox	"	20.8	17.00	81.7	16.15	323	......	......
		Tioga.							
415	J. P. Forman......	Nichols ...	22.6	19.75	82.4	18.76	375	......	......
416	Jerome Oakes	Ketchumv.	21.3	17.70	83.1	16.82	336	......	......
		Tompkins.							
417	E. Lobdell.........	Freeville..	19.3	15.65	81.1	14.87	297	12.76	3790
418	T. H. King	Trum'sbg .	23.6	20.68	87.6	19.65	393	15.68	6162
419	Jas. Heffron.......	Slaterville.	21.9	18.20	83.1	17.29	346	20.69	......
420	W. H. Burnham...	Groton	21.3	18.00	84.5	17.10	342	18.95	7076
421	G. C. Gooding.....	"	20.2	16.35	80.9	15.53	311	......	5893
422	F. D. Sincebaugh .	Ithaca	22.1	19.50	88.2	18.53	371	......	......
423	C. C. Fitch........	W. Groton.	22.1	18.05	81.7	17.15	343	......	......
424	H. W. Preswick ...	Forest H..	17.4	13.50	77.6	12.83	257	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Clay L	17	Hay		S., 8	6	M'y 20	Jun 15	Oct 18	32	11.0	1.63	1.76
Stony “	15	Corn		“ 8	2	Jun 10	Jul 11	“ 16	18	12.0	.92	.56
Sandy “												.79
“												.95
“												.77
“												1.34
“												1.03
“												1.15
“												.79
“												.77
“												.55
“												.48
“												1.08
“												1.00
“												1.03
“												.86
“												1.34
“												1.08
“												1.15
“												.85
“												.98
“												.84
Loam		Potatoes		S		M'y 20		Oct 11				.38
		Meadow			3	“ 20	Jul 27	“ 19	30			1.46
Muck				S					24	8.0	.73	1.08
Clay L		Potatoes		“	6	M'y 28	Jul 26	Nov 10	28	6.0	.85	.92
												.69
Gravel “		Corn	'96	“		“ 8	“ 10	Oct 9	32	7.0	1.46	1.12
Sandy “		Beets		“	5	“ 1	“ 15	“ 13	32	11.0	2.17	2.37
												.46
												.63
Loam									36			1.49

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Wayne.							
425	Porter Butts	Sodus	20.8	16.25	76.3	15.44	309	13.34	4122
426	E. B. Norris	"	19.7	15.50	78.6	14.73	295	10.78	3180
427	W. H. Baker	"	18.0	15.00	83.3	14.25	285	14.70	4189
428	W. F. Filkins	"	21.8	18.20	83.5	17.29	346	7.12	2464
429	Warren Nicholas ..	"	18.4	15.70	85.3	14.92	298	13.55	4038
430	E. W. Danford	"	20.8	17.50	84.1	16.63	333	14.72	4902
431	Jas. Leadley	"	20.0	15.55	77.7	14.77	295	16.12	4755
432	Chas. Hullett	"	20.2	17.15	84.9	16.29	326	6.97	2272
433	Jas. Hanby	"	20.6	16.95	82.3	16.10	322	14.15	4556
434	C. R. Sprang	"	21.5	19.05	88.6	18.10	362	8.71	3153
435	J. T. Piersall......	"	19.5	16.25	83.3	15.44	309	7.01	2166
436	Martin Percy......	"	20.9	17.25	82.5	16.39	327	7.84	2564
437	Willis Dufloo......	"	19.3	15.55	80.5	14.77	295	7.40	2183
438	Peter DeMay......	"	18.2	14.70	80.7	13.97	279	24.83	6928
439	Lawson Arms	"	20.4	17.00	84.7	16.15	323	11.10	3585
440	A. J. Folland......	"	20.9	17.85	85.4	16.96	339	12.63	4282
441	F. Blanchard......	"	18.1	13.50	74.6	12.83	257	19.00	4883
442	R. Robinson.......	"	20.4	16.40	80.4	15.58	312	......	......
443	Frank Butts	Joy	18.80	15.05	80.0	14.30	286	10.45	2989
444	A. Hollebrant	"	17.70	14.00	79.1	13.30	266	9.58	2548
445	Jacob Shuler	Lyons.....	20.65	17.98	87.0	17.08	342	9.15	3129
446	L. H. Clark	Sodus.....	20.6	17.35	84.2	16.48	330	......	......
447	H. G. Hotchkin....	Lyons.....	19.5	16.70	85.6	15.87	317	20.04	6353
448	E. P. & C. S. Rogers	"	21.2	17.20	81.1	16.34	327	......	......
449	J. H. Albright	Ontario ...	20.7	18.95	91.1	18.00	360	......	......
450	W. D. Post........	Wolcott...	23.4	20.70	88.4	19.67	393	......	......
451	E. B. Pindar	Westbury.	21.7	18.65	85.9	17.72	354	10.89	3855

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Clay L....	60	Roots	'97	S., 10..	6	M'y 19	Jul 9	Oct 5	28	10.0	1.22	1.58
" "....	60	Mangolds ..	'97	" 8..	9	" 25	Jun 25	" 5	32	10.5	1.18	1.35
Sandy "....	70	Potatoes ...	....	" 4..	..	" 20	" 18	" 9	24	6.0	.70	1.03
Clay "....	40	Hay........	....	F., 8..	4	Jun 1	Jul 2	" 5	30	5.0	.43	1.12
Gravel "....	65	Garden......	....	" 5..	4	M'y 20	Jun 21	" 8	18	8.0	.65	1.06
Clay "....	70	"	....	S., 7..	4	" 20	" 18	" 8	36	5.0	.95	1.21
Sandy "....	60	"	'97	" 6..	5	Jun 5	Jul 1	" 7	20	10.0	1.05	.68
" "....	70	"	'97	" 6..	7	M'y 15	" 10	" 7	36	6.5	.55	.75
" "....	60	Buckwheat.	....	" 6..	3	Jun 10	......	" 7	24	5.0	.67	.60
Clay "....	65	Grass	'97	" 7..	3	M'y 22	Jun 20	" 8	24	8.0	.54	.83
" "....	6	....	'97	" 5..	6	Jun 14	Jul 12	" 8	20	7.5	.37	.59
Sandy "....	65	Oats, peas..	'96	" 6..	6	M'y 18	Jun 14	" 6	28	6.0	.44	.96
Clay "....	70	Corn	'96	" 7..	5	" 7	" 23	" 7	30	10.0	.70	1.02
" "....	60	Potatoes ...	'96	" 8..	3	Jun 1	" 28	" 7	20	6.5	1.06	1.65
Sandy "....	70	Corn	....	" 8..	3	" 15	Jul 12	" 6	24	12.0	1.04	1.20
Gravel "....	70	....	'96	" 6..	5	M'y 20	Jun 20	" 7	28	11.0	1.29	1.00
Sandy "....	60	Pigyard....	....	" 8..	3	" 28	......	" 8	16	10.0	.92	1.13
....	..	....	....	....	..	" 25	......	" 23	..	.....	....	1.33
Sandy "....	60	Grass	'97	" 5..	6	" 25	" 25	" ..	30	12.0	1.20	1.32
" "....	40	Potatoes ...	'96	" 8..	5	" 25	" 25	" ..	28	11.0	1.14	1.43
Clay "....	..	Cabbage ...	'96	" 6..	2	" 15	" 15	" 4	24	12.5	.90	.97
....	..	....	....	....	..	" 15	Jul 3	" 23	20	5.0	.52	.77
Clay.........	..	....	....	....	..	Apr 30	Jun 10	" 21	32	12.0	2.42	2.00
Sandy L....	..	....	....	....	..	M'y 15	......	" 25	32	.....	....	1.35
....		....	....	....	6	......	......	......	..	.....	....	....
Sandy "....	40	....	....	" 7..	6	......	......	" 8	28	.....	.62	.94
Clay "....	..	....	....	....	..	M'y 15	" 15	" 1	18	7.0	.42	.57

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Yates.							
452	Ed. C. Wilkinson..	Penn Yan .	23.6	20.00	84.6	19.00	380	22.88	8694
453	" "	"	21.2	18.65	88.0	17.72	354	22.88	8694
454	" "	"	21.4	18.65	87.1	17.72	354	22.88	8694
455	" "	"	20.8	19.40	93.2	18.43	369	22.88	8694
456	" "	"	21.7	19.70	90.7	18.72	374	22.88	8694
457	" "	"	23.6	21.30	90.3	20.24	405	22.88	8994
458	" "	"	22.5	20.50	91.1	19.48	390	22.88	8694
459	" "	"	20.1	17.00	84.6	16.15	323	22.88	8694
					The following six analyses are on a				
		Monroe.							
460	M. H. Cusick.......	Clarkson..	19.7	15.85	80.5	15.06	301	13.29	4000
461	Jas. Wilson	Churchv'le	15.4	12.10	78.6	11.50	230	20.69	4759
		Erie.							
462	Fred. Geiger	N. Collins.	13.8	10.75	77.9	10.21	204	26.00	5304
463	" "	"	11.9	8.60	71.4	8.17	163	26.00	4238
		Orleans.							
464	S. C. Bowen.......	Medina....	12.1	8.50	70.3	8.08	162	......	......
				The following twenty-four analyses are on a					
		Chau'qua.							
465	R. L. Newton	Irving	19.9	17.45	87.7	16.58	332	28.00	9296
466	" "	"	19.9	16.70	83.9	15.87	317	33.10	10493
467	W. T. Christy	Silver Cr'k	19.5	16.40	81.0	15.58	312	23.52	7338
468	B. L. Baker	Irving	16.3	12.50	76.7	11.88	238	35.00	8330
469	"	"	16.5	11.55	70.0	10.97	219	35.00	7665
470	John Rakes	"	22.8	20.00	87.7	19.00	380	28.00	10640
471	"	"	22.8	20.10	88.2	19.10	382	28.00	10696
472	Insley Mott	"	15.6	11.45	73.4	10.88	218	26.00	5668
473	"	"	21.0	18.45	87.9	17.53	351	......	......
474	Chas. Crawford ...	"	22.4	20.10	89.7	19.10	382	16.00	6112
		Wayne.							
475	H. G. Hotchkiss...	Lyons.....	17.9	14.35	80.2	13.63	273	22.87	6244
476	Jas. Gould	"	20.2	17.55	86.9	16.67	333	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Gravel L				S	6	M'y 27	July	Nov 27	32			1.07
" "				"	6	"	"	"	32			.76
" "				"	6	"	"	"	32			1.15
" "				"	6	"	"	"	32			1.46
" "				"	6	"	"	"	32			1.11
" "				"	6	"	"	"	32			1.33
" "				"	6	"	"	"	32			1.22
" "				"	6	"	"	"	32			1.46
variety of sugar beet known as "Rose Imperial."												
Clay L	65	Beets	'96	S., 8	7	M'y 8	M'y 24	Oct 13	20	10.0	.85	1.05
" "				" 6	8	" 16	Jun 20	" 18	36	5.5	1.36	1.05
" "						Jun 1		" 13				1.29
" "						" 1		" 13				1.59
												1.76
variety of sugar beet known as "Vilmorin."												
												1.01
Bottom L				S	4	M'y 30	Jun 20	Oct 6	18	8.0	1.55	1.07
Gravel "	35			" 8	5	" 8	M'y 20	Nov 6	18	6.5	.90	1.02
Bottom "	30			"	4	" 17	Jun 10	Oct 13				1.35
" "				"	2	" 17	" 10	" 13				.89
Black "						" 8	" 20	" 13				.82
" "						" 8	" 20	" 13				.86
Bottom "						Jun 2		" 13				.92
												.89
" "						M'y 28	" 25	" 13				.66
Clay						Apr 30	" 10	" 21	32	10.0	2.28	2.03
												1.42

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Erie.							
477	E. G. Fenton......	Fenton....	16.8	13.20	78.6	12.54	251	34.74	8720
478	"	"	17.5	14.75	85.3	14.01	280	......	......
479	"	"	17.0	13.95	82.1	13.25	265	......	......
480	Chas. Sager	"	21.2	18.65	88.0	17.72	354	......	......
481	C. Oldenburg......	"	23.3	21.15	90.7	20.09	402	......	......
482	W. C. Sherman....	"	17.9	14.40	80.4	13.68	274	18.00	4932
483	A. B. Fenton	Buffalo....	23.6	20.00	84.7	19.00	380	......	......
484	"	"	21.0	15.65	74.5	14.87	297	......	......
		Ontario.							
485	C. Coolidge	Phelps	19.4	15.25	78.6	14.49	290	......	......
		Oneida.							
486	J. Mason	Clinton ...	18.1	13.35	73.7	12.68	254	30.00	7620
487	"	" ...	18.6	14.80	79.6	14.06	281	30.00	8430
		Chau'qua.							
488	F. Dean	Silver Cr'k	20.3	17.25	85.0	16.39	328	......	......
	The following five analyses are on a								
		Onondaga.							
489	L. L. Cramer......	Baldwinsv	19.2	14.85	77.3	14.11	282	......	......
		Monroe.							
490	M. H. Cusick......	Clarkson ..	23.9	19.20	80.3	18.24	365	15.03	5486
		Erie.							
491	E. G. Fenton	Fenton....	18.3	14.70	80.3	13.97	279	......	......
492	"	"	17.9	13.90	77.6	13.21	265	27.88	7388
		Wayne.							
493	H. G. Hotchkiss...	Lyons.....	18.4	14.95	81.3	14.20	284	22.65	6433
494	Data missing......	....	19.1	16.15	84.6	15.34	307	......	......
495	....	....	19.3	15.75	81.6	14.96	299	......	......
496	....	....	21.5	19.00	88.4	18.05	361	......	......
497	....	....	22.2	20.50	92.3	19.48	......	......	......
498	....	....	20.3	16.70	82.3	15.57	317	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows.	Harvested.	In samples analyzed.
Light L....	35	Strawberr's	'96	S., 8..	5	Apr 27	M'y 24	Sep 26	18	8.0	1.61	2.62
												3.63
												4.43
Stiff "						M'y 27	Jun 15	" 16				1.08
" "						Jun 15	" 30	" 22				1.25
Gravel "						M'y 25	" 25	" 13				1.76
Lowland	20					Jun 1	" 20	Nov 1				.59
												2.85
Loam		Hay	'96	S......	5	M'y 19	" 12	Oct 14	36			1.32
Bottom L....						M'y 30	" 15	" 13				.82
" "						" 20	" 15	" 13				1.23
						" 20						.58
variety of sugar beet known as "French White."												
Sandy L....						M'y 5	M'y 24	Nov 9	16		4.00	1.00
Clay "	65	Beets	'95	S	7	" 8	" 24	Oct 13	20	9.5	.91	.81
												4 90
Sandy "				"	7	" 15	Jun 27	" 21	30	11.0	2.91	3.09
Clay "						Apr 30	" 10	" 21	32	10.5	2.48	2.22
				"	6	M'y 27	July .	Nov 27	32			1.20
				"	6	" 27	"	" 27	32			2.14
				"	6	" 27	"	" 27	32			1.53
				"	6	" 27	"	" 27	32			1.10
				"	6	" 27	"	" 27	32			1.68

SAMPLES OF MANGOLD WURZEL ANALYZED AS FOLLOWS:

Date harvested.	Weight of beet without crown. Lbs.	Brix° or per cent. solids in the juice.	Per cent. sugar in the juice.	Purity Per cent.
Sept. 25	4.05	7.5	3.50	46.7
" 25	4.05	10.4	6.70	64.4
" 29	3.05	10.4	7.20	69.2
" 29	2.49	9.0	4.50	50.0
Oct. 6	1.96	13.8	10.45	75.7
" 20	2.05	11.1	5.65	50.9
" 20	1.57	13.2	7.90	59.8
Nov. 6	1.49	9.9	5.50	55.6
Samples of red turnip garden beet analyzed as follows:				
Oct. 6	1.39	14.0	11.30	80.7
" 6	3.13	12.8	9.80	76.6

From the preceding tables the following general averages are drawn:

A comparison of the beets grown on sandy loam with those from clay loam shows only a slight difference in favor of the clay.

	Per cent. sugar in juice.	Per cent. purity.
Quality of beets grown on *sandy loam*: 112 analyses, averaged	16.66	83.1
" " " *clay* " 109 " "	17.29	83.8

The distance between rows did not seem to affect materially the quality of the beets.

Quality of beets grown in rows 30 inches or more apart: 108 analyses, averaged	16.71	83.0
Quality of beets grown in rows less than 20 inches apart: 115 analyses, averaged	16.96	83.3

The statement that barn manure should be applied to the preceding crop and not directly to the beets as affecting the quality is substantiated in the following table:

	No. Cases.	Per cent. sugar in juice.	Per cent. purity.
Manure applied in 1896	45	17.37	83.96
" " 1897	59	16.62	82.94

The following cases have been selected showing what influence, if any, is exerted by the preceding crop:

EFFECTS OF PREVIOUS CROPS.

Previous Crop.	No. Cases.	Per cent. sugar in juice.	Per cent. purity.
Hay	24	17.47	84.5
Potatoes	28	16.86	83.1
Corn	26	17.20	84.9
Cabbage	12	17.56	84.9
Grain crop not tilled	11	17.94	85.3

PER CENT. OF SUGAR AND PURITY OF THE JUICE INFLUENCED BY SIZE OF BEETS.

	No. of samples analyzed.	Per cent. sugar in juice.	Per cent. purity of juice.
		Average.	Average.
Beets weighing less than .50 lbs.	7	18.46	85.4
" " from .50 lbs. to .75 lbs	48	17.91	85.5
" " " .75 lbs. to 1.00 lbs	95	17.37	83.9
" " " 1.00 lbs. to 1.25 lbs	123	17.17	84.3
" " " 1.25 lbs. to 1.50 lbs	95	16.42	82.6
" " " 1.50 lbs. to 1.75 lbs	47	16.09	81.8
" " " 1.75 lbs. to 2.00 lbs	15	15.33	81.4
" " " 2.00 lbs. to 3.00 lbs	22	15.45	81.0
" " " 3.00 lbs. to 4.00 lbs	4	14.99	84.6
" " " 4.00 lbs. to 5.00 lbs	3	13.47	78.6
" " " 5.00 lbs. and over	1	13.75	78.1

In general the smaller the beet when mature, the higher the per cent. of sugar and purity; and the larger the beet when mature, the lower the per cent. of sugar and purity.

Sugar beets may be so small that it would not pay to grow and harvest them. They may also be grown too large and coarse to be profitably used in sugar making. Between these two extremes there is a size of beet that can be most profitably grown—this ranges from 1¼ to 2 pounds.

Per Cent. of Sugar and Purity of Beet Crowns.

It is generally supposed that the per cents. of sugar and purity of beet crowns are much lower than in the beet proper. In several cases beets were taken and the crowns removed, and each analyzed separately with the following results :

Crowns and Crownless Beets Compared.

	Per cent sugar in juice.	Per cent. purity in juice.
Crown	12.00	73.6
Crownless beet	13.45	79.1
Crown	10.20	65.8
Crownless beet	12.50	73.5
Crown	13.30	83.1
Crownless beet	16.05	85.4
Crown	12.40	74.2
Crownless beet	13.95	79.3
Crown	12.25	77.5
Crownless beet	14.70	87.0
Crown	10.40	65.8
Crownless beet	13.35	79.9
Crown	11.45	71.5
Crownless beet	13.35	79.0

How Much Plant Food does the Sugar Beet Plant Consume?

On November 6, 1897, composite samples of three freshly-pulled plants were made as follows: The leaves were put in one lot, the crowns in a second lot, the crownless beets in a third lot, and the moisture determined in each with the following results:

	When pulled green.	Dry.	Per cent. dry matter.
Weight of leaves (from three plants)	237.8 grams	53.0 grams	22.29
" crowns "	279.7 "	56 7 "	20.27
" crownless beets "	902.0 "	183.5 "	20.34

ANALYSES OF THE DRY OR WATER-FREE SAMPLES.

	Nitrogen. Per cent. N.	Potash. Per cent. K_2O.	Phosphoric acid. Per cent. P_2O_5	Calcium oxide. Per cent. CaO.	Ash. Per cent.
Leaves	2.89	4.88	0 51	1.86	19.31
Crowns	2.13	2.21	0.59	0 27	6.68
Crownless beets	1.38	1.77	0.55	0.15	4.14

These analyses when calculated to the *fresh or green samples* at time of pulling are as follows:

	Nitrogen. Per cent. N.	Potash. Per cent. K_2O.	Phosphoric acid. Per cent. P_2O_5	Calcium oxide. Per cent. CaO.	Ash. Per cent.
Leaves	0.64	1.09	0.114	0.41	4.30
Crowns	0.43	0.45	0.120	0.05	1.35
Crownless beets	0.28	0.36	0.112	0.03	0.84

Any one of these percentages when multiplied by 20 will give the number of pounds of that substance in a ton of the material taken. Thus green leaves analyzed 0.64 per cent. nitrogen: then $20 \times 0.64 = 12.8$ pounds of nitrogen in one ton of green or fresh leaves. The amount of the other substances in a ton may be obtained from the analyses in a similar manner.

In order to approach the question of how much plant food a crop of sugar beets takes up per acre, it is of great importance to know the relative proportion of *leaves*, *crowns* and *crownless beets* by weight in the crop grown.

The following table gives the weights of these parts in 24 samples weighed at time of harvesting:

PROPORTION OF LEAVES, CROWNS AND CROWNLESS BEETS.

Weight when harvested.			In 100 parts by weight of the entire beet plant when harvested.		
Beet without crown in pounds.	Crown in pounds.	Leaves in pounds.	Parts in beet without crown.	Parts in crown.	Parts in leaves.
0.72	0.30	0.43	49.66	20.69	29.65
0.83	0.33	0.42	52.53	20.89	26.58
0.85	0.26	0.32	59.44	18.18	22.38
0.88	0.21	0.35	61.11	14.59	24.30
1.02	0.39	0.22	62.58	23.93	13.49
1.30	0.36	0.38	63.73	17.64	18.63
1.09	0.23	0.51	59 56	12.57	27.87
1.17	0.38	0.22	66.10	21.47	12.43
0.92	0.53	1.05	36.80	21.20	42.00
1.32	0.39	1.04	48.00	14.18	37.82
1.35	0.33	0.71	56.49	13.81	29.70
0.79	0.23	0.69	46 20	13.45	40.35
0.79	0.29	0.41	53.02	19.16	27.52
2.12	0.32	0.45	73.36	11.08	15.56
0.84	0.27	0.61	48.84	15.70	35.46
1.52	0.34	0.25	72.04	16.11	11.85
1.14	0.32	0.25	66.67	18.71	14.62
1.01	0.36	0.86	45.29	16.14	38.57
1.10	0.39	0.30	61.45	21.79	16.76
1.06	0.35	0.46	56.68	18.72	24.60
0 93	0.39	0.42	53.45	22.41	24.14
1.39	0.34	0 42	64.65	15.82	19.53
0.86	0.28	0.37	56.96	18.54	24.50
0.95	0.24	0.41	59.38	15.00	25.62
Total weights, 25.95	7.83	11.55	57.24	17.28	25.48
Average weight, 1.08	0.33	0.48	Average parts per 100.		

Individual cases in the foregoing table differ greatly from each other, but it may be assumed that the average of the 24 cases will be very nearly correct.

In round numbers, then, in 100 parts of the whole plant when harvested *57 parts* are beet without crown, *17 parts* crown and *26 parts* leavcs, so that in one ton (2,000 pounds) of the whcle beet plant there are in:

Fresh leaves..................................	520 pounds.
Fresh crowns..................................	340 pounds.
Fresh crownless beets..........................	1,140 pounds.
	2,000

This ton of plants will contain the following amounts of plant food:

	Pounds nitrogen.	Pounds potash.	Pounds phosphoric acid.
Fresh leaves, 520 lbs. contains	3.33	5.67	0.59
Crowns, 340 lbs. contains	1.46	1.53	0.41
Fresh crownless beets, 1,140 lbs. contains	3.19	4.10	1.28
Total............2,000 lbs	7.98	11.30	2.28

Generally the leaves are left on the ground and only the beet and crowns taken from the field; this being so, it is necessary to know *what proportion of the beet is crown*, and so in several hundred cases beets were weighed before and after removing the crowns with the following results:

The average of 454 cases weighed, showed that in every 100 parts of the whole beet (leaves not included), 80.86 parts were crownless beets and 19.14 parts were crowns; or, in round numbers, 81 parts were crownless beets and 19 parts crowns.

Therefore, in one ton of beets harvested, leaves not taken into account, there are in:

Fresh crownless beets........................	1,620 pounds.
Fresh crowns.....	380 pounds.
	2,000

This ton contains the following amounts of plant food:

	Pounds nitrogen.	Pounds potash.	Pounds phosphoric acid.
Crownless beets, 1,620 lbs. contains......	4.54	5.83	1.81
Crowns, 380 lbs. contains......	1.63	1.71	0.46
Total, 2,000 lbs. contains......	6.17	7.54	2.27

From the preceding analyses it may be said that, when freshly harvested and not withered:

	Nitrogen.	Potash.	Phosphoric acid.	Water.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1 ton of *whole plants* (roots, crowns and leaves) contains	7.98	11.30	2.28	1583.3
1 ton of *beets* (roots and crowns) contains	6.17	7.54	2.27	1593.5
1 ton of *leaves* contains	12.80	21.80	2.28	1554.2
1 ton of *crowns* contains	8.60	9.00	2.40	1594.6
1 ton of *crownless beets* contains	5.60	7.20	2.24	1593.2
Factory By-products.				
1 ton of extracted cossettes,* or beet pulp	1.82	1.72	.32	1828.0
1 ton of molasses*	21.40	65.20	.34	832.0
1 ton of lime-cake*	2.48	3.05	8.47	871.2

*The extracted cossettes, molasses and lime-cake were received from the Rome Beet Sugar Factory. The extracted cossettes, or beet pulp, is a by-product of the diffusion tanks. The molasses is a by-product of the centrifugal machines. The lime-cake is a by-product of the carbonatation tanks.

The lime-cake contained 25.96 per cent. of lime (CaO).

NOTE.—*Pounds per ton* of any of the above plant-foods divided by 20 will give the *per cent.* of that plant-food in the material—thus: 7.98 lbs. nitrogen ÷ 20 = .399 per cent. of nitrogen in *whole plant.*

New York State Weather Conditions, from April 1 to October 31, 1897.

It may be said that the general average, or *normal* temperature for corresponding months does not vary much from year to year; and that the temperature conditions in New York State are good for the growth and development of *sugar* in the sugar beet plant. The average amount of sunshine also is amply sufficient for the proper growth and development of the sugar beet.

The *rainfall* or *moisture* condition is of the greatest importance. The total rainfall during any one year is ample for growing sugar beets, provided it has been sufficiently distributed through the growing season.

In brief* we may say that during:

APRIL.—There was a slight increase over the normal rainfall for most of the state. Temperature 1.3 degrees above the normal.

MAY.—Decidedly more than the normal rainfall. Temperature averaged 0.8 degrees below the normal.

JUNE.—Very nearly normal rainfall. Temperature 4.1 degrees below the normal.

JULY.—Extremely wet, having 3.26 inches more than normal rainfall. Temperature 2.4 degrees above the normal.

AUGUST.—Slightly below the normal rainfall. Temperature averaged 1.7 degrees below normal.

SEPTEMBER.—Dry, 1.37 inches below the normal rainfall. Temperature 0.1 degree below normal.

OCTOBER.—Exceedingly dry, 2.45 inches below the normal rainfall. Temperature 2.8 degrees above the normal. The New York State Weather Bureau Report for October, 1897, page 3, says: "The rainfall over the greater part of New York ranks among the least recorded for October, and the average for the state was less than for any preceding month since the establishment of this Bureau in 1889. A severe drouth prevailed in the western and central sections, and portions of the Hudson and Champlain Valleys, ground-water being reported as lower than for many

*Condensed from the New York State Weather Bureau Report, Central Office at Cornell University. Professor E. A. Fuertes, Director, Ithaca, N. Y.

years past. Winter wheat and pastures suffered considerably, and in many cases the ground was too dry for plowing."

The following table gives the rainfall for each month, April to October inclusive, and in those counties that have grown sugar beets and have had analyses made at the Cornell Experiment Station. If there are two or more *Signal Stations* in a county reporting rainfall, then the average rainfall of the several stations is given.

PRECIPITATION IN INCHES.

	COUNTY.	April.	May.	June.	July.	Aug.	Sept.	Oct.
1	Albany	3.12	4.69	4.45	6.67	4.43	1.87	1.01
2	Broome	2.16	4.45	3.35	2.42	1.61	3.30	0.74
3	Cattaraugus	2.08	3.62	2.71	6.83	......	1.25	0.56
4	Cayuga	2.34	2.92	3.93	4.11	2 26	3.27	1.31
5	Chautauqua	3.29	3.65	2.32	6.79	3.55	0.81	1.56
6	Erie	2.18	2.72	1.87	6.16	1.93	0.47	1.07
7	Genesee*	1.87	2.45	1.85	4.54	1.49	0.84	1.04
8	Herkimer	3.99	4.73	5.47	5.00	2.98	1.88	1.38
9	Jefferson	......	......	2.05	8.22	3.54	0.78	0.42
10	Livingston	1.66	2.15	2.03	3.14	0.55	1.21	0.66
11	Monroe	2 10	1.94	2.65	6.10	1.46	0.77	0.92
12	Montgomery	1.93	4.10	4.91	5.58	3.13	1 89	0.84
13	Niagara	2.52	2.87	1.79	5.68	1.54	0 93	1.06
14	Oneida	3.36	4.12	4.87	4.92	2.71	2.30	0.38
15	Onondaga	2.67	2 77	3.19	5.44	2.36	1.97	0.80
16	Orleans	2.62	2.77	1.77	5.07	2.08	0.38	1.01
17	Oswego	2.19	2.60	3.67	3.98	2.42	1.09	0.57
18	Saratoga	3.68	6.35	6.63	8.83	4.70	1.65	1.45
19	Schuyler	2.64	3.00	3.00	3.27	2.19	2.66	0.71
20	Seneca	2.53	4 80	2.71	4.14	0.78	3.95	1.21
21	Steuben	2.55	3.54	2.56	6.30	2.49	2.51	0.96
22	Tioga	2.95	3.98	3.59	4.32	3 19	4.05	0.56
23	Tompkins	2.65	3.90	3.65	3.78	2.48	4.59	0.94
24	Wayne	2.33	1.98	3.85	4.44	1.19	1.15	0.62
25	Yates	......	......	......	......	1.28	1.90	0.62

* No report sent in, so the rainfall given is the average for Signal Stations at Ridgeway, Avon and Akron.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

38 Native Plums and Cherries, 73 pp.
39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
59 Does Mulching Retard Maturity of Fruit? 14 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
67 Some Recent Chinese Vegetables, 27 pp.
69 Hints on the Planting of Orchards, 16 pp.
70 The Native Dwarf Cherries, 12 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
83 A Plum Scale in Western New York, 23 pp.
84 The Recent Apple Failures in New York, 24 pp.
85 Whey Butter, 8 pp.
87 Dwarf Lima Beans, 24 pp.
88 Early Lamb Raising, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
94 Damping Off, 42 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
99 Blackberries, 26 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
115 The Pole Lima Beans, 26 pp.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
118 Food Preservatives and Butter Increasers, 8 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Hogs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.

Bulletin 144. January, 1898.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

Entomological and Horticultural Divisions.

NOTES ON SPRAYING

—AND—

ON THE SAN JOSÉ SCALE.

By H. P. GOULD.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	Trustee of the University.
Hon. B. F. TRACY,	President State Agricultural Society.
Professor I. P. ROBERTS,	Agriculture.
Professor G. C. CALDWELL,	Chemistry.
Professor JAMES LAW,	Veterinary Science.
Professor J. H. COMSTOCK,	Entomology.
Professor L. H. BAILEY,	Horticulture.
Professor H. H. WING,	Dairy Husbandry.
Professor G. F. ATKINSON,	Botany.
M. V. SLINGERLAND,	Entomology.
G. W. CAVANAUGH,	Chemistry.
L. A. CLINTON,	Agriculture.
B. M. DUGGAR,	Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	Director.
E. L. WILLIAMS,	Treasurer.
EDWARD A. BUTLER,	Clerk.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.

CORNELL UNIVERSITY, ITHACA, N. Y., January 28, 1898.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: This bulletin is submitted for publication under Chap. 128 of the Laws of 1897.

The following notes, which have been prepared by Mr. H. P. Gould, under the direction of Mr. M. V. Slingerland and Professor L. H. Bailey, embody some additional information on spraying and supplement the information contained in Bulletins Nos. 86, 101 and 114, together with investigations looking toward the control of the San José scale which has appeared in several sections of the state.

Perhaps no subject connected with fruit-growing requires more careful study and investigation at the present time than this new pest, which has already secured a firm foothold in many localities. Unless some means can be found for arresting its spread and eradicating it where it has already appeared, the great fruit industry of New York, which now brings many millions of income to the farmers, will have to be largely abandoned.

I am inclined to believe that if the orchardists are kept promptly informed of the spread of this scale and can be furnished with information as to the best means of destroying it, most of the young and thrifty plantations may be saved, if not entirely freed, from this the most dangerous pest which has yet appeared in the orchards.

Very respectfully yours,

I. P. ROBERTS,

Director.

ORGANIZATION.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.

CORNELL UNIVERSITY, ITHACA, N. Y., January 28, 1898.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: This bulletin is submitted for publication under Chap. 128 of the Laws of 1897.

The following notes, which have been prepared by Mr. H. P. Gould, under the direction of Mr. M. V. Slingerland and Professor L. H. Bailey, embody some additional information on spraying and supplement the information contained in Bulletins Nos. 86, 101 and 114, together with investigations looking toward the control of the San José scale which has appeared in several sections of the state.

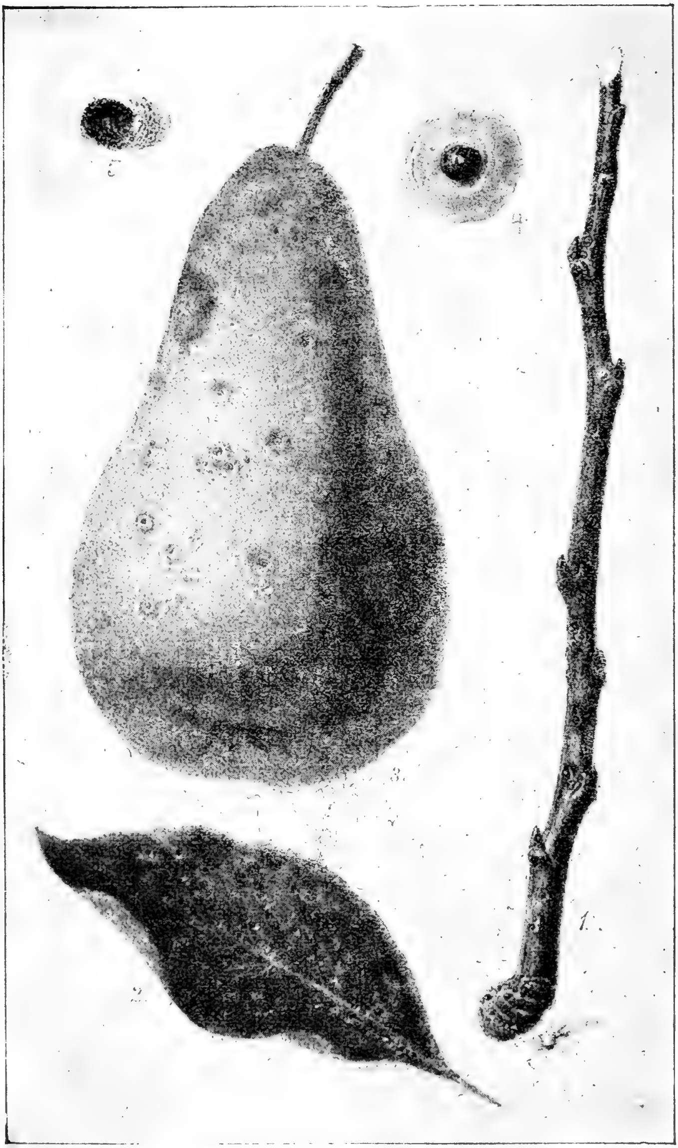
Perhaps no subject connected with fruit-growing requires more careful study and investigation at the present time than this new pest, which has already secured a firm foothold in many localities. Unless some means can be found for arresting its spread and eradicating it where it has already appeared, the great fruit industry of New York, which now brings many millions of income to the farmers, will have to be largely abandoned.

I am inclined to believe that if the orchardists are kept promptly informed of the spread of this scale and can be furnished with information as to the best means of destroying it, most of the young and thrifty plantations may be saved, if not entirely freed, from this the most dangerous pest which has yet appeared in the orchards.

Very respectfully yours,

I. P. ROBERTS,

Director.



THE SAN JOSÉ SCALE.

1, *Infested branch; 2, infested leaf; 3, pear, bearing a few of the scales; 4, female scale—enlarged; 5, male scale—enlarged.*
(*Adopted from report of W. G. Klee, 3d Rept., Cal. Bd. Hort.*)

SUGGESTIONS ON SPRAYING.

The expediency of spraying plants has already passed the experimental stage. The fact of its value has been too thoroughly and too often demonstrated to permit any doubts concerning the advisability of such an operation; yet there is much to be learned about spraying. The fact, however, that it pays to spray does not seem to be so fully appreciated by fruit growers and others as it ought to be; so the first part of this bulletin is intended not so much for the purpose of recording new facts as to emphasize and reiterate a few fundamental principles upon which successful spraying depends.

During the first few years after spraying began to receive attention in this country, the efforts directed thereto resulted in setting forth the fundamentals of the operation, together with extensive trials of apparatus and materials. The experience of the past two years or so, while fruitful of much that is valuable, has not propounded new principles and perhaps fewer spraying materials have been introduced and less apparatus invented than for some years previous; but much apparatus already on the markets has been improved and perfected so that advancement in this direction has been considerable. It would seem now that most of the progress in spraying must be along the lines of improved materials and perfected apparatus.

Some remarks on spraying materials.—In regard to new insecticides and fungicides a word of caution is not out of place. Many of these materials are recommended for almost every disease to which plants are subject. By this we do not wish to be understood to say that the compounds, such as those in question, are necessarily worthless; on the other hand, many of them have a place, and in that place they are good, yet the sweeping recommendations of many of them are misleading.

We are frequently asked concerning substitutes for Paris green. Arsenite of lime is doubtless one of the cheapest and safest compounds which can readily be obtained. The basis of this insecticide is white arsenic, or "arsenic" as it is more commonly called. In the *Mich-*

igan Farmer of Feb. 13, 1897, Dr. R. C. Kedzie, of the Michigan Agricultural College, gives the following method of preparing it, which may well be termed the "Kedzie mixture." "Dissolve the arsenic by boiling with carbonate of soda, and thus insure complete solution; which solution can be kept ready to make a spraying solution when wanted." Then more specific directions follow, which are, "To make material for 800 gallons of spraying mixture, boil two pounds of white arsenic with eight pounds of salsoda (crystals of carbonate of soda, 'washing soda,' found in every grocery and drug shop) in two gallons of water. Boil these materials in any iron pot not used for other purposes. Boil for fifteen minutes, or till the arsenic dissolves, leaving only a small, muddy sediment. Put this solution into a two-gallon jug and label 'Poison—stock material for spraying mixture.'"

"The spraying mixture can be prepared whenever required, and in the quantity needed at the time, by slaking two pounds of lime, adding this to forty gallons of water; pour into this a pint of the stock arsenic solution. Mix by stirring thoroughly, and the spraying mixture is ready for use. The arsenic in this mixture is equivalent to four ounces of Paris green."

In other words, the stock solution may be made by boiling together white arsenic and salsoda, at the rate of one pound of the former to four of the latter. This will keep indefinitely in a closed vessel, and as it is extremely poisonous it should be carefully taken care of. In applying this stock solution, use two pounds of fresh lime for every pint of the solution. One pint is sufficient to put into a barrel of water.

The materials for this poison cost about 3¼ cents a barrel, making a very cheap and effective poison.

We do not know that this substitute for Paris green has been tried with Bordeaux mixture, but in answer to a question on this point, Dr. Kedzie replied that he saw no objection to the two mixtures being used together.

Our observations upon the effectiveness of this mixture have been confined to its action on potato bugs and here it has proved a very satisfactory substitute for Paris green. It has several advantages over Paris green, chief of which are its cheapness and uniformity of strength.

Since the arsenic, in the form in which it exists in the stock solution, is extremely caustic on the foliage, the addition of a sufficient quantity of lime to neutralize it is very important. Added at the rate given above, however, it seems to be perfectly safe.

As we frequently have inquiries concerning powdered Bordeaux mixture, it seems best to state that, having given it a fair trial, we are not warranted in recommending it for use as a substitute for Bordeaux mixture. The adhesive properties of such material are often poor, and, on the whole, they have given very meagre results in comparison with liquid Bordeaux. The results obtained at other experiment stations seem to confirm the results of the work at this station.

Certain modifications of Bordeaux mixture have been made at the New Jersey Agricultural College Experiment Station,* which compare favorably with the usual formula for Bordeaux. In one of these modifications, termed "Soda Bordeaux," caustic soda was used instead of lime to neutralize the copper sulphate; the quantity of caustic soda recommended is 1.1 pounds for every five pounds of copper sulphate. A second modification substitutes caustic potash for the lime, three pounds of the potash being used to neutralize five pounds of copper sulphate. In this case, however, potash, such as is obtained in bulk, is referred to, and, as this contains varying proportions of impurities, the quantity (in weight) required to neutralize the copper sulphate will also vary, so in using this formula, as also the one for soda Bordeaux, it is advisable to test with red litmus paper. Add the caustic soda or potash solution to the copper sulphate until upon inserting into it a little piece of red litmus paper a faint tinge of blue appears; when the blue tinge begins to show, enough has been added. These modified Bordeaux mixtures, in somwhat extended trials, seemed to be nearly if not quite as effective as the common form, and in certain cases, perhaps, present some advantages. They do not clog the nozzle.

Apply the proper remedy at the right time.—One of the essential features of successful spraying, and one often overlooked, is to apply the proper remedy at the right time. To know what to apply, and when to apply it, is generally not a difficult matter if a few facts be kept in mind. Practically all insect enemies of plants, for which spraying is a specific, may be divided into two classes with respect to their habits of feeding, and the remedy to be applied will depend upon these habits. The insects of one class, of which the potato bug and

* Ninth Ann. Rep., 1896 (Report of Botanist).

apple-tree tent-caterpillar are familiar examples, eat parts of the plant —usually the leaves. The remedy for such pests is to apply a poison to their feeding ground. Paris green is the poison most commonly used in such cases.

The other class of insects comprises those which suck the juices of the plant. The aphides or plant lice, which have been so abundant the past season on the growing shoots of apple, plum and cherry-trees represent this type; the scale insects, as the San José scale, also belong here. A moment's thought will make it plain that Paris green could in no wise injure an enemy of this sort since it does not get the poison with its food. This type of insect must be destroyed by applying something which will kill it by coming in contact with it. Kerosene, usually as an emulsion, is the remedy in most common use. It must be remembered, however, that this will destroy only those insects with which it comes in contact. This, perhaps, will explain at least one of the reasons why *thoroughness* is so essential to success. While kerosene emulsion has been very generally recommended for insects of this type, with the advent of certain pumps which have recently been perfected, this may not be the best way of applying it; with these pumps the kerosene may be so mixed and diluted with water as it is forced through the pump and out of the nozzle that no emulsion is necessary.

It seems almost a waste of time to say that Bordeaux mixture is the great specific for fungous diseases, and that it is not for destroying insects, yet recent experience convinces us that such a statement may well be made with considerable emphasis.*

---

* Very often in the springtime persons come to us with this or a similar remark: "My rosebushes are all covered with little white insects. What can I do for them?" We usually say, "Spray them with kerosene emulsion," for that is about the best thing in common use, yet it is somewhat difficult to make, and the chances are that persons who ask for this information, rather than bother with making the emulsion, simply look on while the insects continue to eat up their rosebushes and other ornamentals. During the past season we have had various insecticides and fungicides under observation. Among them was one called "Fir-tree Oil Soap," another "Kill-m-right," both of which have given excellent satisfaction in combating aphis, rose-leaf hopper and other soft-bodied insect pests common to the front yard and garden. Each of these is a salve-like material conveniently put up in small tin cans, and they are made ready for use simply by dissolving in a little hot water and then diluting to the desired strength. About one ounce to a gallon of water seems sufficient for destroying aphis and other soft-bodied insects.

Two cases where Bordeaux prevents loss by insects.—There are only two cases, so far as we definitely know, wherein Bordeaux is of service in preventing the ravages of insects, and in these instances it cannot properly be called an "insecticide" for it does not kill the insects but simply makes their feeding ground unpleasant. These two cases may be briefly mentioned. It has been repeatedly observed that potatoes well sprayed with Bordeaux are much freer from the attacks of the flea-beetle than unsprayed potatoes are. It was with this fact in mind that the writer, the past spring, sprayed with Bordeaux some cucumber vines which were being destroyed by the striped cucumber beetle. It was with some surprise, considering the persistent habit of these insects, that they were found to have disappeared when the plants were examined a short time after the application was made. Several sprayings served to protect the plants from further injury. This is the result of only one season's experiment; further observations may not confirm this opinion, although similar results have been reported from the New Jersey Agricultural College Experiment Station.* This report had not been seen by the writer when the above experiment was made. The fact ought to be reiterated that the beneficial results of Bordeaux in these cases is simply in making the foliage of the plants an unpleasant place for the insects, and, as a rule, it is of no value as an insecticide.

Thoroughness is most important.—While the application of improper materials and use of right materials at improper times are productive of much dissatisfaction with spraying, we are convinced that carelessness and work indifferently done are the cause of more unsatisfactory results from spraying than almost all other causes combined. Comparatively few people yet know how to spray and do it well, notwithstanding the fact that it is generally not a difficult thing to do. So the one essential to satisfactory results from spraying, as it appeals to us, which needs more emphasis than any other, is *thoroughness* in the work. The requisites for such a job of spraying are a tree or plant well pruned, a good pump, a good nozzle, abundance of spraying material (it is not expensive), and with all, a fair degree of patience on the part of those who are doing the work; then spray the tree until every leaf is moistened—until the material begins to drip from the

* Ninth Ann. Rep., 1896, p. 358.

tree. Of course a few other accessories are necessary aside from those mentioned, but they are what anyone attempting to spray would almost of necessity possess.

In these times of low prices, the question of whether to spray or not to spray has often been asked. First-class and fancy fruit of all kinds will usually sell at a profit while inferior grades are a drug on the market at any time. It is a fact of common observation that the finest fruit is that which has been sprayed. Not long ago the writer was comparing two vineyards which were situated side by side and under similar conditions in practically every respect. One vineyard had been thoroughly sprayed and the fruit was perfect, selling at a profit, and the foliage was healthy. The other vineyard had been left unsprayed and scarcely a perfect cluster of fruit could be found and the vines were in as pitiable a condition as the fruit. Such a product could not have sold for enough to pay for picking. This is only one of many instances which might be mentioned as an argument for careful spraying; and what is true of grapes is often true of other fruits. Again, it sometimes happens that conditions are unfavorable for the development of bugs and fungi and, for a single year, there is very little difference between sprayed and unsprayed fruit. It should be remembered that the effect of spraying is not confined solely to the year in which it is done, but among those who have had abundant opportunities for observing it is held that trees sprayed for a series of years and then left unsprayed for a season, are more vigorous and produce better fruit than trees which have not been sprayed at all.

When to spray and when not to spray.—The time of making the applications varies with the condition of the season, but for orchard fruits, when treated against the more common insect and fungous foes, we may say in a general way, spray first, just before the fruit buds open; second, just after the blossoms fall; and third, ten days or so after the second spraying. In a dry season, the third application may not be necessary, while in an excessively rainy one more than three may pay.

When to spray cannot be regulated by rule. When not to spray, at least in one particular, can be stated with emphasis. If the spraying solutions contain poisons, as they should at that season of the year, *do not under any conditions spray when the trees are in bloom.* Nothing is accomplished by spraying at this time which cannot be attained either before the blossoms open or after they fall. More than this, irreparable damage is almost sure to follow spraying at this time. Everyone has observed how active the bees are among the blossoms of fruit trees, and on this activity of the bees depends very largely the development of the fruit. As they carry pollen from one blossom to another, they are doing a kindness to the fruit grower which he little appreciates. If, then, these friends of the orchardist find the blossoms covered with poison, as they will do if the trees are sprayed when in bloom, their death from the effects of the poison is only too sure to follow, and with the death of each bee the fruit grower loses a friend. This loss is not only to the man who grows fruit, but to the bee-keeper as well. It is also a question if the spray may not injure flowers when they are in full bloom.

Conclusion.—All of the foregoing leads to the remark that the man who sprays or directs the work must think for himself. The various spraying materials can be made by rule, but when it comes to applying them it is a different matter; general directions may be given, but these must be adapted to each case. A man who has regard for the health of his trees becomes to that extent a doctor; let him take the same care in diagnosing the ailments of his trees which the physician takes when called to see a patient.

Recapitulation.

1. Many of the recently introduced insecticides and fungicides are no better than some of the older and better known materials, and they are sometimes inferior to them. Page 249.

2. Arsenite of lime prepared according to the directions of Dr. Kedzie seems to be the best substitute for Paris green. Page 249.

3. Powdered Bordeaux mixture has not given good satisfaction with us. Page 251.

4. Certain modifications of Bordeaux as proposed by Halstead may possess some advantages over the common formula for special purposes. Page 251.

