U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 9.

THE MULBERRY SILK-WORM;

BEING A

MANUAL OF INSTRUCTIONS IN SILK-CULTURE.

BY

C. V. RILEY, M. A., PH. D.

SIXTH, REVISED EDITION.

WITH ILLUSTRATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

Compliments of

Norman J. Colman,

Commissioner of Agriculture.

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16136—No. 9

TABLE OF CONTENTS.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 20, 1888.

SIR: The sixth edition of Bulletin No. 9 of this Division, on the Silk-worm, having been exhausted, I have the honor to present for publication a seventh edition, which is little more than a reprint of the sixth, with such slight changes as late experience has suggested.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

PREFACE TO THE SECOND EDITION.*

That there exists just now a very general and widespread interest in the subject of silk-culture in the United States is manifest from the recent large increase in the correspondence of the Entomological Division in relation thereto, and from the demand made for this Manual. To avoid the disappointment that is sure to follow exaggerated and visionary notions on the subject, it may be well here to emphasize the facts that the elements of successful silk-culture on a large scale are at the present time entirely wanting in this country; that the profits of silk-culture are always so small that extensive operations by organized bodies must prove unprofitable where capital finds so many more lucrative fields for employment; that extensive silk-raising is fraught with dangers that do not beset less ambitious operations; that silk-culture, in short, as shown in this Manual, is to be recommended only as a light and pleasant employment for those members of the farmer's household who either can not do or are not engaged in otherwise remunerative work.

The want of experience is a serious obstacle to silk-culture in this country; for while, as is shown in the following pages, the mere feeding of a certain number of worms and the preparation of the cocoons for market are simple enough operations, requiring neither physical strength nor special mental qualities, yet skill and experience count for much, and the best results can not be attained without them. In Europe and Asia this experience is traditional and inherited, varying in different sections both as to methods and races of worm employed. With the great variety of soil, climate, and conditions prevailing in this country, experience in the same lines will also vary, but the general principles indicated in this Manual should govern.

The greater value of labor here as compared with labor in the older silk-growing countries has been in the past a most serious obstacle to silk-culture in the United States, but conditions exist to-day that render this obstacle by no means insuperable. In the first place, comparative prices, as so often quoted, are misleading. The girl who makes only twenty or thirty cents a day in France or Italy does as well, because

* This preface was written in 1882, and some passages are omitted which had only a temporary interest and which might be misleading to-day.

of the relatively lower prices of all other commodities there, as she who earns three or four fold as much here. Again, the conditions of life are such in those countries that every woman among the agricultural classes not absolutely necessary in the household, finds a profitable avenue for her labor in field or factory, so that the time given to silk raising must be deducted from other profitable work in which she may be employed. With us, on the contrary, there are thousands—aye, hundreds of thousands—of women who, from our very condition of life, are unable to labor in the field or factory, and have, in short, no means, outside of household duties, of converting labor into capital. The time that such might give to silk-culture would, therefore, be pure gain, and in this sense the cheap-labor argument loses nearly all its force. This holds more particularly true in the larger portion of the South and West, that are least adapted to the production of merchantable dairy products or where bee-keeping and poultry-raising are usually confined to the immediate wants of the household.

The want of a ready market for the cocoons is now, as it always has been, the most serious obstacle to be overcome, and the one to which all interested in establishing silk-culture should first direct their attention. Ignore this, and efforts to establish the industry are bound to fail, as they have failed in the past. A permanent market once established, and the other obstacles indicated will slowly, but surely, vanish as snow before the coming spring. Owing to the prevalence of disease in Europe, there grew up a considerable demand for silk-worm eggs in this country, so that several persons found the production of these eggs quite profitable. Large quantities are yet shipped across the continent from Japan each winter; but this demand is, in its nature, transient and limited, and, with the improved Pasteur method of selection and prevention of disease, silk-raisers are again producing their own eggs in Europe. Silk culture must depend for its growth, therefore, on the production of cocoons, and these will find no remunerative sale except where the silk can be reeled. I find no reason to change the views expressed relative to the part this Department might take in succoring silk-culture through Congressional aid; for, however just and desirable direct protection to the industry may be by the imposition of an import duty on reeled silk, no such protection has yet been given by Congress, and silk filatures can not be fully and profitably established without some fostering at the start. Under a heavy protective tariff our silk manufactures have rapidly grown in importance and wealth, until, during the year 1881 (according to the reports of W. C. Wyckoff, secretary of the Silk Association of America), raw silk to the value of $11,936,865 and waste silk and cocoons to the value of $769,186 were imported at the ports of New York and San Francisco, while our manufactured goods reached in value between $35,000,000 and $40,000,000. Now, the so-called raw silk thus imported to the value of nearly $12,000,000 is just as much a manufactured article as the woven goods, and its importation free of duty is as much an encouragement to foreign manufacturers and an impediment to home industry as the removal of the duty would be on the woven goods. The aid that Congress, through this Department, should, in my judgment, give to silk-reeling, and thereby to silk-production, may be supplied by private and benevolent means.