5. In spraying for insect foes, the kind of material used must be governed by the feeding habits of insects for which the treatment is made. Page 251.

6. Bordeaux mixture seems to lessen the ravages of the striped cucumber beetle, as also the flea beetle. Page 253.

7. Thoroughness in spraying is one of the most important elements of success and one often disregarded. Page 253.

8. Spray at the proper time. Under no conditions spray with poisons when fruit trees are in full bloom. Page 254.

BRIEF NOTES ON THE SAN JOSÉ SCALE.

The San José scale has already become so widely distributed that its discovery in new and unexpected localities ought not to occasion surprise. And yet, when in the spring of 1897 it was discovered on the horticultural grounds of this station, it was a matter of considerable surprise to those who were directly interested in the case. As soon as the fact of its presence was known, active measures were taken to dispose of the pest and the record of the experience of the past season constitutes the substance of the following notes.

Its occurrence at Cornell.—Whence came the scale to us, no one knows; the time of its coming is equally obscure. It was first discovered during the past spring on dwarf apple trees which had been set some five or six years. When first observed the scales were found in almost innumerable numbers; so thick were they that the bark was completely covered in places. These trees were at once rooted up and burned, a procedure which we have since regretted. An examination of some shrubs of Cornus Baileyi, which were growing close to the apple trees, revealed the presence of the scales in great numbers. The insects were later found upon small shrubs of Pyrus nigra and Pyrus Aria.

The first impression was that it came to us on the dwarf apple trees, but these had been under very close observation for a year or two, and if the scales had been present then, it seems hardly possible that they could have escaped notice. The fact that they were found upon a bush of Cornus Baileyi somewhat removed from the other affected plants seems to give some support to the supposition that the scales came on them and spread to the other species. This seems improbable, however, since all of the plants of cornus came from the wild along the shores of Lake Michigan.

The mystery is the greater when we take note of the fact that all of the affected shrubs and trees have been growing in their present location for five or six years. It is not unlikely that the scale was with us for some years before its discovery, and on account of some favorable condition or combination of conditions during the summer of 1896, a rapid multiplication took place, and its presence became conspicuous. See picture on title page.

Treatment.—For certain reasons it was determined to save these shrubs of cornus and pyrus if it were possible, and by the advice of Mr. Slingerland, who, it should be said, has rendered valuable assistance in locating infested plants, noting the effects of sprays, etc., the trunks and larger branches of the shrubs were treated with whale-oil soap, dissolved in water at the rate of two pounds of soap to one gallon of water. This has been much recommended, it being considered the most destructive to the scales of any insecticide which could be used without injury to the host. Even this material will injure foliage, so that it must be used when the plants are dormant or else, as in the case in question, applied only to the trunks and larger branches. It should be stated that the infested shrubs under treatment had already leaved out when the scale was discovered.

The effects of the whale-oil soap, thus applied, were all that could be desired. No live scales could be found, after a lapse of several days, where this solution had been applied. A few of the shrubs which had been treated with a solution containing only half as much soap as the above, that is, one pound to a gallon of water, still bore live scales in considerable numbers.

The whale-oil soap was applied about the first of May. Nothing more was done for several weeks, but a careful watch was kept of the condition of the scales, with the intention of treating them with kerosene when the proper time should arrive. In the meantime, numerous experiments were made to determine how strong a mixture of kerosene and water could be safely applied without injury to the foliage. The result of this investigation indicated that a mixture of four parts of water and one of kerosene could be used with little or no danger of burning the foliage.

Accordingly, on June 25, when the condition of the scales seemed to indicate that the young insects were about to migrate, the shrubs were thoroughly sprayed with a mixture of kerosene and water in the strength indicated, that is, one volume kerosene to four of water. On July 2, a second application of kerosene and water was made. Treatment was now delayed for a time and on July 23, the shrubs were very carefully examined by Mr. Slingerland and not a single living scale was to be found. We felt encouraged. There seemed to be no need of further attention, so the shrubs were left to themselves; but the end was not yet.

About the first of November, after the leaves had all fallen, the shrubs were again examined to see if any living scales could be found. After a half hour's careful search, one or two young insects were discovered and a little distance from these was an old scale, apparently the mother-scale, which had doubtless escaped the spray. On another shrub at some distance from most of the infested ones, several old scales were found with numerous young ones in all stages of development.

The fight was again renewed, and on November 16 the shrubs were all thoroughly sprayed, the same as they had been earlier in the season. December 8, the spraying was again repeated; each time great care was taken to strike every part of the shrubs with the spray, the one-to-four mixture of kerosene and water being used.

January 4, 1898, the services of Mr. Slingerland were again requested, and on the shrub last referred to a considerable number of scales, mostly young ones, were found alive, although a rough estimate was made that nine-tenths of them were dead.

This shrub upon which the most scales were found is one which was not known to be infested until sometime after whale-oil soap had been applied to the majority of those infested and consequently this treatment was withheld from the shrub. The foliage was dense, and it was nearly surrounded by vigorous large-leaved shrubs of other species so that the June and July sprayings were doubtless less thoroughly applied than in case of the others which were more exposed, and in consequence more readily treated.

When this work was first undertaken it was our hope that a complete extermination of the foe might be the result, and, indeed, the condition of affairs in July seemed to indicate that our hopes might be realized. It is not surprising, however, considering the extreme rapidity with which the San José scale multiplies, that a few of them are now to be found. If only a very small number of scales remained uninjured after the spraying on July 2, the natural result would be a great increase, as there was then several weeks in which reproduction would proceed. So the fact that some scales yet remain does not indicate that the method of treatment is at fault; it does indicate, considering the work as a whole, that in certain instances it was not sufficiently thorough.

Comparing the results of the sprayings made in June and July with those made in November and December, it would seem that the earlier applications are the more effective. In July, as already stated, no live scales could be found, although later developments make it apparent that there were at that time a few isolated scales unharmed. The more recent sprayings, particularly the last one, were as thorough as it was possible to make them, and while only a few scales are alive at the present time the number is more conspicuous than was the case in July, hence the conclusion that the scales are more easily killed in the spring than in the fall or early winter. That this is true seems reasonable when we consider that in the spring the scales are in a growing condition while during the winter they are in a dormant state.

Methods of applying the insecticides.—Whale-oil soap in a solution of two pounds of soap to a gallon of water is somewhat difficult to apply. In our work with the San José scale, thoroughness was conceived from the first to be the basis of all operations connected with the spraying, and it seemed best to apply the soap solution with a brush; an old paint brush with stiff bristles was used. This makes an operation of this kind a little tedious, but it is surprising how rapidly the work may be done even with a brush; and a no more thorough way could be imagined. When this solution is hot it is sufficiently thin to permit its being applied with a pump, but on cooling, as it will do very quickly in small quantities, it becomes more or less stringy and semi-solid in its nature, so that it is difficult to put it on as a spray.

The kerosene mixture was applied with a Success bucket pump with a kerosene attachment. This pump is made by the Deming Co., Salem, Ohio, and is an acquisition to spraying apparatus. By means of this pump the necessity of making an emulsion with the kerosene is removed.

General remarks.—Diluted kerosene, if as effective as our experience indicates, will have several advantages over whale oil soap in fighting the San José scale. Not the least important of these is its cheapness when diluted for use, as compared with whale-oil soap, which costs about four cents a pound at wholesale and about six cents in fifty pound lots. The kerosene may be applied to the leaves or buds at any time without injury, while whale-oil soap, in solution sufficiently strong to kill the scales, will injure the foliage and buds, and it can be applied only to the trunks and larger limbs except when the plants are thoroughly dormant. Kerosene is more easily applied than whale-oil soap. It is of uniform strength, while the qualities of whale-oil soap are quite uncertain.

Pure kerosene has been recommended as a specific for this pest, and doubtless it is, but its effects upon the host plant are less certain. It is a well known fact that pure kerosene may be used on some plants with perfect safety and it has been so used on some of the orchard-hosts of this scale with apparent impunity; it has also been used with decidedly fatal results to the host.

Natural enemies of the scale.—There are several of these, to which only a passing reference can here be made.

There are several insects which feed more or less upon it and a number of fungi are its parasites, but its most destructive enemies, both insect and fungous, are natives of southern or warm climates and it is doubtful if these can be of much use in combating it in the north. The most destructive enemy, apparently, is a fungus (*Sphaerostilbe coccophila*) which is found in Florida. Its utility as a destroying agent has been studied and reported by Rolfs of the Florida Experiment Station.*

In the first part of this bulletin an attempt was made to point out the necessity of being thorough in the work of spraying. We would again emphasize the close connection which exists between thoroughness and success. As important as this is in all ordinary spraying, it is even more so in attempting to combat the San José scale. The insect is so small and often attached to uneven places on the bark, particularly if the bark is rough and full of little crevices, that it is only with the utmost care that even a large percentage of the scales can be reached by the spray, to say nothing of exterminating the foe, and reproduction takes place with such phenomenal rapidity that one scale will soon give rise to thousands.

---

*Bull. 41, Fla. Exp. Sta.

Summary on Treatment of San José Scale.

1. Whale-oil soap used at the rate of two pounds to a gallon of water will kill the scale, but its use is more or less restricted on account of its consistency when cold and from the fact that it injures the foliage and buds if they are in other than a dormant condition. Page 258.

2. Kerosene applied at the rate of one part kerosene to four of water will destroy the scale. Page 258.

3. The results of spraying in the spring compared with those obtained from late fall or early winter applications indicate that the scale is more susceptible to the action of insecticides in the spring than in the fall. Page 260.

4. Whale-oil soap in solution may be applied by means of a pump while it is hot, but after it becomes cold a brush or some similar implement is necessary to do thorough work. A spray pump with kerosene attachment is the most convenient apparatus for applying kerosene. Page 260.

5. There are several insects and fungous enemies of the scale but it is yet doubtful if they are of much economic importance in the north. Page 261.

6. The San José scale does not seem to be very difficult to kill when insecticides are brought in contact with it. The difficulty arises chiefly from the fact that the scales are often more or less protected by the rough bark, crevices and other natural conditions of the host, and from the rapid increase of the pest.

7. Great care and thoroughness are of paramount importance. When the work is thoroughly well done and frequently repeated, satisfactory results may be expected. Page 261.

H. P. GOULD.

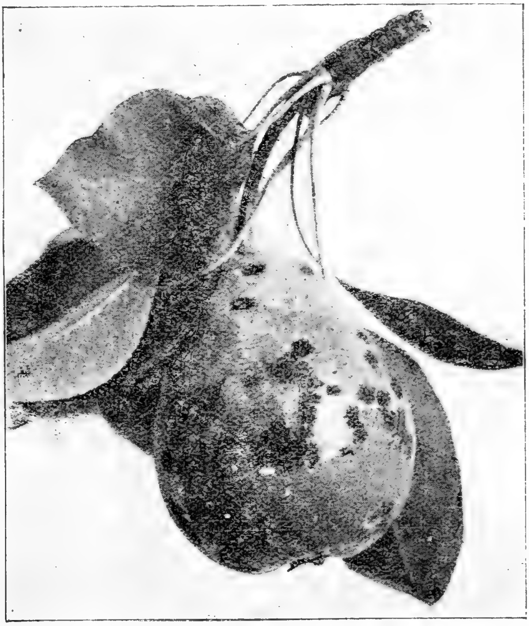
The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
83 A Plum Scale in Western New York, 23 pp.
84 The Recent Apple Failures in New York, 24 pp.
85 Whey Butter, 8 pp.
87 Dwarf Lima Beans, 24 pp.
88 Early Lamb Raising, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
94 Damping Off, 42 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar
115 The Pole Lima Beans, 26 pp.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp
128 A Talk about Dahlias 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Hogs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale.

Bulletin 145. February, 1898.
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

BOTANICAL DIVISION.

Some Important Pear Diseases.



By B. M. DUGGAR.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

BOARD OF CONTROL:
THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	Trustee of the University.
Hon. B. F. TRACY,	President State Agricultural Society.
Professor I. P. ROBERTS,	Agriculture.
Professor G. C. CALDWELL,	Chemistry.
Professor JAMES LAW,	Veterinary Science.
Professor J. H. COMSTOCK,	Entomology.
Professor L. H. BAILEY,	Horticulture.
Professor H. H. WING,	Dairy Husbandry.
Professor G. F. ATKINSON,	Botany.

M. V. SLINGERLAND,	Entomology.
G. W. CAVANAUGH,	Chemistry.
L. A. CLINTON,	Agriculture.
B. M. DUGGAR,	Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	Director.
E. L. WILLIAMS,	Treasurer.
EDWARD A. BUTLER,	Clerk.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.

Cornell University, Ithaca, N. Y.,
March 1, 1898.

Honorable Commissioner of Agriculture, Albany:

Sir: This bulletin is our first attempt to answer the many questions respecting the diseases of the pear. There is a special reason for taking up the investigation from the fact that the common leaf disease of the pear in this state is a different fungus than has been supposed. The inquiry has shown that two very distinct diseases have been confused, and in the future we should speak of leaf-blight less and of leaf-spot more. The bulletin also calls attention to the dreaded fire-blight; and although nothing can be done to directly intercept the disease, the injury may be somewhat averted if the grower's eyes are so sharpened that he discovers the disease upon its first appearance.

I. P. Roberts,
Director.

SOME IMPORTANT PEAR DISEASES.

I. LEAF-SPOT.*

I. General Account.

In horticultural writing much attention has been given to the leaf-

157.—*Leaves of Anjou pear injured by leaf-spot fungus.*

blight of the pear, a disease sometimes called leaf-spot. The leaf-blight is a fungus of wide distribution and of much economic importance,

* *Septoria piricola* Desm.

Recent critical study, however, shows that an entirely different injurious pear-leaf fungus is very probably much confused with the leaf-blight. I would suggest that the name leaf-blight may well be confined to the well-known disease about which so much has been written, and that the term leaf-spot may appropriately be used to denote the fungus to which I wish here to call special attention.

This leaf-spot is not one of those fungi of minor economic importance to be wholly neglected, or which should secure attention at the hands of botanists alone. Nevertheless, in this country it had not been mentioned in the bulletins or other economic publications until the notes sent out from this laboratory last year;* yet it has been casually mentioned in several German works.† I do not find anywhere, however, that it has received deserved attention from the economic point of view, being entirely overlooked or neglected in this country.

While studying some pear diseases during the summer of '95, Professor Atkinson found this leaf-spot abundant in the orchards of Ithaca and vicinity, and before the close of the summer he observed it at Syracuse and Geneva, where considerable injury was done to the foliage of orchard trees.

During the season of '96 and '97 I have continued observations upon this leaf-spot, and it proves to be a disease of considerable importance, and a fungus widely distributed. To the ordinary observer the character of the spots may not seem to differ materially from those of the leaf-blight, but careful observation will readily distinguish them. The mature leaf-spot as it appears on the green leaves is usually larger, more sharply defined, and somewhat angular, being roughly limited by subdivisions in the venation. See figures 157 and 158.‡ The spots may show three fairly well differentiated zones of color. The center is grayish white, and herein appear the

---

*1)Atkinson, Geo. F.—Leaf-spot of Pear. Garden and Forest, X. pp. 73-74, 1897.

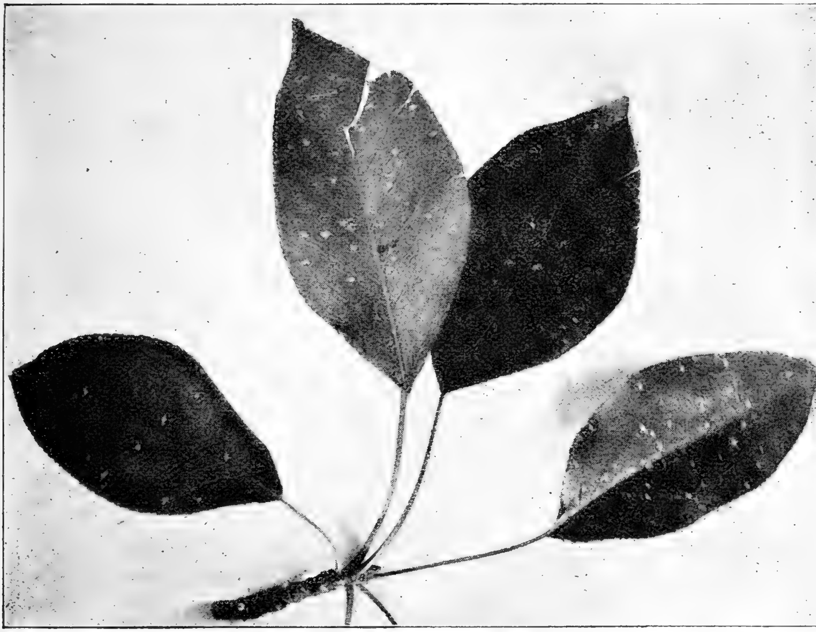
2)Duggar, B. M.—Another Injurious Leaf-spot of Pear. Report Proceedings West. N. Y. Hort. Soc., 1897.

†1)Sorauer, P.—Pflanzenkrankheiten, Zweite Auflage, II. p. 390.

2)Tubeuf, K. F. Von.—Diseases of Plants Induced by Cryptogamic Parasites (English edition) p.

‡Figures 157, 166, 168, and the frontispiece are from photographs made by Professor Geo. F. Atkinson.

minute black fruit bodies, or pycnidia, in which the spores are borne. The next zone is brown, and this often grades into a region purplish in color. The details of these characters are lost in old or dried leaves; but the cluster of fruit-bodies is very evident in the center of the spot



158.—*Small, angular spots produced by the leaf-spot fungus on an unknown variety of pear in a neglected orchard.*

on one or both surfaces of the leaf, especially if examined with a hand lens.

2. GEOGRAPHICAL DISTRIBUTION OF THE FUNGUS.

There is every reason to believe that in New York State this fungus is to be found wherever there are pears. I have collected it in three-fourths of the counties bordering the N. Y. C. and H. R. R. R. from Buffalo to New York, and it is also abundant in south central portions of the state. It has been sent to me from Pennsylvania, Maryland

and Virginia, and pear leaves from Alabama show spots characteristic of this disease, although the immature condition of the fungus renders a definite determination difficult. Nevertheless, from the above we are assured of its general distribution in the eastern states, and in many places it is the most abundant leaf fungus of the pear.

3. Occurrence in Orchards.

By far the majority of observations as to distribution were made upon orchard trees, since these are generally more accessible. Fortunately, there is no evidence to show that this disease ever attacks the fruit, so that there is little danger of losing a growing crop. The foliage of susceptible varieties, however, is often greatly injured by midsummer, and many trees are partially defoliated in August. At Black Hook I observed a number of yard pear trees more than half defoliated on June 17. At Cayuga large blocks of several varieties were considerably defoliated by the latter part of August, but during the midsummer the leaves were only spotted and somewhat discolored. Under ordinary circumstances, a number of varieties are so slightly injured that the defoliation is scarcely evident before the appearance of frost, unless there are adjacent resistant varieties for comparison. At any rate, many varieties suffer more or less, and even though affected leaves should adhere until after the summer pears are gathered, the injury to the leaf throughout the summer and its fall a month or more before the normal time are sufficient injuries to demand our attention. We must assume that the vigor of the tree is thus reduced for the perfection of its product another year. Only a series of experiments through a period of years could determine accurately the extent of such injuries.

There has been collected a considerable amount of data as to varieties affected, but mostly in small orchards. Such matters are also liable to great variation, and I present a general account merely for the suggestion it may give. In this connection notes on a single orchard are valuable for the comparison of varieties, as far as they go. In the orchard of Mr. H. S. Coleman, of Geneva, no spraying was done during '96. In round numbers there were about one thousand trees, distributed as to number in variety as mentioned below. In order of injury, this one orchard gave the following results, defoliation being not very great, even on October 1; it is mainly a comparison of leaf injuries:

Variety.	Number of trees.	Effect.
Bosc	1–5	Quite bad.
Anjou	100	"
Louise Bonne	10–25	"
Giffard	1–5	"
Buffum	1–5	"
Clairgeau	10–25	Considerable.
Summer Doyenne	1–5	"
Seckel	100	"
Sheldon	10–25	"
Bartlett	100	"
Lawrence	10–25	"
Flemish Beauty	10–25	Slight.
Josephine de Malines	1–5	"
Vicar of Winkfield	1–5	"
Clapp's Favorite	10–25	"
Reeder	1–5	Very slight.
Souvenir du Congress	1–5	"
Duchess	500	"
Winter Nellis	1–5	None.
Kieffer	1–5	None.

On the University grounds the orchard of the department of horticulture was given at least one spraying during the season of '96, but even here the disease was generally prevalent to slight extent. Observations upon this orchard and upon others indicate that among the varieties more commonly cultivated, Anjou, Seckel, Bosc, Summer Doyenne, and Bartlett are very generally affected to considerable extent; Louise Bonne, Clairgeau, Clapp's Favorite, Flemish Beauty, and others much less, falling into an intermediate and variable grade; Duchess uniformly very slightly affected; and Kieffer free from the leaf-spot fungus.

The leaf-blight fungus in pear orchards is apparently not very abundant in this state, and instances of the confusion of the leaf-spot with the leaf-blight have come to our attention. This may account for the statement that the leaf-blight, although of general occurrence in New York, rarely causes cracking of the fruit in this state. Leaf-spot never affects the fruit. Nevertheless, one cannot go amiss in the treatment of these diseases, mistaking one for the other, for the treatments as suggested are about the same.

4. SPRAYING EXPERIMENTS IN THE ORCHARD.

For the season of '97 it was decided to make some experiments for the prevention of this leaf-spot. Cayuga seemed our most convenient point, and on visiting some orchards at that place, I found that a small orchard owned by H. S. Wiley contained a number of trees of two desirable varieties, and upon an examination of the old leaves of the previous year, it was found that the leaf-spot had been present to considerable extent. Mr. Wiley consented to have the work done, and put his orchard at our disposal, as well as the use of his barrel pump; and I was assisted in the work by F. T. Wiley.

As originally planned, these experiments were designed to test the effect of three standard fungicides, the number of sprayings necessary, and the best time for spraying. Owing, however, to a difficulty in securing certain materials for the first application, the original plan could not be fully carried out.

The three fungicides used and the formulæ employed were as follows:

Bordeaux.

Sulphate of copper (blue vitriol)	6 pounds.
Quick lime	4 pounds.
Water	50 gallons.

Ammoniacal copper carbonate.

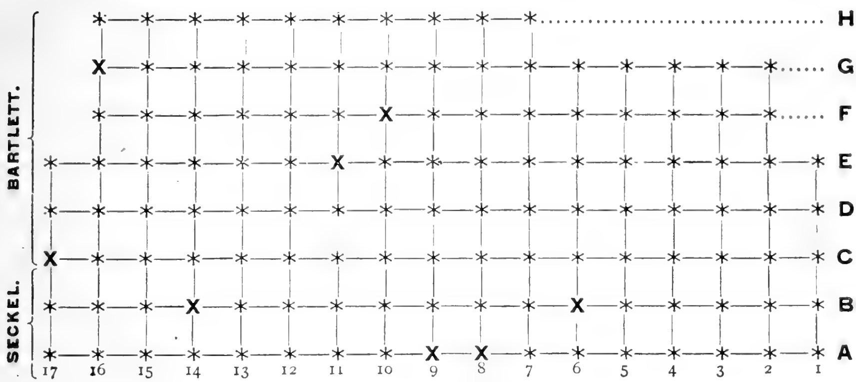
Carbonate of copper	5 ounces.
Strong ammonia	3 pints.
Water	45 gallons.

Liver of sulphur solution.

Potassium sulphide	30 ounces.
Water	50 gallons.

The general arrangement of the orchard is given in the diagram below. The only changes from original settings are that in row A. Nos. 3, 4 and 5 are top grafted to Idaho; in B, No. 1 to Vermont Beauty, and throughout No. 8 the trees are top grafted to Kieffer, Missing trees are indicated by crosses.

The original rows run as indicated by the lettered rows, and the spraying was made across both varieties, hence according to the numbered rows.



Row 1, Ammoniacal copper carbonate, four times, May 6 and 27, June 11, July 17.

Row 2, Ammoniacal copper carbonate, three times, May 6, June 11, July 17.

Row 3, Bordeaux mixture, four times, May 6 and 27, June 11, July 17.

Row 4, Bordeaux mixture, three times, May 6, June 11, July 17.

Rows 5 and 6, Potassium sulphide, three times, May 27, June 11, July 17,

Row 7 and 9, check, unsprayed.

Row 10, Ammoniacal copper carbonate, three times, May 27, June 11, July 17.

Row 11, Ammoniacal copper carbonate, two times, June 11, July 17.

Row 12, Bordeaux mixture, two times, June 11, July 17.

Rows 13–17 unsprayed.

Row 8 not included (Kieffer).

It is seen that the first spraying (omitted from some) was made before the blossoms were fully open, the next soon after the petals fell, and two sprayings were made during the summer months. Notes were taken on August 3, September 2, and October 5. Defoliation began during August, and on September 2 the unsprayed trees were about one half defoliated; but detailed notes of this date will not be given, since those of October 5, some time previous to the autumn frosts, will show better the final status of the protection rendered.

Row 1, very slightly affected. Leaves green and fresh.

Row 2, same as 1.

Row 3, almost no indication of spot. Leaves remarkably healthy.

Row 4, about the same as 3.

Row 4 and 5, affected by the spot to considerable extent, but almost no defoliation by September 1. Badly spotted and slightly defoliated on October 5.

Rows 7 and 9, badly defoliated.

Row 10, slight attack throughout, Seckels showing more injury.

Row 11, badly spotted, about as in 5 and 6.

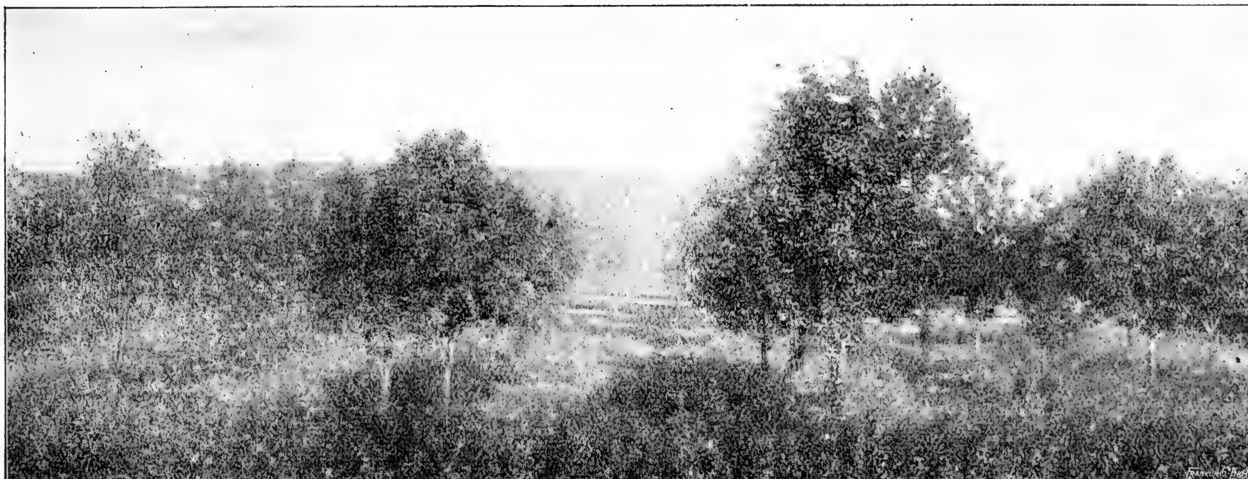
Row 12, injured throughout, but not so much as row 11.

At this time, and even earlier, the difference between the check rows and certain of the sprayed rows was so evident as to be noticed at considerable distance. The sprayed trees maintained their leaves well, and the earliest autumn winds were not sufficient to jar them off. This became so evident late in October, that Mr. Wiley further emphasized my earlier observations by writing me: "The trees you sprayed (that is, the fruiting pear trees) have retained their leaves most remarkably, while the others are now all defoliated."

Figure 159 shows, in the center, rows 3 and 4 sprayed with Bordeaux; and on the right, rows 1 and 2, sprayed with ammoniacal copper carbonate.

Figure 160, at the center, gives comparison between the check, on the right, and three sprayings with ammoniacal copper carbonate on the left.

Summarizing the spraying experiments, it is well to suggest that three sprayings with Bordeaux gave almost perfect protection against the leaf-spot. This spot may probably be quite effectually treated by the usual treatments given for pear scab. Where the codling-moth, but not the scab, prevails, the first treatment may be made in conjunction with the Paris green application, immediately after the petals fall, and two subsequent sprayings at intervals of two or more weeks, if thoroughly done, would secure protection throughout the season, it appears. My observations have been, moreover, that neglected



159.—*Central two rows sprayed with Bordeaux. Rows to the right sprayed with ammoniacal copper carbonate.*

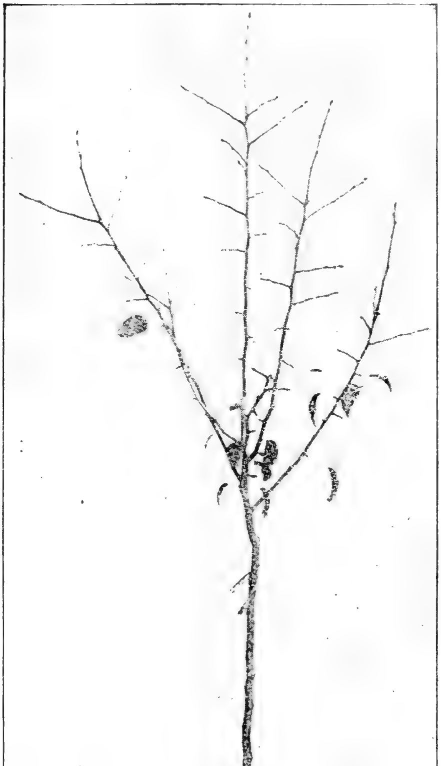
160.—*In the center, to the right,* ***is*** *row* **9**, ***unsprayed;*** ***and to the left,*** *row* 10, *sprayed three times with ammoniacal copper carbonate* orchards, trees in turf and in small garden lots are more affected than a properly cultivated orchard.

5. OCCURRENCE IN THE NURSERY.

The principal nursery regions which I have examined in this connection are those in the vicinity of Dansville, Geneva, and Cayuga. While the leaf-blight is the financial bane of seedling pears, this leaf-spot is uniformly the fungus monopolist of budded stock after the first year. Budded stock of two years or older is often badly injured late in the summer, and occasionally I have found the leaf-spot to a considerable extent upon one-year stock. Although well aware of its presence, nurserymen, as a rule, do not consider this sufficiently injurious to warrant their attention, especially as there is greater difficulty in spraying the stock of the second year; but many realize that it would be desirable to spray. Some make a practice of spraying the one-year stock early in the season, but those who do this are few, and the fact remains that it suffers less injury than older stock. As to the cause of this apparent immunity, several prominent nurserymen agree that with an abundance of room and with the good culture usually given the first year, the plant finds such favor-

161.—*Sprayed late with Bordeaux.*

able conditions as readily to hold the mastery. This is authenticated by my observations on older stock, which seems to be less affected when the culture has been well attended to. Nevertheless, the spot is abundant on certain varieties in spite of any culture which I have seen.



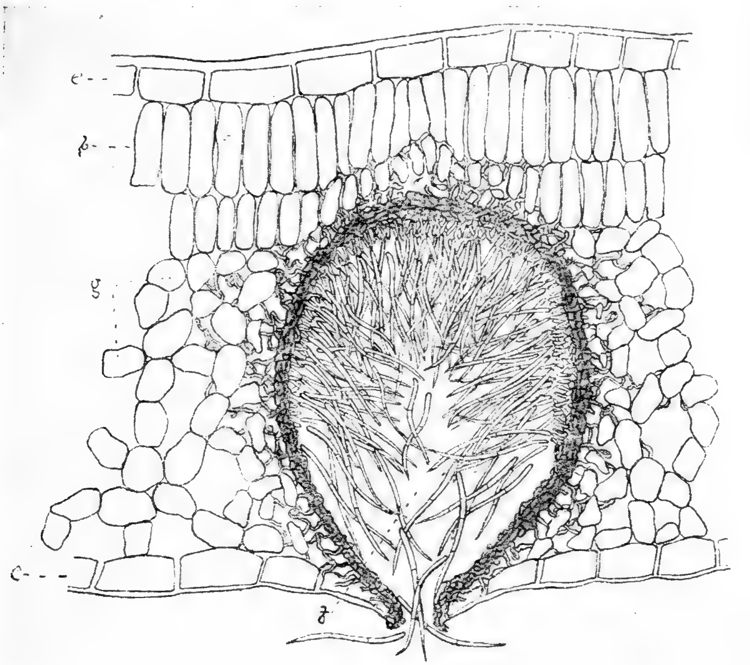
162.—*Sprayed with ammoniacal copper carbonate.*

Extensive notes have been taken as to the extent of injury among the different varieties, but there is so much variation that no definite statement should be made at present. Certainly, however, thus far Anjou, Seckel, Sheldon, Summer Doyenne, Dana's Hovey, Frederick Clapp, and Bartlett have shown the greatest injury, somewhat in the order named; Duchess very slightly affected, with Kieffer quite free; and all of the remaining varieties ordinarily grown suffer more or less.

Spraying experiments on rather old nursery stock were also begun at Cayuga, but through an unfortunate misunderstanding most of the stock was removed after the second spraying, and the only result of interest is the comparison between a few Seckels and Anjous, sprayed late with Bordeaux and ammoniacal copper carbonate respectively. Figures 161 and 162 indicate these comparisons.

6. MICROSCOPIC CHARACTERS.

A thin section through a diseased spot* is shown in figure 163. Here we see at *e* the outer cell layer, or epidermis, of the leaf on both

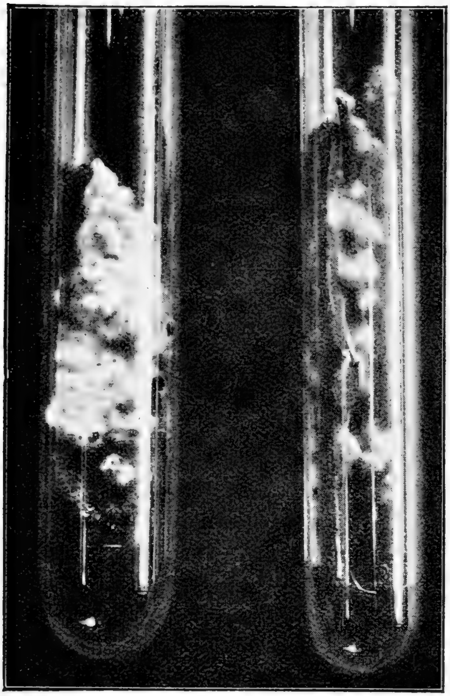


163.—*Cross section through a leaf-spot, showing the fruit body and spores of the leaf-spot fungus.*

sides. At *p* is shown the palisade layer of cells often containing so much of the green coloring matter of the leaves, and below this the

* Portions of leaves showing the fungus, after being properly fixed and dehydrated, were imbedded in paraffine, sectioned, and stained. The Ehrlich-Biondi-Heidenhain combination works well, staining green the deadened host cells and older hyphal elements, while the basidia, younger hyphæ, and fresher leaf tissues are colored red. A carmine and nigrosin combination also works well.

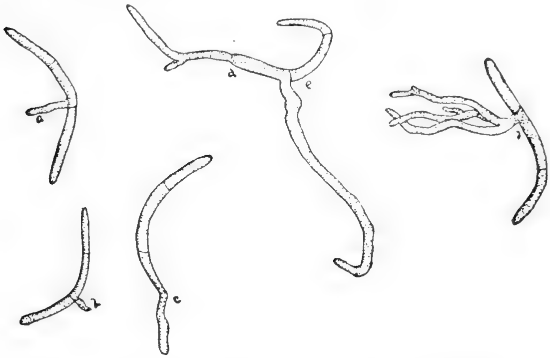
The spores do not germinate very readily in agar alone, but I have secured abundant germination in agar containing pear-leaf decoction. Isolated spores were then removed to bean-stem and pear-stem general leaf tissue, *g*; *f* is a section through the hollow mature fruit body, or pycnidium, containing the countless spores. Each spore was originally borne on a little pedicel, or basidium, which seems to grow out from the wall. When the pycnidium is ripe, water is absorbed, and these masses of spores ooze out of the mouth of the pycnidium in a long horn-like projection, very dark in color. Here, then, they are at the surface ready for dissemination. With suitable conditions of moisture they germinate readily upon other pear leaves. Some germinating spores highly magnified are shown in figure 165. The germ tubes arise from either end (*c* and *d*), or from the middle (*a*, *b*, *e* and *f*) of the spore, and readily penetrate the tissues of the leaf for the final production of another leaf spot.



164.—*Culture of the leaf spot fungus on pods and stems of bean.*

---

cultures. Here the fungus grew slowly at first, producing after several weeks the pycnidia of the *Septoria*. After several transfers this fungus grows quite luxuriantly on bean pods or stems, as seen in figure 164, producing the pycnidia in a short time, and the pycnidia are then not so definite in form but formed of a very loose stromatic mass. The submerged hyphæ are dark in color, while the aerial growth is dense and white, except the stromatic mass inclosing the pycnidium. I have had cultures for eighteen months; and although they have been subjected to various climatic conditions, nothing of further interest has as yet come from them. In nature the fungus is being closely watched for other stages, but I can say



165.—*Germinating spores of the leaf-spot fungus.*

II. LEAF-BLIGHT.†

1. GENERAL ACCOUNT.

The above disease has been known in this country for many decades, and throughout this period it has figured in horticultural discussions. During the past ten years it has been freely discussed from the prac-

---

nothing definite upon this point at present, although other fungi have been found on the old leaves.

This *Septoria* is very evidently to be referred either to *S. piricola* Desm. or to *S. nigerrima* Fuck. Through the kindness of Professor W. G. Farlow, the American specimens have been compared with *S. piricola* in Desmaziere, Herbier de la France, and with *S. nigerrima* in the Mycotheca Universalis and in the Klotzsch collection No. 1755, to which Fuckel referred his nigerrima in the original description. Dr. Farlow would not regard the European specimens as distinct species; and our American form, he finds, differs, if at all, only in that the spores are somewhat more nearly alike at both ends, whereas the European specimens may be somewhat blunter at one end. I have also compared the American specimens with No. 2259 of the Rabenhorst Fungi Europaei, labeled *S. piricola*, and the two are identical. It will be noted that Saccardo doubts the distinctness of these two species from his query concerning the difference of color in the cirrae. In *S. piricola* they are described as white to olivaceous, while in *S. nigerrima* they are given as black. This, however, may be of slight importance since the description is evidently incomplete. The American specimen and the Rabenhorst are both 2-septate, thus agreeing further with the published description of *S. piricola* Desm.

† *Entomosporium maculatum* Lev.

tical and scientific point of view in various publications of the U. S. Department of Agriculture, and in many bulletins of the various Experiment Stations. It will not be amiss further to emphasize the results of general interest, especially in connection with the notes already given concerning the leaf-spot. The leaf-blight is well known wherever the culture of the pear has been introduced, and since what is probably the same fungus occurs abundantly on the quince and some other members of the rose family, it finds abundant host plants for fruitful propagation in almost any region.

The spots are very evident on the upper surface of affected leaves. They occur at first as small discolored areas, becoming dull red with darker margins. Singly, they are small with circular outlines; but often they are clustered together, or merged one into another. With age the spots are darker, losing some of their characteristics. The leaf often becomes yellowed or browned and is readily detached from the branch by jarring. There may be seen in the center of each spot at maturity a minute dark papilla. As noted later, it is herein that the spores are borne.

The spots of this fungus are usually smaller than those of the leaf-spot, more nearly circular, and not so clearly defined on the under surface.

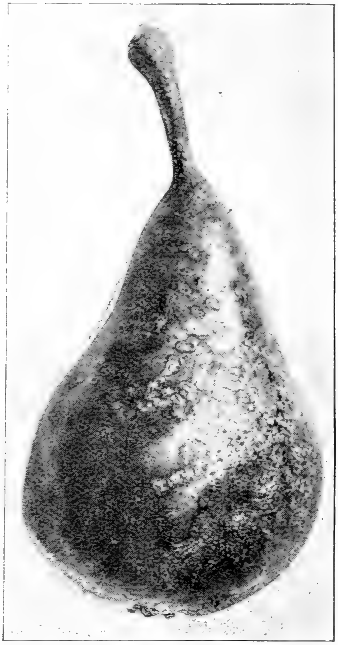
On the fruit the spots of the leaf-blight are red at first, but soon become darker. The drying of the epidermal layers of cells may cause a cracking of considerable extent, as in the case of pear scab, an injury from which rotting may readily ensue. The term cracking is no more to be applied to this disease, however, than to the scab. Figure 166 shows a pear merely spotted by the disease.

2. MICROSCOPIC CHARACTERS.

Making a thin section through the spot of this leaf-blight where the blackened papilla is noted, authors have described the spores as massed just beneath the cuticle. These minute spores are very unique in form, which to the imaginative mind of an early botanist suggested a miniature insect well provided with feelers; hence the generic name of the fungus, *Entomosporium*, expresses this resemblance. See figure 167 for individual spores.

The mycelium, or vegetative threads, of the fungus penetrate the epidermal layer, and to some extent the general tissue of the leaf, breaking down the cells considerably in that region of the leaf showing the spot.

With proper conditions these spores germinate readily, and ultimately produce again the spot wherever they secure an entrance into the tissues of the leaf. Sorauer claims that from the germination of the spore to the appearance of mature spores in the spot it may induce, about one month is required.*



167.—*Pear injured by the leaf-blight fungus, showing no indication of cracking.*

3. OCCURRENCE IN THE ORCHARD AND REMEDIES.†

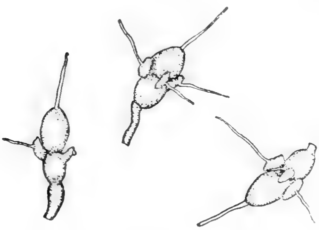
The leaf-blight has proved a pest to orchardists throughout the country, yet it has been less injurious in New York than in many states farther south and west. I find it more abundant in the Hudson Valley than in other sections of New York. It seems to attack quite generally the varieties more commonly cultivated, although Duchess and Kieffer have often been reported resistant. Many varieties in one place reported free from the disease are reported badly injured in other sections.

---

*NOTE.—Sorauer has described at length a winter form or perfect stage of the *Entomosporium* which he has called *Stigmatea mespili*. On wintered leaves of quince Professor Atkinson has also found this fungus, and he has suggested referring it to the discomycetous genus *Fabræa*. See Garden and Forest, l. c.

†It is to be noted that in this connection we can refer to the results only as published, but owing to the comparative abundance of the leaf-spot in a few eastern states where the leaf-blight only has been reported upon, there is danger that some important mistakes have been made.

Experimental work at various places throughout the country has shown that the Bordeaux mixture is the most efficient fungicide. Results obtained by the Division of Vegetable Pathology, both in nurseries and orchards, are especially encouraging. Work on a large orchard in Virginia, during 1893, made it clear that for the particular region early sprayings alone did not at all suffice, and that no very early applications are necessary for the treatment of this disease in the orchard. Unsprayed trees were badly defoliated early in August, while trees which received two rather late sprayings—one after the leaves were well formed, and another within the course of a month—were well protected. If thoroughly done, two sprayings seem to suffice. From the above piece of work, moreover, we learn that in treating 16,000 trees, the cost for two sprayings was less than two cents per tree. As mentioned in connection with the other pear diseases, the 50-gallon formula of Bordeaux is to be recommended.



167.—*Spores of the leaf-blight fungus.*

4. OCCURRENCE IN NURSERIES AND REMEDIES.

In the nursery the principal damage is done to seedling pears, and further injury is usually to be attributed to the leaf-spot. As previously mentioned, the budded stock is much less frequently affected by the leaf-blight. Seedling pears throughout the state, and generally throughout the country, suffer seriously from it. The youngest foliage is first affected, and often the leaves fall early in the season. Later in the season the sunken reddish areas on the tips of the branches indicate the disease on those parts, and Sorauer has shown that in the latter places the disease may readily pass the winter. In this country Fairchild has also corroborated these views.

The premature hardening or ripening of the young wood prevents the budding operation; or, if budding is not entirely prevented, the early cessation of growth in the formative cambium of the stock renders a perfect union of the woods difficult to secure.

The results of all properly conducted experiments upon nursery stock indicate that Bordeaux mixture as a fungicide is essential to success where this disease prevails. Five or more sprayings have not given perfect protection; but they have been extremely profitable on the American, French, and Japan stocks generally. In large nurseries, and with horse-power machines, the cost should not exceed twenty-five cents for each 1,000 trees.

REFERENCES TO LITERATURE.

CHESTER, F. D.—The Treatment of the Leaf Blight of the Pear and Quince. Bulletin 13, Delaware Experiment Station, 1891.

Present Status of Knowledge on the Treatment of Pear Leaf Blight. Report Delaware Experiment Station, 1891, pp. 44-46.

FAIRCHILD, D. G.—Pear Leaf Blight. Abstract in Report Department Agriculture, 1892, p. 226.

FAIRCHILD, D. G.—Experiments in Preventing Leaf Diseases of Nursery Stock in Western New York. Report New York Experiment Station, 1892, pp. 642-652.

Experiments with Fungicides to Prevent Leaf - Blight of Nursery Stock. Journal Mycology VIII., No. 4, pp. 338-351.

*GALLOWAY, B. T.—Experiments in the Treatment of Pear Leaf Blight, Cracking and Scab. Bulletin 3, Div. Vegetable Pathology, pp. 36-47, 1892.

The effect of Spraying with Fungicides on the Growth of Nursery Stock. Bulletin 7, Div. Vegetable Pathology, 1894.

KINNEY, L. F.—The Leaf Blight of the Pear. Bulletin 27, Rhode Island Experiment Station, 1894.

Treatment of Pear Orchard. Bulletin 31, Rhode Island Experiment Station, 1895.

SCRIBNER, F. L.—Leaf-Blight and Cracking of the Pear. Report United States Department Agriculture, 1888, pp. 357-364.

Fungus Diseases of the Grape and Other Plants, pp. 101-104.

SORAUER, P.—Pflanzenkrankheiten, zweite auflage, II., pp. 372-377.

TUBEUF.—Diseases of Plants introduced by Cryptogamic Parasites, English Edition.

WAITE, M. B.—Treatment of Pear Leaf-Blight in the Orchard. Journal Mycology, VII., No. 333-338.

---

*See, also, bibliography of pear scab.

III. PEAR SCAB.*

1. GENERAL ACCOUNT.

During the past two years a number of inquiries have been received concerning pear scab, and among the smaller orchardists or others with a small number of trees, equally as many inquiries have related to the well-known pear blight. Consequently, it has seemed well to incorporate in this bulletin such brief accounts of these two diseases as will give the information desired.

168.—*Summer Doyenne badly injured by pear-scab.*

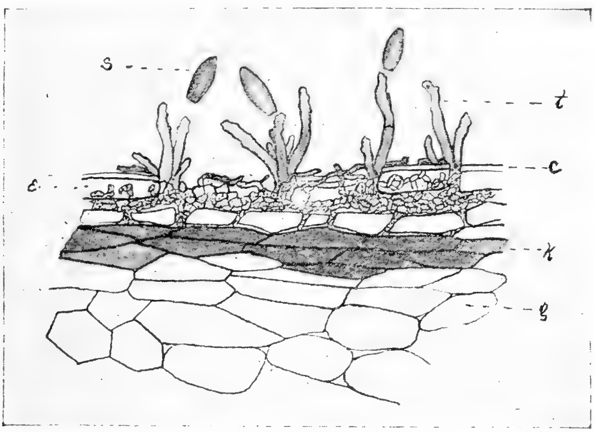
The injurious effects of pear scab are well understood by many orchardists; and by some the disease is combated faithfully and successfully, but to others it is an inevitable attendant of pear culture. During the past summer I was surprised to find how often pear scab is confused with certain insect punctures and other minor injuries. I presume, however, that no one who ever grew so susceptible a variety of pear as the Flemish Beauty could long remain ignorant of the scab. The pear shown in figure 168 is from a photograph of a Flemish Beauty. Although much is lost when colors are

**Fusicladium pirinum* (Lib.) Fckl.

not reproduced, one sees there the essential characteristics of the scab in pronounced form upon the fruit.

With many varieties of pear, this cracking may accompany the scab as well as the leaf-blight, or, apparently even certain irritating external agencies may produce the cracking, provided the respective agencies affect the pear during the growing period.

On the fruit the pear scab produces at first merely brownish or olivaceous markings. These discolorations are due, in part, to a short surface growth of the fungus, and to the deadening of the epidermis



169.—*A cross section through a scab spot on pear fruit, giving the location and the appearance of the fungus.*

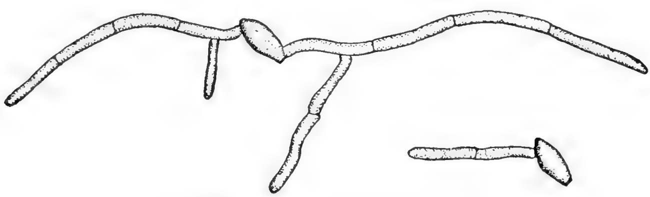
of the pear. Summer Doyenne, illustrated in the frontispiece, shows the characteristic appearance before there is any indication of cracking.

The figures do not show clearly any of these spots upon the leaves, but the leaves are often severely affected, the spots being usually more abundant in the neighberhood of the midrib on tne under surface. During the past year Professor L. H. Bailey received from Michigan some leaves so badly affected that the fungous growth covered the greater portion of both surfaces, and the leaf was considerably curled therefrom.

Pear scab has been known botanically since 1832, when it was found in Belgium; but it is only within the past twenty years that it has had a place in economic literature. Hereafter, at least until unsusceptible and otherwise satisfactory varieties are introduced, to the successful orchardist a knowledge of scab is as essential as a knowledge of pruning.

2. SPECIAL CHARACTERS OF THE FUNGUS.

(*a.*) *Microscopic appearance.*—The olivaceous growth on the fruit, leaves, and twigs is largely made up of short erect threads somewhat uneven at their tips. These threads produce the spores or reproductive bodies. A thin section through a scab spot on the fruit examined under the microscope shows what I have represented in figure 169. Over the entire surface of the pear, as of plants in



170.—*Germinating spores of the pear-scab fungus.*

general, there is a definite outer layer of cells which we call the epidermis, as shown at *e*. The outer wall of this epidermal layer usually becomes thickened into a very tough resistant cuticle, *c*, figure 169. Inside of the epidermal layer of the pear we find the pulpy cells and the gritty cells of the fruit without special regularity, as at *g*. In the diagram it will be seen that the mat-like mass of fungous threads is developed largely just beneath the epidermis,*

It will be seen that the above description of the location of the hyphæ is somewhat different from that given by several authors. Sorauer states that the stroma occupies mainly the epidermal cells in apple scab. Aderhold† in his interesting paper on the Fusicladia finds the hyphæ always subcuticular at first, and mainly subcuticular throughout. My sections, made from pear fruit only, show that the principal stroma in this case is undoubtedly at first subepidermal. The sections studied were made from material imbedded in paraffine, and they were stained with the Ehrlich-Biondi-Heidenhain mixture.

* Pflanzenkrankheiten, Zweite auflage, II., 394.

† Aderhold, Cf. Bibliography.

and they never extend very far into the pulp of the pear. They often penetrate the cells of the epidermis, deriving their nutriment entirely from these outer layers. The erect threads *t*, figure 169, arise from this mass of threads, break the cuticle, and produce the spores as seen at *s*. Later, the epidermis is ruptured, and then we find that a definite corky layer has been formed by the cells of the fruit below the diseased area, figure 169, *k*.

Figure 170 shows how these spores germinate. After falling upon the leaf or the fruit, with suitable conditions, the spore absorbs water, and pushes out a little thread, or germ tube. This germ tube has the power of passing in through the cuticle and epidermis, where it branches greatly and develops the thread-like mass of fungous hyphæ, and soon again the scab spot is seen on the surface.

(*b.*) *How the fungus passes the winter.*—It has been seen that pear scab often attacks the twigs of the first year. The fungous threads are extremely resistant, and buried in the bark of the twigs it is generally admitted that the disease may thus pass the winter, producing the following spring a crop of spores to reinfect the young branches and leaves, as well as the fruit clusters. It is also believed that the fungus may pass the winter in the diseased fruit and leaves. In Germany a winter stage of the fungus has been found belonging to the genus *Venturia*.

In artificial cultures on bean stems and other nutrient media, I have grown for some time the fungi of apple and pear scab. These cultures have yet given no indication of this other fruiting stage, or winter form of the fungus.

(*c.*) *Does pear scab differ from apple scab?*—It is well known that pear scab differs from apple scab in some particulars; but some have claimed that these differences are so small as not to denote that the fungi are distinct. However, it is of considerable practical importance to know that some recent work tends to show that these fungi are distinct species; hence, if this is true, pear scab cannot spread to the apple, and there cause apple scab, or vice versa.

3. VARIETIES AFFECTED.

Scab affects to a greater or less extent a number of the varieties commonly grown in New York. The data upon this subject are limited, but it is generally reported that Le Conte, Kieffer and Bartlett are less attacked than such varieties as Anjou, Lawrence, Duchess, Clairgeau, Sheldon, Seckel, Summer Doyenne, Flemish Beauty and Jones. On Seckel, Flemish Beauty and Summer Doyenne I have found it very abundant during the past two years. In a list of about 24 varieties given by Beach in Bulletin 84 of the N. Y. State Exp. Sta. we find none other than the three mentioned included among those only slightly attacked.

4. REMEDIES.

Since we may assume that this fungus lives over winter in the young branches or diseased fruit, it is quite evident that there is all the more reason for beginning any work of prevention at the earliest time expedient. Fairchild found that before the flower buds open the young scab spots may appear upon them. It is very important to prevent the early establishment of the disease; for once having secured a foothold, spores are rapidly produced and dissemination is very rapid during seasons favorable for the disease.

For the prevention of this fungus, many experiments have been made at various stations with the different fungicides. During the past few years special attention has been given to pear scab at the Geneva Station in New York. The final results are not at all discordant with those of other stations, and recommendations are made somewhat accordingly. Spray three times with Bordeaux mixture of the 50 gallon strength.* The first spraying should be made before blossoming, but after the fruit buds burst; the second, immediately after the petals fall; and the third, about two weeks after the second.

REFERENCES TO LITERATURE.

ADERHOLD, RUDOLPH.—Die Fusicladien unserer Obstbäume, I Teil. Landwirthschaftliche Jahrbücher 25; 875-914; 1895; pl. XXIX.-XXXI.

ARTHUR, J. C.—Leaf Blight and Pear Scab. Report N. Y. State Experiment Station, Geneva, 1884, 367-368.

BAILEY.—L. H. *Fusicladium pirinum.* Bulletin XIX., Cornell University Experiment Station, Ithaca, N. Y., 1890, pp. 49 and 52.

* See page 288. Beach recommends the 66-gallon formula.

BEACH, S. A.—[Report of the committee on plant diseases.] Report of Proceedings Western N. Y. Hort. Soc. 1893, pp. 14-20.

Experiments in Preventing Pear Scab. Report N. Y. State Experiment Station, Geneva, 1893, pp. 694-717.

Experiments in Preventing Pear Scab in 1893. Bulletin 67, N. Y. State Experiment Station.

Some Experiments in 1893 in Treating Pear to Prevent Pear Scab. Report of Proceedings Western N. Y. Hort. Soc., Rochester, 1894, pp. 56-60.

Treatment of Pear Scab in 1894. Bulletin 84, N. Y. State Experiment Station, Geneva, Jan. 1895, also report 1894, pp. 647-663.

CHESTER, F. D.—Spraying with Potassium Sulphide for Pear Scab. Bulletin VIII., Del. Experiment Station, 1890, pp. 11-14.

CHURCHILL, G. W.—Bulletin 35, N.Y. State Experiment Station, Geneva, N. Y., 1890; also Report 1890, pp. 337-339.

ERIKSSON, J.—Bidrag till Kannedomen om vara odlade växters sjukdomar [Reviewed in Bot. Centrb. XXVI., 347-348, 1886.]

GALLOWAY, B. T.—Experiments in the Treatment of Pear Leaf-Blight, Cracking and Scab. Bull. 3, Div. Veg. Path. U. S. Dept. Agr. 1892.

GALLOWAY, B. T.—Pear Scab and Leaf-Blight. Journal Mycology VI., 14, and FAIRCHILD, D. G.—Treatment of Pear Leaf-Blight and Scab in the Orchard. Jour. Myc. VI., pp. 137-142.

GREEN, W. T.—Pear Scab. Bulletin VI., Ohio Experiment Station, 1891, pp. 212-213.

GOFF, E. S.—Soda Hyposulphite Contrasted with Potassium Sulphide and Calcium Sulphide for the Apple Scab. Report N. Y. State Experiment Station, 1888, pp. 154-157.

JONES, L. R.—Apple and Pear Scab. Pt. IV., Bulletin 28, Vermont Experiment Station, pp. 30-34.

Report Vermont Experiment Station, 1891, p. 132.

Bulletin 44, Vermont Experiment Station.

Report Vermont Experiment Station, 1894, pp. 109-113.

KINNEY, F. L.—The Scab of the Apple and Pear. Report Rhode Island Experiment Station, 1894, pp. 185-187.

LAMSON, H. H.—Spraying Experiments in 1894. Bulletin 27, New Hampshire Experiment Station.

LUDWIG.—Die Niederen Kryptogamen, p. 316.

SCRIBNER, F. L.—Fungous Diseases of the Grape and Other Plants, 1890, Chapter XIV.

SORAUER, P.—Pflanzenkrankheiten, Zweite auflage II., pp. 8 and 395-397.

STURGIS, W. C.—"Scab" of Apple and Pear. Bulletin 111, Conn. Experiment Station, New Haven, 1892.

STURGIS, W. C.—Diseases of the Pear. Scab. Bulletin 115, Conn. Experiment Station, p. 5, 1883.

STURGIS, W. C.—Spraying for "Scab" of Apple and Pear. Report Conn. Experiment Station, 1893, pp. 72-73.

TUBEUF, K. F. von.—Diseases of Plants Induced by Cryptogamic Parasites, English Edition, pp. 218-220, also 507.

PEAR BLIGHT.*

(*Fire blight.*)

1. GENERAL APPEARANCE.

Of all the diseases which affect the pear, there is no other which commands attention like the pear blight, or so-called fire blight. One may say that it commands attention, for surely its injuries are usually sufficiently evident—the progressive blackening of leaf and twig, or the death of the tree limb by limb—injuries which must appeal to any one with due interest, either æsthetic or pecuniary. The most evident cases of blight are at first manifest on the tender shoots or younger twigs by the blackened leaves and withered stems; gradually the progress of the disease is downward, an inch more or less each day, it may be; and finally the death of largest limbs may point out the very destructive course of this malady.

With the more susceptible varieties, and under conditions favoring more succulent growth, blight may involve the entire body of the tree. Often, however, the disease is temporarily or permanently checked at definite places by the denser wood or other conditions, and at such places there is a sharp line of demarcation between the healthy part below, and the shriveled, blackened part above. In larger limbs, this break is quite as evident by the cracked appearance of the bark.

Unfortunately, the forms of injury above described are not the only ones. Those who have suffered by this disease know well that frequently the blossoms and the young fruit turn black and dry up. The disease may then remain in the fruits alone, or it may here, also, extend itself to larger limbs through the fruit spurs and twigs.

---

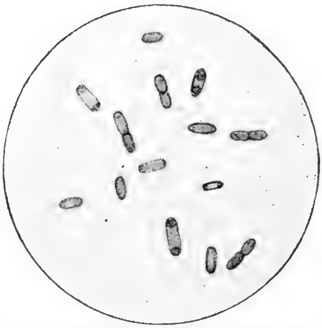
* *Bacillus amylovorus*, Burrill.

2. HISTORICAL.

Pear blight has probably been known in this country for over a century. It was crudely attributed to one or another of countless causes until 1880. At that time, through the studies of Professor T. J. Burrill, of the University of Illinois, we became acquainted with the indisputable means by which this disease is induced and disseminated. The germs of pear blight belong to that class of minute organisms known as bacteria, so many species of which are concerned in the many contagious diseases of man and animals, and so many others useful in various processes of fermentation. From 1883 to 1887, while connected with the Geneva station, Arthur greatly increased our knowledge of this disease. Lastly, Waite of the U. S. Department of Agriculture, has cleared up many points regarding the disease in the flower, its spread by bees and other insects, with added suggestions concerning its eradication.

3. SPECIAL FEATURES OF THE DISEASE.

(*a.*) *The Bacteria.*—We may well dwell upon some of the interesting points concerning the life and action of these pear blight bacteria. Often, when young shoots are affected, slight ruptures in the bark may be noted, and from these ruptures may be exuded minute gummy droplets. Examining under high powers of the microscope such exudation, or even the sap from diseased parts, we find innumerable little oval bodies floating about singly or in chains of two or more, each individual being a plant with great power of rapidly growing longer and dividing again and again into similar simple bodies (see figure 171). These individual bacteria are so small that it requires a mass of them to be evident to the unaided eye; indeed, to attempt to see the individuals in the little gummy droplet, or in the sap, would be like an attempt to see the separate rain drops in the approaching storm more than a mile away.



171.—*The bacteria of pear blight.*

Nevertheless, we can grow these bacteria in large quantity upon slices of cooked potato, beef broth, and many other culture media. Here, with certain precautions, they may be grown entirely free from other germs—in pure cultures. Then these cultures may be used to inoculate healthy twigs, and the production of the disease in the latter gives all needed evidence of the true cause. These inoculation experiments were made by Burrill, and they have been confirmed time and again; so that, (1) finding these disease germs in affected twigs, (2) securing pure cultures of them, (3) by inoculation producing the disease, (4) characterized by the same germ—these make the cause undoubtable. Thus we learn, also, that the disease is contagious, and that we need to take precautions against its spread.

(*b.*) *Kinds of trees affected.*—By means of cross inoculations from tree to tree it has been abundantly shown that the fire blight, or twig blight, of the apple, quince and crab; of the mountain ash, service berry, and several species of hawthorne are all due to the same organism; and hence the disease may spread from one to the other. During the past two years, I have found it attacking a Japanese Hawthorn and *Pirus Kaido.* In short, this blight is a disease of many pomaceous plants of the rose family.

(*c.*) *Bacteria in the flowers.*—Waite has shown that these bacteria will grow freely in the nectaries of the pear flowers, later penetrating into the solid tissues of flower, fruit and stem. By the agency of bees, which feed upon this nectary, the disease may be abundantly disseminated during the blossoming period; but the bees are essential for cross pollination of the flowers.*

(*d.*) *Bacteria in the wood.*—The germs cannot enter the older tissues except through abrasions of the bark, and it is believed that there must be some insect or other slight injury in order that they may enter even the growing tip. The leaves afford no inlet for them, and localized trunk injuries may have been established by means of young shoots or water suckers.

In order to understand how these bacteria may pass downward, once having gained entrance, we must recall the structure of a limb. Just between the soft bark and the wood is a layer of growing tissue,

---

*Waite, M. B.—The Pollination of Pear Flowers, Bulletin 5. Div. Vegetable Pathology, U. S. Dept. Agr.

the cambium, which develops each year a layer of new wood on the inside and a layer of new bark on the outside, so that all the young, active tissue is very closely connected. The younger inner bark, however, is the favorite region for the bacterial growth, containing, as it does, much nutritive material.

Sometimes the cambium is also affected. In these tissues the bacteria grow abundantly, passing gradually from cell to cell and destroying much of the living portion of the branch as they go, but never circulating rapidly from branch to branch. The surface is reached by means of the little cracks through which the gummy exudations arise.

4. REMEDIES.

(*a*.) *The knife and the saw.*—With a disease working as this does, it is very evident that there is no chance either for cure or prevention by means of spraying. The heroic treatment of the knife and saw must be adopted and vigorously pursued, as has been claimed from the beginning. The blackened leaves, alone, must not serve as signs of the diseased area, but one must examine carefully the branches and remove them six inches or more below the lowest discolorations. Often before cutting, pruners slice the bark downward to see where the injury ends. This should not be done; it is better to be sure that you are below the infected area and run no such risk of infecting anew the tissue below. The cut surfaces of larger limbs and branches should be painted for protection against wound rots.

(*b*.) *When to cut.*—Cutting out diseased portions should be done whenever the disease is evident. This may check the injuries temporarily; but it has been shown that much can be done in the autumn to prevent the establishment of the disease the following spring. It has long been known that the disease may pass the winter in the branches by a slow growth in the neighborhood of late infections. Thorough work of eradication should especially be performed after the season of growth. Then cut out every diseased branch and burn, so that in the spring, when the succulent growth begins again, there will be few places in which insects may come in contact with the bacterial exudations. Sometimes trees which are affected during the summer and autumn show no indication of the disease the next year, and I have observed this especially in the case of hawthorn and apple, but it seems much more likely to pass the winter in the pear.

(*c.*) *Conditions favoring the disease.*—The knife is our only hope of extermination, but there are undoubtedly conditions which favor the disease. In a succulent, rapidly growing tree the bacteria find more favorable conditions for their development than in one which grows slowly, yet with sufficient vigor. For this reason too much nitrogenous manure is dangerous, and, for the same reason, a succulent growth induced by severe pruning should be avoided. It has been demonstrated by experiment that withholding water from potted trees which had been inoculated with blight would immediately stop the course of the disease.

REFERENCES TO LITERATURE.*

ARTHUR, J. C.—Pear Blight. Report N. Y. State Experiment Station, 1884, pp. 357-367.

Pear Blight, Bulletin 2, New Ser., N. Y. State Experiment Station.

Proof that bacteria are the direct cause of the disease in trees known as pear blight. Proc. Amer. Assoc. Adv. Sci., XXXIV., 295-298, 1885. [Same in Bot. Gaz. X., pp. 343-345, 1885.]

Pear Blight. Report N. Y. State Experiment Station, Geneva, 1885, pp. 241-248.

Pear Blight and Its Cause. Amer. Nat., XIX., pp. 1177-1185, 1885.

History and Biology of Pear Blight. Proc. Phila. Acad. Nat. Sci., 1886, pp. 322-342.

Pear Blight. Report N. Y. State Experiment Station, 1886, pp. 275-289; also "Important Articles on Pear Blight," same report, pp. 300-315.

BECKWITH, M. H.—Blight affecting the body of pear and apple trees. Report Delaware Experiment Station, 1895, pp. 158-159.

BURRILL, T. J.—Anthrax. of fruit trees or the so-called fire blight of pear and twig blight of apples. Proc. Amer. Assoc. Adv. Sci., XXIX., pp. 583-597.

Blight of Pear and Apple Trees. Report Industrial University of Illinois, 1880, pp. 62-84,

Pear Blight, Amer. Naturalist, XV., pp. 529-532, 1881.

Trans. Ill. Hort. Soc., 1880, pp. 157-168.

Bulletin 2, Illinois Experiment Station, pp. 16 and 17.

CLARK, J. W.—Pear or Fire Blight. Bulletin 16, Missouri Experiment Station.

---

* For earlier references see Arthur, J. C. Important Articles on Pear Blight. Report N. Y. State Experiment Station, 1886, pp. 300, 315.

STURGIS, W. C.—Fire blight. Report Conn. Experiment Station, 1894, pp. 113-117.

TUBEUF, K. F. VON.—Pear and Apple Blight. Diseases of Plants induced by Cryptogamic Parasites, English edition, pp. 531-532.

WAITE, M. B.—Pear Blight. Report of Proc. Western N. Y. Hort. Soc., 1895, pp. 96-99.

The Cause and Prevention of Pear Blight. Year Book of the Department of Agriculture, 1895, pp. 295-300.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.

Bulletin 146. **February, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

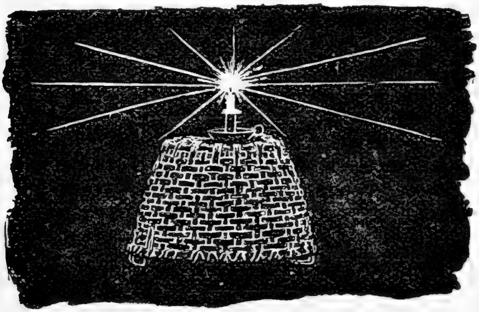
ALL DIVISIONS.

FOURTH REPORT OF PROGRESS

ON

EXTENSION WORK.

(Being a Report of Work done under Chapter 128, Laws of 1897, of the State of New York, otherwise known as the Nixon Bill.)



By I. P. ROBERTS.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1898.

ORGANIZATION OF THE EXPERIMENT STATION.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases,
146. Report of Progress.

ORGANIZATION OF EXTENSION WORK.

CONSULTING STAFF.

J. G. Schurman,	President
I. P. Roberts,	Director
G. C. Caldwell	Chemistry
James Law,	Veterinary Science
J. H. Comstock,	Entomology
L. H. Bailey,	Horticulture
G. F. Atkinson,	Botany
H. H. Wing,	Dairy Husbandry
V. A. Moore,	Dairy Bacteriology

WORKING STAFF.

I. P. Roberts,	Director
John W. Spencer,	Conductor; Western half of State
George T. Powell,	Conductor; Eastern half of State
B. M. Duggar,	Cryptogamic Botany
L. H. Bailey,	Horticulture
M. V. Slingerland,	Entomology
G. W. Cavanaugh,	Agricultural Chemistry
L. A. Clinton,	Agriculture
G. A. Smith,	Dairy Husbandry
W. W. Hall,	Dairy Husbandry
J. L. Stone,	Agriculture
Mrs. A. B. Comstock,	Entomology and Nature Study
Miss Mary F. Rogers,	Nature Study
A. L. Knisely,	Agricultural Chemistry
H. B. Cannon,	Chief Clerk
C. E. Hunn,	Horticulture
H. A. Surface,	Ornithology
Miss Mathilda Schlegel,	Ornithology
A. R. Ward,	Dairy Bacteriology
C. W. Mudge,	Agricultural Chemistry
Edward A. Butler,	Accountant
Julia Z. Kelly,	Stenographer

Some of the persons comprising the Working Staff have given all their time to the work, and others have been employed for only a few months, or for a few lectures or other special duty.

The efficiency of the work has been promoted by the helpful co-operation of the Secretary of Agriculture, Honorable James Wilson, Director A. C. True and Professor H. W. Wiley, of Washington, D. C. No less helpful has been the hearty support of the Commissioner of Agriculture, Honorable Charles A. Wieting, and the Superintendent of Education, Honorable Charles R. Skinner, and their associates. But most of all do we desire to acknowledge thanks to the many citizens of the state who have so appreciatively received the instruction and to those who have so heartily entered into the work of investigation.

THE PROGRESS OF THE STATE EXTENSION WORK IN AGRICULTURE.

(*Work done under Chapter* 128, *Laws of* 1897, *known as Nixon Bill.*)

PART I.

Investigational Work.

A bulletin (No. 137) was issued in May, 1897, on the Origin and Progress of Agricultural Extension Work. Preliminary reports were made in Bulletins 110 and 122.

The present bulletin is issued for the purpose of recording as briefly as possible the work done from May 1, 1897, to February 1, 1898. The scope of the work under Chapter 437, Laws of 1896, set forth in Bulletin No. 137, was somewhat restricted, since the law required that the money appropriated should be expended in the Fourth Judicial Department in investigations and experiments and for disseminating horticultural knowledge by means of schools, lectures and bulletins.

Chapter 128 of the Laws of 1897 provides for carrying on work throughout the entire state as follows:

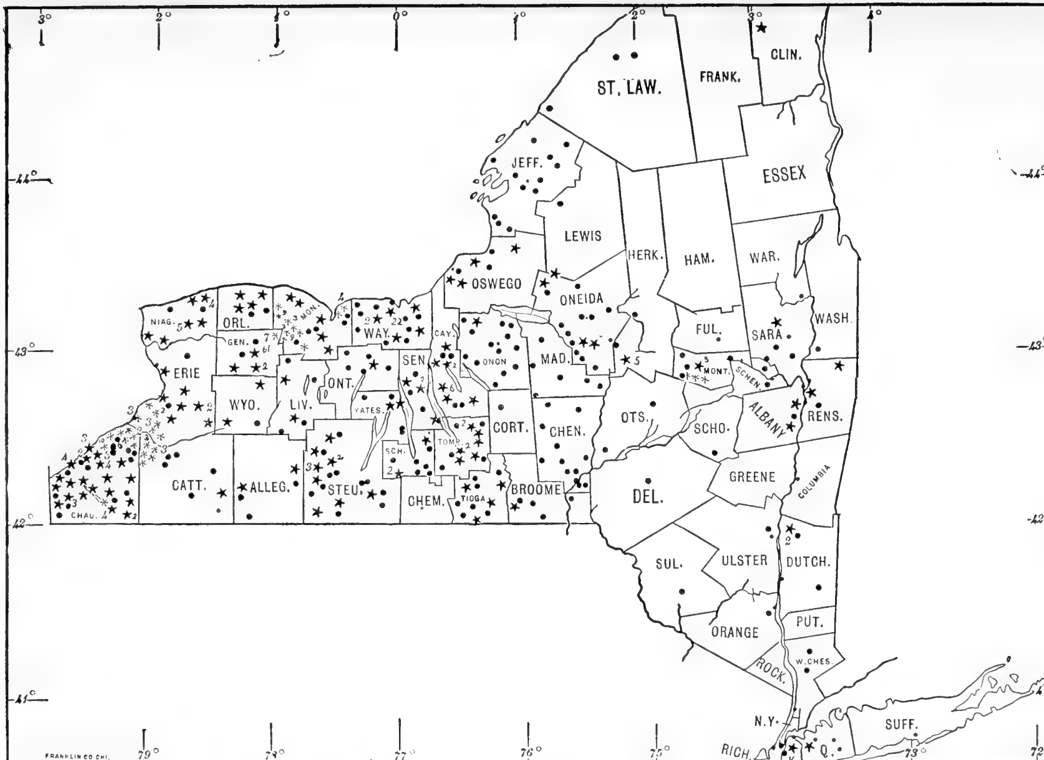
"In giving instruction by means of schools, lectures and other University Extension methods, or otherwise, and in conducting investigations and experiments; in discovering the diseases of plants and remedies therefor; in ascertaining the best methods of fertilization of fields, gardens and plantations; and best modes of tillage and farm management and improvement of live stock; and in printing leaflets and disseminating agricultural knowledge by means of lectures or otherwise; and in preparing and printing for free distribution the results of such investigations and experiments, and for republishing such bulletins as may be useful in the furtherance of the work; and such other information as may be deemed desirable and profitable in promoting the agricultural interests of the state."

The contemplated work was planned with care but there were many unknown conditions; therefore the scheme was pliable and provided only for the work contemplated for six months, at the end of which time it was adjusted to meet the actual conditions and wants which were then found to exist.

The work under the Nixon Bill has been thrown into two general categories—that which is primarily investigational, and that which is more directly educational. Brief reports of progress in the investigational work have been furnished by the divisions having the special subjects in charge. In some cases much of the work has been done by the head of the division; in others, it has been carried on by assistants under his direction.

It is impossible to fully set forth in this brief space the full scope of the investigations completed and now in progress. The work has been unusually fruitful in results which have either been set forth at length in bulletins, or will be published in the near future.

Following are reports of the various departments concerned in the investigational work:



172.—*Showing the post offices at which sugar beet investigations have been made.*

* Shows location of sugar beet experiments.

● Shows location of fertilizer experiments.

The numerals indicate the number of experiments at the different points.

The Work in General Agriculture (I. P. Roberts, Chief).

BY J. L. STONE.

With the view of carrying the University Extension Work in Agriculture to the farmers, early in the spring a circular was prepared describing some simple tillage experiments with potatoes, corn or sugar beets. Such decided results have been secured at the Station grounds by frequent and long continued tillage of the potato, that it was desired to learn if similar results might be secured by the farmers of the state, and with other crops as well as with potatoes. Correspondence was solicited with farmers who were willing to undertake experiments in co-operation with the Station. The Department of Agriculture at Washington supplied us with a quantity of sugar beet seed which was sent to farmers asking for it so long as the supply lasted.

The interest of the farmer seems to center in the sugar beets, very few undertaking tillage experiments with any other crop. Nor were many of them so much interested in the effect of different methods of cultivation upon the crop as they were to discover if, under the system of cultivation most common in the vicinity or most convenient to them during the season, their soils would produce a large yield of beets of sufficient richness to be profitably manufactured into sugar. There was, therefore, very little uniformity of methods in preparing the soil or cultivating the crop, and few attempted the comparison of different methods on the same field.

During August, members of the Station staff visited a large number of these experimental plats to note the conditions existing and advise the farmers in regard to their care. Again, in October, representatives of the Station helped to harvest parts of many of them. The result of this work is fully set forth in Bulletin No. 143. The data relating to other work has not yet been tabulated for publication. Figure 172 shows the post offices at which sugar beet investigations have been made.

Horticultural Division (L. H. Bailey, Chief).

The horticultural enterprises which have been prosecuted under the auspices of the Nixon Bill during the past year have been of two general types, those conducted in various parts of the state, and those undertaken at the central Station at Ithaca. Work of a distinctly scientific nature can be prosecuted successfully only at the central Station, where facilities are at hand and where the subjects are constantly under the eye of the investigator.

In field work in the state, the newer enterprises are at work with fertilizers in strawberries in Oswego county and experiments in celery culture on the onion lands of Orange county. The strawberry studies were begun by the late E. G. Lodeman, and they have now completed their second year. Some very satisfactory and practical results have been obtained, but it is desired to prosecute the work at least another year before reporting on it. Three years' study of the effects of fertilizers on treed nursery lands at Dansville has now been brought to a close with satisfactory conclusions. Experiments begun some time since in Chautauqua and Yates counties in the fertilizing of vineyards are also going forward.

At Ithaca, experiments were made during the summer on new spraying materials and devices, and on the means to combat the San José scale, which, fortunately for experiments, colonized itself on the horticultural grounds. Some of the results of the work appear in Bulletin 144. Other work at Ithaca is proceeding along the following lines: Studies of Japanese plums, of methods of tilling and handling orchard lands, mushroom growing, strawberry forcing (a preliminary report published in Bulletin 134), experiments in floriculture, and studies of practicable means of combating insects and fungi.

Chemical Division (G. C. Caldwall, Chief).

1. SUGAR BEET INVESTIGATIONS (BY G. W. CAVANAUGH).

During the spring of 1897, this Station received from the U. S. Department of Agriculture, Washington, D. C., 500 pounds of sugar beet seed. This seed was distributed in pound packages to 500 farmers throughout the state, together with directions for planting the seed and cultivating the crop.

In order to obtain as correct information as possible relative to the conditions of soil, fertilizers, culture and atmosphere, a second circular was prepared and distributed during the latter part of September. This circular, besides containing directions for sampling the plats in such a way that estimates of the yield per acre might be determined, contained also a model and blank form for recording all data relative to tillage and fertilizing.

About 400 of these circulars have been returned; in general, the data given indicated careful and painstaking work on the part of the experimenters. This mass of data is extremely valuable to the Station as furnishing a basis for future work on the subject of beet culture in New York. All this matter is contained in Bulletin 143.

Shortly after issuing the circular on sampling the beets, the samples for analysis began to arrive and continued to come in until January, 1898. They were, on the whole, carefully packed and showed evidence of a great interest in the subject on the part of the grower.

Besides analyzing some 475 samples sent in by growers throughout the state, about 125 samples grown on the Station grounds were examined. In addition to the analysis of the beets for their sugar content, studies were made of the food and fertilizing values of some of the by-products of the beets, *i. e.*, the pulp, lime cake, molasses, as well as the crowns and leaves. It was possible to obtain for this purpose samples of the pulp, lime cake and molasses through the courtesy of the First New York Beet Sugar Company at Rome, N. Y.

2. FIELD WORK WITH FERTILIZERS (BY A. L. KNISELY).

During the month of February, 1897, Bulletin No. 129 was issued, giving hints and suggestions about the use of plant foods and explaining "How to Conduct Field Experiments with Fertilizers." This bulletin was accompanied by an application blank to be filled out and returned to the Station by any farmer in the state who wished to try a series of field experiments with fertilizers. The fertilizers necessary for a single series of experiments were then sent to each applicant, so far as the funds of the Station would allow, with directions for their application.

In all, 460 applications were received and 230 applicants were supplied with the fertilizers for the experimental work. The set of fertilizers sent to each farmer consisted of:

4 sacks	nitrate of soda	containing	10	pounds	each.
2 "	muriate of potash	"	10	"	"
2 "	superphosphate	"	20	"	"
2 "	each containing a mixture of 20 lbs. superphosphate and 10 lbs. muriate of potash.				

Thus, each experimenter received 40 pounds nitrate of soda, 40 pounds muriate of potash and 80 pounds superphosphate. In all, 2,030 sacks were sent out in sets of 10 each, containing 8,120 pounds nitrate of soda, 8,120 pounds muriate of potash and 16,240 pounds superphosphate, making a total of 32,480 pounds.

Experiments were carried on in the following counties: Albany 1, Allegany 3, Broome 4, Cattaraugus 5, Cayuga 4, Chautauqua 18, Chenango 11, Cortland 1, Delaware 1, Dutchess 2, Erie 2, Herkimer 2, Genesee 2, Jefferson 12, Lewis 1, Livingston 6, Madison 7, Monroe 5, Montgomery 5, Niagara 2, Oneida 11, Onondaga 13, Ontario 6, Orange 2, Orleans 2, Oswego 3, Otsego 2, Queens 1, Rensselaer 1, Saratoga 3, Schenectady 2, Schoharie 1, Schuyler 6, Seneca 4, St. Lawrence 3, Steuben 11, Sullivan, 1, Tioga 7, Tompkins 8, Ulster 1, Washington 1, Wayne 13, Westchester 2, Wyoming 1, Yates 4, making a total of 45 counties with 203 experiments.

A Station representative spent most of the summer visiting the experimenters throughout the state, taking notes and some photographs of experimental plats; giving suggestions and explaining the work; finding out where mistakes and blunders had been made, and ascertaining just how the farmers received and took hold of this kind of work.

There were a few total failures; about half were doing the work fairly well and some 25 to 30 per cent. were doing exceedingly well and had everything right. In all cases, the farmers were very much interested in the work, and said that this way of experimenting with fertilizers, to learn what their land needed, was what they had been wanting to find out. In some cases, where mistakes in applying the fertilizer had been made so that the experiment was a failure, the experimenter would say that if it were not too late he would purchase another set of fertilizers in order to carry on the work through the season.

The amount of benefit that the farmers will receive from these experiments cannot be measured by the success or failure of their experimental plats alone. Where the experiments were carried on properly, the farmers were usually wide awake and energetic and had been in the habit of experimenting more or less.

In some other instances the experiments were almost total failures because the farmer had not been in the habit of experimenting, in fact, did not know how to do it, or had no time for it. To such this work was a revelation. The probability is, that such farmers, even though their experimental plats this year were failures, have been helped proportionately more than those who had successful experimental plats and had been accustomed to experimenting.

The experiments have been all the more beneficial and instructive because the farmers have done the work themselves and, therefore, were much more interested in it than they would have been had it been done by the Station and the results then read by the farmers.

In September, a circular concerning field experiments with fertilizers was sent to each experimenter, giving directions for harvesting the crop on each experimental plat, and for making out and sending the reports to the Station. Up to the present writing, nearly all the reports have been received and, on the whole, they are very satisfactory, considering that this is the first time that the experimenters have made such reports.

In the near future we expect to publish the results of the summer's work with fertilizers, so that all can see what the farmer can do in carrying on experimental work.

Entomological Division (*J. H. Comstock, Chief*).

BY M. V. SLINGERLAND.

The final results from our extensive experiment against the peach borer, extending over a period of three years, were ascertained during the past summer. This investigation has revealed some striking and valuable facts which will add much definite data to our knowledge of how to fight this serious peach pest. We are now collating and digesting the details of this work, which have accumulated during the past three years, and we hope to get the conclusions ready for publication during the coming year.

The above extensive experiment on 450 trees, and the increasing correspondence of the division have occupied a large share of our attention since last spring. The funds placed at our disposal by the so-called "Nixon Bill" have enabled us to get in closer touch with New York fruit-growers and general farmers, and this has resulted in a marked increase in the quantity and quality of our correspondence. The leaven of the educational features of the work is undoubtedly beginning to work, for our queries are becoming more and more definite and intelligent. We consider our correspondence one of the most valuable and important features of the work of this division, for we are thus often enabled to reach special and urgent cases quickly.

In 1896, an insect known as the quince curculio was so destructive in some localities as to lead growers of this fruit to seriously consider the advisability of cutting down their orchards. Early in 1897, we began a critical study of the habits of this pest, and continued our observations during the season, or until we had learned its life-story and had become familiar with its habits. Our observations show that there is little, if any, possibility of poisoning the insect with an arsenical spray, and that early cultivation will have but little effect upon it, thus disproving two of the so-called "remedies" by which it has been supposed that the pest could be reached. Our study of its life revealed some striking variations from its habits of the preceding year. By carefully watching the insect in our cages at the insectary, we were enabled to give several large quince growers warning that the pest was appearing in alarming numbers nearly two months later than its schedule time of the preceding year. By following our suggestions, one extensive grower of this fruit, whose crop was nearly an entire failure in 1896, due principally to the work of this insect, was enabled tc harvest the finest crop of quinces he ever had. A few careful observations in our cages at the insectary upon this single insect pest thus resulted in the saving of hundreds of dollars worth of fruit in a single orchard. The result of our study of this quince curculio will be ready for publication as soon as funds are available.

For several years, hundreds of acres of apple orchards in western New York have been annually stripped of their foliage by canker-worms. The Station has clearly demonstrated, Bulletin No. 101, that these pests can be controlled by thorough work with a poison spray, and yet their ravages go on unchecked in many localities. We had supposed that most, if not all, of the damage was being done by the spring canker-worm, but in November last we received definite information from one locality that at least three other similar insects were then ascending the trees and laying their eggs. One of these insects is new to us and we have not yet learned its name. We have obtained good pictures of nearly all of the forms, and have arranged to go into the field and make a critical study of all of the four kinds of canker-worms which are apparently responsible for the destruction being wrought in western New York orchards.

Past experience shows that it is impossible to predict what insect pest will require attention during the coming year. Whether the tent-caterpillars, plant-lice, the pear psyllas, or any of the other insects which were so numerous in 1897 will again be as destructive in 1898 or not, we do not care to hazard a guess.

Dairy Bacteriology (*V. A. Moore, Chief*).

BY A. R. WARD.

It has been demonstrated that many of the difficulties encountered by our dairymen in obtaining desirable butter and cheese are attributable to bacterial agencies. The varieties of their troubles are numerous and their effect is often disastrous to the prosperity of the creameries and cheese factories where they occur. What are the causes of the bad butter and poor cheese, and how can these causes be removed, are questions which are constantly being asked and which cannot, in most cases at least, be answered satisfactorily until the fundamental principles underlying their causes are carefully worked out and formulated.

During the past summer, by the aid furnished by the New York State Veterinary College, we have started work on certain of these highly practical problems. The results are not yet ready for publication, but when the work is completed it will throw much light upon the relation existing between the bacteria of the immediate surroundings of the cows and of those in the flora of the milk ducts themselves and the gassy curds, bad flavors and taints of the milk products. There are in progress important experiments looking to a practical method for disinfecting the milk passages of those cows which harbor undesirable species of bacteria, and also investigations for determining the character of the bacteria in the milk ducts of cows kept in clean and properly ventilated stables. It has already been found by others, and verified by us, that the condition of the environment of the cows has much to do with the character of the bacteria necessarily present in the milk. These, in turn, have much to do with the quality of the milk products.

Unfortunately, we have but recently been able to start this work, and are now in temporary quarters. It is hoped that in the near future we may have a well-equipped laboratory and funds sufficient to carry on these investigations to the extent their economic importance demands.

Botanical Division (*G. F. Atkinson*, *Chief*).

BY B. M. DUGGAR.

Investigations are in progress, which already have extended over several years, upon the fungus diseases of forest trees, and of timber. Material is nearly ready for a bulletin on some diseases of the timber spruce, and on the effect of wind on trees weakened by the action of fungi. Researches are also being prosecuted upon the embryology of the conifers, and upon the development and structure of seedling trees.

A bulletin on Some Important Pear Diseases has been published. This included, especially, notes upon the leaf-spot of pear, another injurious leaf fungus, probably often confused with leaf-blight. Spraying experiments showed that Bordeaux mixture may be effectually used to prevent this disease. Leaf-blight, scab and pear blight are also discussed. Other more obscure and less injurious pear fungi are under study.

The black mold of peach and apricot, and the shot-hole fungus of the peach, apricot and plum have received some attention, but the work is incomplete.

Field spraying experiments for the prevention of the late blight of celery were conducted at the celery gardens of South Lima. While this blight was less injurious during the past season, it was demonstrated that weak Bordeaux mixture could be used until within about five weeks of bleaching, and that as a fungicide for celery blight the Bordeaux is superior to the ammoniacal copper carbonate. It is well, however, to use the latter fungicide if spraying must be done within a month of bleaching.

The "damping off" fungi of lettuce and other plants grown under glass have been studied with special reference to the conditions favoring the disease. An attempt is being made to follow out the life histories of the fungi concerned. This work is still in progress.

A rot of greenhouse tomatoes has received considerable attention, and while no fungus has been found associated with it, experiments are being made to ascertain, if possible, the conditions which may induce it.

Investigations upon a mold growth occurring upon the parchment paper lining and upon the wood of butter tubs have determined the conditions of growth of the fungus. Care in the selection of tubs made from well-seasoned heart wood, the storing of tubs in a dry place, and the use of the best parchment paper will probably reduce the liability of mold. However, experiments indicate that the use of one per cent. formalin solution, or a very weak solution of copper sulphate upon the parchment paper will prevent the growth of mold.

An effort is being made to look more carefully into some of our bacterial diseases of plants, and to study those which may be due to such organisms.

PART II.

EDUCATIONAL WORK.

It was decided at the first meeting of the Faculty of Agriculture to emphasize the educational work, since the Federal Experiment Station, a department of the College of Agriculture, was able to carry on many investigations, especially those which, of necessity, must extend through considerable periods of time, and which require ample and permanent laboratories, equipment and investigators, while most of the work contemplated under Chapter 128 could best be carried on away from the college.

The problem of how to successfully introduce into the schools of the state a study of the fundamental principles which govern the soil, the plant and the animal, or the study of Agriculture, has been considered most carefully by many distinguished educators. This subject was long and carefully considered by the Faculty of Agriculture before entering upon the work. The leaflets on Nature-study, which were already issued, had been so kindly received and so fully appreciated that it was decided to issue others, and to employ trained teachers to visit the schools and to attend teachers' institutes for the purpose of explaining how the subject-matter of the leaflets, as well as other similar subjects, might be used as texts by the teacher, while the illustrations could not help but be useful to the teachers or classes in drawing. It was hoped, too, that after the teacher had given instruction on some subject intimately connected with natural objects which attract the attention of the pupil, the object having been used for a drawing in the class room, the description of such object would form a most interesting subject for compositions, which are now required in most departments of the public schools. By correlating with composition and drawing work, the objection of an added study was removed.

It is believed that a study of the more common and familiar objects of nature leads directly to a better understanding of those laws and phenomena which are the very foundation of improved agriculture. In the hands of the skillful teacher the leaflets may be used to impart valuable lessons in natural history and in the conservation of energy as applied to rural affairs, and may, in some cases, serve to interest teacher and pupil in the economics of agriculture. Briefly stated, it is hoped that such instruction will lead logically and naturally to a greater love for rural affairs and a more rational understanding of them among the old and young both in city and in country.

Eight leaflets in all have been published, electrotyped and republished on the following subjects:

No. 1.	"How a Squash Plant Gets Out of the Seed."	Four	Editions.
No. 2.	"How a Candle Burns."	Three	"
No. 3.	"Four Apple Twigs."	Five	"
No. 4.	"A Children's Garden."	Six	"
No. 5.	"Some Tent-Makers."	Four	"
No. 6.	"What is Nature-Study?"	Four	"
No. 7.	"Hints on Making Collections of Insects."	Two	"
No. 8.	"The Leaves and Acorns of Our Common Oaks."	Two	"

The demand for these leaflets is so great that other editions will be required in the near future. The work in Nature-study has passed the experimental stage; the demand for it is far beyond our facilities for carrying it forward.

This educational work in agriculture divides itself naturally into six divisions:

Nature-study.

Schools of Agriculture and Horticulture.

Dairy Instruction.

Lectures on special subjects, such as the Sugar Beet Industry.

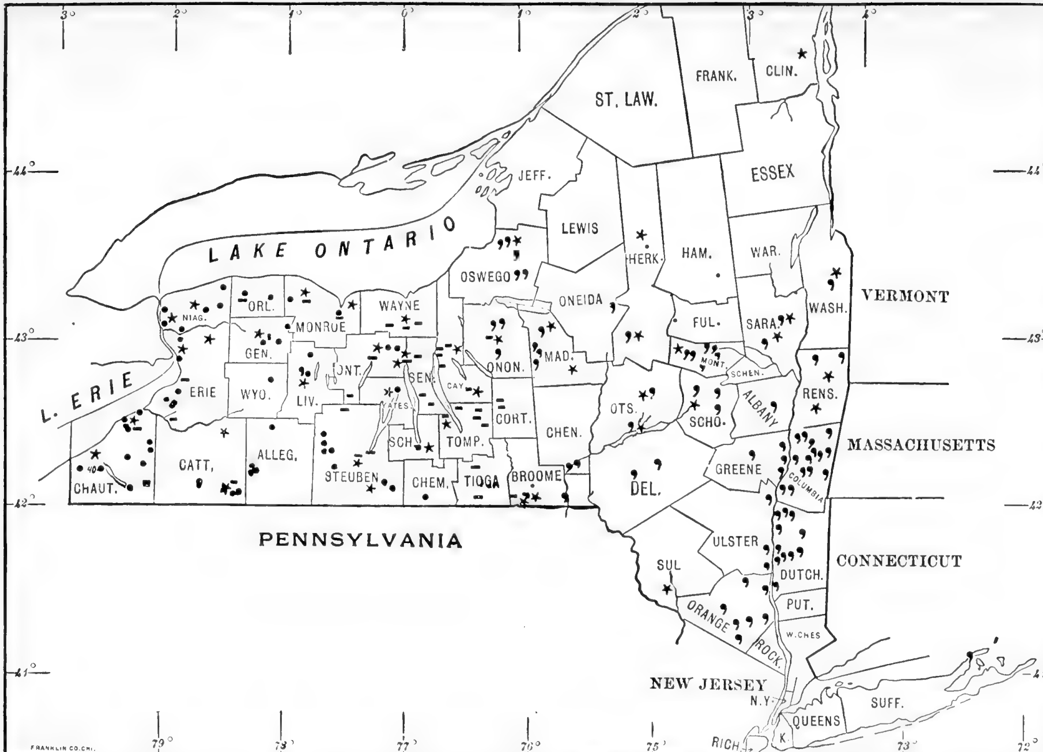
A course of reading and instruction for farmers.

Publications.

There are many principles of agriculture which are well understood by the scientist but which are not familiar to the farmer. It is proposed to secure the co-operation of progressive agriculturists in the endeavor to learn how best to fit these principles into practice.

It is impossible to sharply separate these various activities, as one often overlaps the other. Suffice it to say that more than seven hundred lessons and lectures have been given throughout the state by persons selected on account of their special fitness for the work in hand.

Twenty thousand teachers are enrolled on our lists and have received leaflets, and many have attended the lectures explaining the methods of presenting Nature-study work in the schools. Sixteen thousand



174.—*Showing where meetings have been held and schools visited in the advancement of nature-study work.*

school children have received those leaflets which are especially adapted to their needs. Two thousand five hundred young farmers are enrolled in the Agricultural Reading Course. These are assisted from time to time by means of printed circulars which give directions and assistance to the farmer in carrying on his studies at home. From time to time question papers are sent out for the purpose of giving opportunity to the farmer to make known his needs, that they may be more fully understood and met. The location of Nature-study centers is shown in figure 174.

Mr. A. C. True, Director of Office of Experiment Stations, Washington, D. C., suggested that the members of the instructing corps of the University give a course of lectures on Agriculture in the schools of Ithaca with the view of determining whether such instruction could be fitted into the present curriculum without adding seriously to the work already required. The Superintendent of the city schools and the Superior of the parochial school entered into the scheme most heartily. Their opinion of this work is set forth in the following communications:

BOARD OF EDUCATION.

ROGER B. WILLIAMS, *President.*
H. W. FOSTER, *Superintendent of Schools.*
OFFICE—32, 33, SAVINGS BANK BUILDING.

ITHACA, N. Y., January 28, 1898.

PROF. I. P. ROBERTS,

Dear Sir:—On behalf of the A room of the Grammar School, I wish to thank you and the professors whom you sent for the lectures and demonstrations which were given before the pupils of that room during the past term. I was present but very little myself, but the teacher reports a very great interest on the part of the pupils. Every one of the lectures was used as a basis for composition work. It seemed to us that the English work resulting was unusually good and that there was a decided improvement, a part of which at least we attributed to the very great interest of the pupils and their desire to give expression from a mind full of the subject. It appears to me that full and free use of language must necessarily arise from an abundance of thought pressing for expression. A full flowing stream implies an overflowing reservoir.

This work is not to be classed under the head of science or Nature-study purely, wherein the method is to employ the child's powers of observation and judgment. Its purpose was rather to arouse an interest in the science of agriculture. These city pupils will always have hereafter the highest respect for the work and life of a farmer, and many of them without doubt will observe and think intelligently upon the methods of agriculture. I have no doubt that some will put into practice much that they have learned. It is conclusively proved that agriculture may be made an extremely interesting and valuable subject of study in all schools. Yours very truly,

H. W. FOSTER, Supt.

CHURCH OF THE
IMMACULATE CONCEPTION,
REV. A. J. EVANS, *Rector*.

ITHACA, N. Y., January 31, 1898.