*   *   *   *   *   *   *

The obstacles which I have set forth are none of them permanent or insuperable, while we have some advantages not possessed by other countries. One of infinite importance is the inexhaustible supply of Osage Orange (*Maclura aurantiaca*) which our thousands of miles of hedges furnish; another is the greater average intelligence and ingenuity of our people, who will not be content to tread merely in the ways of the Old World, but will be quick to improve on their methods; still another may be found in the more spacious and commodious nature of the barns and outhouses of our average farmers. Every year's experience with the *Maclura* confirms all that I have said of its value as silk-worm food. Silk which I have had reeled from a race of worms fed on it, now for eleven consecutive years, is of the very best quality, while the tests made at the recent silk fair at Philadelphia showed that in some instances a less weight of cocoons spun by *Maclura*-fed worms was required for a pound of reeled silk than of cocoons from mulberry-fed worms.

C. V. R.

WASHINGTON, D. C., *February* 20, 1882.

PREFACE TO THE SIXTH EDITION.

The growing interest shown in the culture of silk, in the United States, is attested by the demands upon this Department for copies of this manual, which has hitherto been published as Special Report No. 11. Originally prepared as a brief manual, based on my own experience of the industry in America, the present demands of silk-growers, or rather of those desirous of becoming such, call for some further details, and in elaborating the work it has been thought best to include it among the bulletins of the Division. I have also divided the matter into chapters, and those on the implements which are necessary to, or facilitate, the work; those on diseases, reproduction, reeling, and the physical properties of raw silk embrace essentially new material, parts of Chapters V and VI being from my current annual report not yet distributed.

In Chapter VIII, in speaking of machinery I have omitted the detailed descriptions of special machines given in former editions and explained rather the mechanical principles that should be involved in all. A description of the Serrell Reel would have been very appropriate, but the inventor has been promised by the Commissioner that such should not be made public until all patents are secured. I shall hope to elaborate this chapter in some future edition.

It must not be forgotten that the original manual was never intended as an extended treatise on silk-raising or reeling, but was prepared to give, in a simple and most condensed way, information to those interested, and in a form applicable to the United States. It is gratifying to know that a number of other pamphlets on the Silk-worm have of late years been published, and that this manual has been quite freely used in their preparation. In one instance, in fact, an almost verbatim copy has been published and sold privately. I have found little or no occasion to alter opinions expressed in the manual, but in the present edition have revised the estimates of profits given in the Introduction to the original edition, leaving out those on egg production, because of the changed conditions since 1879, which have rendered such work, as a profitable business, obsolete in this country, and the production of sound and reliable eggs much more difficult and expensive.

Though particular pains were taken to impress upon readers the fact that the estimates of profits in silk-raising were based on definite market prices at that time, and that prices and profits must needs, as in all trades, vary from year to year, and though I especially omitted the cost of food, eggs, special buildings, etc., because the manual was addressed to those who would not have to incur these expenses (and I would not now recommend any one to embark in the industry who did not have these necessaries at command), yet these estimates have been criticised because silk-raisers have been unable to realize, in 1885, the profits which I considered attainable in 1879. For, though sharing the opinion of those directly connected with the silk trade, I then believed that the prices of raw silk and cocoons had reached as low a figure as they ever would, the belief proved subsequently unfounded, for fresh cocoons which in Europe sold in 1879 for 47 cents could be purchased, in 1885, for 35 cents per pound. Again, any estimates must needs be approximate only, as they will vary with the race.