PROF. I. P. ROBERTS,

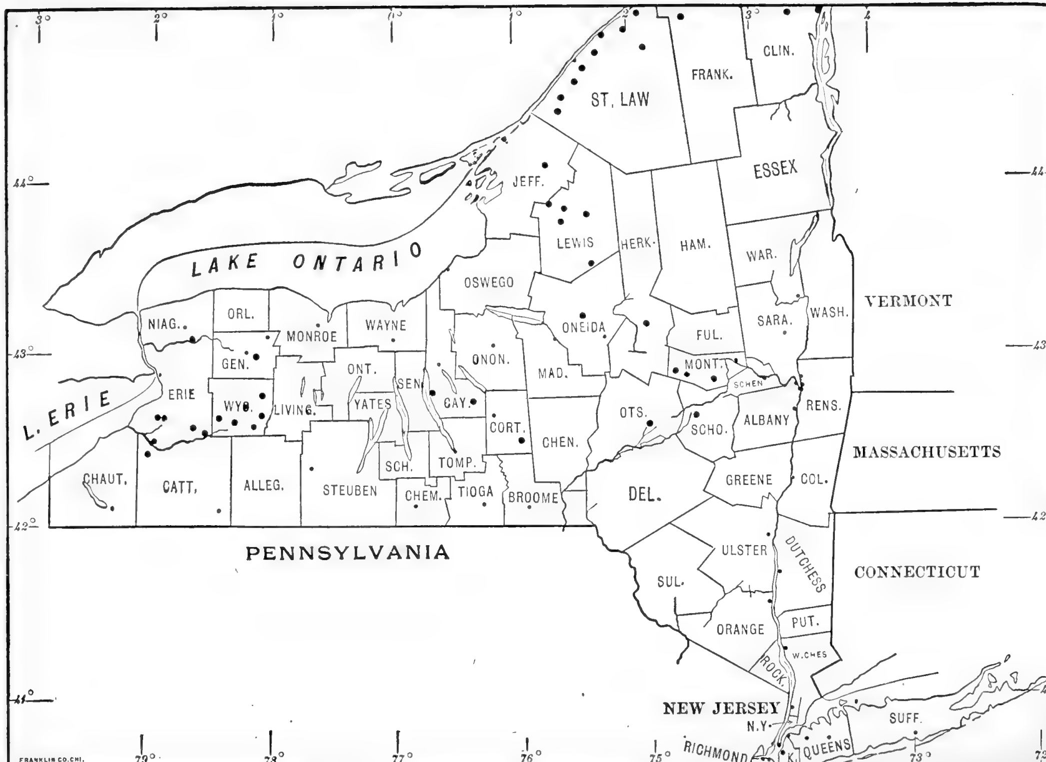
Dear Sir:—I have attended three or four of the lectures on "Nature-study" delivered by you and your associates at our parochial school. Judging by the good attention shown by our pupils, and the earnest manner in which they answered the questions put to them, I am convinced that the lectures were pleasing and instructive.

The work in which you are engaged cannot fail to be productive of much good in our schools, because the pupils are made familiar with those things which will be of much benefit to them in after life. I sincerely trust that you will be enabled to continue the lectures, not only this year, but permanently.

Thanking you for the many past favors, I am,

Yours sincerely, A. J. EVANS.

It is believed that the benefits derived from carrying the experimental work beyond the limits of the Station grounds are very great. First, the data obtained are valuable. In some cases they are much more valuable than could possibly be obtained from experiments conducted at the Station. In corroboration of this statement, reference is made to the bulletin on sugar beets already mentioned. Second, the Station is brought into closer touch with the farmers. Meeting



173 —*Showing points where dairy schools were held.*

them on their own farms, the Station workers become better acquainted with their peculiar surroundings and needs, and can offer more appropriate assistance than they otherwise could do. On the other hand, the farmers learn better how the Station can help them and how to avail themselves of that help. Third, the experiments serve as object lessons to the farmers. As such they impress themselves upon a large class of farmers that would give little heed to a printed description of experiments conducted at the Station. Fourth, the experiments have a high educational value for the farmers performing them. Perhaps, at the present time this is the most important consideration. There are many questions affected by soil and climate that must be decided for each locality individually, and the greatest hindrance is the want of trained experimenters to take up the work. It is hoped and believed that we shall find in various localities in the state intelligent and public spirited farmers who, for the benefits to be derived by themselves and their fellows, will be willing to co-operate with the Station in this work.

DAIRY HUSBANDRY.

Observations in the dairy districts led to the conclusion that this branch of agriculture needed assistance. The theory of making butter and cheese is fairly well understood, but the art, in many cases, was found to be lamentably wanting. To bridge over this gap between science and art, two expert dairymen were employed during the summer, men who not only knew much of the science but of the art of dairy husbandry as well. These men went from factory to factory, called a few dairymen together and gave valuable instruction by first teaching the leading principles and then by practically applying them, thus showing how art and science in dairy husbandry could be joined. Many difficult problems appear in the factories during the midsummer season; these can only be solved by a trained dairyman at the factory. Incidentally, these instructors did much valuable service by calling attention to untidy surroundings and irrational treatment of cattle. The location of dairy schools is shown in figure 173.

SCHOOLS OF AGRICULTURE AND HORTICULTURE.

The effort to organize schools of general Agriculture, Horticulture and Dairy Husbandry has not, in all cases, been successful, as there was often a great diversity of specialized agricultural activities represented by the persons in attendance, each calling for help. Wherever practicable, it has been the aim to secure the attendance of those persons who were engaged in like specialized activities. In such cases it was not difficult to organize schools and carry on the work consecutively and logically on restricted lines.

The instructors in this line have also given attention to the pupils in the country schools, and while it has been possible to reach and teach but a comparatively few pupils in the "red school-house," we are led to believe that this work has been of great value, since it touches agriculture at its fountain head.

It is fully realized that it will be impossible for us to reach all the school children directly, but it is believed that all can be reached as soon as the public school teachers of the state have mastered the leading fundamental principles which govern the soil and plant and animal life, and have come to love the study of Nature in any or all of her varied forms.

Rural life gives unexcelled opportunities for securing fresh, living objects for illustration. All that is now lacking is a teacher trained to see the beauties and uses of the common objects which surround the pupils of village and city alike. How all the teachers may secure such an education in the particular lines referred to above is a problem which is receiving careful consideration. Something has already been done in this direction and the results reached lead to the conclusion that much more should be done and that the wards of the state, the children in both city and country, have a right to demand that they have opportunity for securing some knowledge of and acquaintance with the natural objects with which they are surrounded and with which they will have much to do in after life.

SPECIAL LECTURES.

There has been a demand for information on many subjects, but especially on the subjects of sugar beet and potato culture. This demand has been met so far as possible by sending out from time to time members of the staff who are especially qualified to give the information desired. This branch of educational work has been most satisfactory, the meetings being well attended and the interest shown unusual.

A valuable feature of many of the meetings was the demonstration of how certain scientific tests relative to soil might be made by the farmers. In this connection the test for acid in soils by the use of litmus paper may be mentioned. Results from this work show that sour soils are quite prevalent and promise a good field for investigation.

FARMER'S READING COURSE.

Last year an attempt was made to establish a Farmer's Home Reading Course, but it was not fully organized because of press of work in other directions. At the present time 3,000 young farmers are registered with us and a circular containing 16 pages entitled "Farmer's Reading Lesson, Texture of Soil and Conservation of Moisture" has been issued with the view to giving help, direction and definiteness to the work. Accompanying this circular is another one of eight pages which contains 27 questions, the aim being to draw out the reader and awaken interest. It is believed that the young farmer already possesses much valuable information, which, if drawn out and supplemented, would be mutually interesting and valuable.

It is our plan to arrange a course of topics having a logical connection and divided into stages of advancement. The study of these topics can be carried on at the farmer's home with a review by correspondence, after the Chautauqua reading course plan. If neighbors can form a circle for discussing the subject under consideration, interest and benefit will be very much enhanced.

The effort has been to give such instruction as will not only promote "agricultural knowledge" throughout the state, but to get parents and pupils in sympathy with the fundamental object of our endeavors, which in all of this work has been to train the intellect, the eye and the judgment with the view to educating the farmer to better methods.

The educational work which had already been done prior to April, 1897, by Professor L. H. Bailey and his associates in horticulture in the western part of the state, made it possible to secure the co-operation of more than 300 farmers in the investigations in sugar beet culture, and 203 farmers in the experiment with fertilizers. The time has come when the help of the farmers must be secured if valuable investigations are to be conducted which shall be applicable to varied conditions. Climate, soil, environment and needs are so varied in the state that comparatively little help can be given unless the investigations can be conducted in the locality where the help is needed.

It follows, then, that many trained farmers and even farmers' boys and girls must be enlisted in the work. We now have in this state a considerable number in the rural districts who are able and quick to see and to comprehend dangers which threaten, and to report them. They are also ready at all times to conduct plat investigations, free of cost, at their own farms, if direction and help can be given by the Station. Many investigations suited to local needs will be undertaken the next season by reason of the instruction which has been given. So well assured are we of the twofold benefit of the educational work which has been carried on that it is proposed to extend it another year.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale.
145 Some Important Pear Diseases.
146 Report of Progress, 20 pp.

Bulletin 147. April, 1898.

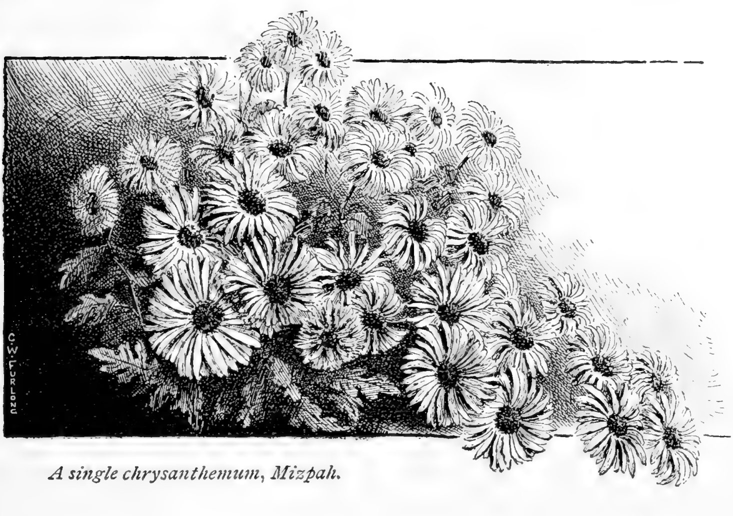
Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

FOURTH REPORT UPON

CHRYSANTHEMUMS.



A single chrysanthemum, Mizpah.

By WILHELM MILLER.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	Trustee of the University.
Hon. B. F. TRACY,	President State Agricultural Society.
Professor I. P. ROBERTS,	Agriculture.
Professor G. C. CALDWELL,	Chemistry.
Professor JAMES LAW,	Veterinary Science.
Professor J. H. COMSTOCK,	Entomology.
Professor L. H. BAILEY,	Horticulture.
Professor H. H. WING,	Dairy Husbandry.
Professor G. F. ATKINSON,	Botany.
M. V. SLINGERLAND,	Entomology.
G. W. CAVANAUGH,	Chemistry.
L. A. CLINTON,	Agriculture.
B. M. DUGGAR,	Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	Director.
E. L. WILLIAMS,	Treasurer.
EDWARD A. BUTLER,	Clerk.

In pursuance of the provisions of Chapter 67 of the Laws of 1898, several persons have been appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work require.

See Bulletin 146, Report of Progress of work done under Chapter 128 of the Laws of 1897.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.

Cornell University, March 21, 1898.

Honorable Commissioner of Agriculture, Albany.

Sir: The popular interest in chrysanthemums continues to be unabated. The chrysanthemum fills a season which is occupied by no other important flower, and it presents the most astonishing ranges of form, color and behavior. In addition to all this, the plant is easily grown and it responds quickly to all the little modifications of treatment which the plant-lover habitually bestows upon his plants. For these reasons, the chrysanthemum must continue to be popular and to demand the attention of experimenters.

We desire to still further popularize the plant among the amateurs and especially with those who live in the country. We have therefore given general hints upon the cultivation of the plant when glass houses cannot be had.

On the other hand, we desire to aid the professional florist; and for him we have grown the novelties, have begun experiments with fertilizers (which we shall continue), have studied some of the problems associated with variations in color, and have now made a full review of the vexed questions involved in the selection of crown and terminal buds.

This report, therefore, considers the following matters:

I. P. Roberts,
Director.

174. *An amateur's ideal. A mass-effect with many flowers of different ages and sizes. Same variety as in figure* 175.

I. THE ECONOMIC STATUS OF THE CHRYSANTHEMUM.

The chrysanthemum industry in New York State probably involves more capital than the growing of peaches. When the chrysanthemum craze began in America in 1888, there were loud complaints from those florists who thought that there would be no great permanent popularity after the first fever was passed. At first the chrysanthemum seriously infringed for six weeks upon the year-round favorites, the rose, carnation and violet, but it must now be considered one of the four staples of greenhouse floriculture. We have more chrysanthemums now than ever, but the feverish element is nearly gone. The times of universally excessive prices are forever past, the readjustment to a final acceptance of this new-comer's permanent place is nearly made, and the chrysanthemum has become distinctly a flower of the people.

What, then, is the permanent place of the chrysanthemum? Doubtless its mission is to fill the dull interval between the middle of October and the last of November. The skilled amateur, it is true, may prolong the season by early flowers out-of-doors and by late ones in the greenhouse, but it is at a cost of time, money and skill that the people cannot give. He may even have large flowers in every month of the year, at a large price, but the true chrysanthemum niche is a period of about six weeks, and the people would not want chrysanthemums the year round even if they could have them.

The people, then, buy the flowers; they do not raise the plants themselves. The only possible objection to the Japanese chrysanthemums is that the people of the north cannot cultivate them in their gardens, that is, they cannot produce large, exhibition flowers, or even typical ones, in satisfactory quantities out-of-doors. Until twenty-five years ago this would have been a fatal objection. Never until the development of the peculiar forcing-house industry of America, the commercializing of floriculture on a vast national scale, was it possible for a flower grown almost exclusively by the florists, and under glass, to win its way into the hearts of the masses. It is the greater general use of cut flowers that makes American floriculture unique. The popular demand for long-stemmed flowers, and for some favorites in every month of the year, has conspicuously changed the methods of cultivation of chrysanthemums, roses and violets, and has given to the world a distinctly American type of carnations. Americans buy cut-flowers, keep them in vases as long as they are thoroughly satisfactory, and are very sensitive to the delights of arrangement for form and color effects. The keeping qualities of chrysanthemums are extraordinary, and this happy circumstance is one reason why this greenhouse flower has so won its way into the hearts of the masses.

Nevertheless, the cry is sometimes raised that the chrysanthemum is a "rich man's flower." Moreover, the love of the *blossom* is only the beginning of nature-wisdom. Until there is developed a feeling for *the plant*, there is no deep sympathy with, or real insight into the meaning and mystery of nature. The best relation with plants is the living with them, the appreciation of every stage of their life cycle. Ten cents will buy a magnificent flower, but no one may own a chrysanthemum in the highest sense without a year's comradeship with the plant. You must produce it—evolve it, as it were, from your own understanding of life.

II. SUGGESTIONS ON GROWING CHRYSANTHEMUMS AT HOME.

It is not true that the farmer's wife may not have a few fine chrysanthemums. She may have them in her garden for the price the least part of which is paid in money, but they will give the highest pleasure when they blossom indoors during November. They cannot be raised as easily as a geranium (which in this single respect is the ideal plant for the window garden) but they can be grown in the home by all who really love to care for plants. People are always asking (and I hope they always will ask) just how to do it. The horticultural journals answer, the daily newspapers tell the story during show time, and a brief account was given in Bulletin 136 from the Station. But it is discouraging to be referred to back numbers, and a more extended account is needed in a separate form.

---

*Portions of the following have been published in the *American Agriculturist*, with illustrations.

The very first requisite of success is to cherish an ideal! Some one of at least four different objects must be clearly conceived at the start and kept in view till the very end.

1. Do you want a few large flowers such as you see at the shows? Then you can have only one stem in a flower pot and only one flower on that stem (figure 175), and you must have pots of various sizes up to six or eight inches in diameter at the rim. Pinch off the young shoots as soon as they show themselves, so that the plant can never branch. If you are successful, you will have the beauty of an individual object. It will be a wonderful thing and may not fit in with anything else, but will demand attention for itself alone. Remember that size alone is vulgar, and that. the delicate and fanciful may be made gross and characterless by over-feeding.

2. Do you wish enough size of flower so that you can recognize the variety, and are you willing to sacrifice somewhat in point of numbers? Then you had better aim to produce about four flowers to every plant, each flower six inches in diameter, and with only one flower on each branch. These branches should be as long as possible and therefore you should pinch out the central shoot of the young plant when it is five or six inches above the soil and make it branch. Teach it to cherish a high ideal—the ideal of four fine flowers, each at the top of a long branch. On the whole, this is the best method for the home window, and, with practice, from three to six large characteristic flowers may be grown in a six-inch flower pot.

3. Would you like a handsome, symmetrical, bushy plant with twenty or more flowers? Don't try it expecting great success with little care. The flowers will be small, sometimes partially developed, and so lacking in character that you can scarcely ever tell the variety. It also takes too much tying and training and disbudding, and the result is more or less artificial and has no artistic value except for mass effect. Skilled gardeners can do it, but it costs more time than most people can give. The plants must be started early, fed with great care and must be shifted successively from small-sized flower pots to those of eight to ten inches at least. The English gardeners are far more skillful than we in such work, and it is not uncommon to see pictures of plants with from 50 to 300 large, well-formed blooms upon

them. But specimen plants and standards* are far less frequent, proportionately, in America. It is partly because of higher-priced labor, and partly because we do not like them so well as Europeans do. Figures 174 and 179 illustrate two types of bush plant that may be raised at home in a six-inch pot.

4. Do you want a few chrysanthemums in your window with the least trouble and expense? Then you had better aim either at ideal 2, or else have your own way and make the best of what you get. Most people will not repot their plants in successively larger sizes, and they are afraid to disbud or do not believe in it. In such cases they can only hope for a goodly number of flowers that look well enough at a distance and make a brave show of color, but the beauty of form is largely lost. Size and form are the products of disbudding. Everybody has some color sense, but the conscious pleasure in form is a later development. However, it ought to be said that imperfectly blown flowers of chrysanthemums often have a beauty in mass effect. They are rarely painful, as is a partially blown dahlia. This is probably because the fully-developed flower in one case is loose and free, while in the other it is often set and formal.

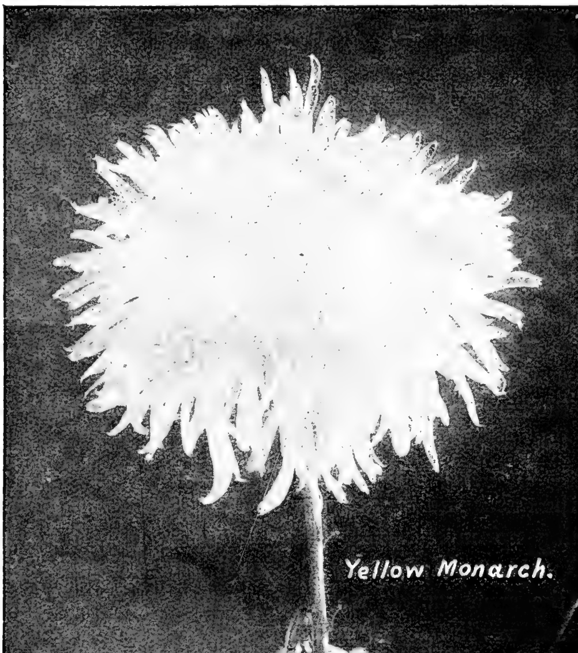
Whatever ideal is chosen, the best way to begin, in general, is to buy a young plant of the florist. Young plants of any size from two to twelve inches in height can usually be had at any time from March to July 1. Trust to the florist for the variety, unless you have made a memorandum at the flower-show or elsewhere of the desirable varieties, or unless you wish to reproduce some of the effects pictured in Cornell Experiment Station Bulletins 91, 112, 136 or 147. In general, dwarf, short-jointed varieties are best for the window-garden. Probably most people will prefer to buy their plants in May, or early June, plant them outdoors in boxes and remove them bodily indoors at the approach of frost. It is possible to plant them in the open ground for the summer, take them up carefully in the autumn, and then put them into flower pots. The box method, however, avoids the shock of transplanting. It is not necessary to buy flower pots of graded sizes. Old soap boxes will do very well, although not handsome or as good as pots; but tin cans are too small, and transplanting from them is

---

*A "standard" is a plant with many branches at the top of a single, stout, self-supporting stem. The term is not confined to chrysanthemums.

practically impossible. Some hints on the drainage and watering of plants in general are given in Bulletin 136, and the rest is usually easy.

The growing of chrysanthemums out-of-doors all the year round for the production of large flowers is too complicated and special a topic for the present. Those Americans who are determined to succeed at such work should read in *Garden and Forest*, 1 : 522 (1888) and else-



175.—*A florist's ideal. One large flower on a long stem that will sell, and will bear railway shipment.* (*Florists' Exchange*, December 5, 1896.) *See figure* 174.

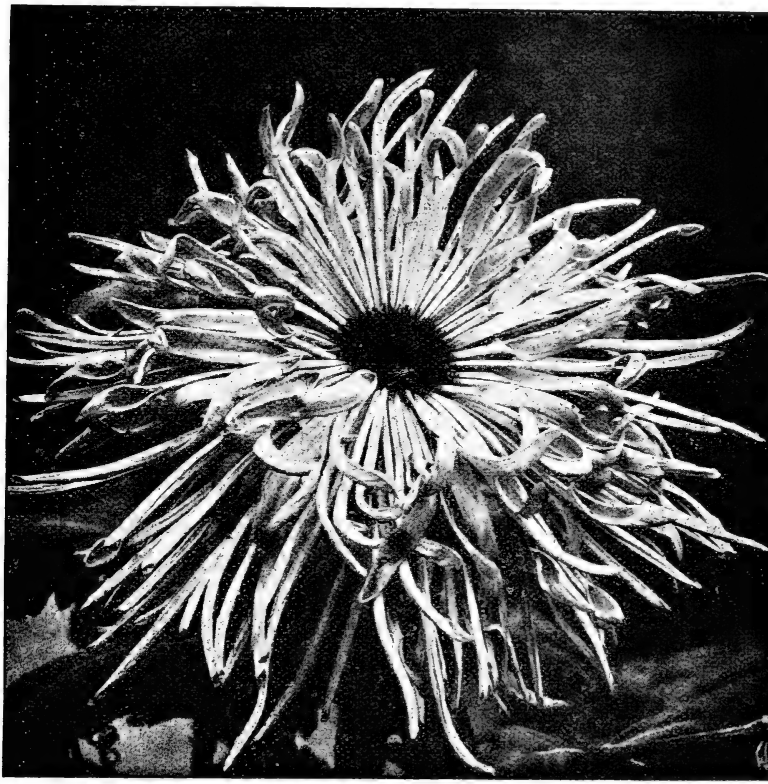
where, the experience of J. N. Gerard, of Elizabeth, N. J., an experience that richly deserves separate publication.

The amateur and the florist.—If we had to depend upon the commercial florists for the preservation of all varieties, many of the finer creations that appeal to the fancy would doubtless be lost to the world. The florist cannot always grow what he likes. He must follow the fashions; he must keep what the people demand, and he must have the kinds that last well and ship well. His business is chiefly with cut flowers. The amateur is chiefly concerned with plants. It is highly unfair to reproach the florist with want of taste. The mixed bouquet, with its tin foil, is passing away. Dried grasses and dried immortelles are still in demand, but the florist does not create this demand. Indeed, the fashions in the world of dress and in the world of flowers have fundamental differences in their origin. Whoever starts them, the florist does not, and the general taste of the American florist is higher to-day than ever before.

The amateur class, however, is the great conserving element. The commercial motive being absent, the amateur can keep a variety whose flower he likes, even if the plant has a poor habit. Not poor taste but practical reasons compel florists to discard some of the finest flowers. Hundreds of varieties of chrysanthemums are discarded because they are too tall, or require too much staking or disbudding. Others cannot be planted close enough together in the modern method for cut flowers, where the total salable product of a whole plant is one unbranched stem and one flower. The amateur can afford to keep varieties with bare or drooping necks if he likes the flowers. He may be willing to stake and tie such plants as are illustrated by figure 174, and perhaps he may like the droop of the stems so much that he does not mind the stakes and the strings. Perhaps he likes the great hollow cone leading up mysteriously into the warm, golden heart of the flower. But the florist cannot sell such things. Figure 175 shows a flower of the same variety which is presumably grown on a single stem. The flower in figure 175 is larger, has no yellow disc, will ship better, last longer when cut, and it will sell. Figure 176 represents another amateur's ideal, and so do the loose, free and fantastic forms figured in Bulletin 112. As a rule, only compact and globular chrysanthemums can be depended on to stand a long railway journey; therefore, the florist must, perforce, adhere to these forms if he would make a living.

As this may be the last bulletin of this Station in which varieties are prominently mentioned, it is worth while to make a strong appeal to the amateurs of this country to keep a firm hold upon all the main types, and especially to retain the sorts whose delicate flowers will not bear transportation.

We are behind the English in the appreciation of all but two or three of the eleven "sections" recognized by the National Chrysanthemum Society. (For a specimen of the "single section" see title-page.) There are certain classes and certain ideals that are peculiar to the



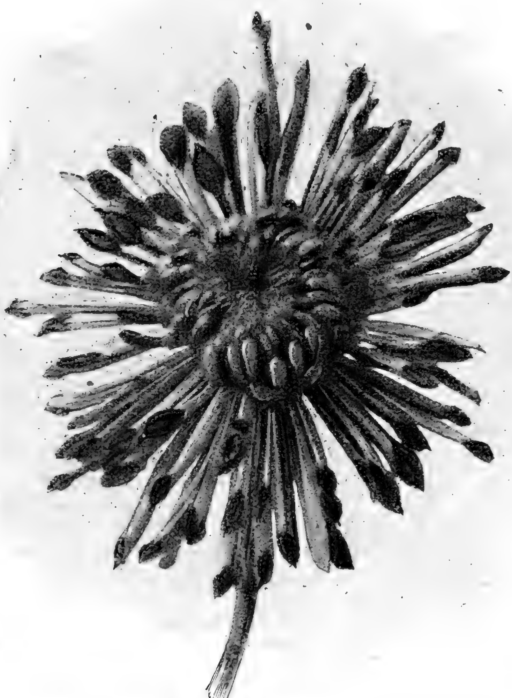
176.—*Another type that the amateur likes.* (*Variety, A. H. Wood.*)

amateur and the artist. Figures 177 and 178 illustrate one of these classes. They show the same variety, but one would never think it from seeing only the two stages. The fascination of watching the daily changes of an expanding flower in one of these artistic sections the florist may enjoy, but he cannot sell it.

The whole class formerly called "Japanese Reflexed" but now included in the Japanese section by the National Chrysanthemum

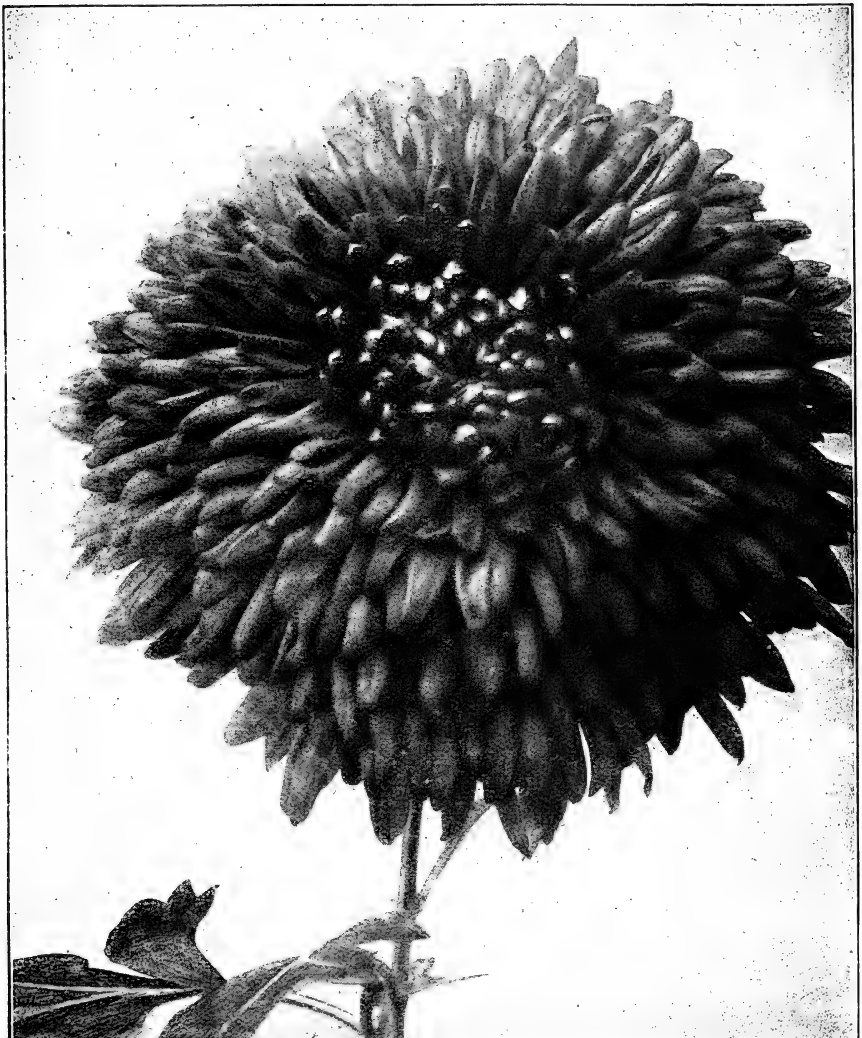
Society of England, is of especial interest to the amateur. Day by day new characters appear. Successive tiers of florets flop over and the entertainment is ever changing. *Shavings* is full of curious motions before it looks like figure 185, page 368. *Geo. S. Kalb* has two different expressions and the change comes quickly.

This watching of daily changes is one of the chief rewards of cultivating plants. A cut flower is bought at its perfection and changes



177.—*An early stage of Millbrook. See figure* 178.

little. A potted plant, like that in figure 179, has a higher beauty than any cut flower. It has the greater artistic value of different sizes and shapes, even if one does not watch the flowers develop. Such a plant may be bought from a florist, but there is nothing like growing it yourself. The plant in figure 179 is *J. W. McHattie*, but the name



178.—*A later stage of Millbrook. See figure 177. These changes are good things to watch.*

179.—*What any one may raise with care in the home window. (Variety, J. W. McHattie.)*

does not matter. Almost any dark colored variety gives a fine mass effect, especially when there is a suggestion of gold in the backs of the young florets, to set off the rich reds of the developing flower. The plant in figure 179 is more symmetrical than that in figure 175, and there are no stakes or strings to be seen. It is only one of many beautiful shapes that may be obtained.

III. CONTROLLING THE COLOR OF CHRYSANTHEMUMS.

Out of 31 pink flowered varieties of different shades and grown under the same conditions at the Cornell Experiment Station in 1897, 14 turned out to be practically pure white, while three others showed much less color than the descriptions called for.* This was no accident. The varieties were true to name. The flowers averaged six

---

* These varieties were G. F. Atkinson, Mrs. Theo. F. Beckert, Belle of Castlewood, Bellem, Brian Boru, G. Carvell, Col. Curzon, Miss A. L. Dalskov (Syn. Pink Ivory), Mrs. W. C. Egan, Elainora, Gladys, Sibyl Kaye, Gov. Matthews, Merula, Rose Owen, Mrs. A. H. Wood, J. H. Woodford.

inches in diameter, and were satisfactory in every other respect. The color alone was lacking.

The economic importance of this fact is very considerable. At least a fourth of all the new varieties are advertised to be pink. Perhaps, also, a fourth of all the cut flowers sold are pink or something near it. The market reports, at any rate, often quote only four groups, white, yellow and pink chrysanthemums, and "other colors."

The case would not be so serious if all the pink sorts were able to lose their color gradually and uniformly, and still remain attractive, as *Iora* does. Unfortunately, they do not. As a rule they fade out unevenly and look weak, blotched, undecided. The mass effect may be good, but one cannot look at the flowers closely. Two specific examples may be cited as typical of two different phases of the problem.

One of the important commercial varieties of to-day is *Fred Walz*, yet it frequently shows three or more easily distinguishable shades of pink in the same greenhouse. Being somewhat stiff and formal in outline, it is easily ruined for artistic effect by unevenness of color. Now, the amateur usually grows many kinds and few specimens of a kind, but the florist pins his faith to a very few varieties. It is a common practice for him to depend upon only one or two varieties to furnish all his cut flowers of a given color. Moreover, the very compactness and formality that make *Fred Walz* a distinctively commercial variety (for these traits are associated with cut flowers that stand a railway journey nicely) are the same qualities that betray the fatal unevenness of color. An eccentric form may have eccentric coloring. The ragged, straggling sorts are usually valued for their freedom of form rather than for their color, but a perfectly regular, globular flower must be of one tone to have a unity of color effect. The whole Chinese section is very formal, and there are dozens of varieties in the Japanese section that are in the same predicament with *Fred Walz*.

As *Fred Walz* is typical of a form of flower that is suitable for shipping, so is the white variety, *Ivory*, a type of certain habits of plant growth much sought after by the florists. Most American dealers place it on a list of 12 best varieties for commercial purposes. The amateur likes it, and it is used for exhibitions, for pot plants and for cut flowers. It is, in short, a typical "all-round" variety. Naturally pink sports of it are in great demand, but they are hard to retain. One of these many efforts is *Miss Agnes L. Dalskov* (commonly called *Pink Ivory*). It has been much praised elsewhere, but with us it had no color at all in 1896, and even from our own stock, showed barely a trace of it in 1897.

But this is not all. The trouble is not confined to the pure pink color. As a matter of fact, the pure pink of F. Schuyler Mathews' color-chart has not yet been attained in chrysanthemums, but this is not so serious in itself, for it means only one particular shade. There seems to be an entire series of colors whose value is determined far more by the skill of the cultivator than by the variety. Here are some of the grades in this "pink" series: amaranth, crimson, rosy pink, crimson-pink, light pink and blush white. These are current trade names, not artists' terms. It seems probable that any of these shades may, in some cases, be obtained from a single variety. Not all varieties, of course, are so highly variable as this, but frequently the difference is enough to make the flowers unsalable.

The control of color, therefore, becomes a problem of great practical interest. It is doubtless a complicated problem. There seems to be at least six factors concerned, any one of which may change a pink to a white. (1) The choice of buds is said to be sufficient in some cases. Thus, *J. H. Woodford*, one of Mr. Spaulding's novelties, is advertised as shell-pink from terminal and pure white from crown buds. (2) Over-propagation is generally believed to weaken colors. (3) Temperature and ventilation (the two factors can hardly be separated in greenhouse practice throughout the entire year) are advertised to produce three distinct and desirable shades in *Mrs. Col. Goodman*.* (4) Mere position (in pots, beds or benches) should not in itself make a difference, but in practice it does. (5) The effect of shade is variously stated. (6) And, most complicated of all, the food factor is known to influence color, but just how is a mystery.

It was convenient to single out only two of the supposed factors this year. We resolved to see whether shading the flower buds would make the flowers a darker or lighter pink, and whether a liberal supply of nitrogen would weaken or deepen the colors.

The conditions of the experiments are briefly given. Sixty plants

---

* High temperatures with close air tend to weaken colors. Conversely, cool temperatures with plenty of air tend to deepen the colors.

representing 17 varieties were used in the two experiments, but ultimately only 26 plants, representing seven varieties, were strictly comparable in each experiment, for reasons stated hereafter. Each plant had four long branches, and each branch bore one flower. The flowers averaged about five inches in diameter. The cuttings were rooted early, and the plants shifted successively to six-inch pots in which they were flowered. The same potting soil was used as for all the other potted chrysanthemums, which was three parts rotted clay sod, one part sand and bog mold, but no manure. The object was to produce typical potted plants of a salable character by the methods commonly used by florists, and all the plants proved to be of this character, though some of them were not typical of the variety as to color, and some could not have sold for pink flowers. In only two respects was the common treatment varied.

In the shading experiment, 24 plants were exposed to the sunlight at every stage of their growth, while 36 plants were shaded soon after the flower buds appeared by means of a rather heavy coat of whitewash applied to the glass directly above them. Some of the varieties in the experiment were shaded from the time the buds were the size of marbles until they came into full flower. Others had already burst their buds and were out an inch or more before the glass overhead was whitewashed. This coat of whitewash remained until the flowering season was over.

In the nitrogen experiment, 23 plants were given only the amount of nitrogen which all our potted plants received, while 37 plants were given an extra supply of nitrogen. This extra supply of nitrogen was applied in liquid form. It was a solution of nitrate of soda. In 100 pounds of this nitrate of soda, there would be 13.90 pounds of nitrogen. The applications were begun when the plants were well rooted in the flowering pots. At first the interval between applications was four days. Later it was reduced to three. When the flower buds appeared the applications were stopped.

The results of the two experiments were very interesting, and contrary to what I had been led to expect from some statements in the trade publications. Shade is said by some to deepen the color, but the reverse was true in this case. The difference was perceptible at once in five varieties (*Mrs. Perrin*, *Madame Felix Perrin*, *Marie Valleau*, *Helen Bloodgood* and *Iora*) and at a second glance in two others, *William Simpson* and *Maud Dean*. In only two cases, however, was this difference enough beyond question to destroy their salable character, but they are the most important varieties in the list. *Mrs. Perrin* and *Madame Felix Perrin* are among the most important midseason commercial sorts of the day. They are so much alike that only an expert can tell them apart. Their peculiar charm is their sparkling, bright rosy-pink color. The flowers of these two varieties, whose buds were shaded, were very uneven in color. The loss of color was the only loss, and it alone was enough to destroy their salable character. This cannot be attributed to a general lack of vigor in the plants. The experiment shows clearly that during the reproductive phase the forming flowers are extremely sensitive to shading, and are sometimes practically ruined by it. There was only one contradictory plant among 26 that were strictly comparable.

This experiment deals only with obtaining a good degree of the pink color, and does not show how the color once secured may be retained. The fading of the pink varieties after the flowers are once fully expanded is a different matter, and is beyond control at present. It may be the inevitable associate or uncontrollable chemical changes that are not understood. All the pink-flowered varieties in the forcing-house began to fade as soon as the flowers were fully expanded, no matter whether they were in the sun or shade. Some faded very slowly, and in others the change could be noted day by day. It seemed to be a matter of variety. We could discern no other principle.

There is another interesting fact which should be put on record in connection with chemical changes and change of color. In still earlier and later stages than any referred to above, it is common for secondary colors to appear. I have noted some 30 white varieties that show pink at late stages. Sometimes this secondary color is attractive and prolongs the season of the flower and adds to its charm, but it is commonly associated with loss of crispness and marks the end of the salable period.

The results of the nitrogen experiment were not certain enough to be published, but it is safe to say that the extra amount of nitrogen did not seem to deepen the color in any case. Of the 60 plants used in the two experiments, only 26 were strictly comparable. The others may be arranged in three groups.

In the first group were eight plants of three varieties (*Violescent*, *Rosy Imperatrice* and *Sibyl Kaye*), which did not attain their typical color under any of the four kinds of treatment, but had shown enough color (although short-lived in the last two varieties) in 1896.

In the second group were 13 plants of five varieties (*Gov. Matthews*, *Miss A. L. Dalskov*, *Mrs. W. C. Egan*, *Mrs. Harry Toler* and *Bellem*) which, like the first group, did not attain their typical color under any treatment, but, unlike the first group, they had not attained their typical color in 1896. In both groups the second year's trial resulted in no gain. In these particular cases the home grown stock did not, of itself, give enough advantage to make the flowers well-colored, but these results must not be taken as contradicting the established principle that home-grown stock, if carefully selected, gives better results than newly purchased stock that has not been carefully selected.

In the third group were 14 plants of two varieties (*Lenawee* and *Our Mutual Friend*) that are not normally pink, but white. In *Lenawee* I had never seen any pink color, but in *Our Mutual Friend* I had noticed, in 1896, some flowers that showed almost enough pink to make them unsalable as white flowers. These plants had been highly fed, and under the same conditions the normally pink varieties had been very highly colored. This treatment, I believe, was very liberal with nitrogen. Nitrate of soda, says one chrysanthemum specialist, deepens the color of certain pink varieties. If one kind of treatment deepens the color of pink flowers, may it not force some pink color into white ones? This query explains why two normally white varieties were included in these experiments with pink varieties. In these experiments *Lenawee* and *Our Mutual Friend* showed no color at all.

It should also be said that *Bellem* and *Marie Valleau* are sometimes described as chiefly or entirely white, and sometimes as chiefly or entirely pink. I have not excluded *Marie Valleau* from the list of varieties that were strictly comparable, as the flowers of it grown in the sunlight would have sold as pink flowers and not as white ones.

Next to the pink series of colors, the bronzes seem to be most sensitive, and next comes the dark colors, especially the darker reds. All the bronzes I have seen are blendings of red and yellow, and the two elements are often easily separable. Thus *Charles Davis*, one of the leading commercial sorts, is recorded in the magazines in every shade, from rosy bronze to pure yellow. Yellows will show red and bronzes will lose it, but the changes are probably not so serious in dollars and cents as the loss of color in the bright pink varieties.

IV. CROWN AND TERMINAL BUDS.*

The choice of buds in chrysanthemums presents some phenomena that are extremely interesting and absolutely unique in the cultivation of plants. At the outset it should be said that the whole subject may be safely ignored only by amateurs who do not grow flowers for the shows. Every competitor at the shows, and every florist who tries for the earliest flowers on the market should master the subject. While the terminal bud is the best for general purposes in America, the crown bud usually gives the earliest flower, but there are exceptions to both rules. The whole problem is a curious one. One kind of bud will sometimes give an incurved flower and another a reflexed flower, and other great changes in form may occur not often only in the same variety, but actually on the same plant. Terminal buds give pink flowers, while crown buds may give flowers that are pure white or nearly so. Form and color may be so completely changed as to make the variety entirely unrecognizable; foliage is often seriously affected, and, in short, the bud factor alone may make all the difference between success and failure in competitive exhibition.

A proper perspective of this subject may be gotten only by reflecting on the importance of disbudding in the amelioration of plants. The Chinese and Japanese seem to have practiced the disbudding of chrysanthemums from an antiquity that is scarcely credible to the western mind. Their achievements are just as wonderful as if we had produced the same forms and colors from our own much hated weed, the ox-eye daisy (*Chrysanthemum Leucanthemum*), by disbudding and by patient care through the centuries. In 1845, chrysanthemums had barely emerged into some degree of general notice in England, and the oldest extant horticultural journal of the country was in its fifth year. Yet in the *Gardeners' Chronicle* of 1845, a chrysanthemum culturist mentions disbudding as an essential. For the last twenty-

---

*This account is slightly extended from an article in the *Florists' Exchange* for March 26, 1898.

five years, at least, English gardeners have been using the terms "crown" and "terminal" buds in a technical sense peculiar to chrysanthemum culture alone. These words have grown in a natural fashion, and nobody knows when they were first defined in their present sense. Although the literature of this subject is very extensive, the phenomena have never been illustrated, so far as I know, by more than two sets of pictures. What, then, are these unique phenomena that gardeners have noticed for twenty-five years, and what are crown and terminal buds?

A crown bud is surrounded by vegetative shoots, and not by other buds (see figure 180). *A terminal bud (in chrysanthemums) is surrounded by other buds and not by vegetative shoots* (see figure 181). These definitions may be literally adhered to for practical results. The chrysanthemum specialists are pretty well agreed in accepting these definitions, but there is reason to believe that hundreds of the lesser growers in America have entirely missed the whole problem. This is due chiefly to the fact that chrysanthemums for commercial purposes are planted out much later than in England, July 12 to 20 being the American rule. Now, late struck cuttings give very few crown buds, and the state of things pictured in figure 180 very rarely occurs in America except when plants are started very early for special purposes, such as exhibitions and standards. As a consequence, it is commonly supposed that the crown bud is the top bud of the cluster shown in figure 181, and that the only question to decide is whether to keep that one, or one of the other flower buds of the cluster. Thus the whole point is missed entirely, for it is a matter of time primarily, and only incidentally a matter of position. (As a matter of fact, the central bud of the cluster is much larger and rounder than it is shown in figure 181, and usually gives the best results. But a bug may nip it, or an accident make it useless.) This widespread popular misconception must be entirely removed at the start. The mistake, however, is an easy one to make for other reasons. Every good catalogue now-a-days tells in many cases which bud to use, the periodicals reiterate the directions, the mass of writings on the subject is very great, and the beginner naturally infers that the choice is always offered to him, and that it is a mere matter of choosing. Only the experienced grower knows that he cannot always get what he wants, and that he must scheme for his crown buds—plan for them a whole season in advance. A third source of error is the terminology. How shall a beginner know that "taking" a bud is really leaving it? And, moreover, the word terminal covers two distinct ideas of great practical importance, which can be separated only by close observation and thinking. Thus, when the shoot A in

180.—*A crown bud is seen below* A. *To save the crown, cut off the shoots* A, B *and* C. *To secure a terminal bud cut off the crown bud and the shoots* B *and* C. *The shoot* A *will eventually bear clusters of flower buds as in figure* 181.

figure 180 was very small, the little flower bud seen below it in the picture may have actually reached higher up into the air than the shoot A. The flower bud was then the terminus in the sense that it was at the top of the stem. But it does not stop vegetative growth.

181.—*A cluster of terminal buds. Whichever one is saved becomes the terminal bud. Note that there are no vegetative shoots.* (This and figure 180 from the *Gardeners' Chronicle.*)

It does not mark the end of vegetative stage, and the beginning of the reproductive stage of the plant's life-history. Not at all. But in figure 181 the whole cluster of buds does actually stop the vegetative phase altogether until the flowering time is over.

In figure 180, the vegetative shoot A is shoving the little flower bud aside, sapping its vitality, and will soon straighten out the axis of growth so that one would never know the difference. The flower bud remains rudimentary or dormant. The whole cluster of buds shown in figure 181 is terminal because it ends the vegetative phase of the plant's history, and it is only the particular bud in the cluster that is left to flower, which is what the chrysanthemum specialists call *the* terminal bud. Finally the beginner is easily led to mistake the whole problem by such writing as this:

"For garden purposes, the term 'crown' bud does very well, for it is the center or crown of a group of buds* at the end of the growth; indeed, the term can only be fully appreciated by those who have a practical knowledge of 'taking' the buds. There is the larger bud in the form of a crown in the center, and standing above all the others. [The true terminal bud of the botanist.]† The question to be determined at the time is, whether the center bud shall be left or taken out; in some instances it is better to leave it and remove the side buds with the finger nail; in the case of another variety, the center bud is removed, and one of the side buds is trained up to take its place, and this bud, to all intents, becomes the terminal bud, with a number of lateral buds clustering around it; but except that the two terms are in general use, there is no reason why 'terminal' should not apply to each."‡

How many beginners reading the above and seeing no illustration would infer that the whole problem was merely to choose between the center and one of the side buds in a given cluster of flower buds? Nearly all, I think.§

---

* Does not the reader here naturally think of a cluster of flower buds as in figure 181?

† This seems to be the comment of the editor of *Gardeners' Chronicle*.

‡ J. Douglas in *Gardeners' Chronicle*, November, 1893, p. 620.

§ I cannot imagine that the veteran cultivator, Mr. Douglas, has missed the whole point. His subsequent writings make it seem impossible. And it would be very odd if Mr. Molyneux, who is the chief writer on this subject, and who was engaged with Mr. Douglas in a controversy at the time, should have overlooked so complete an error. It is misleading only, and the trouble comes from using "buds" when the writer should discriminate between a flower bud (the crown) and its accompanying vegetative shoots. These young growths ought not to be called buds, but shoots.

But why are crown buds wanted at all? One reason is that the crown bud sometimes gives a flower ten days earlier, which is an important consideration to those commercial florists who make a point of getting the earliest blooms of the season into the large cities. Moreover, there are many sorts which would naturally bloom too late for the exhibitions. Some of these may be secured for an arbitrary date by the use of crown buds. As a rule the crown bud gives a larger flower, and mere size alone is valued out of all proportion to its artistic worth at the shows. Again, some weak and crooked growing plants are straighter and stiffer under crowns than terminals. Finally in some cases crowns give better results (taking all things into consideration) than terminals. Such cases should be regarded by Americans as exceptions to the general tendency, but they are very numerous. Earliness and size, then, are the chief merits of crowns, and they are often at the expense of many and serious defects.

The general tendency among crowns is towards a loss in form, substance, color and foliage. The regularity of the incurved section (which is aided in the English shows by artificial "dressing") is often lost. The whole outline may suffer, the broad, ragged florets hanging in a heavy, flabby mass instead of curving inward to make a solid ball. They are often "hollow-eyed," and there may be several yellow discs or one so badly confused as to be called "cross-eyed." Superfluous florets commonly mar the unity of effect, and it is even recorded that the tubularity of florets may be affected. The flowers often lose in depth and solidity, the stems are devoid of foliage near the flower, the keeping qualities are sometimes spoiled, and the colors lose both in quality and quantity. Probably exceptions could be cited in every point above mentioned, but some of these symptoms are likely to occur even in blooms that win prizes.*

The crown bud is often spoken of as essentially abortive in its nature. The analogy is helpful. In figure 180 the small bud below

---

*Exception may also be taken to the direction of a general tendency. Thus Grove P. Rawson writes in the "American Chrysanthemum Annual," 1895, "Crown buds in general are preferable for exhibition flowers, especially when they are shown on boards, as was formerly the practice. Foliage and stem not being taken into account, the blooms from crown buds average larger, fuller, clearer tone of color, and have more substance than the terminals."

A may be looked upon as nature's device for making the plant branch. It is not designed to produce flower or seed itself, but by giving a temporary check, it makes the plant branch, and a branched chrysanthemum stands a better chance in the struggle for existence than an unbranched one, because it bears more flowers and, therefore, more seeds. The chief merits of crowns, viz., earliness and size, may easily be explained by the earlier setting of the bud and the longer period of growth.

Terminals, on the other hand, are likely to be better in every way except size and earliness.

The practice of bud taking may be formulated into the following rules, but there are numberless exceptions, and, not to mention other complications, two factors alone—the locality of the grower and the date of the show—are enough to make the whole matter a personal problem.

(1) The season may be lengthened at both ends by the judicious choice of buds.

(2) Crowns may be used on late varieties to show them at exhibitions for which they would be, naturally, too late. Conversely, terminals may be used on early varieties for a similar purpose.

(3) Crowns may be used for close-jointed and terminals for long-jointed varieties. This does not mean that on dwarf varieties crowns will give better results than terminals. It means that tall, long-jointed varieties are likely to become too tall and bare-necked under crowns. Dwarfs under crowns may be elongated just as much relatively as tall sorts under crowns, but not so much absolutely.

(4) In England, crowns are preferable in the north and terminals in the south, in order to compete at the London shows.*

(5) In England, crowns are preferable for the Japanese sorts, and terminals for the incurved.†

(6) Never keep a July bud.

(7) In England the best time to select crowns is between August

---

*W. Hinds in *Gardeners' Chronicle*, March, 1879, p. 376, where the writer states that the North Country growers would have few flowers before December except for general decorations unless crowns were used. Similar statements have been frequently repeated.

† E. Molyneux in *The Garden*, 34 : 228 (1888).

18 and September 1.* In America, most of the crown buds are selected between September 10 and 15.† The difference in time may be due chiefly to climate.

(8) The later the bud, the higher the color.‡

(9) As a rule crown buds give earlier and larger flowers, which are likely to be deficient in some or all other respects. Chief among these defects, for America, is the long neck bare of foliage.

(10) The earlier the crown the greater the chances of failure.

182.—*Another picture of a crown bud.* (This and figure 183 were adapted from Mr. Molyneux's book and used by Elmer D. Smith in the *American Florist*, 9: 8, Aug., 1893.

The difference in practice between England and America are well worth setting forth. Crown buds are used more commonly in England, largely because of the aversion to pinching out the leading shoot at any height. This prejudice is probably not so strong in America. The commercial element is more prominent here, and chrysanthemums for sale as potted plants are started late, kept as dwarf as possible, and grown on side benches where there is the least headroom. Such plants are pinched as early as possible to make them branch. In England, the amateur and exhibiting classes are stronger than in America, and the plants are started much earlier and never pinched to induce branching, but are grown under the "three break" or natural system. The first break may come at any time from April to June 15, and at a height of from one to three feet. The second break is caused

*E. Molyneux in *The Garden*, 34: 228 (1888). H. S. in *The Garden*, 42: 174 (1892).

†E. D. Smith in *Florists' Exchange*, 5: 790, Aug. 1890.

‡C. E. Shea in *The Garden*, 38: 407, Nov. 1890.

by the crown or single buds. If these buds are not selected to produce flowers, but are removed, the third break produces clusters of flower buds which are called terminals. But, after all, differences in cultural methods do not go to the root of the matter, for they are largely dependent upon differences in public taste. In England, flowers are chiefly shown on boards. The stems are cut short and each flower is supported by a collar placed over the top of the vessel of water that holds it, and the leaves are not seen. They are judged as individual objects. Americans like mass effects, and the feeling for foliage is general. With us a flower without foliage is like a gem without its setting. Our best vase effects are loose, airy, graceful, fluffy, and they are obtained by using long stems and plenty of foliage.

It will now be clear that there are special as well as general reasons why English varieties do not succeed in America as a rule, and *vice versa.* The English favor crowns, and crowns, as a rule, have poor foliage. Choosing varieties from the exhibition halls is a fertile source of disappointment. There are many general reasons for it, one of which is that the habit is not seen, and a special reason in chrysanthemums is that the show flower may be the product of a crown bud. The practical application to American novelties is also not far to seek. The terminal bud is the rule for American commercial purposes, and no variety that is poor from the terminal may ever hope for anything like permanent general prosperity in America.

The actual work of disbudding can hardly be entrusted to anyone who has not a stake in the welfare of the plants. It needs patient, skillful, interested hands and the highest powers of discretion employed in the growing of plants. If the crown bud is to be selected, all the vegetative shoots should be removed at a stage much earlier than shown in figure 180. Figure 182 shows a better time. If, however, the crown bud is not desired, it is removed together with all the vegetative shoots save one. The shoot A in figure 180 will naturally be given the preference, as it may be expected to give a straighter stem. The shoot that is saved will eventually bear a cluster of flower buds, one of which is saved and thereby becomes the terminal. If possible, the unnecessary buds in the cluster should be picked off earlier than those shown in figure 181. The earlier the better, if successful, but the risk in handling is greater. The more the flower buds are advanced, the easier is the manipulation, and the less is the amount of plant energy saved which should be concentrated into the development of only one flower. The same rule applies in the choice of the crown, but the principle is different. In selecting a crown, the cultivator removes shoots; in selecting a terminal, he removes flower buds, and therefore he saves in the first case energy of vegetative growth, and in the latter case reproductive (*i. e.*, flowering) power. Some cultivators use a tooth pick to dislodge the very young parts, and others wait until they can be picked or cut out with a knife. Others are expert with the thumb-nail. Mr. Molyneux advises that the work be done in the early morning, or in the evening when the parts are brittle and may be snapped off. The ingenious cultivator is likely to invent all sorts of methods and formulas, but the work is tedious at best.

183.—*Terminal buds.* (*They are less clustered here than in figure* 181, *and the central bud is larger.*)

In the description of novelties, the trade catalogues, as a rule, give directions about the buds. This is especially true of the English catalogues. As a rule, also, whenever no directions are given, the American cultivator has a right to infer that the terminal bud is to be preferred. Every silence, when the opposite is true, is an invasion of the rights of the purchaser by the disseminator. As a rule, however, exhibitors cannot afford to put any large share of faith in novelties. The special cultural requirements of varieties are indefinitely varied and complicated, and a cultivator can hope for nothing more than acquaintance with a new sort in a single season. Often and often he fails and cannot be sure of the cause of his failure. Mercilessly cut down the list of varieties and learn the chosen few like a book! The references to the behavior of *Viviand-Morel*, which is only one variety, would probably occupy three times the space of this entire article, if gathered from the various magazines.

After the flower has opened it is not always possible to tell from the plant itself which kind of bud was used. Sometimes it is possible. This year we ascertained from catalogues and by correspondence the bud preferred by the grower for each named variety, and we have records of the exact date when each of more than 600 buds was taken. The characters used to identify the results after flowering, are age, size, color and form of flower head, size and form of the yellow disc, number, size and form of florets, length of bare neck, size, position and form of scars, and the angle of divergence caused by the removal of parts. In my limited experience no one of these characters, nor any combination of them, made it certain in even a majority of cases what bud had been used.

The terms "early" and "late crowns" are much used in England, and the terms "first" and "second buds" are less commonly seen in American catalogues. The two sets of terms are synonymous and refer to the fact that a crown bud may be removed, and the shoot selected to continue the growth may bear a single bud which is called a "late crown," "second crown," or "second bud."

If, now, this "second crown" is removed, a cluster of buds may subsequently be secured, and the one reserved for flowering is, of course, the terminal.* The reason and relation of these phenomena may be cleared up by reflecting that all crowns, *i. e.*, all flower buds that appear singly (and they may appear in almost any month before the clusters of flower buds come) are essentially premature and not designed by nature to produce flowers. "Early" and "late" are therefore seen to be only relative terms, where months of the year might be specified, and "first" and "second" refer only to the effects produced by the removal of parts by the cultivator.

It is, of course, useless to try to divert the growth of language. A more logical terminology would use "first natural break" for the branching that takes place when plants are started very early and

*No cluster of buds can ever be referred to as crowns without abandoning all definitions and all clear thinking. I know of no recorded case where clusters of buds appear in large numbers so prematurely as to necessitate removal.

grown continuously without a check. "Single" and "cluster buds" mean something. "Crown" and "terminal" do not mean anything on their face, and their technical use in chrysanthemum culture violates botanical usage and must be arbitrarily memorized. "First single bud" and "second single bud" are awkward at first, but they are clear. And "taking" the bud is unnecessarily misleading, while we have "use," "keep" and "save," in the language. It should be stated, however, that nature does not keep to definitions. It is often difficult to say what is a cluster. This doubt is chiefly due to the fact that such a cluster as is shown in figures 181 and 183 rapidly elongates, and what one seems to see is a number of buds scattered distantly along the stem. Similarly there may be more vegetative shoots on the same stem with a single flower bud than the three that are pictured in figure 180. (Six of them are seen in figure 182.) Every axil, in fact, below that flower bud wants to make a growth, but as a rule the three at the top get the start. If the student will burn figure 180 into his mind, and understand the definitions previously given in italics, he will have no trouble in knowing a crown from a terminal.

184.—*What happened to two crown buds that were not removed.*

Some cultivators will wish to know what happens if a crown bud escapes their notice and is not removed. Figure 184 shows part of a belated chrysanthemum plant that we allowed to have its own way. The first crown bud was formed at A. Beneath it were two vegetative shoots b^1 and b^2. The upper of the two shoots, b^1, got the start and grew so vigorously that the poor crown bud is side-tracked, and sapped of all its ability to produce a good-sized flower. At C, may be seen the second crown bud. This bud checked the lusty growth of the shoot b^1, just long enough to cause the plant to branch. Four vegetative shoots started out at d^1, d^2, d^3, and d^4, and they have sapped the strength out of the second crown bud C. In this case d^2 is the strongest shoot. It has side-tracked the crown bud C which was once directly in the line of promotion and has now so nearly straightened out the axis of growth that, merely to look at the picture, one might suppose that d^2 is a part of the original stem itself. These four shoots d^1, d^2, d^3 and d^4 would have gone on to produce terminal buds (*i. e.*, cluster of buds) but the flowers would be entirely worthless commercially because out of season, and small and poor in every way.

In conclusion, although the whole matter is one of the last refinements of specialization, its importance for the exhibitor can hardly be overstated. It is often called a vital and critical element, and in a proper sense it may be called the secret of chrysanthemum culture. Aside from the terminology of the subject, the present confusion is due to three causes—first, to differences in observation as to what actually takes place; secondly, to differences in the interpretation of the facts and the generalization of them into rules of conduct; and thirdly, to differences in the application of these rules. As previously pointed out, the problem is, in practice, essentially local and personal, and after the principles are thoroughly mastered, there is positively no other way for the exhibitor than to make his own dates and buds for his own varieties by yearly observation and experiment.

REFERENCES TO LITERATURE.

The writings on this special subject are exceedingly numerous and scattered, and, in the earlier times particularly, references may be found only by the diligent search for them in general cultural directions and miscellaneous notes. A complete bibliography is out of the question, the labor involved being out of all proportion to the value of the results. Workers in cultivated plants know that completeness is practically impossible in such tasks. I can only hope that the selection I have given covers the essentials of the subject, and represents the most important articles published in the periodicals cited.

ENGLISH PERIODICALS.

The Gardeners' Chronicle.—

Taylor, March, 1851, p. 183. No reference is made to the relative value of early and late buds.

Wm. Holmes, January, 1859, p. 23. This is the earliest mention known to me at present of the different values of early and late buds, and the first use of "terminal" in this special sense. The word "lateral," I take it, is here used as we use "crown" to day.

R. Fleming, September, 1869, p. 942. This is the first mention of the word "crown" in chrysanthemum culture that I know of, but the term is not yet specialized into the definition quoted previously in italics at page 349 of this bulletin. "Some of the shoots will be found to be more forward than others, and are apt to bloom before them, but by judicious disbudding this may be avoided. This is effected by nipping out the crown or earliest bud of the earliest shoots, leaving a good side bud [He means, I think, a vegetative shoot such as A in figure 180.—W. M.], and retaining the crown or earliest bud of the late shoots; this will cause all the buds to be equally forward."

W. Hinds, March, 1879, p. 376. The writer says that "crown terminals" are favored in the north, and "terminals" in the south.

Editorial, November, 1893, p. 592. This explains that with botanists a terminal bud is at the end of a stem, but that chrysanthemum growers use the term with reference to time, not to position. "For them the terminal is the last bud formed, not the first." The word "final" is suggested to avoid confusion.

J. Douglas, November, 1893, p. 620. An extract from this article has been quoted at page 352 as a type of misleading writing.

E. Molyneux, May, 1895, p. 584.

E. Molyneux, August, 1896, p. 248. This is the earliest picture known to me at present of a crown bud in any English journal.

E. Molyneux, September, 1896, p. 309. The terminal bud illustrated for the first time in any English journal. There is, I believe, an all-important typographical error in the fourth line from the bottom. For "figure 59" read "figure 49."

The Garden.—

E. Molyneux, 34 : 227, September, 1888.

E. Molyneux, 38 : 407, November, 1890. Importance of the bud factor in variation of color.

C. E. Shea, 38 : 407, November, 1890.

C. Gibson, 39 : 7, January, 1891.

E. Molyneux, 42 : 173, August, 1892.

H. S., 42 : 173, August, 1892.

E. Molyneux, 44 : 126, August, 1893.

AMERICAN PERIODICALS.

The American Florist.—

Elmer D. Smith, 9 : 8, August, 1893. The cuts enlarged from Mr. Molyneux's book are the only illustrations of this subject that I know of that have ever appeared in any of the American periodicals previous to March 26, 1898.

Garden and Forest.—

T. D. Hatfield, 5 : 513, October, 1896.

The Florists' Exchange.—

E. Asmus, 3 : 54, January, 1891.

Elmer D. Smith, 5 : 790, August, 1893.

A. D. Rose, 6 : 639, July, 1894.

V. THE CORNELL VARIETIES OF 1897.

The variety test was conducted in 1897 as in the two previous years, but with better results. There were 166 varieties grown as cool as possible in the same house under the same conditions, and with only one plant of each variety. Four flowers were grown on each plant and they averaged nearly six inches in diameter. Inasmuch as a variety test has no absolute scientific value, but is more nearly related to personal experience, judgments of varieties are here offered, and the descriptive matter reduced to a minimum. Of the 166 sorts grown for comparison, only 86 are now reported upon, as 59 were mentioned in Bulletin 136, and the remaining 21 were chiefly numbered seedlings that were kindly sent by various dealers in advance of their distribution under names. Of the 86 kinds now reported, only 54 are novelties of American origin offered for the first time to the trade in the catalogues of 1897.*

It is unfair to finally judge any novelty of any plant on one season's acquaintance, but opinion is called for, nevertheless, and must be given. The 86 kinds now considered are divided into only two groups, 34 in one and 52 in the other. In the first group the 10 "very good" sorts are distinguished from the other good varieties by SMALL CAPITALS. The asterisk (*) is prefixed to varieties of foreign origin, most of them being English and Australian sorts of 1896, kindly sent by H. Cannell & Sons, Swanley, Kent, and Robert Owen, Castle Hill, Maidenhead. The dagger (†) means that the varieties are of American origin, and named, but not yet published in trade catalogues. These estimates are our own judgment for our own conditions and may not hold for other conditions and other ideals. The plants were skillfully grown by Mr. Hunn, and his judgments enter largely into the estimates.

The chrysanthemum specialists who have sent their novelties to the Station are:

---

* Fifteen others of American origin were not tried, as follows: Allegro, Miss Lottie D. Berry, Robert Edgerton, Gold Bug, Clara Goodman, Mrs. Col. Goodman, Kentucky, Mrs. A. P. Meredith, Henry Nanz, Pendennis, The Times, Vineta, West Newton, Miss May Williamson, Yellow Monarch. The Californian varieties are excluded from this list, because of their importations from the Orient, and the different cultural conditions.

E. G. Hill & Co., Richmond, Ind.

John N. May, Summit, N. J.

Nathan Smith & Son, Adrian, Mich.

T. H. Spaulding, 40 E. 25th Street, New York.

Many choice seedlings were sent by the late firm of Pitcher & Manda. Others who publish no catalogues but sent their novelties to the station are J. Condon, 734 Fifth Ave., Brooklyn, N. Y.; Fisher & Ekas, 1st Toll Gate, Belair Ave., Baltimore, Md.; Theo. Bock, Hamilton, O.; and the late Calvin S. Goddard, Woodfords, Me.

FIRST GROUP—GOOD AND VERY GOOD.

White-flowered Varieties.

* Early.

MIDGE.—Height, 12 to 15 inches. Foliage ideal. Flowers fit to cut from October 5 to November 15. Said to be fuller than *Mme. Bergmann*, the chief early commercial white variety up to this time. An ideal pot plant.

GEO. S. KALB.—Flowers of the snowball type like *Midge*. Fit to cut October 10 to 28. Fuller than *Midge*. Foliage ideal. Height, 22 inches.

Halycon.—Japanese Anemone section.

** Mid-season.

Marsia Jones.—Japanese Anemone section.

† DR. C. H. PARKHURST.—This was easily the most attractive of all the chrysanthemums grown at the Cornell Experiment Station in 1897. Height, 51 inches. Our only plant had four flowers averaging 8 x 4 inches, which changed in appearance daily for over a month. Unfortunately the neck was weak and bare, due possibly to its position near a steam-pipe. A rich, warm white flower. Pictured in *The American Agriculturist*, 61: 93, January 22, 1898.

† WM. J. BRYAN.—Flowers nearly as large as the last, later, and a colder white. Habit better, but rather tall. Height, 46 inches.

* *Mrs. Jas. Carter.*—Small, a curiosity.

† *Edith Gunnison.*—Flowers large, reflexed, and as good as *Our Mutual Friend.* Not as good as the next for pot plants.

† *Mrs. J. Condon.*—Flowers small, reflexed and, like the last, as good a pot plant as *Robert F. Hibson* or *Snow Field.* Not as good as *Edith Gunnison* for cut flowers.

*** Late.

Mrs. Martin A. Ryerson.—A worthy sort to precede *Yanoma*, which is probably the best late white variety.

† *Mrs. Wm. B. Brown.*—In season November 5 to 24.

Yellow-flowered Varieties.

* Early.

GOLDEN TROPHY.—A soft, light yellow flower in salable condition from October 10 to November 15, incurved during the first half of the season and partly reflexed during the remainder. Habit ideal.

** Mid-season.

† *Ophir.*—Flowers rich yellow, globular, rather formal and lasted a month.

Maud Adams.—An interesting type for the amateur.

* *Mrs. Filkins.*—Essentially a curiosity, but beautiful.

*** Late.

† *Levi P. Morton.*—Too late for the shows.

* *A. H. Wood.*—A type for the amateur (see figure 176).

Pink-flowered Varieties.

* Early.

ELVENA.—The best early, light pink of its form ever grown at Cornell. October 12 to 24.

** Mid-season.

† *Brooklyn.*—Slow in opening and coarse in color at first. Marketable for a month after October 20. A first-rate commercial sort much preferable to *Sibyl Kaye*, which it resembles.

Merula.—Same shape as *Ophir.* Color coarsely lined at first, but afterwards charming.

Chebeague.—A splendid sort for local exhibition. Probably too flat for commercial use. Ours suffered from burned florets.

† *Henry Ward Beecher.*—A rather Chinese type. Color dull, but rich.

*** Late.

Thanksgiving.—The best late light pink we know.

Amaranth-flowered Varieties.

* Showing the silver backs of the florets.

* *Australie.*—The reverse is the chief feature. Only a suggestion of the amaranth interior, and no disc seen.

* *Pride of Madford.*—Both colors show. Disc appears early.

* *General Roberts.*—Flower practically same as the last.

** Not showing the backs of the florets.

* WOOD'S PET.—Early, worthy to precede *Viviand-Morel.*

LEONIDAS.—Early. A different form from the last. Otherwise an equal choice.

Other Colors.

LOANTIKA.—Early. Red, reverse yellow. Worthy to precede *Pluto.*

Chito.—Red with yellow stripes. Flower very large, odd and striking.

CASCO.—An excellent dark sort, early and lasting.

* *Alice Carter.*—Unique, curious, beautiful. A type for the amateur.

* *E. G. Hazeldene.*—Large Anemone section.

Mizpah.—(See title-page.) A single variety, an excellent type and a good pot plant. One of our plants 14 inches high had 80 flowers at once. Unfortunately, they fade and must be picked off.

The varieties above commended are now redistributed into two other groups. The Amateur List contains many of the finer types that the private gardener and skilled amateurs, it is hoped, will save from oblivion. In both groups the * is prefixed to varieties suitable for pot culture, and the † to those suitable for exhibition.

Amateur List.

White.—† Dr. C. H. Parkhurst, † Wm. J. Bryan, Marsia Jones, Mrs. Jas. Carter, Halycon, * Mrs. J. Condon. *Yellow.*—A. H. Wood, Mrs. Filkins, Maud Adams, Levi P. Morton. *Pink.*—† Elvena, Chebeague, Henry Ward Beecher. *Other Colors.*—Gen. Roberts, Australie, † Chito, E. G. Hazeldene.

Commercial List.

White.—* Midge, * Geo. S. Kalb, Mrs. Martin A. Ryerson, Edith Gunnison, Mrs. Wm. B. Brown. *Yellow.*—* Golden Trophy, Ophir.

Pink.—Brooklyn, † Merula. *Other Colors.*—Leonidas, * Casco, * Mizpah, Loantika, † Wood's Pet.

SECOND GROUP—LESS PROMISING.

Doubtless there are good sorts in this list. Some of them need special cultural conditions, but in a variety test they must all be treated alike. If this were a second year's trial of them, we should not have any of these names on our own personal list of 50 for commercial purposes. If any are especially interested in some of these varieties we shall be glad to recount our experience with them.

The phrase "less promising," therefore, expresses merely our own feelings about these varieties, and does not assume to say how these varieties may please others. The plants themselves were well grown when we received them from the dealers and they received careful attention during the entire season.

Adelaide.
Atkinson, G. F.
Barrington, The.
Beckert, Mrs. Theo. F.
Belle of Castlewood.
† Bennett, James Gordon.
Brian Boru.
* Carvell, G.
Castleton.
* Centaurea.
Cole, King.
* Curzon, Col.
Defender.
Devens, Dorothy.
Doone, Lorna.
Douglas, Mrs. R. D.
Elainora.
Eureka.
Evangeline.
Gifford, J. M.
Gladys.
Glessner, Mrs. John J.
Gold Standard.
Golden Wonder.
Harriott, The.
* Hepper, Mrs. F.
Hyde, Mrs. E. F.
* King of Plumes.
Lawn Tennis.
* Levick, Sydney B.
Lorelei.
Mars [Spaulding's].
McKinley, Pres.
McArthur, Mrs. R.
Morse, T. B.
† Nix, Jessie.
* Oceana.
* Owen, Rose.
* Pride of Swanley.
Rothenbush, Mrs. P. [1896, Yoshiike, California].
Spaulding, Dorothy.
Sundew.
Sunstone.

Sunclad [1896].
Symphonia.
* Turk, T. L.
Wallace, M. M.
Ward, C. W.
Western King.
Withers, Mrs. J.
* Wood, Mrs. A. H.
Woodford, J. H.
Yellow Kid, The.

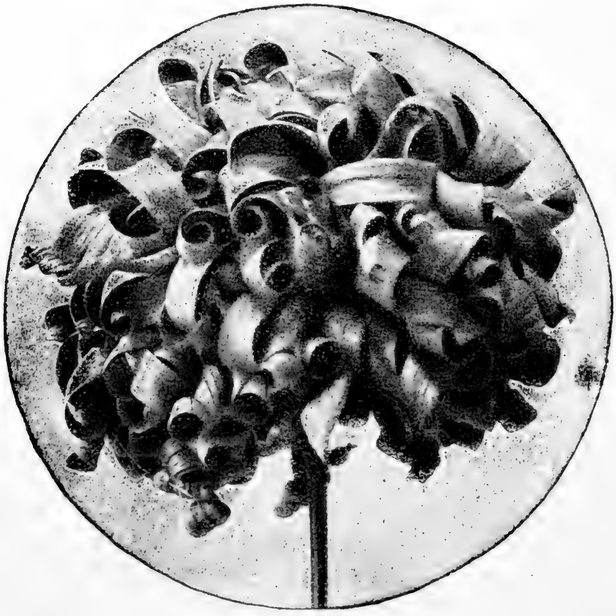
SUMMARY.

1. Special directions for cultivating plants at home are given at pages 334 to 342.

2. Lists of newer varieties for special purposes are given at page 367.

3. In order to grow chrysanthemums at home it is not necessary to know the difference between crown and terminal buds. It is desirable that every florist should master the subject. Page 348.

4. The pink color in chrysanthemums is very unstable. Its regulation depends more upon the skill of the cultivator than on the variety. Pages 342, 348



185.—*Shavings, an oddity.* (See page 340.)

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale, 18 pp.
145 Some Important Pear Diseases, 36 pp.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums, 36 pp.

Bulletin 148. **May, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

THE QUINCE CURCULIO.

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

STATION COUNCIL.

President, JACOB GOULD SCHURMAN.

Hon. A. D. WHITE,	Trustee of the University.
Hon. B. F. TRACY,	President State Agricultural Society.
Professor I. P. ROBERTS,	Agriculture.
Professor G. C. CALDWELL,	Chemistry.
Professor JAMES LAW,	Veterinary Science.
Professor J. H. COMSTOCK,	Entomology.
Professor L. H. BAILEY,	Horticulture.
Professor H. H. WING,	Dairy Husbandry.
Professor G. F. ATKINSON,	Botany.
M. V. SLINGERLAND,	Entomology.
G. W. CAVANAUGH,	Chemistry.
L. A. CLINTON,	Agriculture.
B. M. DUGGAR,	Botany.

OFFICERS OF THE STATION.

I. P. ROBERTS,	Director.
E. L. WILLIAMS,	Treasurer.
EDWARD A. BUTLER,	Clerk.

In pursuance of the provisions of Chapter 67 of the Laws of 1898, several persons have been appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work require.

See Bulletin 146, Report of Progress of work done under Chapter 128 of the Laws of 1897.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.

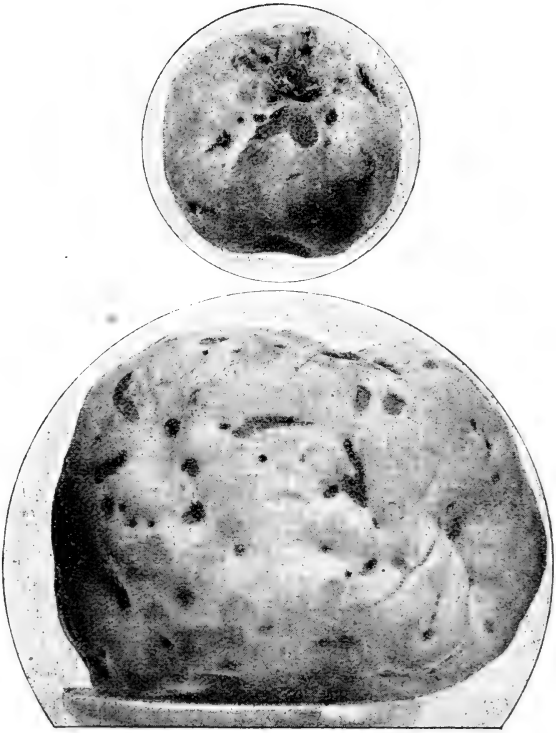
CORNELL UNIVERSITY, ITHACA, N. Y., May 20, 1898.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY:

Sir: This bulletin is submitted for publication under Chap. 67 of the Laws of 1898. It has been prepared by Mr. M. V. Slingerland and embodies the results of experiments extending over two years and the latest reliable facts related to the subject had under investigation.

In 1896, an insect known as the quince curculio was so destructive in some localities as to lead growers of the quince to seriously consider the advisability of cutting down their orchards. Early in 1897, a critical study was begun of the habits of the curculio, and continued during the season until its life-story and habits had been ascertained. Observations show that there is little, if any, probability of poisoning the insect with an arsenical spray, and that early cultivation has but little effect upon it, thus disproving two of the so-called "remedies" by which it has been supposed that the pest could be reached. Our study of its life reveals some striking variations from its habits of the preceding year. By carefully watching the insect in the cages at the insectary, we were enabled to give several large quince growers warning that the pest was appearing in alarming numbers nearly two months later than its schedule time of the preceding year. By following our suggestions, one extensive grower of the quince, whose crop was nearly an entire failure in 1896, due principally to the work of curculio, secured in 1897 the finest crop of quinces he ever harvested. A few careful observations in the cages at the insectary upon the habits of the curculio resulted in the saving of hundreds of dollars worth of fruit in a single orchard.

I. P. ROBERTS,
Director.

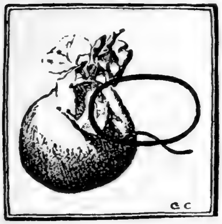


186.—"*Knotty*" *quinces; lower one, natural size, and upper one half natural size.*

THE QUINCE CURCULIO.

Conotrachelus cratægi, Walsh.

Order COLEOPTERA. Family CURCULIONIDÆ.



QUINCES are more largely grown in western New York than elsewhere in the Union. The indus try has grown up slowly and quietly, and has not attracted general attention; yet, in its way, it is one of the important agricultural interests of the state. Quince growing can never assume the proportions of other orchard industries, because of the limited demand for the fruit, and for this reason, also, the most careful attention must be given to marketing the crop *and to reducing the injuries from a number of insects and fungous enemies.*" *

The insect enemies which have thus far seriously interfered with the growing of quinces in New York may be counted on the fingers of one hand. Such an enumeration would include the round-headed apple-tree borer, the codling-moth,† the New York plum lecanium scale,† and the insect discussed in this bulletin—the quince curculio. Of these insect enemies, the first and the last one mentioned have caused New York quince growers by far the most trouble and damage; the lecanium scale was noticeably injurious for only one or two seasons in a few isolated orchards, and comparatively few of the wormy quinces are to be credited to the work of the codling-moth. Quince trees often suffer more from the attacks of the round-headed apple-tree borer than do apple trees. Fortunately, however, this borer is not as yet well established in many of our quince orchards, and is thus rather local in its distribution. One quince grower may have to keep constantly on the alert to prevent the borers from ruining

---

*Bulletin 80, Cornell Experiment Station. The Quince in western New York, by Professor Bailey.

†Discussed in Bulletins 142 and 108.

his trees, while his neighbor only a few miles away may never have occasion to dig the "grubs" out of his trees.

However, most of the complaint we get from quince growers in regard to insect pests comes in the form of queries about "wormy" and "knotty" fruits. Nearly all of those who grow quinces are only too familiar with such "knotty" fruits as are shown in figure 186. Most "wormy" quinces have been the home of the grubs of the quince curculio, and we believe that most of the "knottiness" of the fruits is caused by the same insect. We have examined dozens of quinces like those figured, without finding a single worm, so that often the fruits may be "knotty" and not "wormy." The probable explanation of how the "knots" are produced is given in the discussion of the feeding habits of the curculios.

During the past few years this quince curculio has caused a greater monetary loss to some of the larger quince growers in western New York than all the other insect foes and the fungous diseases of the quince combined. In 1896, 95 per cent. of the fruits in one large orchard at Lockport, N. Y., were badly injured, and a very extensive grower at Geneva, N. Y., became so discouraged in trying to check the pest as to seriously contemplate uprooting his whole orchard. However, both of these orchardists are now fighting this insect so successfully that last year they harvested one of the finest crops of fruit the trees ever bore, and this in spite of the fact that in some cases hundreds of the curculios appeared on a single tree during the season; in one instance last year over 200 of the beetles were collected from only seven trees one morning in August. In our discussion of the methods of fighting this pest, we have drawn largely from the practical experience of these successful growers.

ITS HISTORY, DISTRIBUTION AND FOOD.

This insect, which is so serious a menace to successful quince culture in New York, is a native of this country, and its natural food is the fruits of the common wild hawthorn. As early as 1837 one of the beetles had found its way into the celebrated collection of Dejean in Paris, France; but nothing more seems to have been heard of the insect for a quarter of a century. In 1863, it was discovered by Walsh, in Illinois, where it then "swarmed" on the hawthorn. It was reported from Pennsylvania, in 1867, on peach trees, and the next year it was found in New Jersey on pears. It was not until 1870, however, that anything was known of the habits and early stages of the pest. That year, Dr. Riley found that it bred very abundantly in the common haws in the West, and Trimble reported that it was breeding freely in quinces and pears in the East; one quince crop in New Jersey was reduced from 100 to 30 barrels, and late varieties of pears had also suffered severely in New Jersey, Pennsylvania and western New York.

This is the first definite record of the occurrence of the insect* in New York, and there seems to have been no other report of its occurrence in the state in injurious numbers for eleven years. Nearly every year since 1881, however, western New York quince growers have reported that a large percentage of their fruits were "wormy" or "knotty." We have also seen evidences of the work of the pest wherever we have found quinces growing in the central and eastern parts of the state.

Cooke records having captured two specimens of the insect in California in 1882. There are specimens in the National Museum from the District of Columbia, Kentucky and Canada, and in the LeConte collection at Cambridge, Mass., from Georgia, and it is also known to occur in Michigan. Thus, it seems to be quite widely distributed throughout the eastern, central and extreme western portions of the United States, and also occurs in Canada. It doubtless breeds freely in the wild haws in these regions, and in the East has unfortunately developed an especial liking for the quince, and often attacks the pear also. It has not been recorded as breeding in apples, and, although the curculios will feed freely on apples in confinement, efforts to induce them to breed in apples have failed. Thus, during years when there are few or no quinces, the insect doubtless breeds in wild haws or pears, rather than in neighboring apple orchards.

---

*It is quite probable, as Riley stated in his Third Missouri Rept., that Dr. Fitch had met with the grubs of this insect in haws in New York as early as 1859, but had mistaken them for those of the plum curculio. The context in Dr. Fitch's "Address on the Curculio and Black Knot on Plum Trees." (Trans. N. Y. State Agr. Soc. for 1859, p. 609), indicates this fact. The plum curculio has rarely, if ever, been recorded as breeding in haws, while these fruits are the natural food of the quince curculio.

THE CHARACTERISTICS AND APPEARANCE OF THE INSECT.

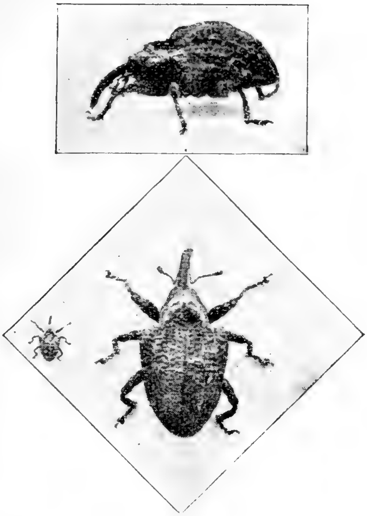
Like all beetles, this quince curculio passes through four different stages during its life—the egg, larva or grub, pupa, and the adult or beetle. It is injurious to the quince in two of its stages. The beetles "sting" the fruits, forming many of the familiar "knotty" places, as shown in figure 186; and "wormy" quinces (figure 194) are the work of the grubs or larvæ. Quince growers should thus familiarize themselves with these two stages of the insect. The other stages—the egg and pupa—are discussed later on in connection with the story of the life of the pest.

The beetle or curculio.—The pictures of the curculio, natural size and enlarged (side and back views) in figure 187, and still more enlarged in the frontispiece, will give one a very good idea of the general appearance of this stage of the insect. It is somewhat larger than the common plum curculio, has a comparatively longer snout, and is very "broad-shouldered."* For comparison, we have introduced, in figure 188, an enlarged picture of the plum curculio, the pest with which every successful plum, peach or cherry grower is usually already too familiar. Note the peculiar elevations or "humps" on the back of the plum curculio. There are no similar elevations on the quince curculio, whose wing covers are simply longitudinally ribbed with seven narrow ridges, with two rows of punctures in each space between these ridges. Its general color is of a rather uniform brownish gray, mottled more or less with white, especially on the thorax.

The peculiar long snout possessed by this quince curculio, in common with all the other members of the immense family of snout-beetles, is of peculiar construction, which well adapts it to the many uses to which the beetle puts it. This snout is simply a prolongation of the head, but it is interesting and peculiar from the fact that the mouth-parts of the insect are out at the snout's tip, and the antennæ also arise from near the tip. As can be seen in the frontispiece, the antennæ can be neatly folded back for half their length in a little groove along the snout; the snout of the female is a little longer and

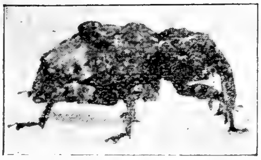
---

*LeConte and Horn state that this curculio is "broader and more squat than any other of our species, and it is easily distinguished by the humeri being obliquely truncate, with the outer angle dentiform."



187.—*The quince curculio, natural size and enlarged.*

190.—*The pupa of the quince curculio, enlarged.*



188.—*The plum curculio, enlarged.*

189.—*Grub of the quince curculio, enlarged and natural size.*

less deeply striated than in the male. This peculiar situation of the eating apparatus renders the snout a very useful instrument for the quince curculio, but at the same time increases its destructive power. These points are discussed in detail in our story of the life and habits of the pest.

The grub or larva.—This stage of the insect is well shown, natural size and much enlarged, in figure 189.

It is a fleshy, maggot-like, footless grub of a semi-transparent, light flesh color. Its head is dark brown, with the horny jaws darker, and there is a lighter brown, shield-like area on the back of the first thoracic segment. The main trachea running along each side of the body shows quite distinctly through the skin (see the figure), and the pulsations of the "heart" can also be seen along the back. The spiracles are light brown in color, and the body bears a few brownish hairs.

This grub can be readily distinguished from the caterpillar of the codling-moth which also infests the quince, as the latter always has distinct legs.

ITS NAME.

This quince pest belongs to the largest and most important of the families—the *Curculionidæ*, or popularly, *curculios* or *weevils*—of the *snout-beetles*, of which more than a thousand different kinds are already known to occur in North America. This great family of curculios includes several of our most destructive insects, such as the acorn and nut-weevils, the well-known plum curculio, the strawberry weevil, and that recent importation from Mexico, the cotton-boll weevil.

When Walsh discovered and described the snout-beetle under discussion in 1863, he gave to it the scientific name, *Conotrachelus cratægi*, by which it is still known.* The first or generic part of the name is said to signify "conical thorax or throat," and *cratægi*, the specific name, was suggested by the fact that the insect was first found "swarming" on the common thorn, *Cratægus*.

---

*The insect was given the specific name of *humeralis* in Europe in 1837, but as no description accompanied this name, it cannot take the place of Walsh's name proposed twenty-six years later; a Brazilian species of the same genus now bears the name of *humeralis*.

Its very suggestive and expressive popular name of "quince curculio" was given to it by Dr. Trimble in 1870.

THE STORY OF THE LIFE AND HABITS OF THE QUINCE CURCULIO.

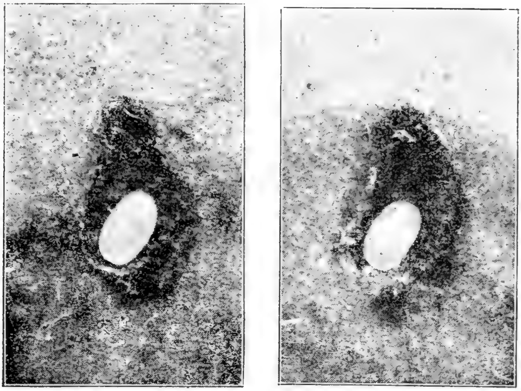
The quince curculio is so nearly related to the plum curculio* that one would naturally suppose that the stories of their lives would differ but little. However, careful observations have revealed some striking and important differences, thus again emphasizing the necessity for observations, rather than generalizations, upon the habits and lives of our insect enemies.

Its winter quarters.—It is in its grub stage (figure 189) that the quince curculio passes the winter. The long dreary months are spent by the grub in a little earthen cavity or cell two or three inches below the surface. After leaving the fruit in the fall, the grub burrows its way into the soil and there forms its winter home by rolling and twisting its body around and thus packing the earth back, leaving a small, oval, smooth-walled cell in which its winter nap is undisturbed by the elements above.

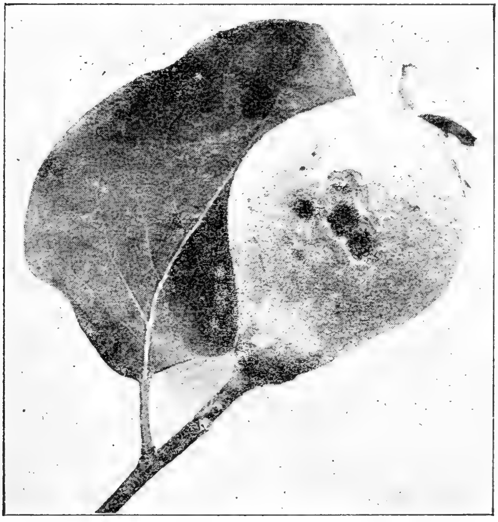
Its spring habits and transformations.—With the warmth of the spring-time, the grubs begin their destined transformations necessary to complete their life cycle. Wonderful changes take place beneath the grub's skin, which is finally cast off, and a form, quite unlike the grub; known as the *pupa*, appears. One of these yellowish-white, tender pupæ is shown, much enlarged, in figure 190. They are curious objects, with the developing legs, wings, snout and antennæ of the adult insect closely pressed against the body. From ten to twenty days are spent by this insect in the spring in this quiescent pupa stage in its earthen cell. Finally, the pupal shroud or skin is cast off, and the active adult or curculio appears. At first, the beetle is light colored and quite tender. On this account, it remains in the earthen cell for ten days or more, gradually acquiring its normal coloring and the maturity and hardness of body necessary to enable it to make its way through the soil to the surface, to meet there the various vicissitudes of its life.

---

*Both bear the same generic or "sirname" (*Conotrachelus*) and thus present only specific differences.



193.—*Sections through the egg-pits, showing the eggs in position; much enlarged.*



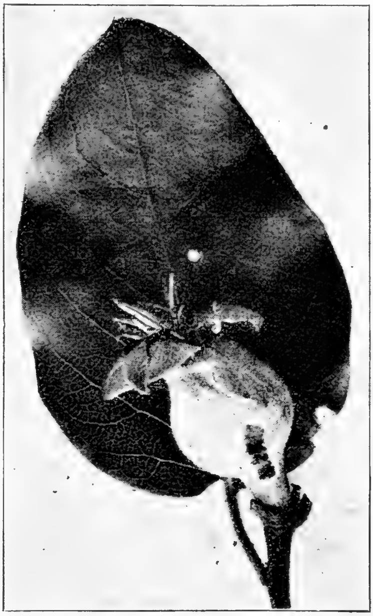
192.—*Young quince, showing the manner of feeding of the curculios.*

As some of the grubs go into the soil in August, and the beetles which develop from them may not appear above ground before the middle of the next July, a quince curculio may spend eleven months of its life in the soil in the orchard. However, some of the grubs do not leave the fruit until much later in the fall, and in some years the spring climatic conditions are such as to hasten the development of the insect, so that the beetles sometimes appear as early as the latter part of May; thus only about seven months of its life may be spent in the ground.

In all our experience in rearing and observing insects, we never before met with one whose habits were so remarkably affected as were the quince curculio's by what was apparently simple variations in the climatic conditions in early spring. In 1896, the beetles appeared in full force on the quince trees at Geneva, N. Y., during the last week in May, when the quinces had reached the stage shown in figure 191. In April, 1897, Mr. R. A. Barnes, of Lockport, N. Y., kindly furnished us with many of the grubs undisturbed in their winter homes. Some of these were kept on our office table, but most of them were placed in another part of the insectary where they would be subject to out-door or more natural conditions. Those in our office developed into the beetles about June 1, or practically on the schedule time of the preceding year in the orchards. But the grubs, kept under natural conditions, did not change to pupæ until the last week in June, and none of the curculios emerged in our cages until nearly a month later. Thinking that these results must be abnormal, due, perhaps, to some unknown and unnatural conditions in our cages, we at once wrote to Geneva and Lockport, asking that jarring experiments be made on a few trees to ascertain if the curculios were present in any numbers. Reports soon came from both places that the beetles were then out in full force; the quinces had then attained the size shown in figure 192. At Geneva, they began jarring the trees in the latter part of May, or at the same time they caught the curculios the previous year, but soon stopped, as practically none were found, and the jarring machines were laid aside with the belief that the pest would not need to be fought in 1897. It was very gratifying to have our breeding experiments thus verified in the field; and the fact that the information thus gained enabled some of our largest quince growers to destroy hundreds of the curculios, which would otherwise have undoubtedly ruined many bushels of quinces, is a good illustration of the value of such experiments.

The explanation of the appearance of the curculios during the last week in July in 1897, and about May 26, or two months earlier, in 1896, is undoubtedly to be found in the difference in climatic conditions of early spring in the two years. From the report of the New York State Weather Bureau, we learn that "periods of abnormal warmth obtained during April and May (1896), the maxima for the former month being among the highest recorded for April." The temperature conditions during a similar period in 1897 were nearly normal. Our breeding experiments with the grubs in a warm office and under normal out-door conditions, as detailed above, together with the known climatic conditions just mentioned, seem to afford conclusive evidence that the appearance of the curculios in the last week in May, in 1896, was unusual, and abnormal for the latitude of central New York. It is unfortunate that our observations on this point do not extend over more than these two years, for it leaves it still somewhat uncertain at what time in the spring the curculios usually appear in New York. It is very doubtful if they often appear as early as June 1, and we believe that the last week in July is unusually late; probably their normal time for appearance is about July 15, or possibly a little earlier in our state. Or the curculios probably do not appear on the trees until the quinces are somewhat larger than those shown in figure 191.

Habits of the curculios or beetles.—For a week or more after they emerge from the ground in the spring, the curculios feed upon the growing quince fruits, and possibly to a slight extent upon the leaves. The young fruits are covered with a thick fuzzy coating (in figure 191 a bit of this covering is loosened and turned back), but this offers little or no protection against the attacks of the beetles. While they seem to prefer to feed near the stem end of the fruit where the fuzzy coating is thinner, still they are often seen feeding at other points. In feeding, the curculio works its snout down through the fuzzy coating, eats a hole about the size of a common pin through the skin of the fruit, then proceeds to gouge out a pit or hole, often about the size of a half pea, in the flesh just beneath the skin; its curved snout, with the jaws at its end, is well adapted for this work. In figure 192, the skin has been removed to show several of these holes made by the curculios in feeding. Just to the left of these large holes, the fuzzy coating was scraped away to show two little holes eaten through the skin, which lead into similar large pits in the flesh. When we saw the beetles feeding, in May, 1896, the fuzzy covering was quite thick (figure 191), and when the beetle withdrew its snout the coating closed up, entirely obscuring the hole in the skin, so that it was impossible, in many cases, to determine if a fruit had been eaten, without first scraping off this fuzzy covering. Oftentimes the constricted portion of the fruit, near the stem, will be riddled with holes where the curculios have fed.



191.—*Young quince, with small flap of the thick fuzzy coating of the skin turned back.*

We have no positive evidence, but our observations indicate that the pits and hard kernels which are so familiar to quince growers in the "knotty" fruits, are the direct result of the feeding habits of the curculio. We believe the holes thus made in the skin and fruit when it is small finally result in the "knots" of the mature fruit. If this be true, the insect injures the market value of the fruits quite as much in its curculio or beetle stage as it does later as a grub.

Egg-laying.—After feeding on fruit for about a week, as described above, the beetles copulate and soon begin laying eggs. In 1896 the eggs must have been laid early in June, while in 1897 egg laying did not take place until early in August. The eggs are laid in little pits made by the mother beetles in the fruit. A small hole is first eaten through the skin, and then a pit about the size of a half pea is gouged out of the flesh. These pits thus made are indistinguishable from the ones made by the beetles in feeding, so that it is impossible to tell on the surface of a fruit whether the pin-holes through the skin lead into egg chambers or feeding pits. In figure 193 are shown sections through two egg chambers. It will be seen that the pits are considerably larger than the eggs, and are irregular in shape. After eating out the pit with her snout, the mother beetle doubtless simply turns around and deposits the egg through the hole in the skin, perhaps then pushing it down to the bottom of the pit with her snout. This completes the operation, there being no crescent cut made as in the case of its near relative, the plum curculio.

The quince curculio's egg is of a semi-transparent, whitish color, and of the form shown in figure 193. It measures .56 mm. in diameter, and is .9 mm. long. Under low magnifying powers, the shell of the egg appears smooth, but when greatly magnified, the whole surface is seen to be finely reticulated with ridges which outline small, four to six-sided areas. The egg seems to have a harder or thicker shell than that of the plum curculio, for it is certainly less easily crushed. This fact and the fact that the quince fruit grows comparatively slower than the plum may explain why the quince curculio finds it unnecessary to make any crescent cut to prevent its egg from being crushed by the growth of the fruit.

Evidently the egg-laying period of the beetles is of considerable duration. We examined the ovaries of one curculio soon after she had begun to lay her eggs, and found therein many eggs, as yet only partially developed. We were able to count nearly 30 eggs in all stages of development in the ovaries of the beetle examined. Thus, 30 is doubtless approximately the number of eggs which each curculio lays, and probably two weeks or more elapse before this full quota is laid.

In August, 1897, the eggs hatched in from seven to ten days, and the little grubs at once began eating their way into the fruit.

Habits of the grubs.—The grubs continue feeding in the fleshy part of the fruit for about a month, forming therein a large "worm-eaten" cavity, as shown in figure 194. They usually do not extend their operations into the core of the fruit, as does the codling-moth caterpillar. When full grown, the grubs eat their way to the surface of the fruit, forming the familiar "worm hole" leading into the blackish, disgusting-looking cavity in the flesh.

Usually most of the "wormy" fruits remain hanging on the tree, and it is often impossible to distinguish them until the grub makes its exit through the tell-tale "worm hole." If the fruit falls to the ground before the grub is full grown, it continues feeding in the fallen fruit until full-fed or the fruit rots. In one instance, it is reported that one-twentieth of the infested fruit dropped, the grubs continuing therein until the fruit decayed. As many as six of these grubs have been found infesting a single quince.