This great alteration in the value of silk products has necessarily impaired the accuracy of the estimates given by me in the first edition of this pamphlet. I have therefore prepared another series of figures which are more nearly accurate to-day than the former ones, and are based on the French yellow race.

PROFITS OF PRODUCING COCOONS: ESTIMATES FOR TWO ADULTS, OR MAN AND WIFE.

Average number of eggs per standard ounce of 25 grams, in ordinary yellow races, 37,500.

Number of fresh cocoons per pound, 300 to 400.

Average reduction in weight for choked cocoons, 66 per cent.

Maximum amount of fresh cocoons from 1 ounce of eggs, 93 to 125 pounds.

Allowing for deaths in rearing—26 per cent. being a large estimate—we thus get as the product of an ounce of eggs 69 to 92 pounds of fresh, or 23 to 31 pounds of choked, cocoons.

Two adults can take charge of the issue of from 1 to 3, say 2, ounces of eggs, which will produce 138 to 184 pounds of fresh, or 46 to 62 pounds of choked cocoons.

Price per pound of fresh cocoons (1885), 35 cents (300 cocoons per pound).

184 pounds of fresh cocoons, at 35 cents, $64.40.

Price per pound of fresh cocoons (1885), 25 cents (400 cocoons per pound).

138 pounds of fresh cocoons, at 25 cents, $34.50.

Price per pound of choked cocoons (1885), 80 cents to $1.15.

Value of above products, choked, $36.80 to $71.30.

APPROXIMATE COST OF REELING.

Estimated product of 6 non-automatic steam reels for the 300 working days of the year—1,200 pounds of reeled silk, and 300 pounds of waste silk.

Cost of production of 1,200 pounds of reeled silk, based on the Government experiments at New Orleans, in 1885:

Value of plant:		
Six reels	$500.00	
One steam engine	600.00	
Shafting and miscellaneous	400.00	
	1,500.00	
Interest and depreciation on plant, 20 per cent. per annum		$300.00
Raw material:		
5,076 pounds of choked cocoons, at $1		5,076.00
Labor (as shown at New Orleans), $1.12½ per pound of silk		1,350.00
Fuel, oil, etc		150.00
Total		6,876.00

Value of the above product:

1,200 pounds reeled silk, at $5.50	$6,600.00
300 pounds waste silk, at $1	300.00
Total	6,900.00

In studying these estimates the reader must, as I have said, bear in mind that the silk industry, like all industries, will have its ups and downs—its periods of buoyancy and depression. For the past few years it has been going through one of the latter. But late last fall an upward tendency was shown in prices for raw silk, which, if they remain firm, can not but influence for the better the value of cocoons.

In the preface to the second edition I mentioned the advantages to be gained by raising Silk-worm eggs, though I called attention to the fact that the market for them was in its nature limited and transient, and that European merchants were again producing their own seed by the aid of the improved Pasteur system of selection. Notwithstanding the facts there stated as to the limited nature of the egg market, silk-raisers have been disappointed, after having produced large quantities of eggs, in not finding a ready sale for them. But though the egg market is important in its place, it will readily be seen that it can be, when in a healthy state, no more extensive than is necessary to supply each season the wants of silk growers. In 1884, in France, about 2½ per cent. of the total crop was employed in the production of eggs. These figures, from a country where silk culture is established, furnish a foundation upon which to estimate. Every pound of cocoons which is sold at the filature puts money into the pockets of the silk-raising class; while every pound used in the production of eggs in excess of the amount actually required robs it of the money that it would otherwise receive. The only way to build up the industry, then, is, as I have so often insisted, to create, by the establishment of filatures, a durable and profitable market for cocoons. The production of eggs is simply an incident of comparatively little importance.