The grubs doubtless drop to the ground upon leaving the fruit which remains on the tree, and they soon burrow into the soil for a distance of from one to three inches; those grubs which mature in the

194.—*A "wormy" quince cut open.*

fallen fruit, also leave it and enter the soil. During normal seasons, some of the grubs doubtless leave the fruit in August; but often many of them are still in the fruit when it is picked, and, upon emerging, find themselves in the packing-case or barrel. In 1897, some of them were still in the fruit on the trees on October 4. Thus, the grubs may be found in the fruits at any time after July, and sometimes even in June. However, there is but one brood of the grubs in a season or year; for it matters not if some of them get full grown and enter the soil early in August, because these, as well as those which do not leave the fruit until October, all remain unchanged in the soil throughout the winter in a little earthen cell, as described in discussing its winter quarters.

NATURAL ENEMIES.

We have found no record of any natural enemy attacking this quince curculio in any of its stages. However, such an enemy is at work upon the curculios in New York. Among the grubs sent us in April, 1897, was one which behaved unnaturally, not burrowing back into the soil when disturbed as did the others. A few days later, the cause of this was revealed, when, in the place of the grub, we found a neat little cocoon lying beside the head and skin of the grub. This was on April 26, and eighteen days later, there emerged from this cocoon a pretty little hymenopterous fly, which bears the scientific name of *Sigalphus canadensis.* This little friend occurs in widely separated portions of America, and has been bred from other curculios or weevils. In Iowa, where it is parasitic upon the plum gouger, it is thought that the little fly sticks its egg through the flesh of the plum into the cavity where the grub is at work, and the grub succumbs before it leaves the fruit. We have no data as to how the parasitism is accomplished in the case of the quince curculio in New York; evidently, however, the grub sometimes gets into the ground before succumbing. Probably, at present, this parasite exercises but little influence in controlling the numbers of the curculio in New York.

HOW TO COMBAT THE QUINCE CURCULIO.

It will require much intelligent and well-directed effort on the part of the quince-grower to circumvent this curculio, but it can be done, as some of our fruit-growers are demonstrating. While we have conducted no experiments against the insect personally, we have had the direction of the warfare in some of the larger quince orchards, and have been fortunate in having the experience of successful growers placed at our disposal.

The fact that the eggs are laid in pits in the flesh beneath the skin of the fruit (figure 193) renders it practically impossible to reach the insect in this stage with any insecticide, or by any other practicable method. Also, when the eggs hatch, the young grubs are inside the fruit, practically as fully out of the reach of insecticidal measures as are the eggs. The only chance to reach any of the grubs while in the fruit is to gather up and destroy at once the comparatively small proportion of the infested fruits which fall to the ground before the grubs leave them. It is often very difficult to determine, without mutilating it, if a quince is infested while it still remains on the tree, so that the picking off and destroying infested fruit is not practicable. After the grub leaves the fruit, making its familiar "worm-hole" exit, infested fruit is easily distinguished, but then "the bird has flown."

Cultivation of the soil.—The fact that the grubs leave the fruits, enter the ground a short distance, and there remain for many months, has led several writers to recommend that a thorough cultivation of the soil, either in the fall or spring, would disturb and destroy many of the grubs. Theoretically, this should prove an effective remedial measure. But the experience of some of our largest and most successful quince growers who have cultivated their orchards thoroughly, both in the fall and spring, for several years, proves quite conclusively that cultivation has but little, if any, effect in reducing the numbers of the curculio.

We were unable to understand the reason for this until we saw the grubs do a very simple thing in our breeding cages here at the insectary in April, 1897. Mr. R. A. Barnes, of Lockport, N. Y., had kindly sent us a lot of soil, from his quince orchard, in which there were many of the grubs undisturbed in their earthen cells, made the fall before. We broke into these winter cells or homes and removed the apparently inactive or dormant grubs, and placed them on the surface of some other soil in our cages, intending to cover them with soil later. What was our surprise a few minutes later to discover that the grubs had waked up from their winter's nap and had disappeared. Investigation later showed that they had burrowed into the soil and formed another earthen cell, just as they had done the previous fall. Hence our thorough breaking up of the soil, resulting in their being subjected to practically similar, or even more adverse conditions than would result from cultivation, had not even discouraged the grubs. We disturbed, in a similar manner, some of the grubs several times, and always with the same result, that they quickly burrowed into the soil again. We believe, therefore, that the non-success of cultivation either in the fall or spring, as demonstrated in practice in several badly infested orchards, is due principally to the fact that the grubs simply burrow back into the soil, however often they may be disturbed. In 1897, one large infested quince orchard was plowed in January to a depth of three or four inches; the ground was bare and it froze very soon after plowing. During the latter part of March and early in April, this orchard was thoroughly cultivated, and the cultivation continued later in the season. Yet, in spite of this, hundreds of the quince curculios were captured on the trees in August. This cultivation cannot be depended upon to check this pest, while in its grub stage in the soil, either in the fall or spring.

Theoretically, however, thorough and rather deep cultivation at the time the insect is passing through its tender pupa stage in the soil, should destroy many of these pupæ. Probably, during normal seasons, the pupa stage is passed in the latter half of June or early in July. We have no definite data as to the effect of deep, thorough cultivation at this time or at this critical period in the life of the pest, except the general statement of quince growers, who are considered good cultivators of their orchards, that they can see no effect from it upon the numbers of the insect.

Spraying.—Until within a few years, nearly everyone who has made any serious attempt to control this pest, has used a poison spray for this purpose. As a perusal of our story of its life will show, the only stage of the pest that could be reached by a poison, is the curculio or beetle; the grub is inside the fruit, out of harm's way, from the moment it hatches from the egg. The only chance to poison the beetles is during the week or more which they spend in feeding on the fruit, previous to and during the period of egg-laying. Although the beetles are quite ravenous eaters, their method of feeding, as described on page 382 and illustrated in figure 192, will at once show how little chance there is to poison them. Most of their food they get from beneath the skin in the flesh, only eating a minute hole through the skin.

Theoretically, then, the chances for poisoning the quince curculio are small. Fortunately for the theory, it is the universal testimony of quince growers who have thoroughly tested the arsenical sprays, London purple and Paris green, against this pest, that they have been able to see little or no benefit from spraying. One large grower after faithfully spraying with poison for several years without success, became so discouraged as to seriously consider uprooting his trees.

Applications to the soil.—We doubt if the application of any substance to the soil, in practicable quantities, would destroy enough grubs to pay for the trouble of applying it.

Hogs in the orchard.—In one quince orchard, Mr. R. A. Barnes, of Lockport, N. Y., "allowed hogs to run from early in the spring until just before time to gather the fruit, when, because they would reach up and pick the fruit, they were excluded for a time;" small grain was from time to time scattered on the ground to induce more thorough "rooting" by the hogs. From this orchard he gathered his finest fruit. Either the orchard was not badly infested by the insect, or else the hogs found most of the grubs in the spring before they transformed into the beetles.

Jarring method.—Like the plum curculio, this quince curculio quickly drops to the ground when the tree is *jarred*, not *shaken*. This habit of the insect seems to be its most vulnerable point; and it is undoubtedly the point against which the most successful attacks can, with our present knowledge, be made by quince growers. The process of jarring is very simple and is too familiar to need description here. Nearly every fruit-grower who practices it has his favorite padded "jarring-pole" and there are several kinds of receptacles in use for catching the curculios when they drop. These "curculio-catchers" vary in design from a simple sheet of cloth stretched on a wooden frame (to be held by the operator with the aid of straps over the shoulders or to be simply laid on the ground) to elaborate wheelbarrow-like machines carrying a canvas arranged like an inverted umbrella, as shown in figure 195.

It is a much more difficult matter to jar quince trees than it is plum trees, on account of their great difference in habit of growth. The main branches of the quince often start from very near the ground, thus making the trees so low that it would be impossible to work one of the ordinary "wheelbarrow catchers" under them. This compels one to use simple sheets or do as one large grower did, prune up the trees and have a cart built especially low. Figure 195 is from a photograph taken in this orchard and shows this low form of "curculio-catcher" built to order for fighting this pest. It was this orchard which the owners thought seriously of uprooting (as mentioned above under spraying) on account of this curculio, but thorough work with these jarring machines for a few years has made it a very profitable

195.—*Jarring for the quince curculio with a low "curculio-catcher" designed especially for the work.*

orchard again; the pest has not been exterminated, and it is still necessary to keep an eye on the insect. Thus, with our present knowledge of its life and habits, the jarring process is the most successful method for fighting the quince curculio yet suggested and tested.

Some of the curculios are to be found on the trees at any time during the day or night. It is said to be more active at night and rather secretive during the day, perhaps sometimes hiding in the crevices of the bark or in grass or soil at the base of the tree. We have made no observations upon this point. Those who practice the jarring method begin the work early in the morning and continue it all day, if necessary.

The more important question, as to just when to begin jarring for this pest, we are unfortunately unable to set any definite date. In 1896, the beetles were out in force in the last week of May when the quinces were of the size shown in figure 191, while in 1897, they did not appear until the last week in July, when the fruits were as large as the one shown in figure 192. We have offered an explanation for this remarkable difference of two months in the date of appearance, in our discussion of the life-story of the pest. In 1897, one large grower began jarring in the latter part of May expecting to capture the curculios as he had done at this time the year before, but finding no insects, he put away his machines, thinking there would be none to trouble his fruit. We notified him when the beetles began to emerge in our cages in the latter part of July, and he got out his machines again and found the enemy this time.

We believe, however, that 1896 was quite an abnormal year, and that the curculios will not often appear so early as the last week in May. On the other hand, we suspect that the last week in July is uncommonly late for their appearance. In the latitude of St. Louis, the curculios appear about June 1, and we believe that they normally appear in New York State about July 15, perhaps a little earlier. However, this is not a matter for the quince-grower to guess at, and there are two ways open for him to find out about when to look for the beetles. It will be a simple matter to spade up some soil in the orchard in April, examine it carefully to make sure it contains some of the grubs in their earthen cells, and then put the soil in a box or can of some sort whose top can be covered with netting.

Keep the soil moist, and await developments. In short, start an experiment in breeding the insect. Nothing will interest your children more than a simple experiment of this kind. When you find that the beetles have emerged from the soil in your cage, then get out the jarring machines.

A second method of determining when the beetles are at work is to begin in the latter part of May and jar a few trees every day. It will be an easy matter to discover just when to turn loose the rest of your batteries upon the enemy.

Those who practice the jarring method successfully, jar the trees every day, if possible, from the time the beetles appear until their numbers decrease beyond the danger point, or only a few are captured each time. In one orchard in 1897, 200 curculios were jarred from seven trees, and it was not an uncommon thing to get nearly 50 beetles from a single tree at one jarring when they were the most numerous. Usually it will not be necessary to jar the trees for more than six or eight weeks, often less.

This jarring process involves considerable labor and expense, but experienced fruit growers tell us it costs only from 15 to 20 cents to jar a tree during the season. One should consider that this slight expenditure may often favorably decide the important question of a large crop of fine fruit, or a meagre crop of "knotty" and "wormy" fruit. Fruit growers and others who have insect foes to fight do not often think of this phase of the question when considering the expense which a certain method may involve.

After you capture the curculios with your jarring device, then exercise your own ingenuity in killing them. Some put them in kerosene or boiling water, while others have a charcoal stove built for the purpose, in which everything that falls onto the sheet is burned.

MARK VERNON SLINGERLAND.

BIBLIOGRAPHY.

1837. Dejean. Catalogue des Coleopteres de la coll. de M. Dejean, p. 321. Lists the insect as *C. humeralis*, from boreal America.

1863. Walsh. Prairie Farmer, Vol. XII., p. 37. Original description of the beetle.

1864. Walsh. Proc. Boston.Soc. of Nat. Hist., Vol. IX., p. 311. Above reference republished.

1867. Walsh. Practical Entomologist, Vol. II., 81, brief reference; p. 120, reported by correspondent on peach.

1870. Trimble. Address before New York Farmers' Club, Oct. 22d. Report of its having done much damage to quinces and pears in New Jersey, Pennsylvania and western New York. Gave it the popular name of "quince curculio."

1871. Riley. Third Missouri Rept. on Insects, pp. 35-39, with figures. The first and best account of its habits and life-history, to which later writers have added but little.

1873. Riley. Ill. Jour. Agr., No. 161, pp. 109-110. Habits, history and treatment.

1876. LeConte and Horn. Rhynchophora of America (Proc. Am. Phil. Soc., Vol. XV.), p. 230. Detailed description.

1877. Thomas. First Rept. on Insects of Ill., pp. 141-142. Brief discussion.

1881. Lintner. Country Gentleman, Vol. XLVI., page 535. Good account in answer to correspondent from S. Byron, N. Y. Republished in Second Report on Insects of New York (1885), p. 11-12.

1881. Harrington. Rept. Ont. Ent. Soc., for 1880, p. 56. Mention, with figure.

1883. Cooke. Injurious Insects, p. 124-125. Compiled account. Records finding two specimens in California in 1882.

1883. Saunders. Insects Injurious to Fruits, p. 226. Compilation from Riley's accounts. Same account in 1892 edition.

1884. Lintner. Country Gentleman, Vol. XLIX., p. 897. Probable occurrence of insect in Virginia quinces. Republished in Fourth Rept. on Insects of New York (1888), p. 87.

1884. Devereaux. Canadian Entomologist, Vol. XVI., p. 29. Brief mention.

1887. Doran. Bienn. Rept. Com. Agr. Tenn., p. 224. Brief account.

1888. Lintner. Fourth Rept. on Insects of New York, pp. 15, 208. Report of formidable attack in a Geneva, N. Y., orchard.

1888. Meach. Quince culture, p. 131-132, Brief compilation.

1889. Hamilton. Canadian Entomologist, Vol. XXI., p. 34. Mention as "the great haw worm."

1890. Packard. Fifth Rept. U. S. Ent. Com., p. 535. Quotes Walsh's description of beetle.

1890. Smith. Cat. of Insects of New Jersey, p. 257. Recorded as common in some parts and rare in others.

1892. Riley. Insect Life, Vol. IV., p. 393. Reports that typical specimens of the beetle are in his collection and in that of Le Conte at Cambridge, Mass.

1893. Smith. An. Rept. N. J., Exp. Station for 1895, p. 394. Brief mention of local damage in 1892.

1893. Devereaux. Proc. W. N. Y. Hort. Soc., p. 97. Brief mention as rarely feeding on anything but haws.

1894. Bailey. Bull. 80, Cornell Expt. Station, p. 629. Brief account, with treatment.

1895. Lintner. Tenth Rept. on Insects of New York, pp. 419, 511. Brief account; arsenical spraying of little avail.

1895. Beach. Bull. 86, N. Y. State Exp. Station, p. 92. Brief account with remedies. The same account appears in An. Rept. of the Station for 1895, p. 368.

1896. Smith. Economic Entomology, p. 234. Brief mention.

1896. Slingerland. Rural New-Yorker. Dec. 12, 1896, p. 816. Discussion of its life-history, habits and treatment.

1897. Slingerland. Proc. W. N. Y. Hort. Soc., p. 130. Brief discussion on habits and remedies.

1898. Slingerland. Proc. W. N. Y. Hort. Soc., p. 22-23. Report of original observations on habits and life-history in 1897.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report Upon Japanese Plums 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale, 18 pp.
145 Some Important Pear Diseases, 36 pp.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums, 36 pp.
148 Quince Curculio, 26 pp.

Bulletin 149. **June, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

CHEMICAL DIVISION.

SOME SPRAYING MIXTURES

A PRELIMINARY REPORT ON THEIR CHEMICAL COMPOSITION.

By GEO. W. CAVANAUGH.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

THE AGRICULTURAL COLLEGE AND STATION COUNCIL.

JACOB GOULD SCHURMAN	President of the University.
FRANKLIN C. CORNELL	Trustee of the University.
ISAAC P. ROBERTS, Dean of the College and Director of the Experiment Station.	
EMMONS L. WILLIAMS	Treasurer of the University.
LIBERTY H. BAILEY	Professor of Horticulture.
JOHN H. COMSTOCK	Professor of Entomology.

STATION AND UNIVERSITY EXTENSION STAFF.

I. P. ROBERTS	Agriculture.
G. C. CALDWELL	Chemistry.
JAMES LAW	Veterinary Science.
J. H. COMSTOCK	Entomology.
L. H. BAILEY	Horticulture.
H. H. WING	Dairy Husbandry.
G. F. ATKINSON	Botany.
M. V. SLINGERLAND	Entomology.
G. W. CAVANAUGH	Chemistry.
L. A. CLINTON	Agriculture.
B. M. DUGGAR	Botany.
J. W. SPENCER	Extension Work.
J. L. STONE	Sugar Beet Investigation.
MISS M. F. ROGERS	Nature Study.
A. L. KNISELY	Chemistry.
C. E. HUNN	Gardening.
W. W. HALL	Dairy Husbandry.
H. P. GOULD	Horticulture.
W. MILLER	Floriculture.
G. N. LAUMAN	Horticulture.
A. R. WARD	Dairy Bacteriology.
L. ANDERSON	Dairy Husbandry.

OFFICERS OF THE STATION.

I. P. ROBERTS	Director.
E. L. WILLIAMS	Treasurer.
E. A. BUTLER	Clerk.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

SOME SPRAYING MIXTURES.

Since spraying has taken its place as a part of the routine work connected with the fruit farm, much attention has been given to the substances used for spraying. The results of many trials with various materials have been published in the bulletins from the different stations, and now special spray calendars are issued by some stations. Bulletin 114 of this Station is a spray calendar.

Among the standard remedies for chewing insects are Paris green, London purple and hellebore, while the Bordeaux mixture, ammoniacal copper carbonate, liver of sulphur, etc., are recommended for fungous diseases, blights and mildews.

Paris green is composed of copper, acetic acid and arsenous oxide, and when pure should contain at least 50 per cent. of arsenous oxide. Arsenous oxide is the chemical name for white arsenic.

Five samples of Paris green recently examined at this laboratory contained:

I =	54.63	per cent. arsenic.
II =	54.47	" "
III =	54.32	" "
IV =	55.32	" "
V =	54.90	" "

London purple is a waste product in the manufacture of some dye stuffs and consists chiefly of arsenic lime and the dye. Paris purple and English purple are quite similar in character to London purple.

A sample of English purple gave on analysis:

Arsenic (As_2O_3)	36.75 per cent.
" " soluble in water	5.36 per cent.

Paris Purple.	Total.	Soluble in water.
No. I. Arsenic (As_2O_3)	47.05	11.86
No. II. " "	34.10	13.88

The arsenic is here combined with lime. When any of the purples are used as insecticides, two or three times their weight of quick lime should be used to counteract the effect of the arsenic soluble in water.

During the past few years various substitutes for the arsenical poisons have been on the market. In 1888, the Vermont Station published the analysis of slug shot.

Arsenic (As_2O_3)	1.58 per cent.
Copper oxide	.60 per cent.

A sample recently examined at this Station contained:

Arsenic (As_2O_3)	.60 per cent.
Copper	1.15 per cent.

The Massachusetts State Station in 1893 examined several insecticides, and, among others, found the Oriental Fertilizer and Bug Destroyer to contain 2.38 per cent. arsenic.

During the present season, a number of inquiries have been received at this Station concerning insecticides and fungicides. As it is too soon to give results of actual trials, only the chemical composition of the substances can be given, which the reader may compare with the older insecticides and fungicides.

LAUREL GREEN.

A new preparation under the name of Laurel Green, is on the market, and is offered for sale as a substitute for Paris green. It also claims virtue as a fungicide. A chemical analysis shows it to contain arsenic, copper and lime and sulphuric and carbonic acids. These same substances would be found in a mixture of Paris green and Bordeaux mixture after drying. The copper and arsenic were determined.

Copper (Cu)	10.00 per cent.
Arsenic (As_2O_3)	7.75 per cent.

BUG DEATH.

While it may be possible to combine both insecticidal and fungicidal properties in the same compound, there may be some doubt about the economy of depending on such preparations to act as fertilizers also. Nevertheless, in the advertising matter accompanying a sample of Bug Death, the following statement is made:

"I will undertake to guarantee it, as not only is it a fungicide and insecticide, but, as well, it acts as a fertilizer. It is sure death to all the tribe of bugs from A to Z, and it will prevent potato blight, tomato rot, melon disease and strawberry-leaf blight—all of which diseases are formidable in the Northern and Eastern states. Bug Death is a tenacious powder, and wherever it takes hold it serves its purpose."

W. H. MORSE, M.D., F.S.S.,
Consulting Chemist.

WESTFIELD, N. J., April 25, 1898.

It contains neither arsenic nor copper, and what its value rests upon it is difficult to see, for it consists principally of zinc, lead and iron oxides, in the following proportions:

Zinc oxide	76.5 per cent.
Lead oxide	9.8 per cent.
Iron oxide	7.8 per cent.

The remainder consisted of silica, chlorine, potash and a trace of phosphoric acid. While it may prove useful in combating some pests, there is not, I believe, any record of the use of oxides of iron, zinc or lead as successful insecticides.

The consulting chemist above mentioned claims fertilizing value for Bug Death.

A fertilizer analysis gave the following results:

Nitrogen	.00 per cent.
Phosphoric acid	.08 per cent.
Potash	2.00 per cent.

The average of analyses of five samples of soil of ordinary productivity was found to be:

Nitrogen	.21 per cent.
Phosphoric acid	.16 per cent.
Potash	1.63 per cent.

Inasmuch as Paris green must now contain 50 per cent. of arsenic when warranted to be pure, other arsenical compounds whose insecticidal value depends on the arsenic should be sold on a comparative basis. When users of spraying mixtures demand that the goods bought be of a certain quality, the supply will be forthcoming, as it was in the case of commercial fertilizers.

GEO. W. CAVANAUGH.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in New York, 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western New York, 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western New York, 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in New York, 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western New York, 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report Upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant - Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar-Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

APPENDIX II.

Detailed Statement of Receipts and Expenditures of the Cornell University Agricultural Experiment Station, for the fiscal year ending June 30, 1898.

RECEIPTS.

FROM AGRICULTURAL DIVISION.

1898.			
June 30.	Products sold (Farm)	$118 29	
" 30.	Testing herds	16 00	
			$134 29

FROM HORTICULTURAL DIVISION.

1898.			
June 30.	Hauling coal	53 63	
" 30.	Products sold	54 95	
			108 58
	Total for receipts		242 87

EXPENDITURES.

FOR SALARIES.

1897.			
July	31.	I. P. Roberts, Director	$125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman, ½ mo	52 08
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Agriculturist	100 00
"	31.	G. W. Cavanaugh, Chemist	83 33
"	31.	E. A. Butler, Clerk	50 00
Aug.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman, ½ mo	52 08
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Agriculturist	100 00
		Amount carried forward,	$1,104 15

		Amount brought forward,	$1,104 15
Aug.	31.	G. W. Cavanaugh, Chemist	83 33
Sept.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman, ½ mo	52 08
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Agriculturist	100 00
"	30.	G. W. Cavanaugh, Chemist	83 33
Oct.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	83 34
"	30.	M. V. Slingerland, Assistant Entomologist	125 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Agriculturist	100 00
"	30.	G. W. Cavanaugh, Chemist	83 33
Nov.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	62 50
"	30.	M. V. Slingerland, Assistant Entomologist	125 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Agriculturist	100 00
"	30.	G. W. Cavanaugh, Chemist	83 33
"	30.	E. A. Butler, Clerk	50 00
Dec.	24.	I. P. Roberts, Director	125 00
"	24.	L. H. Bailey, Horticulturist	125 00
"	24.	H. H. Wing, Dairyman	62 50
"	24.	M. V. Slingerland, Assistant Entomologist	125 00
"	24.	G. F. Atkinson, Botanist	83 33
"	24.	L. A. Clinton, Agriculturist	100 00
"	24.	G. W. Cavanaugh, Chemist	83 33
1898.			
Jan.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	M. V. Slingerland, Assistant Entomologist	125 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Agriculturist	100 00
"	31.	G. W. Cavanaugh, Chemist	83 33
Feb.	28.	I. P. Roberts, Director	125 00
"	28.	L. H. Bailey, Horticulturist	125 00
"	28.	H. H. Wing, Dairyman	125 00
"	28.	M. V. Slingerland, Assistant Entomologist	125 00
"	28.	G. F. Atkinson, Botanist	83 33
"	28.	L. A. Clinton, Agriculturist	100 00
		Amount carried forward.	$5,389 53

		Amount brought forward,	$5,389 53
Feb.	28.	G. W. Cavanaugh, Chemist	83 33
"	28.	E. A. Butler, Clerk	50 00
Mar.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	M. V. Slingerland, Assistant Entomologist, ½ mo.	62 50
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Agriculturist	100 00
"	31.	G. W. Cavanaugh, Chemist	83 33
"	31.	E. A Butler, Clerk	50 00
Apr.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Agriculturist	100 00
"	30.	G. W. Cavanaugh, Chemist	83 33
May	28.	I. P. Roberts, Director	125 00
"	28.	L. H. Bailey, Horticulturist	125 00
"	28.	H. H. Wing, Dairyman	125 00
"	28.	G. F. Atkinson, Botanist	83 33
"	28.	L. A. Clinton, Agriculturist	100 00
"	28.	G. W. Cavanaugh, Chemist	83 33
		Total for Salaries	$7,560 34

FOR PRINTING.

1897.			
Sept.	25.	L. V. R. R. Co., Freight and Cartage	$1 43
"	28.	Campus Delivery, Cartage	25
"	30.	W. F. Humphrey, Printing 150 copies Annual Report	100 61
Oct.	3.	L. V. R. R. Co., Freight and Cartage	88
"	14.	J. Horace McFarland Co., 8 Half-tones	33 00
"	15.	W. F. Humphrey, Printing 20 M copies Bulletin No. 138	326 25
"	15.	Franklin Engraving & Printing Co., Making Cuts	75 67
"	19.	Campus Delivery, Cartage	1 50
"	20.	L. V. R. R. Co., Freight and Cartage	6 40
"	25.	New York Engraving & Printing Co., 2 Electros	2 00
"	30.	G. W. Tailby, Labor	6 08
"	30.	C. B. Tailby, Labor	5 08
Nov.	3.	U. S. Express Co., Expressage	75
"	8.	Franklin Engraving Co., 6 Half-tones	17 31
"	15.	L. V. R. R. Co., Freight and Cartage	2 12
		Amount carried forward,	$579 33

		Amount brought forward,	$579 33
Nov.	16.	W. F. Humphrey, Printing 20 M copies Bulletin No. 139	161 40
"	17.	W. F. Humphrey, Making Electrotypes	43 00
"	23.	U. S. Express Co., Expressage	30
"	24.	Lovejoy Co., 1 Half-tone	3 00
Dec.	6.	U. S. Express Co., Expressage	25
"	7.	L. V. R. R Co., Freight and Cartage	1 43
"	13.	L. V. R. R. Co., Freight and Cartage	4 69
"	13.	Cornell Engraving Co., 2 Electros	5 06
"	13.	W. F. Humphrey, 500 copies Bulletin No. 141	3 50
"	13.	W. F. Humphrey, 20 M copies Bulletins 140 and 141	362 80
"	14.	Wm. C. Baker, Making Drawings	6 00
1898.			
Jan.	3.	Andrus & Church, Wrapping Paper	2 85
"	12.	M. A. Adsitt, Mimeograph Paper	1 75
Feb.	1.	L. V. R. R. Co., Freight and Cartage	9 87
"	8.	W. F. Humphrey, Printing 15 M copies Bulletin No. 142	645 52
"	8.	W. F. Humphrey, Making Electrotypes	41 00
"	9.	L. V. R. R. Co., Freight and Cartage	7 58
"	15.	Andrus & Church, Wrapping Twine	2 16
Mar.	1.	Lovejoy Co., 1 Cut	1 58
"	15.	L. V. R. R. Co., Freight and Cartage	3 45
"	28.	W. F. Humphrey, Printing 20 M copies Bulletin No. 144	209 00
"	25.	Andrus & Church, 500 Postals and Printing	6 00
June	14.	W. F. Humphrey, 500 copies Bulletin No. 104, Reprint	16 80
		Total for Printing	$2,118 32

FOR OFFICE EXPENSES.

1897.			
July	6.	L. V. R. R. Co., Freight and Cartage	$4 44
"	7.	Western Union Telegraph Co., Message	25
"	10.	Andrus & Church, Stationery	8 75
"	20.	I. P. Roberts, Traveling Expenses	104 05
"	21.	U. S. Express Co., Expressage	35
"	13.	Andrus & Church, Envelopes	92 40
"	26.	L. A. Clinton, Three Reports	3 00
"	31.	L. V. Maloney, Salary	45 00
"	27.	M. A. Adsitt, Carbon Paper	50
"	27.	M. A. Adsitt, Letter Book and Erasers	3 00
"	27.	M. A. Adsitt, Repairs on Typewriter	80
"	31.	C. B. Tailby, Labor	2 24
"	31.	G. W. Tailby, Labor	3 20
		Amount carried forward,	$267 98

		Amount brought forward,	$267 98
Aug.	4.	J. W. Gilmore, Labor	8 70
"	7.	L. V. R. R. Co., Freight and Cartage	1 57
"	7.	Andrus & Church, Day Book	1 80
"	7.	Andrus & Church, Envelopes	1 50
"	7.	M. A. Adsitt, Repairs on Typewriter	4 22
"	7.	Andrus & Church, Day Book made to Order	4 25
"	7.	Andrus & Church, McGill Fasteners	40
"	7.	Andrus & Church, Ink and Blotters	15
"	7.	C. H. Howes, Photo Plates	1 65
"	7.	M Adsitt, Stationery	1 40
"	7.	Andrus & Church, Stationery	10
"	7.	E. McGillivray, Photo Supplies	9 55
"	16.	Andrus & Church, Stationery	60
"	24.	Rothschild Bros., Shading	1 50
"	28.	Campus Delivery, Cartage	25
"	31.	L. V. Maloney, Salary	45 00
Sept.	1.	J. W. Gilmore, Labor	6 30
"	15.	G. P. Rowell & Co., 1 Directory	5 00
"	15.	U. S. P. O., Postage	25 00
"	18.	Andrus & Church, Stationery	3 35
"	24.	Andrus & Church, Blotters	10
"	27.	U. S. Express Co., Expressage	25
"	30.	L. V. Maloney, Salary	43 33
Oct.	1.	J. W. Gilmore, Labor	13 20
"	4.	C. J. Rumsey & Co., Twine	15
"	4.	U. S. Express Co., Expressage	25
"	4.	U. S. Express Co., Expressage	35
"	6.	M. A. Adsitt, Typewriter Oil	20
"	11.	Campus Delivery, Cartage	25
"	14.	J. H. Comstock Pub. Co., Manual of Insects	3 75
"	14.	Andrus & Church, Postal Cards and Printing	5 75
"	14.	Charles Scribner's Sons, Text Book of Physiology	4 50
"	14.	Andrus & Church, Printing	1 25
"	14.	Garden & Forest Pub. Co., Papers	20
"	14.	Dodd, Mead & Co., Johnson's Encyclopædia, 8 Vols.	40 00
"	19.	Mendota Book Co., 1 Book on Milk Testing	1 00
"	20.	U. S. P. O., Postage	10 00
"	26.	I. P. Roberts, Traveling Expenses	6 62
"	28.	M. A. Adsitt, Mimeograph and Silk Paper	2 65
"	28.	I. P. Roberts, Traveling Expenses	13 70
"	30.	L. V. Maloney, Salary	45 00
"	30.	J. W. Gilmore, Labor	15 60
Nov.	3.	U. S. P. O., Postage	10 00
		Amount carried forward,	$608 37

		Amount brought forward,	$608 37
Nov.	8.	Ithaca Gas Co., Gas	48
"	8.	Bool Co., Furniture	10 77
"	8.	Orange Judd Pub. Co., Myrick's Sugar Beet	38
"	8.	Ithaca Stamp Works, 2 Stamps	1 85
"	18.	Cornell University Dept. of Repairs, Repairs	1 89
"	18.	U. S. P. O., Postage	10 00
"	29.	U. S. P. O., Postage (Stamped Envelopes)	10 80
"	30.	L. V. Maloney, Salary	43 33
"	30.	C. B. Tailby, Labor	4 06
Dec.	1.	J. W. Gilmore, Labor	9 30
"	2.	Andrus & Church, Letter Heads	5 88
"	4.	Bool Co., Repairs on Desk	1 25
"	4.	M. A. Adsitt, Mimeograph and Carbon Paper	2 25
"	6.	U. S. Express Co., Expressage	30
"	7.	I. P. Roberts, Traveling Expenses	9 25
"	7.	Ithaca Stamp Works, Ink	1 25
"	9.	Ithaca Gas Co., Gas	32
"	9.	W. O. Wyckoff, Mimeograph Ink	1 20
"	13.	I. P. Roberts, Traveling Expenses	1 30
"	23.	B. F. White, Photos	27 25
"	27.	Cornell Co-operative Society, Stationery, etc.	8 53
"	27.	L. V. Maloney, Salary	45 00
"	31.	J. W. Gilmore, Labor	14 40
1898.			
Jan.	3.	U. S. P. O., Postage	10 00
"	12.	Andrus & Church, Pamphlet Cases	4 50
"	24.	U. S. P. O., Postage	10 00
"	31.	L. V. Maloney, Salary	45 00
Feb.	5.	Andrus & Church, Letter Heads	2 75
"	5.	A. A. A. C. & E. S., Membership Fee	10 00
"	5.	J. W. Gilmore, Labor	10 05
"	8.	Ithaca Gas Co., Gas	1 28
"	28.	L. V Maloney, Salary	40 00
Mar.	1.	J. W. Gilmore, Labor	11 47
"	5.	U. S. Express Co., Expressage	25
"	9.	Andrus & Church, Stationery, etc.	1 90
"	9.	Ithaca Gas Co., Gas	32
"	9.	Cornell Co-operative Society, Stationery, etc.	4 20
"	9.	M. A. Adsitt, Typewriter Oil	20
"	22.	U. S. Express Co., Expressage	55
"	24.	U. S. Express Co., Expressage	25
"	25.	U. S. P. O., Postage	10 00
"	26.	Mrs. Hunter, Labor, Cleaning Office	2 00
		Amount carried forward,	$984 13

		Amount brought forward,	$984 13
Mar.	28.	White & Burdick, Floor Oil	50
"	28.	L. V. Maloney, Salary	45 00
April	25.	Andrus & Church, Stationery	12
"	30.	L. V. Maloney, Salary	43 33
"	30.	U. S. P. O., Postage	10 00
May	3.	J. E. Higgins, Labor	10 42
"	31.	J. E. Higgins, Labor	7 09
June	14.	Ithaca Gas Co., Gas	16
"	30.	U. S. P. O., Postage	3 90
		Total for Office Expenses	$1,104 65

FOR AGRICULTURAL DIVISION.

1897.			
July	6.	E. G. Hance, Cartage	$0 25
"	8.	Leroy Anderson, Salary	18 00
"	10.	George Small, Water-lime	50
"	20.	J. B. Lang, Labor and Repairs	35
"	22.	L. F. Noxon, Seeds and Plants	6 60
"	22.	P. M. Sharples, Repairs	10 17
"	22.	Charles Scribner's Sons, Publications	3 58
"	30.	C. B. Tailby, Labor	11 41
"	30.	G. W. Tailby, Labor	18 40
"	30.	E. R. Ewell, Labor	38 42
"	30.	J. W. Gilmore, Labor	21 00
"	30.	L. S. Harrington, Labor	4 50
"	31.	Leroy Anderson, Salary	25 00
Aug.	7.	Platt Drug Co., Drugs	1 49
"	7.	American Clydesdale Assn., Publications	4 00
"	18.	U. S. Express Co., Expressage	55
"	18.	Andrus & Church, Note Book	35
"	18.	Gould Mnfg. Co., Casting	19
"	24.	Gould Mnfg. Co., Casting	83
Sept.	1.	C. R. Mellen, Seed Wheat	1 30
"	6.	I. P. Roberts, Traveling Expenses	14 08
"	9.	Leroy Anderson, Salary	25 00
"	24.	White & Burdick, Drugs	11 83
Oct.	1.	R. D. Roberts, Labor	19 20
"	1.	Leroy Anderson, Salary	25 00
"	1.	E. B. Cobb, Labor	10 88
"	2.	E. C. Roberts, Labor	2 48
"	3.	D., L. & W. R. R. Co., Freight and Cartage	46
		Amount carried forward,	$275 82

		Amount brought forward,	$275 82
Oct.	4.	C. H. Howes, Films	1 80
"	6.	L. F. Noxon, Grass Seed	1 38
"	30.	L. Harrington, Labor	28 50
"	30.	E. Cobb, Labor	15 00
"	30.	E. C. Roberts, Labor	3 38
"	30.	C. H. Craatz, Labor	1 80
"	30.	R. J. Roach, Labor	5 18
"	30.	J. Bush, Labor	75
"	30.	F. J. Bowen, Labor	5 78
"	30.	C. M. Crouch, Labor	10 20
Nov.	8.	E. McGillivray, Photo. Supplies	9 08
"	20.	Tom Humiston, Labor	13 95
"	20.	George Humiston, Labor	13 80
Dec.	30.	G. W. Tailby, Labor	5 32
"	8.	Leroy Anderson, Salary	25 00
"	27.	F. T. Patterson, Freight on Potatoes	4 20
1898.			
Jan.	4.	Leroy Anderson, Salary	25 00
"	10.	Platt Drug Co., Drugs	10
"	13.	American Jersey Cattle Club, Registering 3 Animals	6 00
"	15.	Treman, King & Co., Supplies	2 10
"	24.	U. S. Express Co., Expressage	35
"	31.	Farmers' Fertilizer Co., Fertilizer	3 75
"	31.	D., L. & W. R. R. Co., Freight and Cartage	45
Mar.	8.	C. E. Chapman, Spray Pump	90
Dec.	9.	Campus Delivery, Cartage	35
"	10.	L. V. R. R. Co., Freight and Cartage	1 24
"	28.	White & Burdick, Oil for Experimental Purposes	14 15
"	16.	F. Whiting, Labor	7 50
Apr.	25.	Williams Bros., Casting	1 60
"	25.	J. E. Black, Fertilizer	3 85
"	25.	G. E. Stechert, Publications	8 75
June	30.	B. F. White, Photo. Supplies	1 55
		Total for Agricultural Division	$493 58

FOR HORTICULTURAL DIVISION.

1897.			
July	6.	U. S. Express Co., Expressage	$0 30
"	22.	G. E. Stechert, Publications	21 75
"	26.	U. S. Express Co., Expressage	25
Aug.	4.	Ira Grover, Salary	37 50
"	7.	D., L. & W. R. R. Co., Freight and Cartage	50
		Amount carried forward,	$60 30

		Amount brought forward,	$60 30
Aug.	7.	H. V. Bostwick, Barrels, Crates, etc.	2 95
"	18.	B. Chase, Pot Labels	6 75
Sept.	1.	Ira Grover, Salary	37 50
"	1.	F. Hoch, Labor	37 50
"	3.	A. Shore, Labor	1 25
"	7.	D., L. & W. R. R Co., Freight and Cartage	1 41
"	18.	H. A. Dreer, Seeds	94
"	18.	Burns Bros., Blacksmithing	1 45
"	28.	George Small, Lumber	61 06
"	30.	A. I. Wolf & Bro., Ventilating Machine	7 70
"	30.	Driscoll Bros., Tile	1 05
Oct.	1.	Fred Hoch, Labor	39 00
"	1.	Ira Grover, Salary	37 50
"	2.	F. K. Luke, Labor	24 75
"	4.	U. S. Dept. of Agr., Index Cards	2 03
"	4.	C. J. Rumsey, Sundry Supplies	8 02
"	7.	J. B. Lang, Materials and Repairs	24 08
"	25.	A. Blanc & Co., Bulbs and Plants	23 30
"	26.	W. S. Bickel, Labor	17 25
"	28.	G. W. Tailby, Oats	26 18
Nov.	1.	Ira Grover, Salary	37 50
"	1.	F. Hoch, Labor	39 00
"	1.	F. K. Luke, Labor	3 75
"	2.	U. S. Express Co., Expressage	1 15
"	4.	G. R. Chamberlain, Drawings	7 50
"	6.	U. S. Express Co., Expressage	83
"	8.	H. Bayendorfer & Co., Wax Paper	6 75
"	8.	Rothschild Bros., Sundry Supplies	1 00
"	17.	U. S. Dept. of Agr., Index Cards	2 00
"	18.	E. McGillivray, Photographic Supplies	3 24
"	18.	L. H. Bailey, Canada Peas	6 17
"	18.	Syracuse Pottery Co., Flower Pots	8 80
"	18.	C. C. Abel & Co., Plants and Bulbs	29 78
"	20.	W. B. Schutt, Hay	9 65
"	26.	F. Hoch, Labor	27 00
Dec.	2.	Andrus & Church, Supplies	75
"	2.	Ira Grover, Salary	37 50
"	20.	Mrs. Ira Grover, Labor	8 10
"	28.	H. V. Bostwick, Baskets, etc.	12 25
"	28.	J. M. Thorborn & Co., Seeds	41
"	28.	George Small, Lumber	51 73
1898.			
Jan.	3.	Ira Grover, Salary	37 50
		Amount carried forward,	$694 03

		Amount brought forward,	$694 03
Jan.	3.	Enz & Miller, Paper	75
"	12.	M. Carey, Hay	9 35
Feb.	1.	Ira Grover, Salary	37 50
Mar.	1.	Ira Grover, Salary	37 50
"	9.	U. S. Dept. of Agr., Index Cards	2 00
"	22.	U. S. Express Co., Expressage	35
"	26.	U. S. Express Co., Expressage	2 70
"	25.	G. E. Stechert, Publications	3 00
"	25.	Edward Allen, Publications	20 25
"	25.	U. S. Express Co., Expressage	85
Apr.	30.	U. S. Express Co., Expressage	1 00
"	30.	E. Whitlock, Labor	15 00
"	30.	Ira Grover, Salary	37 50
May	27.	W. B. Schutt, Hay	16 30
June	6.	Mrs. Ira Grover, Labor	10 35
"	6.	Ira Grover, Salary	37 50
"	6.	U. S. Express Co., Expressage	90
"	9.	Jamieson & McKinney, Rubber Tubing	50
"	30.	Ira Grover, Salary	37 50
		Total for Horticultural Division	$1,025 13

FOR CHEMICAL DIVISION.

1897.			
July	28.	J. P. Troy, Labels	$1 00
Aug.	11.	B. S. Cushman, Labor	6 66
Sept.	18.	J. P. Troy, Negatives and Silver Prints	90
Oct.	7.	Treman, King & Co., Sundry Supplies	1 44
Nov.	18.	Cornell University Dept. of Repairs, Repairs	9 78
1898.			
June	14.	Rothschild Bros., Toweling	75
		Total for Chemical Division	$20 53

FOR BOTANICAL DIVISION.

1897.			
July	10.	H. Hasselbring, Labor	$7 50
"	13.	Bausch & Lomb Optical Co., Cedar Oil	1 13
"	13.	H. Hasselbring, Labor	3 00
"	17.	Bertha Stoneman, Labor	6 50
"	21.	U. S. Express Co., Expressage	4 15
"	22.	G. E. Stechert, Publications	7 75
"	22.	Reed & Montgomery, Binding Publications	2 40
		Amount carried forward,	$32 43

		Amount brought forward,	$32 43
July	22.	G. E. Stechert, Publications	9 39
"	26.	U. S. Express Co., Expressage	1 55
"	27.	Treman, King & Co., Sundry Supplies	5 75
"	27.	J. Carbutt, Photographic Supplies	7 08
"	27.	Richards & Co., 10 lbs. Formalose	5 30
Aug.	7.	C. L. Anderson, Plant Collection	10 00
"	7.	Bausch & Lomb, Chemicals	8 18
"	7.	H. Hasselbring, Labor	12 11
"	10.	U. S. Express Co., Expressage	30
"	12.	U. S. Express Co., Expressage	2 25
Sept.	22.	H. Hasselbring, Labor	9 80
"	27.	H. Hasselbring, Labor	3 00
"	27.	U. S. Express Co., Expressage	3 50
Oct.	6.	Rochester Optical Co., Photographic Supplies	20 35
"	13.	H. Hasselbring, Labor and Traveling Expenses	7 64
"	14.	G. E. Stechert, Publications	5 63
"	25.	H. Hasselbring, Labor	3 80
Nov.	4.	H. Hasselbring, Labor	6 00
"	8.	Bausch & Lomb, Chemicals and Vials	34 69
"	8.	Bausch & Lomb, Vials and Paraffine	12 75
"	18.	H. Hasselbring, Labor	6 00
Dec.	1.	H. Hasselbring, Labor	6 00
"	14.	H. Hasselbring, Labor	6 00
1898.			
Jan.	8.	C. G. Calder, Botanical Supplies	1 58
"	8.	White & Burdick, Drugs	2 75
"	18.	H. Hasselbring, Labor	9 00
"	31.	Bausch & Lomb, Thermostat	1 34
"	31.	E. McGillivray, Photographic Supplies	11 55
Feb.	7.	H. Hasselbring, Labor	9 00
Mar.	5.	H. Hasselbring, Labor	9 00
"	19.	H. Hasselbring, Labor	9 00
Apr.	19.	U. S. Express Co., Expressage	45
"	25.	Bausch & Lomb, Chemicals	13 71
"	25.	G. E. Stechert, Publications	22 75
May	4.	H. Hasselbring, Labor	12 00
June	4.	E. McGillivray, Photographic Supplies	3 23
		Total for Botanical Division	$327 86

FOR ENTOMOLOGICAL DIVISION.

1897.			
July	6.	L. V. R. R. Co., Freight and Cartage	$0 60
"	9.	Andrus & Church, Ink	50
		Amount carried forward,	$1 10

		Amount brought forward,	$1 10
Aug.	2.	S. Hori, Labor	28 20
"	16.	H. A. Dreer, Seeds and Plants	8 38
"	28.	U. S. Express Co., Expressage	1 87
Sept.	18.	Andrus & Church, Stationery	1 00
Oct.	5.	S. Hori, Labor	46 50
"	14.	E. McGillivray, Paste	23
"	14.	Andrus & Church, Dictionary	1 60
"	14.	Reed & Montgomery, Binding Book	1 00
"	18.	C. V. Riley, Electrotype	2 00
"	18.	Hanson Bros., 3 Electros	65
"	18.	U. S. Express Co., Expressage	50
"	21.	U. S. Express Co., Expressage	35
"	25.	Macmillan Co., 1 Cut	75
"	26.	U. S. Express Co., Expressage	25
Nov.	3.	S. Hori, Labor	5 50
"	8.	Jamieson & McKinney, Glass	15
"	8.	Hanson Bros., 1 Electro and Postage	25
"	8.	G. Cramer, Photographic Plates	1 88
"	11.	E. E. Slingerland, Labor	3 60
"	24.	Lovejoy Co., 2 Cuts	30
"	26.	D. B. Stewart, Oil	4 02
Dec.	4.	University Dept. of Repairs, Removing Boiler, etc.	37 00
"	4.	University Dept. of Repairs, 1 Boiler	175 00
"	4.	Treman, King & Co., Material and Repairs	2 88
"	6.	Jamieson & McKinney, Material and Repairs	32 49
"	6.	U. S. Express Co., Expressage	2 02
"	7.	S. Hori, Labor	5 70
"	9.	Forest City Plumbing Co., Plumbing and Material	124 28
"	20.	U. S. Express Co., Expressage	30
"	30.	Jamieson & McKinney, Greenhouse Plumbing	18 77
"	31.	S. Hori, Labor	12 40
1898.			
Jan.	5.	E. E. Slingerland, Labor	1 40
"	7.	Barr Bros., Sundry Supplies	12 45
"	8.	E. McGillivray, Photographic Supplies	5 04
"	8.	Barr Bros., Sickle	40
"	12.	Andrus & Church, Stationery	8 95
"	17.	A. B. Brooks, Drugs and Supplies	14 49
"	24.	Andrus & Church, Stationery and Supplies	8 65
"	31.	U. S. Express Co., Expressage	60
Feb.	3.	F. K. Luke, Labor	6 80
"	5.	Dept. of Repairs, Repairs	3 10
		Amount carried forward,	$582 80

		Amount brought forward,	$582 80
Feb.	8.	Jamieson & McKinney, Brush	1 00
"	9.	McGillivray, Photographic Supplies	3 38
"	28.	U. S. Express Co., Expressage	1 20
Mar.	1.	L. V. R. R. Co., Freight and Cartage	1 30
"	2.	F. K. Luke, Labor	9 00
"	8.	C. E. Chapman, Sprayer	90
"	9.	H. A. Dreer, Seeds and Bulbs	8 78
"	9.	Treman, King & Co Broom and Tissue Paper	2 55
"	9.	A. P. Little, Typewriter Ribbons	3 00
"	9.	Andrus & Church, Letter Heads	50
"	9.	Bool Co., Shading and Fixtures	7 27
"	9.	American Jadoo Co., Jadoo Fiber	8 80
"	9.	D. B. Stewart & Co., Kerosene	4 51
"	15.	U. S. Express Co., Expressage	90
"	19.	U. S. Express Co., Expressage	1 40
"	28.	Eclipse Ink Co., Ink	50
April	25.	Treman, King & Co., Supplies	1 55
May	2.	F. K. Luke, Labor	8 20
"	7.	U. S. Express Co., Expressage	45
June	6.	E. McGillivray, Supplies	1 13
"	16.	University Dept. of Repairs, Repairs	4 49
		Total for Entomological Division	$653 61

FOR VETERINARY SCIENCE DIVISION.

1897.			
Aug.	16.	Bausch & Lomb, Thermometers and Burner	$7 50
Sept.	18.	A. H. Reed, Milking Tubes	2 57
"	18.	Brown & Barnard, Soap and Soap Powder	4 80
Oct.	6.	Bacteriological Laboratory, Lab. Charges	15 00
"	30.	C. E. Lewis, Milk	3 00
Nov.	26.	N. Y. State Veterinary College, Milk	96
1898.			
Jan.	8.	Bool Co., Screen	6 50
"	19.	G. W. Comfort, Cow	15 00
Feb.	1.	C. E. Bruce, Cow	22 00
"	15.	N. Y. State Veterinary College, Keeping Three Cows .	100 48
Mar.	4.	Dr. James Law, Traveling Expenses	18 17
		Total for Veterinary Science Division	$195 98

SUMMARY.

The Agricultural Experiment Station of Cornell University, in account with the United States Appropriation.

1898.	Dr.		
	To Receipts from Treasurer of the United States as per appropriation for the year ending June 30, 1898, under Act of Congress approved March 2, 1887		$13,500 00
	Cr.		
June 31.	By Salaries	$7,560 34	
	Printing	2,118 32	
	Office Expenses	1,104 65	
	EQUIPMENT, LABOR AND CURRENT EXPENSES.		
	Agriculture	$493 58	
	Horticulture	1,025 13	
	Chemistry	20 53	
	Botany	327 86	
	Entomology	653 61	
	Veterinary Science	195 98	
			$13,500 00
	RECEIPTS.		
	Balance from 1896–7	$582 08	
	Agricultural Division	134 29	
	Horticultural Division	108 58	
			$824 95
	EXPENDITURES FROM RECEIPTS.		
	For Horticultural Division	$118 89	
	Entomological Division	17 98	
	Office	35 42	
	Salaries	641 66	
	Botany	11 00	
			$824 95

APPENDIX III.

Teacher's Leaflets on Nature Study.

No. 8. The Leaves and Acorns of Our Common Oaks.

No. 9. The Life History of the Toad.

No. 10. The Birds and I.

No. 11. Life in an Aquarium.

TEACHER'S LEAFLETS ON

NATURE STUDY.

No. 8.

SECOND EDITION.

TEACHER'S LEAFLETS.

No. 8.

FOR USE IN THE PUBLIC SCHOOLS.

SEPTEMBER 1, 1897.

PREPARED BY

THE COLLEGE OF AGRICULTURE,
CORNELL UNIVERSITY,

ITHACA, N. Y.

Issued under Chapter 128
of the Laws of 1897.

I. P. ROBERTS, DIRECTOR.

The Leaves and Acorns

OF

OUR COMMON OAKS.

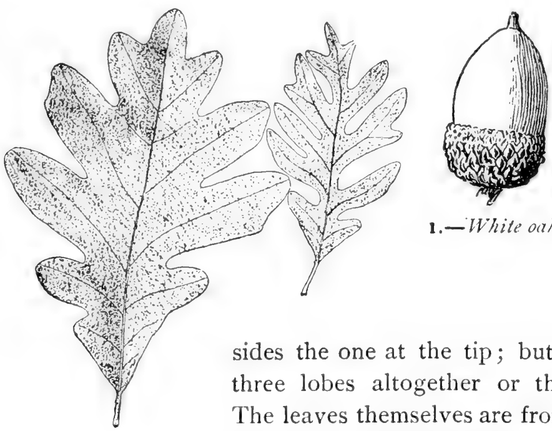
BY ALANSON PHELPS WYMAN.

The best way to find out if a tree is an oak is to see if it bears an acorn. While the leaves and other parts of oaks are different from those of any other group of trees, they are not so distinctive as the fruit. Some of the most common oaks of the state of New York are here described. If an oak is found not corresponding to these descriptions, or if fuller descriptions are desired, consult Gray's "Manual," Britton and Brown's "Illustrated Flora," or other manuals.

WHITE OAK.

The picture shows the leaves and acorn of a white oak. The two forms of leaves in the illustration show how different their shapes may be on different trees. But note some features in common. First look at the general form of the leaf, as if there were no cuts or sinuses in the sides. In outline it is something like a longitudinal section of an egg (ovate), but since the widest part is nearer its tip than its stem, we call it obovate.

Observe the lobes. They are much narrower in the smaller leaf and the sinuses are deeper, but this is not important. The white oak always has lobes much like this and rounded rather than pointed. The lobes are placed about the same distance apart and the sinuses are rounded toward the middle of the leaf. Then, the number of the lobes is three on each side besides the one at the tip; but there may be only three lobes altogether or there may be nine. The leaves themselves are from four to six inches long. Then if the leaves are smooth, of a bright green in summer, paler on the lower surface than on the upper, and if the acorn has the shape of the one in the picture, the tree is a white oak. This narrow lobing of the leaves gives the mass of the tree-top a soft and feathery effect. If the tree is of some size the bark will be light gray and made up of small scales. The trunks of some white oaks rise as single stems to the top of the tree, the branches spreading out crookedly and horizontally from them, while others have a number of trunks or branches which seem to spread in all directions; in both forms the lower branches are often very nearly horizontal. An old white oak is one of the best of ornamental trees, and one growing in a yard is worth in beauty and shade three or four ordinary trees. It spreads so widely, its branches are so crooked and grotesque, and it appears so sturdy and powerful, that it seems to have a stronger character than ordinary trees.

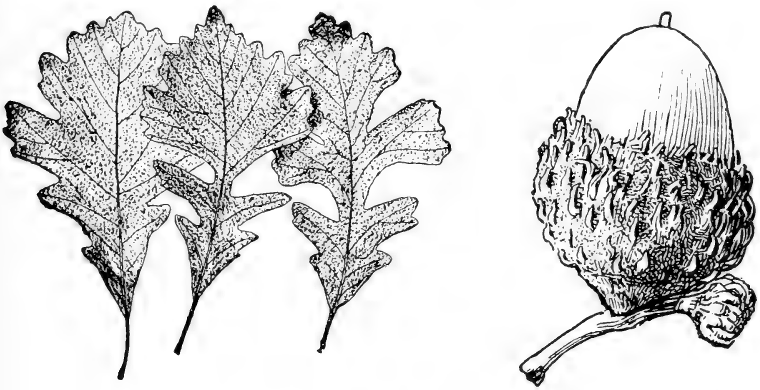


1.—*White oak.*

The Bur Oak.

Another oak which is found in the state of New York and the north, but not so commonly as the white oak, is the bur oak or mossy-cup oak.

The leaf in the center of the picture (figure 2) is the most common form, but other shapes can be found. The bur oak is as variable in the shapes of its leaves as the white oak is, but there are some general features in common: the lobes are rounded as in the white oak, but are placed in a different position and are more irregular. Towards the tip, the leaf is very wavy or toothed, but further

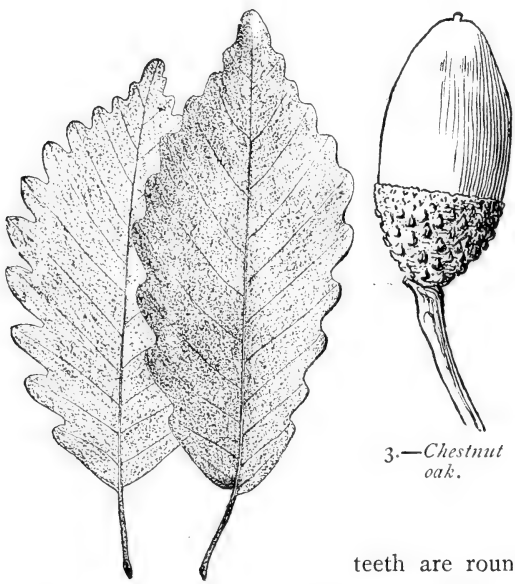


2.—*Bur oak.*

down it is more likely to be lobed and sometimes very deeply lobed. The general form is somewhat obovate, but is narrower towards the stem than in the white oak. A leaf shaped and lobed like the two at the right, and downy on the lower surface or else paler than on the upper, is almost certainly a bur oak leaf. But if it is anything like the left-hand leaf, find an acorn. If the acorn is like the one in the picture, having the cups covered with thick pointed scales, sometimes as coarse as these, sometimes smaller, and the edge bordered with a fringe of narrow scales, it was borne on a bur oak. The bark of the bur oak is light gray, like that of the white oak; but a little darker and not so scaly. Usually, too, its branches are not so horizontal. That which marks it best as being a bur oak is the character of the bark on those branches which are from five to ten years old; the bark is corky or warty, the corky substance standing up in rows along the young branches. This oak is often planted, with good effect, to ornament lawns. On low, rich lands it becomes a very large tree.

The Chestnut Oak.

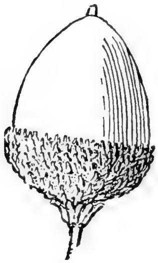
The leaves of this oak are very much like those of the chestnut tree and without the acorns are easily mistaken for them; hence the name, the chestnut oak. The other oak leaves had lobes, but here there are only rounded teeth, unlike the leaf of the chestnut, which has sharp pointed teeth. On one leaf the teeth are a little longer than on the other, but they are rounded in the same way, point in the same direction, and do not become lobes. If the general shape of the leaf is like this and the teeth are rounded, and a hand glass shows a fine down on the lower surface of the thick leaf, it is a chestnut oak. But to be sure, see if the acorn is like the one in the engraving, very long, and the cups with hard scales. The leaf is from five to nine inches in length and the rib at the center is bright yellow, like the stem of the leaf. The bark of the chestnut oak is black, having ridges and deep furrows which cannot be mistaken. The branches do not look so strong as those of the other two oaks and are placed more irregularly. Since the leaves are so large and so little cut the tree has a full and heavy appearance, making it less graceful than many other oaks. It it found on rocky banks and hillsides.



3.—*Chestnut oak.*

The Swamp White Oak.

The swamp white oak bears leaves of a variety of shapes. The leaves are usually toothed, resembling the chestnut oak, as in the two right-hand leaves (figure 4). Rarely, however, instead of being toothed they are irregularly lobed with rounded lobes, as in the left-hand leaf. All three leaves have the same general form. They are narrow at the base, hence wedge-shaped. The teeth are not placed as regularly as in the chestnut oak, and are more angled, but they are not as pointed as in the leaves of a chestnut tree. The middle leaf is much like one of the leaves of the bur oak, but it is fewer lobed and of different



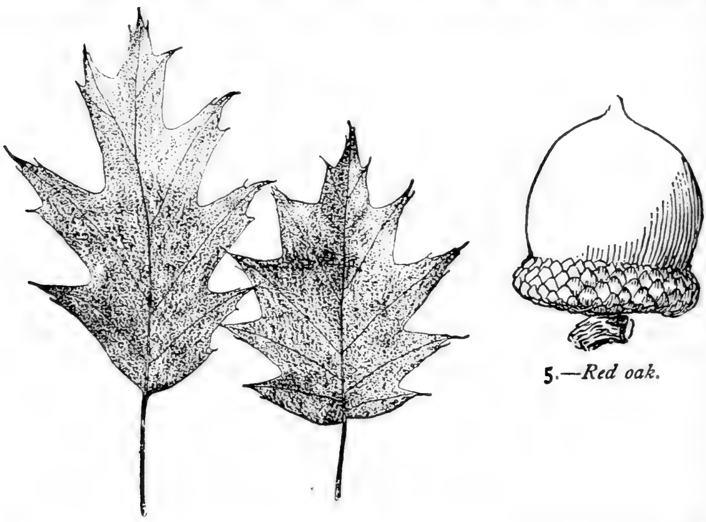
4.—*Swamp white oak.*

shape. Then, too, the under surface is likely to be white and downy. To be certain, one should examine the acorn, which is small and of a different shape from that of the bur oak; the scales on the cup are smaller and thinner, and the fringe at the edge smaller. This oak, which grows mainly on low lands, is a beautiful, round-headed tree, and it grows rapidly in good soil. Its bark, like that of the white oak, is light gray, but it is more scaly. The trunk and branches are slenderer than are those of the white oak and its branches hang more gracefully. The tree is apt to be filled with innumerable little dead twigs which give it a wild effect.

The Red Oak.

Here are some oak leaves very different from those which we have seen. Instead of being rounded, the lobes are pointed and very sharp. The oaks having pointed leaves are so different from those which have rounded ones that botanists make a wholly different group of them. The white oak group has leaves with rounded lobes or teeth and, with the exception of the chestnut oak, light gray scaly bark; the black oak group has leaves with pointed lobes or tips and dark furrowed bark. The first four oaks described belong to the white oak group. This one and the next two belong to the black oak group.

In the illustration (figure 5) are leaves of the red oak. What children have not pinned these leaves together with leaf-stems and

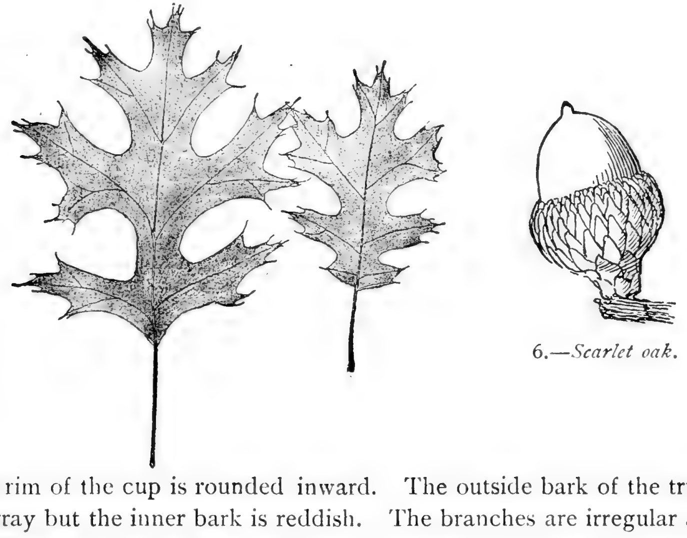


5.—*Red oak.*

made garlands for themselves or to trim the school-house walls? Who does not remember the great acorn with its flat cup and so bitter to the taste? The lobes of these leaves are not long, but taper gradually to a point, making triangles. They are seven or nine in number, all of them seeming to point towards the tip more than in other kinds of oaks. It is very easy to confuse these leaves with those of the next two oaks, but the flat-cupped acorn is distinctive. The bark of the tree is furrowed and sometimes dark gray when old. It is an irregular tree, its arms pointing in all directions and, while often handsome, it has not the grandeur of some of the white oaks. Tree planters like it because it can be transplanted easily and grows rapidly.

The Scarlet Oak.

The oak which is the most brilliant red or scarlet in the autumn is the scarlet oak. Although this oak does not grow naturally anywhere but in America, it is famous also in Europe for its brightness. Before autumn its color is like that of other oaks except that its leaves are usually more glossy. The wide rounded sinuses extending deeply into the leaf and the narrow many-pointed lobes are characteristic. The scarlet oak is easy to distinguish from the red oak but hard to tell from the next one. Observe how deeply the leaves are cut, how thin they are, and that their stems and ribs are slender. Notice also that the triangular scales of the acorn cup are tight to the cup and that



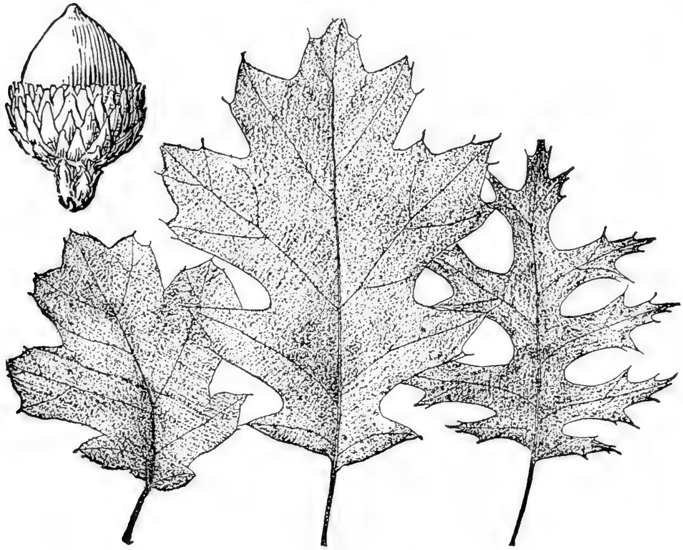
6.—*Scarlet oak.*

the rim of the cup is rounded inward. The outside bark of the trunk is gray but the inner bark is reddish. The branches are irregular and stiff-looking, but the tree is planted because of its beauty in autumn and because it transplants easily and grows rapidly.

The Black Oak.

The black oak is sometimes difficult to distinguish from the scarlet oak. If the leaves were always like the two at the left hand of the picture, it would be an easy matter to distinguish it, as the illustration shows the leaves to be broader at the tip and the sinuses (or hollows) shallow and quite different from those in the leaves of the scarlet oak.

The right-hand leaf, however, is almost exactly the same as that of the scarlet oak, but here the texture should be noted. The leaf of the black oak is likely to be coarser and thicker than that of the scarlet oak and the stem stouter. Its lower surface until midsummer or longer is downy, while in the scarlet oak it is smooth. The acorn is of much the same size and shape as that of the scarlet oak, but the scales are looser, and the cup-rim does not round inwards toward



7.—*Black oak.*

the acorn. The bark is nearly black and the inner bark is orange instead of red. The shape of the tree is much the same as that of the scarlet oak. The tree is useful for planting.

SUMMARY.

The Oaks are distinguished by their fruit, which is an acorn.

THE WHITE OAK GROUP, distinguished by its light gray, scaly bark, and the rounded lobes or teeth of the leaves:

The white oak. The leaves obovate, five or six inches long, their lobes usually seven and at equal distances apart, and their sinuses deep or shallow, acorn small, with a rather shallow and not fringed cup.

The bur oak. The leaves obovate, downy or pale on their lower surface, toothed toward the tips and irregularly and often deeply lobed toward the base, the acorn cups heavily fringed on their margins, the young branches corky.

The chestnut oak. The leaves longer than obovate, toothed with rounded teeth and yellow-ribbed, the acorn long and its cup hard-scaled, the bark dark with broad deep furrows.

The swamp white oak. The leaves obovate, white downy on their lower surface, toothed with squarish teeth, the bases wedge-shaped, the acorn small with the margin of its cup finely fringed.

THE BLACK OAK GROUP, distinguished by its dark furrowed bark and the pointed lobes of the leaves:

The red oak. The leaves obovate or sometimes shorter, their seven to nine lobes triangular and pointing toward the tips, the large acorn flat-cupped.

The scarlet oak. The leaves obovate, bright scarlet in autumn, thin, smooth on their lower surface, their sinuses deep, wide and rounded, the margin of the acorn cups rounding inwards and their scales close, the inner bark reddish.

The black oak. The leaves obovate, coarser, downy on their lower surface until midsummer or later, wider towards the tip, their sinuses shallow (or sometimes as in the scarlet oak), the margin of the acorn cups not rounding inwards and their scales looser, the inner bark orange.

TO THE TEACHER:

It is especially urged that this leaflet shall not be placed in the pupil's hands. It is prepared to enable the teacher to ask suggestive questions about the oak leaves and acorns which the pupils may gather. This involves of necessity a knowledge on the teacher's part of many minute points of difference, which taken in their sum make the specific character of the tree. These points may be best discovered by having the children bring leaves and acorns to the school room and there draw pictures of them. It might also be well to visit the trees.

Teachers and others wishing copies of this leaflet should address:

Chief Clerk,
College of Agriculture,
Ithaca, N. Y.

The following leaflets have been issued to aid teachers in the public schools in presenting nature-study subjects to the pupils at odd times:

1. *How a squash plant gets out of the seed.*
2. *How a candle burns.*
3. *Four apple twigs.*
4. *A children's garden. For the pupils.*
5. *Some tent makers.*
6. *What is nature study?*
7. *Hints on making collections of insects.*
8. *The leaves and acorns of our common oaks.*

SECOND EDITION.

No. 9.

JUNE 10, 1898.

TEACHER'S LEAFLETS.

FOR USE IN THE PUBLIC SCHOOLS.

PREPARED BY

THE COLLEGE OF AGRICULTURE, CORNELL UNIVERSITY,

ITHACA, N. Y.

Issued under Chapter 67
Laws of 1898.

I. P. ROBERTS, DIRECTOR.

The Life History of the Toad.

BY SIMON HENRY GAGE.*

The life-history of the common or warty toad has been selected for various reasons as the subject of a leaflet in nature study: This history is exceedingly interesting. The marvelous changes passed through in growing from an egg to a toad are so rapid that they may all be seen during a single spring term of school. Toads are found everywhere in New York, and nearly everywhere in the world; it is easy, therefore, to get abundant material for study. This animal is such a good friend to the farmer, the gardener, the fruit grower, the florist and the stock raiser that every man and woman, every boy and girl ought to know something about it, and thus learn to appreciate their lowly helper.

And, finally, it is hoped and sincerely believed that the feeling of repugnance and dislike, and the consequent cruelty to toads, will disappear when the children know something about their wonderful changes in form, structure and habits, and how harmless and helpful they are. Then who that knows of the chances, the dangers and struggles in the life of the toad, can help a feeling of sympathy; for

* It was the desire of the author to tell the story of this leaflet in pictures as well as in words, and he wishes to express his appreciation of the enthusiasm and ability with which the illustrations were executed by Mr. C. W. Furlong.

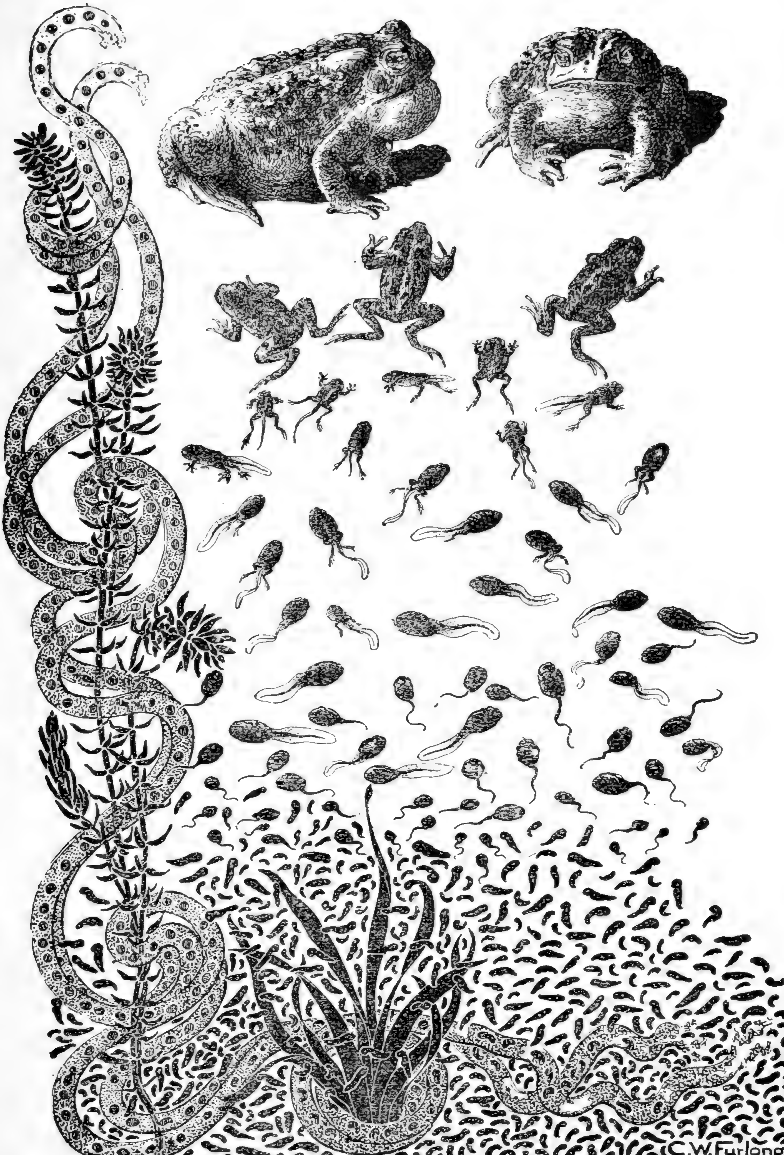
after all, how like our human life it is. Where sympathy is, cruelty is impossible, and one comes to feel the spirit of these beautiful lines from Coleridge's "Ancient Mariner:"

"He prayeth best who loveth best
All things both great and small;
For the dear God who loveth us
He made and loveth all."

It was William Harvey, the discoverer of the circulation of the blood, who first clearly stated to the world the fact that every animal comes from an egg. This is as true of the toad as of the chicken. The toad lives on the land and often a long way from any pond or stream, but the first part of its life is spent in the water; and so it is in the water that the eggs must be looked for.

To find the eggs one should visit the natural or artificial ponds so common along streams. Ponds from springs or even artificial reservoirs or the basins around fountains may also contain the eggs. The time for finding the eggs depends on the season. The toad observes the season, not the almanac. In ordinary years the best time is from the middle of April to the first of May. One is often guided to the right place by noticing the direction from which the song or call of the toad comes. It may be said in passing that toad choirs are composed solely of male voices. The call is more or less like that of tree toads. In general it sounds like whistling, and at the same time pronouncing deep in the throat bu-rr-r-r-r-. If one watches a toad while it makes its call, he can soon learn to distinguish the sound from others somewhat similar. It will be found that different toads have slightly different voices, and the same one can vary the tone considerably, so that it is not so easy after all to distinguish the many batrachian solos and choruses on a spring or summer evening. It will be noticed that the toad does not open its mouth when it sings, but there is a great, expansible, vocal sack or resonator under the mouth and throat (see the left hand toad in the plate).

The eggs are laid in long strings or ropes which are nearly always tangled and wound round the water plants or sticks on the bottom of the pond near the shore. If the eggs have been freshly laid or if there has been no rain to stir up the mud and the water is clear, the



The toad in various stages of development from the egg to the adult.

egg ropes will look like glass tubes containing a string of jet black beads. After a rain the eggs are obscured by the fine mud that settles on the transparent jelly surrounding them.

Take enough of the egg string to include 50 or 100 eggs, and place it in a glass fruit dish or a basin with clean water from the pond where the eggs were found. Let the children look at the eggs very carefully and note the color and the exact shape. Let them see if the color is the same on all sides. If the eggs are newly laid they will be nearly perfect spheres.

Frogs, salamanders and tree toads lay their eggs in the same places and at about the same time as the toad we are to study. Only the toad lays its eggs in strings, so one can be sure he has the right kind. The others lay their eggs in bunches or singly on the plant, so they never need be mistaken for the ones sought.

The eggs which are taken to the schoolhouse for study should be kept in a light place, but not very long in the hot sun, for that would heat the water too much and kill the eggs.

It takes only a short time for the eggs to hatch. In warm weather two or three days are usually sufficient. As the changes are so very rapid, the eggs ought to be carefully looked at two or three times a day to make sure that all the principal changes are seen. If a pocket lens or a reading glass is to be had it will add to the interest, as more of the details can be observed. But good sharp eyes are sufficient if no lens is available.

Hatching.—Watch and see how long it is before the developing embryos commence to move. Note their change in form. As they elongate they move more vigorously till on the second or third day they wriggle out of the jelly surrounding them. This is hatching, and they are now free in the water and can swim about. It is curious to see them hang themselves up on the old egg string or on the edge of the dish. They do this by means of a peculiar v-shaped organ on their heads.

How different the little creatures are, which have just hatched, from the grown-up toad which laid the eggs. The difference is about as great as that between a caterpillar and a butterfly.

Tadpoles, polliwogs.—We do not call the young of the frog, the toad, and the tree toad, caterpillars, but tadpoles or polliwogs. The toad tadpoles are blacker than any of the others.

The tadpoles will live for some time in clear water with apparently nothing to eat. This is because the mother toad put into each egg some food, just as a hen puts a large supply of food within the egg shell to give the chicken a good start in life. But when the food that the mother supplied is used up the little tadpoles would die if they could not find some food for themselves. They must grow a great deal before they can turn into toads, and just like children and other young animals, to grow they must have plenty of food.

Feeding the tadpoles.—To feed the tadpoles it is necessary to imitate nature as closely as possible. To do this a visit to the pond where the eggs were found will give the clue. Many plants are present, and the bottom will be seen to slope gradually from the shore. The food of the tadpole is the minute plant life on the stones, the surface of the mud, or on the outside of the larger plants. Make an artificial pond in a small milk pan or a large basin or earthenware dish. Put some of the mud and stones and small plants in the dish, arranging all to imitate the pond, that is, so it will be shallow on one side and deeper on the other. Take a small pail of clear water from the pond to the schoolhouse and pour it into the dish to complete the artificial pond. The next morning when all the mud has settled and the water is clear, put 30 or 40 of the little tadpoles which hatched from the egg string, into the artificial pond. Keep this in the light, but not very long at any one time in the sun. The children may think this is not imitating nature, because the natural pond is in the full sunlight all day. The teacher can easily make them remember that the natural pond is on the cool earth where it cannot get very hot; but the small artificial pond might readily get very warm if left long in the hot sun.

One must not attempt to raise too many tadpoles in the artificial pond or there will not be enough food, and all will be half starved. While there may be thousands of tadpoles in the natural pond, it will be readily seen that, compared with the amount of water present, there are really rather few.

Probably many more were hatched out in the schoolhouse than can be raised in the artificial pond. Return the ones not put in the artificial pond to the natural pond. It would be too bad to throw them out on the ground to die.

Comparing the growth of the tadpoles.—Even when one does his best it is hard to make an artificial pond so good for the tadpoles as the natural one; and the teacher will find it very interesting and stimulating to compare the growth and change in the tadpoles at the schoolhouse with those in the natural pond.

As growth depends on the supply of food and the suitability of the environment, it is easy to judge how nearly the artificial pond equals the natural pond for raising tadpoles. It will be worth while to take a tadpole from the natural pond occasionally and put it in with those at the schoolhouse so that the difference may be more strikingly shown. There is some danger in making a mistake here, however, for there may be three or four kinds of tadpoles in the natural pond. Those of the toad are almost jet black, while the others are more or less brownish. If one selects only the very black ones they will probably be toad tadpoles.

Every week or oftener, a little of the mud and perhaps a small stone covered with the growth of microscopic plants, and some water should be taken from the pond to the artificial pond. The water will supply the place of that which has evaporated, and the mud and the stone will carry a new supply of food.

The growth and changes in form should be looked for every day. Then it is very interesting to see what the tadpoles do, how they eat, and any signs of breathing.

All the changes from an egg to a little toad (see the plate) are passed through in about two months, so that by the first of June the tadpoles will be found to have made great progress. The progress will be not only in size, but in form and action.

One of these actions should be watched with especial care, for it means a great deal. At first the little tadpoles remain under water all the time, and do not seem to know or care that there is a great world above the water. But as they grow larger and larger, they rush up to the surface once in awhile and then dive down again as if their lives depended on it. The older they grow the oftener do they come to the surface. What is the meaning of this? Probably most of the pupils can guess correctly; but it took scientific men a long time to find out just why this was done. The real reason is that the tadpole is getting lungs, and getting ready to breathe the free air above the water when it turns into a toad and lives on the land. At first the little tadpoles breathe the air dissolved in the water just as a fish does. This makes it plain why an artificial pond should have a broad surface exposed to the air. If one should use a narrow and deep vessel like a fruit jar, only a small amount of air could be taken up by the water and the tadpoles would be half suffocated.

As the tadpoles grow older their lungs develop more and more and they go oftener to the surface to get the air directly from the limitless supply above the water. They are getting used to breathing as they will have to when they live wholly in the air.

Disappearance of the tail.—From the first to the middle of June the tadpoles should be watched with especial care, for wonderful things are happening. Both the fore and hind legs will appear, if they have not already. The head will change in form and so will the body; the color will become much lighter, and, but for the tail, the tadpole will begin to look quite like its mother.

If you keep an especially sharp lookout do you think you will see the tail drop off? No, toad nature is too economical for that. The tail will not drop off, but it will be seen to get shorter and shorter every day; it is not dropping off but is being carried into the tadpole. The tail is perfect at every stage; it simply disappears. How does this happen? This is another thing that it took scientific men a long time to find out. It is now known that within the body there are many living particles that wander about as if to see that everything is in order. They are called wandering cells, white blood corpuscles, phagocytes and several other names. These wander into the tail at the right time and take it up particle by particle. The wandering cells carry the particles of tail into the body of the tadpole where they can be made use of as any other good food would be. This taking in of the tail is done so carefully that the skin is never broken, but covers up the outside perfectly all the time. Is not this a better way to get rid of a tail than to cut it off?

Beginning of the life on the land.—Now when the legs are grown out, and the tail is getting shorter, the little tadpole likes to put its nose out of the water into the air; and sometimes it crawls half way out. When the tail gets quite short, often a mere stub, it will crawl out entirely and stay for some time in the air. It now looks really like a toad except that it is nearly smooth instead of being warty like its mother, and is only about as large as the end of one's little finger.

Finally the time comes when the tadpole, now transformed into a toad, must leave the water for the land.

What queer feelings the little toad must have when the soft, smooth bottom of the pond and the pretty plants, and the water that supported it so nicely are all to be left behind for the hard, rough dry land. But the little toad must take the step. It is no longer a tadpole, or half tadpole and half toad. It cannot again dive into the cool, soft water when the air and the sunshine dry and scorch it. As countless generations of little toads have done before, it pushes boldly out over the land and away from the water.

If one visits the natural pond at about this season (last half of June, first of July), he is likely to see many of the little fellows hopping away from the water. And so vigorously do they hop along that in a few days they may be as far as a mile from the pond where they were hatched. After a warm shower they are particularly active, and are then most commonly seen. Many think they rained down. "They were not seen before the rain, so they must have rained down." Is that good reasoning?

While the little toad is very brave in its way it is also careful, and during the hot and sunny part of the day stays in the shade of the grass or leaves or in some other moist and shady place. If it were foolish as well as brave it might be filled with vanity and stay out in the sun till it dried up.

Food on the Land.

In the water the tadpole eats vegetable matter, but when it becomes a toad and gets on the land it will touch nothing but animal food, and that must be so fresh that it is alive and moving. This food consists of every creeping, crawling or flying thing that is small enough to be swallowed. While it will not touch a piece of fresh meat, woe to snail, insect or worm that comes within its reach.

It is by the destruction of insects and worms that the toad helps men so greatly. The insects and worms eat the grain, the fruits and the flowers. They bite and sting the animals and give men no end of trouble. The toad is not partial, but takes any live thing that gets near it, whether it is caterpillar, fly, spider, centipede or thousand legged worm; and it does not stop even there but will gobble up a hornet or a yellow jacket without the least hesitation.

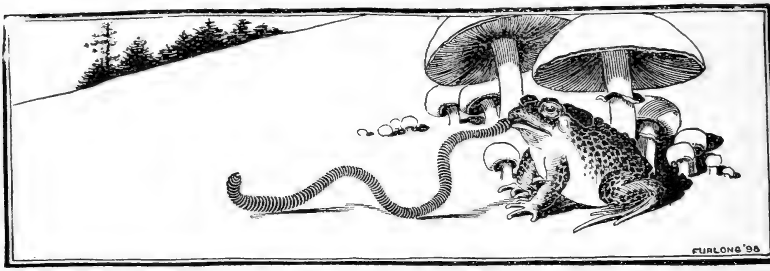
It is astounding to see the certainty with which a toad can catch these flying or crawling things. The way the toad does this may be observed by watching one out of doors some summer evening or after a shower; but it is more satisfactory to have a nearer view. Put a large toad into a box or into a glass dish with some moist sand on the bottom, and put the dish in a cool, shady place so that the toad will not become overheated. In a little while, if one is gentle, the toad will see that it is not going to be hurt, and then if flies and other insects are put into the dish and the top covered with mosquito netting one can watch the process of capture. It is very quickly accomplished, and one must look sharply. As shown in the little picture on this page the toad's tongue is fastened at the front part of its mouth, not back in the throat as with men, dogs, cats and most animals. It is so nicely arranged that it can be extended for quite a distance. On it is a sticky secretion, and when, quick as a flash, the tongue is thrown out or extended, if it touches the insect, the insect is caught as if by sticky fly paper, and is taken into the mouth. (See the picture.)

Toad catching a winged insect, and illustrating how the tongue is extended and brought in contact with the insect. Several other creatures that the toad might eat are shown in various parts of the picture.

Think how many insects and worms a toad could destroy in a single summer. Practically every insect and worm destroyed adds to the produce of the garden and the farm, or takes away one cause of discomfort to men and animals. One observer reports that a single toad disposed of 24 caterpillars in ten minutes, and another ate 35 celery worms within three hours. He estimates that a good sized toad will destroy nearly 10,000 insects and worms in a single summer.

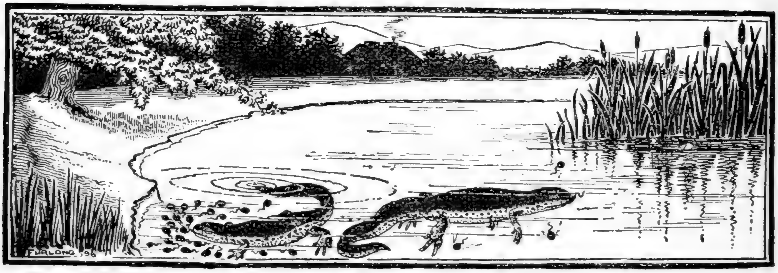
Enemies—The Shadow Side of Life.

So far nothing has been said about the troubles and dangers of the toad's life. The large plate at the beginning is meant to show the main phases in the life-history. If one looks at it, perhaps he may



Toad making a meal of an angle worm.

wonder what becomes of all the tadpoles that first hatch, as only two toads are shown at the top. Is not this something like the human life-history? How many little children die and never become men and women! Well, the dangers to the toad begin at once. Suppose the eggs are laid in a pond that dries up before the little toads can get ready to live on the land; in that case they all die. The mother toads sometimes do make the mistake of laying the eggs in ponds



A couple of newts feasting on tadpoles.

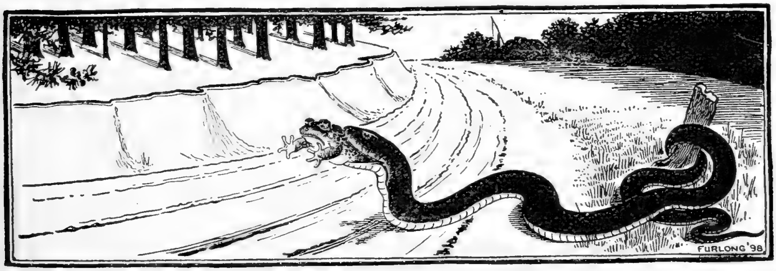
that dry up in a little while. You will not let the artificial pond at the schoolhouse dry up will you? Then sometimes there is an especially dry summer, and only those that transform from tadpoles to toads very early are saved.

In danger from a bird of prey.

In the little picture on page 24 is shown another source of danger and cause for the diminution in numbers. The newts and salamanders find young tadpoles very good eating and they make way with hundreds of them. Some die from what are called natural causes, that is diseases, or possibly they eat something that does not agree with them. So that while there were multitudes of eggs (1,000 or more from each toad), and of just hatched tadpoles, the number has become sadly lessened by the time the brood is ready to leave the water.

Then when they set foot on land, their dangers are not passed. They may be parched by summer's heat or crushed under the feet of men or cattle. Birds and snakes like them for food. The pictures on this page show some of these dangers. Is it a wonder, then, that of all the multitudes of tadpoles so few grow up to be large toads?

We have so few helpers to keep the noxious insects in check, it is not believed that any boy or girl who knows



Snakes usually, if not always, swallow toads hind legs foremost, as shown in the picture.

this wonderful story of a toad's life will join the crows, the snakes and the salamanders in worrying or destroying their good friends.

Moulting and Hibernation.

There are two very interesting things that happen in the life of many of the lower animals; they happen to the toad also. These are moulting, or change of skin, and hibernation or winter sleep. Every boy and girl ought to know about these, and then, if on the lookout, they will sometime be seen.

Moulting.—Probably everybody who lives in the country has seen a snake's skin without any snake in it. It is often very perfect. When the outside skin or cuticle of a snake or a toad gets old and dry or too tight for it, a new covering grows underneath, and the old one is shed. This is a very interesting performance, but the toad usually does it in a retired place, so it is not often seen. Those who have seen it say that a long crack or tear appears along the back and in front. The toad keeps moving and wriggling to loosen the old cuticle. This peels the cuticle off the sides. Now to get it off the legs and feet, the toad puts its leg under its arm, or front leg, and in that way pulls off the old skin as if it were a stocking. But when the front legs are to be stripped, the mouth is used as is sometimes done by people in pulling off their gloves. Do you think it uses its teeth for this purpose? You might look in a toad's mouth sometime and then you would know.

It is said that when the skin is finally pulled off the toad swallows it. This is probably true in some cases, at least it is worth while keeping watch for. After a toad has shed its old skin, he looks a great deal brighter and cleaner than before, as if he had just got a new suit of clothes. If you see one with a particularly bright skin you will now know what it means.

Hibernation.—The toad is a cold-blooded animal. This means that the temperature of its blood is nearly like that of the surrounding air. Men, horses, cows, dogs, etc., are said to be warm-blooded, for their blood is warm and of about the same temperature whether the surrounding air is cold or hot.

When the air is too cool the toad gets stupid and inactive. In September and October, a few toads may be seen on warm days or evenings, but the number seen becomes smaller and smaller; and finally as the cold November weather comes on, none are seen. Where are they? The toad seems to know that winter is coming, that the insects and worms will disappear so that no food can be found. It must go into a kind of death-like sleep in which it hardly moves or breathes. A toad is sensible enough to know that it will not do to go into this profound sleep except in some safe and protected place. If it were to freeze and thaw with every change in the weather it would not wake up in the spring.

The wonderful foresight which instinct gives it, makes the toad select some comparatively soft earth in a protected place where it can bury itself. The earth chosen is moist, but not wet. If it were dry, the toad would dry up before spring. It is not uncommon for farmers and gardeners to plough them up late in the fall or early in the spring. Also in digging cellars at about these times, they are found occasionally.

It is very interesting to see a toad bury itself. If one is found hibernating in the fall, or if one is found very early in the spring on some cold day after a warm spell, the process can very easily be seen. Put some loose earth in a box or a glass dish and put the toad on the top of the earth. It will be found that the toad digs backwards, not forwards. It digs with its hind legs and body, and pushes itself backward into the hole with the front legs. The earth caves in as the animal backs into the ground so that no sign is left on the outside. Once in far enough to escape the freezing and thawing of winter the toad moves around till there is a little chamber slightly larger than its body; then it draws its legs up close, shuts its eyes, puts its head down between or on its hands, and goes to sleep and sleeps for five months or more.

When the warm days of spring come it wakes up, crawls out of bed and begins to take interest in life again. It looks around for insects and worms, and acts as if it had had only a comfortable nap.

The little toad that you saw hatch from an egg into a tadpole and then turn to a toad, would hibernate for two or three winters, and by that time it would be quite a large toad. After it had grown up and had awakened from its winter sleep some spring, it would have a great longing to get back to the pond where it began life as an egg years before. Once there it would lay a great number of eggs, perhaps a thousand or two for a new generation of toads. And this would complete its life cycle.

While the toad completes its life cycle when it returns to the water and lays eggs for a new generation, it may live many years afterward and lay eggs many times, perhaps every year.

Many insects, some fish and other animals die after laying their eggs. For such animals the completion of the life cycle ends the life-history also. But unless the toad meets with some accident it goes back to its land home after laying the eggs, and may live in the same garden or door yard for many years, as many as eight years and perhaps longer. (See Bulletin No. 46, Hatch Experiment Station of the Massachusetts Agricultural College, Amherst, Mass.)

Erroneous Notions About the Toad.

If one reads in old books and listens to the fairy tales and other stories common everywhere, he will hear many wonderful things about the toad, but most of the things are wholly untrue.

One of the erroneous notions is that the toad is deadly poison. Another is that it is possessed of marvelous healing virtues, and still another, that hidden away in the heads of some of the oldest ones, are the priceless toad-stones, jewels of inestimable value.

Giving warts.—Probably every boy and girl living in the country has heard that if one takes a toad in his hands, or if a toad touches him anywhere he will "catch the warts." This is not so at all, as has been proved over and over again. If a toad is handled gently and petted a little, it soon learns not to be afraid, and seems to enjoy the kindness and attention. If a toad is hurt or roughly handled, a whitish, acrid substance is poured out of the largest warts. This might smart a little if it got into the mouth, as dogs find out when they try biting a toad. It cannot be very bad, however, or the hawks, owls, crows and snakes that eat the toad would give up the practice. The toad is really one of the most harmless creatures in the world, and has never been known to hurt a man or a child.

A boy might possibly have some warts on his hands after handling a toad; so might he after handling a jack-knife or looking at a steam engine; but the toad does not give the warts any more than the knife or the engine.

Living without air and food.—Occasionally one reads or hears a story about a toad found in a cavity in a solid rock. When the rock is broken open, it is said that the toad wakes up and hops around as if it had been asleep only half an hour. Just think for a moment what it would mean to find a live toad within a cavity in a solid rock. It must have been there for thousands, if not for millions of years without food or air. The toad does not like a long fast, but can stand it for a year or so without food if it is in a moist place and supplied with air. It regularly sleeps four or five months every winter, but never in a place devoid of air. If the air were cut off the toad would soon die. Some careful experiments were made by French scientific men, and the stories told about toads living indefinitely without air or food were utterly disproved.

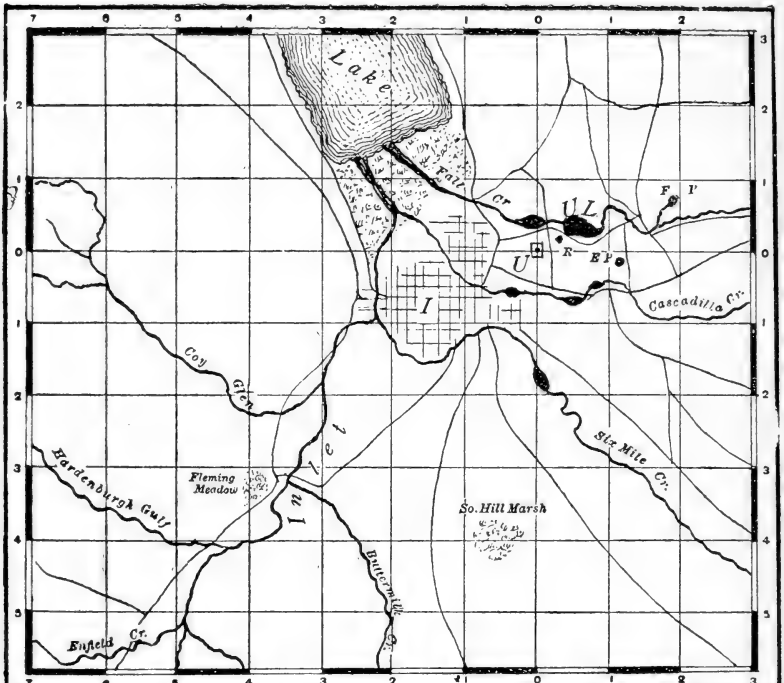
It is not difficult to see that one working in a quarry might honestly think that he had found a toad in a rock. Toads are not very uncommon in quarries. If a stone were broken open and a cavity found in it, and then a toad were seen hopping away, one might jump at the conclusion that the toad came out of the cavity in the rock. Is not this something like the belief that the little toads rain down from the clouds because they are most commonly seen after a shower?

Surveys and Maps.

In considering the suggestions made in this leaflet, we thought of the hundreds of schools throughout the state and wondered if there might not be some difficulty in finding the ponds where the toads lay their eggs, and in finding some of the things described in the other leaflets.

The teachers and students in Cornell University found this difficulty twenty-eight years ago when the University opened. The great Louis Agassiz came to the University at the beginning to give a course of lectures on nature study. The inspiration of his presence and advice, and of those lectures, lasts to this day.

Agassiz, and the University teachers, who had many of them been his pupils, saw at once that the region around Ithaca must be full of interesting things; but they did not know exactly where to find them. Agassiz himself made some explorations, and the professors and students took hold of the work with the greatest enthusiasm. They explored the beautiful lake, the streams, hills, valleys, gorges, ponds and marshes. Careful notes were kept of the exact locality where every interesting thing was found; and simple maps were made to aid in finding the places again. Finally, after several years, knowledge enough was gained to construct an accurate map for the use of all.



Simple map showing the position of Cornell University, the city of Ithaca, Cayuga Lake, and the roads and streams and ponds near the University. From W. R. Dudley's map in "The Cayuga Flora." Scale, 1 centimeter to the kilometer.

U. Cornell University.

U. L. University Lake in Fall Creek.

R. Reservoir supplied from University Lake and supplying the campus.

E. P. East Pond where the eggs of the toad, tree toad, frogs and salamanders are found.

F. P. Forest Home Pond. A very favorable place for eggs, tadpoles, etc.

Inlet. The inlet of the lake. The lampreys are abundant near Fleming's meadow.

A part of this map, showing only the most important features, is put into this leaflet to serve as a guide.

It will be seen that the University is made the central or starting point. With a few hints it is believed that every school can make a good beginning this year on a natural history survey of the region near their schoolhouse, and in the preparation of a map to go with the survey.

Preparation of the map.—It is well to have the map of good size. A half sheet of bristol board will answer, but a whole sheet is better. About the first thing to decide is the scale at which the map is to be drawn. It is better to have the scale large. Twelve inches to the mile would be convenient. Divide the map into squares, making the lines quite heavy. If so large a scale were used it would be advantageous for locating places to have the large squares divided into square inches, but much lighter lines should be used so that there will be no confusion with the lines representing the miles.

Locating objects on the map.—The corner of the schoolhouse containing the cornerstone should be taken as the starting point. If there is no cornerstone, select the most convenient corner. Put the schoolhouse on the map anywhere you wish, probably the center of the map would be the best place. In the sample map the University is not in the center as it was desired to show more of the country to the south and west than to the north and east.

The map should, of course, be made like other maps, so it will be necessary to know the four cardinal points of the compass before locating anything on it. Perhaps the schoolhouse has been placed facing exactly north and south or east and west, that is, arranged with the cardinal points of the compass; if so it will be the best guide. If you are not sure determine with a compass. With it the points can be determined quite accurately. Having determined the points of compass, commence to locate objects in the landscape on the map as follows: Get their direction from the starting point at the corner of the schoolhouse, then measure the distance accurately by running a bicycle on which is a cyclometer, straight between the starting point and the object. The cyclometer will record the distance accurately and it can be read off easily. If no bicycle with a cyclometer is available one can use a long measuring stick, a tape measure or even a measured string; but the bicycle and cyclometer are more convenient and accurate, especially when the distances are considerable.

Suppose the distance is found to be one-sixth of a mile due west. It should be located two inches west of the corner taken as the starting point. If the direction were south-west then the two inches would be measured on the map in that direction and located accordingly. Proceed in this way for locating any pond or marsh, forest or glen. Now, when the places are located on the map, you can see how easy it would be for any one to find the places themselves. While the exact position should be determined, if possible, and located, one does not often take a bee-line in visiting them, but goes in roads, often a long distance around. In locating the objects on the map every effort should be made to get them accurately placed, and this can only be done by knowing the distances in a straight line.

It is hoped that every school in the state will begin making a natural history survey and a map of the region around its schoolhouse this year. The map will show but few locations, perhaps, but it can be added to from year to year, just as the University map has been added to; and finally each school will have a map and notes showing exactly where the toads lay their eggs, where fish and birds are; and where the newts and salamanders, the different trees and flowers, rocks and fossils may be found.

If the dates are kept accurately for the different years one can also see how much variation there is. Indeed, such nature study will give a sure foundation for appreciating and comprehending the larger questions in natural science, and it will make an almost perfect preparation for taking part in or for appreciating the great surveys of a state or a country. It is believed that if accurate information were collected and careful maps made by the different schools, the Empire State could soon have a natural history survey and map better than any in the world.

To the Teacher:

It is the firm belief of those who advocate "Nature Study" that it is not only valuable in itself, but that it will help to give enjoyment in other studies, and meaning to them. Every pupil who follows out the work of this leaflet will see the need of a map of the region around the schoolhouse. This will help in the appreciation of map work generally.

So many of the beautiful and inspiring things in literature are concerning some phase of nature, that "Nature Study" must increase the appreciation of the literature, and the noble thoughts in the literature will help the pupils to look for and appreciate the finer things in nature.

It is suggested that as many of the following selections as possible be read in connection with the leaflet:

"The Fiftieth Birthday of Agassiz," by Longfellow; the "Prayer of Agassiz," by Whittier. (This describes an actual occurrence.)

The first part of Bryant's "Thanatopsis," Coleridge's "Ancient Mariner," Burns' "On Scaring Some Water Fowl in Loch-Turit" and "To a Mouse."

Cowper's "The Task," a selection from Book VI., commencing with line 560. This gives a very just view of the rights of the lower animals. Kipling's Jungle stories will help to give an appreciation of the world from the standpoint of the animals.

In connection with the disappearance of the tail, read Lowell's "Festina Lente," in the Biglow Papers. For older pupils, Shakespeare's picture of the seven ages in the human life cycle might be read. "As You Like It," Act II., Scene II., near the end, commencing, "All the world's a stage," etc.

TEACHER'S LEAFLETS.

FOR USE IN THE PUBLIC SCHOOLS.

PREPARED BY

SECOND EDITION.

No. 10.

JUNE 10, 1898.

THE COLLEGE OF AGRICULTURE, CORNELL UNIVERSITY,

ITHACA, N. Y.

Issued under Chapter 67, of the Laws of 1898.

I. P. ROBERTS DIRECTOR.

The Birds and I.

BY L. H. BAILEY.

The springtime belongs to the birds and me. We own it. We know when the Mayflowers and the buttercups bloom. We know when the first frogs peep. We watch the awakening of the woods. We are wet by the warm April showers. We go where we will, and we are companions. Every tree and brook and blade of grass is ours; and our hearts are full of song.

There are boys who kill the birds, and girls who want to catch them and put them in cages; and there are others who steal their eggs. The birds are not partners with them; they are only servants. Birds, like people, sing for their friends, not for their masters. I am sure that one cannot think much of the springtime and the flowers if his heart is always set upon killing or catching something. We are happy when we are free; and so are the birds.

The birds and I get acquainted all over again every spring. They have seen strange lands in the winter, and all the brooks and woods have been covered with snow. So we run and romp together, and find all the nooks and crannies which we had half forgotten since October. The birds remember the old places. The wrens pull the sticks from the old hollow rail and seem to be wild with joy to see the place again. They must be the same wrens that were here last year and the year before, for strangers could not make so much fuss over an old rail. The bluebirds and wrens look into every crack and corner for a place in which to build, and the robins and chipping-sparrows explore every tree in the old orchard.

If the birds want to live with us, we should encourage them. The first thing to do is to let them alone. Let them be as free from danger and fear as you or I. Take the hammer off the old gun, give pussy so much to eat that she will not care to hunt for birds, and keep away the boys who steal eggs and who carry sling-shots and throw stones. Plant trees and bushes about the borders of the place, and let some of them, at least, grow into tangles; then, even in the back yard, the wary cat-bird may make its home. We once told you how to make a garden ("The Children's Garden," Leaflet No. 4); in this garden we will now put the birds!

For some kinds of birds we can build houses. Some of the many forms which can be used are shown in the pictures. Any ingenious boy can suggest a dozen other patterns. Although birds may not appreciate architecture, it is well to make the houses neat and tasty by taking pains to have the proportions right. The floor space in each compartment should be not less than five by six inches, and six by six or six by eight may be better. By cutting the boards in multiples of these numbers, one can easily make a house with several compartments; for there are some birds, as martins, tree swallows and pigeons that like to live in families or colonies. The size of the doorway is important. It should be just large enough to admit the bird. A larger opening not only looks bad, but it exposes the inhabitants to danger of cats and other enemies. Birds which build in houses, aside from doves and pigeons, are bluebirds, wrens, tree swallows, martins, and sometimes the chickadee. For the wren and chickadee the opening should be an inch-and-a-half auger hole, and for the others it should be two inches. Only one opening should be provided for each house or compartment. A perch or doorstep should be provided just below each door. It is here that the birds often stop to arrange their toilets; and when the mistress is busy with domestic affairs indoors the male-bird often sits outside and entertains her with the latest neighborhood gossip. These houses should be placed on poles or on buildings in somewhat secluded places. Martins and tree-swallows like to build their nest 25 feet or more above the ground, but the other birds usually prefer an elevation less than 12 feet. Newly made houses, and particularly newly painted ones, do not often attract the birds.

But if the birds and I are companions, I must know them more intimately. Merely building houses for them is not enough. I want to know live and happy birds, not dead ones. We are not to know them, then, by catching them, nor stuffing them, nor collecting their eggs. Persons who make a business of studying birds may shoot birds now and then, and collect their eggs. But these persons are scientists and they are grown-up people. They are trying to add to the sum of human knowledge, but we want to know birds just because we want to. But even scientists do not take specimens recklessly. They do not rob nests. They do not kill brooding birds. They do not make collections merely for the sake of making them; and even their collections are less valuable than a knowledge of the bird as it lives and flies and sings.

Boys and girls should not make collections of eggs, for these collections are mere curiosities, as collections of spools and marbles are. They may afford some entertainment, to be sure, but one can find amusement in harmless ways. Some people think that making collections makes one a naturalist, but it does not. The naturalist cares more for things as they really are in their own homes than for museum specimens. One does not love the birds when he steals their eggs and breaks up their homes; and he is depriving the farmer of one of his best friends, for birds keep insects in check!

Stuffed birds do not sing and empty eggs do not hatch. Then let us go to the fields and watch the birds. Sit down on the soft grass and try to make out what the robin is doing on yonder fence or why the wren is bursting with song in the thicket. An opera glass or spy glass will bring them close to you. Try to find out not only what the colors and shapes and sizes are, but what their habits are. What does the bird eat? How much does it eat? Where is its nest? How many eggs does it lay? What color are they? How long does the mother bird set? Does the father bird care for her when she is setting? For how long do the young birds remain in the nest? Who feeds them? What are they fed? Is there more than one brood in the season? Where do the birds go after breeding? Do they change their plumage? Are the mother birds and father birds unlike in size or color? How many kinds of birds do you know?

These are some of the things which every boy or girl wants to know; and we can find out by watching the birds! There is no harm in visiting the nests, if one does it in the right way. I have visited hundreds of them and have kept many records of the number of eggs and the dates when they were laid, how long before they hatched, and when the birds flew away; and the birds took no offense at my inquisitiveness. These are some of the cautions to be observed: Watch only those nests which can be seen without climbing, for if you have to climb the tree the birds will resent it. Make the visit when the birds are absent if possible; at least, never scare the bird from the nest. Do not touch the eggs or the nest. Make your visit very short. Make up your mind just what you want to see, then look in quickly and pass on. Do not go too often, once or twice a day will be sufficient. Do not take the other children with you, for you are then apt to stay too long and to offend the birds.

Now let us see how intimately you can become acquainted with some bird this summer.

FIG. 1.

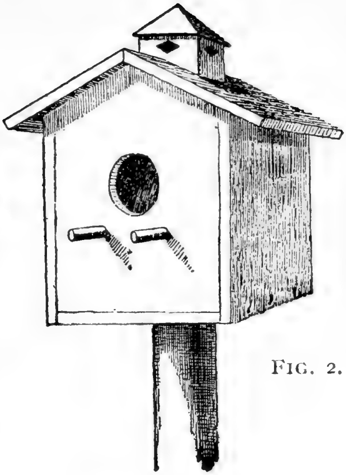


FIG. 2.

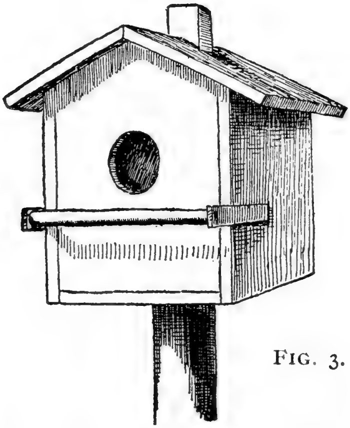


FIG. 3.

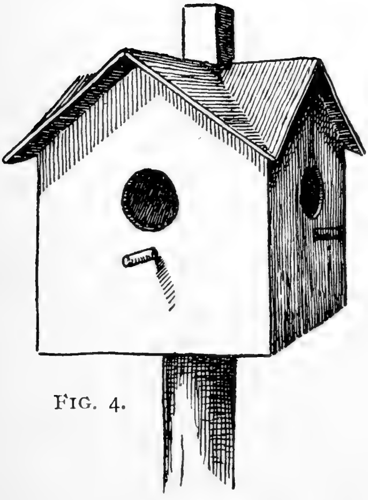


FIG. 4.

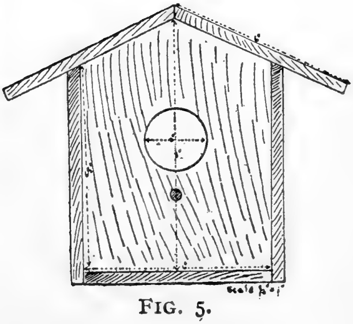


FIG. 5.

Suggestions for bird houses.

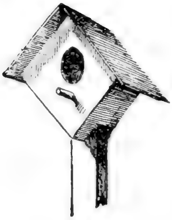


FIG. 6.

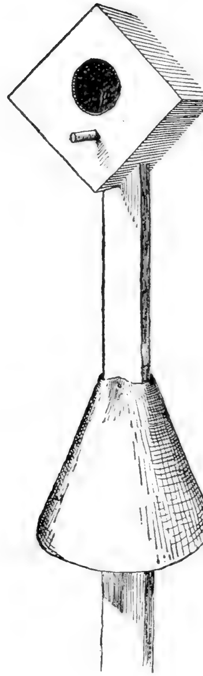


FIG. 7.

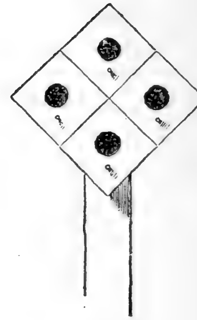


FIG. 8.

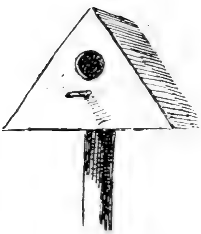


FIG. 9.

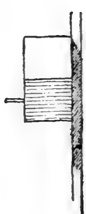


FIG. 10.

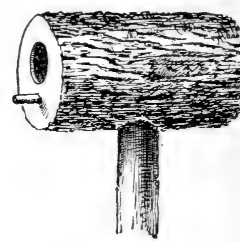


FIG. 11.

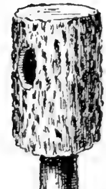


FIG. 12.

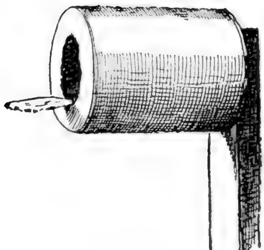


FIG. 13.

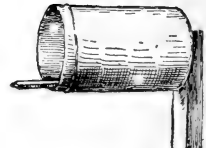


FIG. 14.

Improvised bird houses.

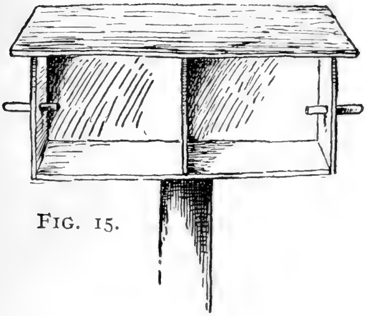


FIG. 15.

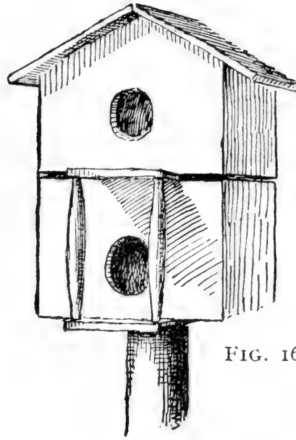


FIG. 16.

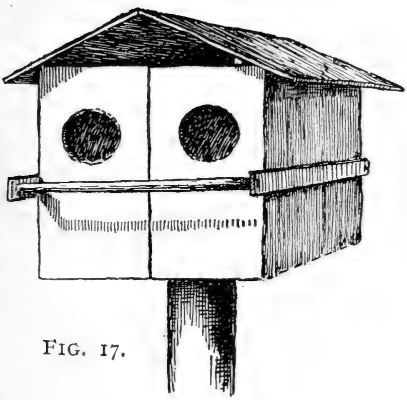


FIG. 17.

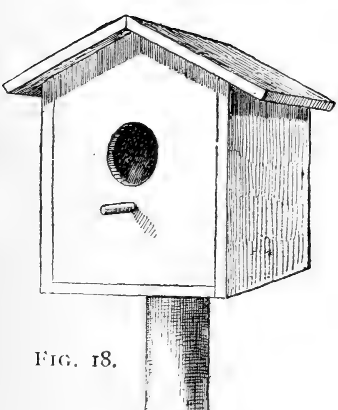


FIG. 18.

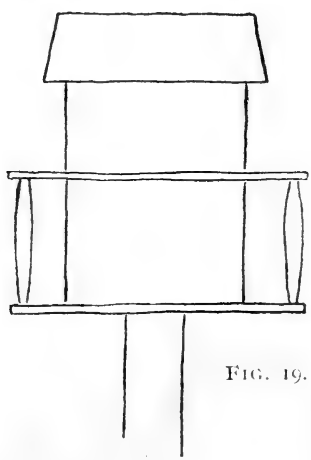


FIG. 19.

Suggestions for bird houses.

TO THE TEACHER :

These leaflets are designed to suggest means and methods by which you may interest children in nature study. The ultimate object of our work is to inculcate a love for country life, and this can best be done by interesting the coming generation in country things. You will also find nature study to be directly valuable as a means of education, or training the mind of the child. We want your full co-operation and your unreserved criticism. Any communication which you may send to us will receive prompt and direct attention.

The present leaflet is a companion to " The Children's Garden," since it is designed as much for the pupil as for the teacher. Its particular mission is to set the pupil right in his way of thinking about birds and in his method of watching them. It will set him to work. It will give him something new and fresh to think about. It cannot be used directly in schoolroom work as well as some others of the series. It is expected, however, that the outlines of bird houses will afford useful problems for classes in drawing; and we ask for suggestions on this point from teachers of drawing.

The following leaflets have been issued to aid teachers in the public schools of the State of New York in presenting nature study subjects to the pupils at odd times.

1. *How a squash plant gets out of the seed.*
2. *How a candle burns.*
3. *Four apple twigs.*
4. *A children's garden. For the pupils.*
5. *Some tent makers.*
6. *What is nature study?*
7. *Hints on making collections of insects.*
8. *The leaves and acorns of our common oaks.*
9. *The life history of the toad.*

Teachers and others wishing copies of these leaflets should address:

Chief Clerk,
College of Agriculture,
Ithaca, N. Y.

TEACHER'S LEAFLETS ON

NATURE STUDY.

No. 11.

TEACHER'S LEAFLETS. No. 11.

FOR USE IN THE PUBLIC SCHOOLS. APRIL, 1898.

PREPARED BY

THE COLLEGE OF AGRICULTURE,
CORNELL UNIVERSITY,

ITHACA, N. Y.

Issued under Chapter 67,
Laws of 1898.

I. P. ROBERTS, DIRECTOR.

Life in an Aquarium.

BY MARY FARRAND ROGERS.

THERE is no more fascinating adjunct to nature study than a well-kept aquarium. It is a never ending source of enjoyment, interest and instruction to students of any age. Children in the kindergarten or at home will watch with delight the lively occupants, cutting all sorts of queer capers for their amusement, and older people may read some of nature's choicest secrets through the glassy sides of the little water world. To many, the word aquarium suggests a vision of an elaborately constructed glass box, ornamented with impossible rock-work and strange water plants, or a globe in which discouraged and sickly looking goldfish appear and disappear, and take strange, uncanny shapes as they dart hither and thither.

Such forms of aquaria have their place in the world, but they are not suited to the needs of an ordinary school room. Every school may have some sort of an aquarium if the teacher and pupils are willing to give it some daily thought and care. Without such attention a fine aquarium may become an unsightly and disagreeable object, its inhabitants unhealthy and its beauty and usefulness lost.

The great fundamental principle underlying success in making and maintaining an aquarium is this: *imitate nature.* We all know how much easier it is to formulate a principle, and even to write a book about it, than it is to put it into practice. Most of us have not had the time and opportunity for the close observation of nature necessary to interpret her methods and imitate her. It is to those teachers who are anxious to learn what nature has to teach and to lead their pupils to a higher and wider conception of life, that these suggestions are offered.

FIG. 1.—*A museum-jar aquarium.* (*More animal life would make a better equilibrium.*)

Four things are important in making and keeping an aquarium:

1. The equilibrium between plant and animal life must be secured and maintained. It is probable that an aquarium in an elementary school is mainly used for the study of animal life; but animals do not thrive in water where no plants are growing. Nature keeps plants and animals in the same pond and we must follow her lead. The plants have three valuable functions in the aquarium. First, they supply food for the herbivorous creatures. Second, they give off a quantity of oxygen which is necessary to the life of the animals. Third, they take up from the water the poisonous carbonic acid gas which passes from the bodies of the animals. Just how the plants do this is another story.

2. The aquarium must be ventilated. Every little fish, snail, and insect wants air, just as every boy and girl wants it. A certain quantity of air is mixed with the water, and the creatures must breathe that

or come to the surface for their supply. How does Mother Nature manage the ventilation of her aquaria, the ponds and streams? The plants furnish part of the air, as we have seen. The open pond, whose surface is ruffled by every passing breeze, is constantly being provided with fresh air. A tadpole or a fish can no more live in a long-necked bottle than a boy can live in a chimney.

3. The temperature should be kept between 40° and 50° Fahr. Both nature and experience teach us this. A shady corner is a better place for the aquarium than a sunny window on a warm day.

4. It is well to choose such animals for the aquarium as are adapted to life in still water. Unless one has an arrangement of water pipes to supply a constant flow of water through the aquarium it is best not to try to keep creatures that we find in swift streams.

Practical experience shows that there are certain dangers to guard against — dangers which may result in the unnecessary suffering of the innocent. Perhaps the most serious results come from overstocking. It is better to have too few plants or animals than too many of either. A great deal of light, especially bright sunlight, is not good for the aquarium. A pond that is not shaded soon becomes green with a thick growth of slime, or algæ. This does not look well in an aquarium and is apt to take up so much of the plant food that the other plants are "starved out." The plants in the schoolroom window will shade the aquarium nicely, just as the trees and shrubs on its banks shade the pond. If we find this slime forming on the light side of our miniature pond we put it in a darker place, shade it heavily so that the light comes in from the top only, and put in a few more snails. These will make quick work of the green slime, for they are fond of it, if we are not.

Some of the most innocent of our "water nymphs" are really concealing habits which we can hardly approve. There are some which feed on their smaller and weaker neighbors, and even on the members of their own families. We know that such things go on in nature, but if we wish to have a happy family we may improve on nature and keep the cannibals by themselves.

After an aquarium has been filled with water and the inhabitants well established it is not necessary to change the water, except in case of accident. The water that is lost by evaporation has to be poured in gently, a little at a time, in order not to disturb the water and destroy its clearness. If a piece of rubber tubing is available, a practical use of the siphon can be shown and the aquarium replenished at the same time. It is a good plan to use rain water, or clear water from a pond, for this purpose.

A piece of thin board or a pane of glass may be used as a cover to keep the dust out of the aquarium. This need not fit tightly or be left on all the time. A wire netting or a cover of thin cotton net would keep the flying insects from escaping, and might be tied on permanently. Dust may be skimmed off the top of the water or removed by laying pieces of blotting paper on the surface for a moment.

If any of the inhabitants do not take kindly to the life in the aquarium, they can be taken out and kept in a jar by themselves — a sort of fresh air and cold water cure. If any chance to die, they ought to be removed before they make the water unfit for the others. Bits of charcoal in the water are helpful if a deodorizer or disinfectant is needed.

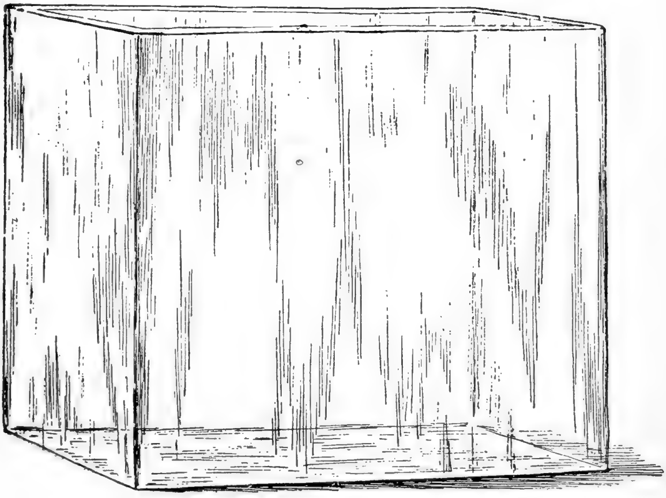


FIG. 2.—*A rectangular glass aquarium.*

Experience, the dear but thorough teacher, is of more value to every one of us than many rules and precepts. Nothing can rob us of the pleasure that comes of finding things out for ourselves. Much of the fun as well as much of the success in life comes from overcoming its difficulties. One must have a large store of patience and courage and hopefulness to undertake the care of an aquarium. After it is once made it is less trouble to take care of than a canary or a pet rabbit. But most things that are worth doing require patience, courage and hopefulness, and if we can add to our store of either by our study of life in an aquarium we are so much the better for it.

Two kinds of aquaria will be found useful in any school. Permanent ones—those which are expected to continue through a season or through a whole year if the schoolroom is warm enough to prevent freezing; and temporary ones—those which are for lesson hours or for the study of special forms.

If some one phase in the life of any aquatic animal is to be studied during a short period, it is well to have special temporary aquaria. Also when a talk on some of the occupants of the larger aquarium is to be given, specimens may be placed in small vessels for the time being and returned later. For such purposes glass tumblers can be used, or small fruit jars, finger bowls, broken goblets set in blocks of wood, ordinary white bowls or dishes, tubs, pails or tanks for large fishes, in fact any wide-mouthed dish which is easy to get. Special suggestions will be made in connection with the study of some of the water insects and others.

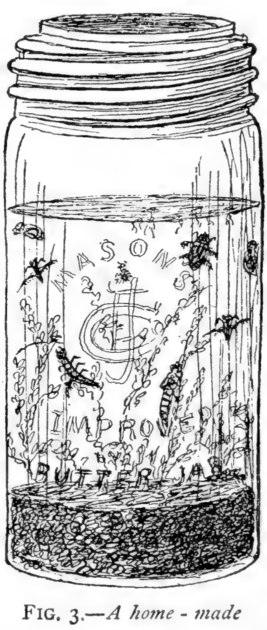


FIG. 3.—*A home-made aquarium.*

A permanent aquarium need not be an expensive affair. The rectangular ones are best if large fishes are to be kept, but they are not essential. Here again, it is easier to write directions for the construction of a perfect aquarium, than it is for the most patient teacher, with the help of the boys who are handy with tools, to put together a box of wood and glass which will not spring a leak some day and spoil everything. But failures do not discourage us; they only make us more determined. If a rectangular, water-tight box is out of the question, what is the next best thing? One of the busiest laboratories in New York State has plants and animals living in jars of all shapes and sizes; fruit jars, glass butter jars, candy jars, battery jars, museum jars, and others of like nature. There are rectangular and round aquaria of various sizes kept by all firms who deal in laboratory supplies, and if some money is to be spent, one of these is a good investment. Figure 2 shows one of these rectangular ones, and figure 21 shows a round one of small size which is useful and does not cost much.

A simple home-made aquarium of glass and wood is described in Jackman's "Nature Study" as follows: * "Use an inch board $11\frac{1}{2}$

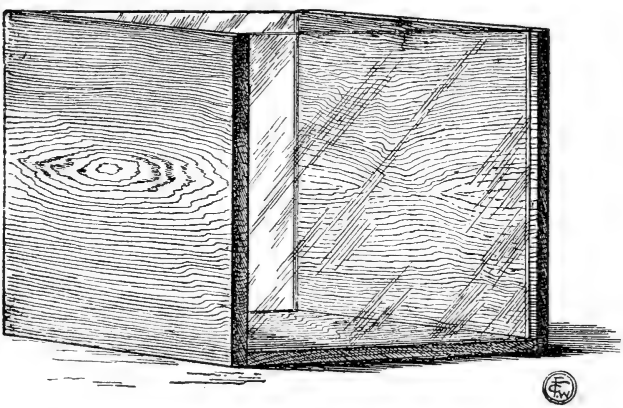


FIG. 4.—*Permanent aquarium made of wood and glass.*

inches wide and 12 inches long for the bottom, and two boards of the same thickness and length, $10\frac{3}{4}$ inches high for the ends. Three-eighths of an inch from the edge on either side, with a saw, make a groove one-quarter of an inch deep, and wide enough to receive loosely double strength glass. Groove the end boards and fasten

---

* The dimensions have been changed slightly from Jackman's text.

them to the bottom with screws so that the grooves will exactly match. Partially fill the grooves with soft putty, or better, aquarium cement, and press into each side a pane of glass. By making the bottom board 11½ inches long, an ordinary 10 x 12 window pane will be the proper size. When the glass is pressed to the bottom of the groove, draw the two ends in at the top until the glass is held firmly and then fasten them in place by narrow strips of wood,

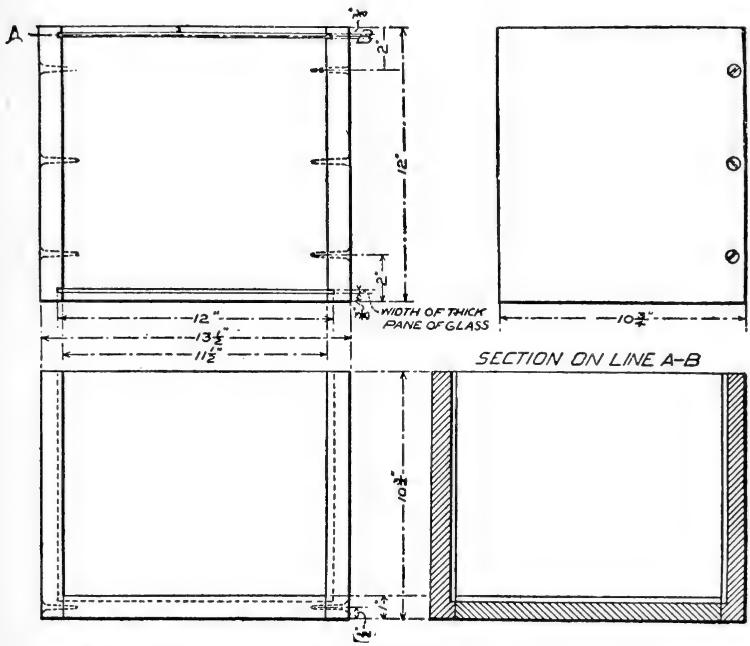


FIG. 5.—*Working drawings for making box shown in figure 4.*

one on each side of the tank, placed on top of the glass and screwed to the end pieces. These strips also protect the hands from injury while working with the specimens in the aquarium. Before filling with water, the inner surface of the bottom and ends should be well rubbed with oil or paraffine and the grooves inside the glass well packed with putty."

Some boy who loves tools and likes better to do things than to read about them will take more interest in the aquarium and its occupants, and in his drawing too, if he can take the drawings given here and try his hand at a difficult subject like this for school use.

After the box is made it would be well to let it stand in water for a day or two. The wooden sides will swell and tighten the joints, and leaking will be less probable.

It is now time to begin to think about what shall be kept in the aquarium. At the bottom a layer of sand, the cleaner the better, two or three inches deep will be needed. A few stones, not too large, may be dropped in on top of this first layer, to make it more natural.

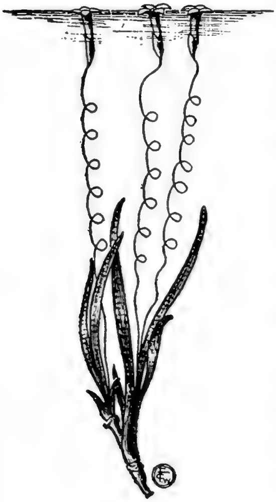


FIG. 6.—*Eel-grass.*

The water plants come next and will thrive best if planted securely in the sand. The most diffiult thing is to get the water in without stirring things up. A good way is to pour the water in a slow stream against the inside of the aquarium. The best way is to use a rubber tube siphon, but even then the water ought not to flow from a very great height. If the aquarium is large it had better be put in its permanent place before filling.

The aquarium will soon be ready for snails, polliwogs, and whatever else we may wish to put into it. In the course of a few days the plants will be giving up oxygen and asking for carbon dioxide.

Plants which thrive and are useful in aquaria.—Many of the common marsh or pond plants are suitable. The accompanying illustrations show a few of these. Nothing can be prettier than some of these soft, delicate plants in the water. The eel-grass, or tape-grass (figure 6), is an interesting study in itself, especially at blossoming time when the spiral stems bearing flowers, appear.

Any who are especially interested in the life-history of this plant can read in reference books a great deal about what other observers have learned from the plant about its methods of growth and development. The best that we learn will be what the plant itself tells us day by day.

Some of the best reference books on both plant and animal life are found in the New York State Teachers' Library and can be obtained by teachers through the school commissioners.

Every boy and girl who likes to taste the fresh, peppery plants which they find growing in cold springs knows watercress. If the aquarium is not too deep, this plant will grow above the surface and furnish a resting place for some snail which, tired perhaps by its constant activity, enjoys a few minutes in the open air.

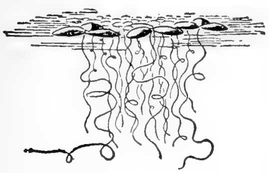


FIG. 7 —*Duckweed.*

Duckweed or duck's-meat (figure 7), grows on the surface, dangling its long thread-like roots in the water. A little of it is enough. Too much would keep us from looking down upon our little friends in the water.

The parrot's feather (figure 8, A), is an ornamental water plant that can be obtained from a florist; there is one that looks very like it which grows in our ponds. It is called water-milfoil.

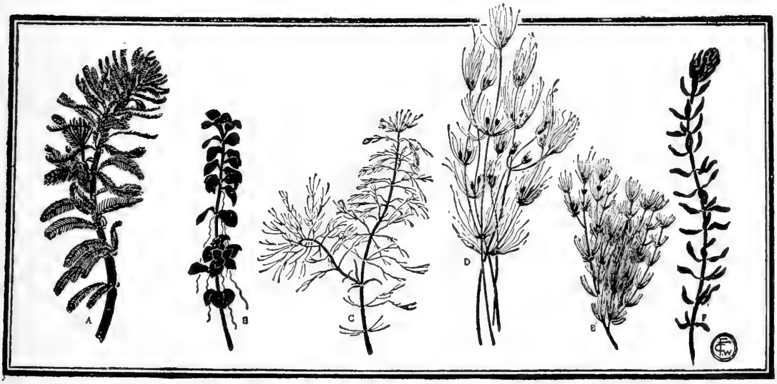


FIG. 8.—*Water plants.*

The water purslane, B, or the common stoneworts, *Nitella* and *Chara*, D, E; the water-weed, F, and the horn-wort, C, look graceful and pretty in the water. If you do not find any of these, you are sure to find others growing in the ponds in your neighborhood which will answer the purpose just as well.

Animals that may be kept in aquaria.—The snail. The common pond snail with the spiral shell, either flat or conical, can be found clinging to the stems of the cat-tails or flags and to floating rubbish in ponds or swamps. If these are picked off carefully and taken home in a pail of water they will be valuable inhabitants for the aquarium. They are vegetable feeders and unless there is some green slime in the water, cabbage or lettuce leaves can be put where the snails can get them. The eggs of the snail are excellent food for fishes, and if a few could be secured for special study, their form, habits and development can be made delightful observation and drawing lessons. Snails can be kept out of the water for some time on moist earth. Land snails and slugs should be kept on wet sand and fed with lettuce and cabbage leaves. The common slug of the garden is often injurious to vegetation. It can always be tracked by the trail of slime it leaves behind it. Gardeners often protect plants by sprinkling wood-ashes about them.

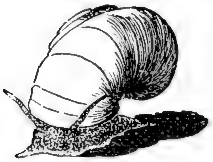


FIG 9 —*Snail.*

Minnows.—Every boy knows where to find these spry little fellows. They can be collected with a dipper or net and will thrive in an aquarium if fed with worms, flies, or other insects. If kept in small quarters where food is scarce they will soon dispatch the other occupants of the jar. They will, however, eat bits of fresh meat. If the aquarium is large enough it would hardly be complete without minnows.

FIG. 10.—*Snail with conical shell.*

Catfish.—It will not be practicable to keep a catfish in the permanent aquarium. If one is to be studied it can be obtained at any fish market or by angling, a slow method, but one which will appeal to every boy in the class. It should be kept in a tub, tank, or large pan of water, and if not wanted for laboratory work, it might be fried for lunch, as catfish are very good eating.

Goldfish are a special delight if kept in large aquaria. These can often be obtained from dealers in the larger cities. Those who wish to obtain other fish for study should write to the New York State Fish Culturist, Glens Falls, N. Y., who will tell them what species are suited to life in still water and how to get and take care of them.

The clam.—If empty clam shells are plenty on the bank of some stream after a freshet, a supply of clams can be obtained by raking the mud or sand at the bottom of the stream. They can be kept in a shallow pan, and if the water is warmish and they are left undisturbed for a time they will move about. If kept in a jar of damp sand they will probably bury themselves. They feed on microscopic plants and might not thrive in the permanent aquarium.

Crawfish or crayfish.—These can be collected with nets from under stones in creeks or ponds. They can live very comfortably out of the water part of the time. There is small chance for the unsuspecting snail or water insect which comes within reach of the hungry jaws of the crawfish, and the temporary aquarium is the safest place for him. Many who live near the ocean can obtain and keep in sea water the lobster, a cousin of the crawfish, and will find that the habits of either will afford much amusement as well as instruction.

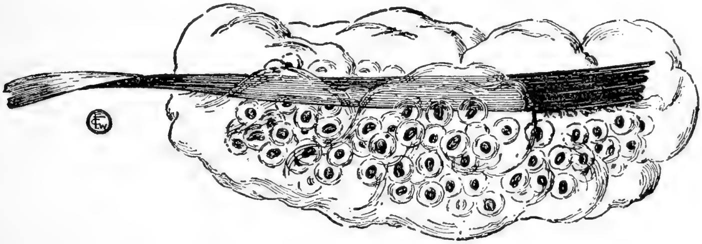


FIG. 11.—"*Frog spawn.*"

The frog.—The study of the development of the common frog is accompanied with little or no difficulty. To be sure there are some species which require two or three years to complete their growth and changes, from the egg to the adult, but most of the changes can be seen in one year. Frogs are not at all shy in the spring, proclaiming their whereabouts in no uncertain tones from every pond in the neighborhood. The "frog spawn" can be found clinging to plants or rubbish in masses varying in size from a cluster of two or three eggs to great lumps as large as the two fists. The "spawn" is a transparent jelly in which the eggs are imbedded. Each egg is dark colored, spherical in shape, and about as large as a small pea. The eggs of the small spotted salamander are found in similar masses of jelly and look very much like the frog's eggs. If a small quantity of this jelly-like mass be secured by means of a collecting net or by wading in for it, it can be kept in a flat white dish with just enough clean, cool water to cover it, until the young tadpoles have hatched. As they grow larger, a few may be transferred to a permanent aquarium prepared especially for them in a dish with sloping sides, and their changes watched from week to week through the season. The growing polliwog feeds on vegetable diet; what does the full-grown frog eat?

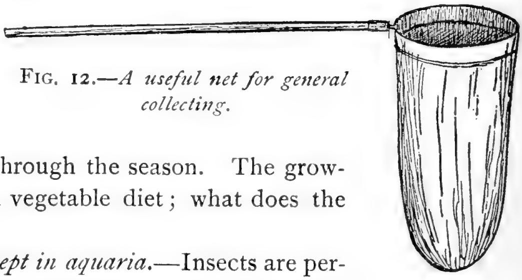


FIG. 12.—*A useful net for general collecting.*

Insects that can be kept in aquaria.—Insects are perhaps the most delightful creatures that one can keep in aquaria. They are plenty, easy to get, every one of the many kinds seems to have habits peculiar to itself, and each more curious and interesting than the last.

Some insects spend their entire life in the water; others are aquatic during one stage of their existence only. Those described here are but a few of those found in the central part of the state of New York, in ponds and sluggish streams. If these cannot be found, others just as interesting can be kept instead. One can hardly make a single dip with a net without bringing out of their hiding places many of these "little people."

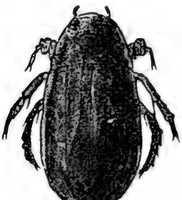


FIG. 13.—*The predaceous diving-beetle.*

The predaceous diving-beetle (figure 13) is well named. He is a diver by profession and is a skilled one. The young of this beetle are known as "water-tigers" (figure 14) and their habits justify the name. Their food consists of the young of other insects; in fact we would better keep them by themselves unless we wish to have the aquarium depopulated. When the tiger has reached his full size, his form changes and he rests for a time as a pupa and then comes forth as a hard, shiny beetle like figure 13.

The water-scavenger beetle (figure 15), so called because of his appetite for decayed matter, is common in many ponds. It has, like the diving beetle, a hard, shiny back, with a straight line down the middle, but they can be distinguished when seen together. The young of this beetle look something like the "water-tiger" but have not such great, ugly jaws.

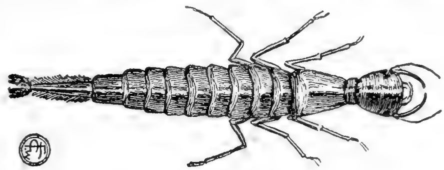


FIG. 14.—*A water-tiger.*

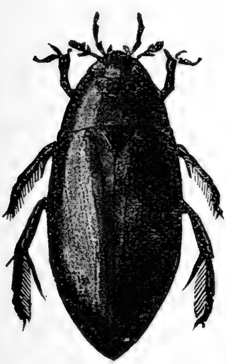


FIG. 15.—*A water-scavenger beetle.*

There are three other swimmers even more delightful to watch than those already mentioned. The water-boatmen (figure 16), with their sturdy oar-like legs and business-like way of using them, are droll little fellows. They are not so large as the back-swimmers. Figure 17 shows a back-swimmer just in the act of pulling a stroke. These creatures swim with their boat-shaped backs down and their six legs up. We must be careful how we handle the back-swimmers, for they carry a sharp bill and may give us a thrust with it which would be painful.

The water-scorpion (figure 18) is a queer creature living in a neighborly way with the boatmen and back-swimmers, though not so easy to find. Do not throw away any dirty little twig which you find in the net after a dip among water plants near the bottom of a stream or pond. It may begin to squirm and reveal the fact that it is no twig but a slender-legged insect with a spindle-shaped body. We may handle it without danger, as it is harmless. This is a water-scorpion, and his way of catching his prey and getting his air supply will be interesting to watch. He is not shy

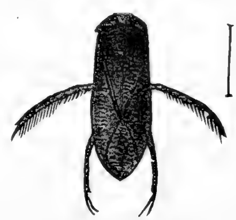


FIG. 16.—*Water-boatman.*

and will answer questions about himself promptly and cheerfully. Figure 18 will give an idea of the size and appearance of this curious insect.

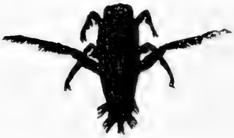


FIG. 17.—*A back-swimmer.*

No water insect except the big scavenger beetle can begin to compare in size with the giant water-bug (figure 19). We may think at first that he is a beetle, but the way he crosses his wings on his back proves him to be a bug. In quiet ponds these giants are common enough, but the boy or girl who "bags" a full-grown one at the first dip of the net may be considered lucky.

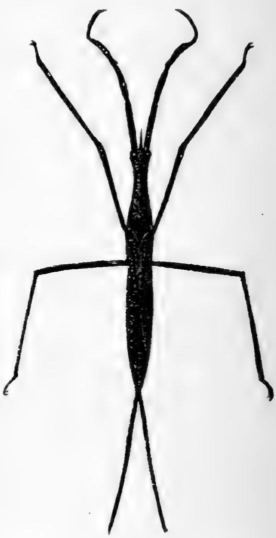


FIG. 18.—*Water-scorpion.*

The boatmen, back-swimmers, and giants all have oars, but are not entirely dependent on them. They have strong wings too, and if their old home gets too thickly settled, and the other insects on which they feed are scarce, they fly away to another place. The giant water-bug often migrates at night and is attracted to any bright light he sees in his journey. This habit has given him the popular name "electric-light bug."

FIG. 19.—*Giant water-bug.*

Among the insects which spend but part of their life in the water, we shall find many surprises. It made us feel queer when we found that the restless but innocent looking wiggler of the rainwater barrel was really the young of the too familiar mosquito. The adult mosquito leaves its eggs in tiny boat-shaped masses on the surface of stagnant water, where food will be abundant for the young which soon appear. Some time is spent by the wigglers in eating and growing before they curl up into pupæ. Insects are rarely active in the pupa stage. The mosquito is one of the very few exceptions. From these lively pupæ the full-grown mosquitoes emerge. Figure 20 shows a small glass tumbler in which the three aquatic stages of the mosquito's life are seen and an adult just leaving the pupa skin. Nothing is easier than to watch the entire development of the mosquito, and the changes must be seen to be fully enjoyed and appreciated. It would be interesting to note the differences between the mosquitoes that come out of the small aquaria. A supply of wigglers should be kept in the permanent aquarium as food for the other insects.

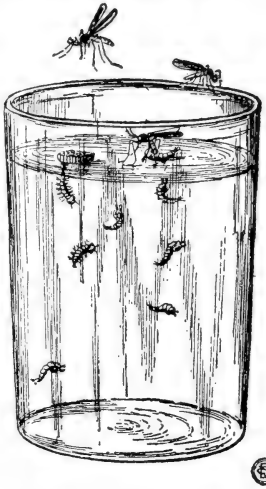


FIG. 20.—*Temporary aquarium, containing eggs, larvæ, and pupæ of mosquito.*

Every child knows the dragon-fly or darning-needle, and none but the bravest of them dare venture near one, without covering ears or eyes or mouth for fear of being sewed. There is no more wide-spread superstition concerning any insect than this one, and it is difficult to bring children to believe that this creature, besides being a thing of beauty, is not only harmless but actually beneficial. If they knew how many mosquitoes the darning-needle eats in a day they would welcome him, instead of fearing the gay creature.

The young of the dragon-fly live a groveling existence as different as can be from that of their sun-loving parents. Their food consists of mosquito larvæ, water-fleas and the like, and their method of catching their prey is as novel as it is effective. Pupils and teacher can get plenty of good, healthy entertainment out of the behavior of these awkward and voracious little mask-wearers. The first dip of the net usually brings up a supply of dragon-fly nymphs and of their more slender cousins the damsel-fly nymphs. The latter have expanded plate-like appendages at the hind end of the body which distinguish them from the dragon-fly nymphs.

The transformation of one of these young insects into an adult is one of the most interesting observation lessons that can be imagined for a warm spring morning. If a dragon-fly nymph should signify its intention of changing its form in my school room, I should certainly suspend all ordinary work and attend to him alone. Each child should see, if possible, this wonderful transfiguration.

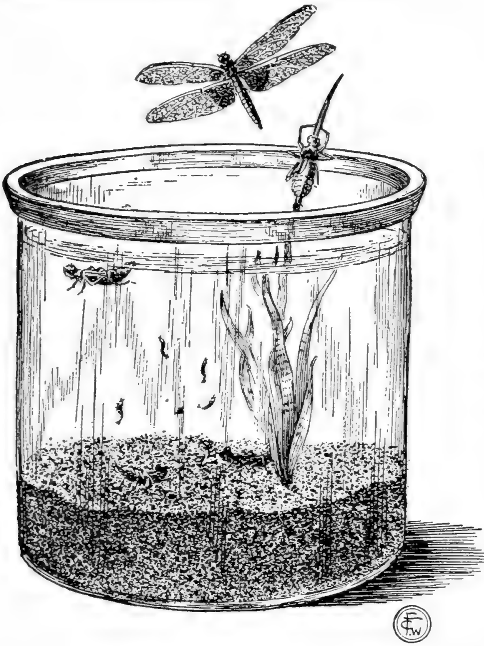


FIG. 21.—*The life history of a dragon-fly as seen in an aquarium.*

Floating in the water of a pond or stream are queer little bundles of grass or weed stems with now and then a tiny pebble clinging to the mass. Close examination will prove this to be the floating dwelling of one of our insect neighbors, the caddice-worm. Contrasting strangely with the untidy exterior is the neat interior, with its lining of delicate silk, so smooth that the soft-bodied creature which lives inside is safe from injury. The commonest of the many forms of houses found here are those illustrated in figures 22 and 23. These will find all they wish to eat in a well-stocked aquarium. When full grown they will leave the water as winged creatures, like figure 24, and return to it no more.

FIG. 22.—*Case of caddice-worm.*

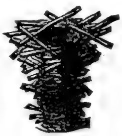


FIG. 23.—*Another caddice-worm case.*

FIG. 24.—*Caddice-fly.*

There is surely no lack of material furnished by Mother Nature for the study of aquatic life. Everyone who really believes in its usefulness can have an aquarium, and will feel well repaid for the time and effort required when the renewed interest in Nature is witnessed which this close contact with living beings brings to every student. Let us take hold with a will, overcome the difficulties in the way, and teacher and pupils become students together.

TO THE TEACHER:

A country teacher chose a boy companion for a Saturday tramp one morning in May. Armed with a long-handled dipper, a net which had been used for collecting bait, and a rusty tin pail, they crossed the fields to a meadow pond, near the edge of a wood lot. Two hours later they returned, wet-footed and tired, but triumphant. In the pail were many wiggling, squirming, swimming things which soon set up housekeeping in the various dishes, pans and glass jars which had been provided. The delight of the children knew no bounds when they found out that these cunning creatures were to be kept in the schoolroom and could be watched when they had a spare minute. The teacher's daily toil was lightened and brightened by this new interest which had been added to school life.

This was one busy teacher's way of making a beginning in nature study. If there are other teachers ready to make this kind of a start, and will let their children write and tell all about these new schoolmates, what they look like and what they do, we will gladly answer all the letters and help both teacher and pupil to take further steps in the study of nature. The sooner we hear from you on this or any other subject that interests you, the better!

TO THE TEACHER:

The following leaflets have been issued to aid teachers in the public schools in presenting nature-study subjects to the scholars at odd times:

1. *How a squash plant gets out of the seed.*
2. *How a candle burns.*
3. *Four apple twigs.*
4. *A children's garden.*
5. *Some tent makers.*
6. *What is nature study?*
7. *Hints on making collections of insects.*
8. *The leaves and acorns of our common oaks.*
9. *The life history of the toad.*
10. *The birds and I.*
11. *Life in an aquarium.*

These will be sent free to all engaged in teaching in the public schools of the State of New York.

Address,

Bureau of Nature Study,
College of Agriculture,
Ithaca, N. Y.

GENERAL INDEX.

INDEX OF CUTS.