I have shown in said preface that silk-raising on an extensive scale is fraught with so many dangers that it is inadvisable to invest capital in such an enterprise. This is partly due to the fact that a large crop must necessarily be raised with the aid of hired labor, and a consequent investment of cash capital. A large rearing requires a large and (for success) a specially constructed building, which must necessarily lie idle for the greater part of the year. It has been found, too, that the average production of cocoons, per ounce of eggs, is much less for large than for smaller crops. Thus one ounce of eggs of good race will produce one hundred pounds of fresh cocoons; while for every additional ounce the percentage is reduced if the worms are all raised together, until for twenty ounces the average may not exceed 25 pounds of cocoons per ounce. Such is the general experience throughout France, according to Guérin-Méneville, and it shows the importance of keeping the worm in small broods, or of rearing on a moderate scale. As a result we see the great magnaneries disappearing from France and Italy, where in some establishments as many as 60 ounces were at one time annually raised. We find this statement confirmed by looking at the French official statistics for 1884, where it is stated that the cocoons produced in France during that year were raised by over one hundred and forty thousand families, who utilized therefor about two hundred and eighty thousand ounces of eggs, or an average of about two ounces per family.

To beginners I would repeat the advice so often given from this Office, to hatch the first season but a small quantity of eggs; not more than an eighth of an ounce. Experience counts in this as in other industries, and it will be found that, where only a small quantity of worms are being fed, there will be much more time to study their habits and wants. With a year's experience there will be a better chance of profit the second year.

It will not be safe for individuals to rely on reeling their own silk. The art of reeling in modern filatures and with steam appliances has been brought to such perfection that none but skilled reelers can hope to produce a first-class article. Skill comes only after full apprenticeship and practice. The only way in which silk-reeling can be managed profitably at present is where a colony of silk-raisers combine to put up and operate a common filature. Though there is a ready market in the United States for large lots of good silk, it will not be found so easy to dispose of small lots of poorer quality.

Two years ago Congress appropriated $15,000 for the encouragement of silk-culture, and the appropriation was repeated for the present fiscal year. The appropriation was general in its nature, and the method of encouragement left with the Commissioner of Agriculture. In my Annual Reports for 1884 and 1885 details are given as to the work done by the Department under this appropriation, and various questions discussed and conclusions reached as to the outcome of the two years' experience. These need not be repeated here.

Owing to the conviction that the establishment of filatures and their successful operation was the *sine qua non* in putting the industry on a firm basis, a large portion of the money thus appropriated has been devoted to experiments in silk reeling. These experiments have shown that the quality of cocoons produced by American silk-raisers is not yet such as to enable this country to compete with others in the production of raw silk. The quality of a cocoon is most conclusively shown by the quantity of silk which may be unwound from it. A good average result, after the experience of European filatures, is the production of a pound of raw silk from 3.80 pounds of dry cocoons. The Government experiments at New Orleans showed a production of but 1 pound of silk from 4.23 pounds of dry cocoons. The cost of producing silk from a poorer quality of cocoons is proportionately much greater than where the cocoons are of better quality, and the difference is much greater than would be thought possible by one unacquainted with the industry. We have, therefore, much to accomplish from this point of view before we can hope to make the industry a profitable one in the United States. The cocoons which have been received at the Government stations during the past year have been, to a large extent, raised by persons who were inexperienced, and who were thus unable to produce a first-class cocoon. There is an inclination among these very persons to blame the industry if they do not receive, the first season, what they consider an adequate compensation for the time which they have expended upon the work. And yet these same individuals would not expect to be successful in any other enterprise until they had made themselves thoroughly acquainted, by practical experience, with the special work involved. It is not, therefore, surprising that with such a quality of raw material it has been impossible to produce silk without financial loss. Such a loss, in fact, as shown in my annual report as entomologist, for 1885, was incurred as the result of the experiments. We, however, performed these experiments with non-automatic machinery, and that even of an unimproved type. The loss was, however, so small that we have reason to believe that it can be more than counterbalanced by the use of improved plant. Automatic silk-reels are now being placed upon the market, which not only effect a slight saving in the quantity of raw material employed, but also a very large saving in labor, the cost of which in this country is the principal cause of our inability to compete with Europe and Asia. These new reels are also capable of producing, with comparatively unskilled labor, as good a grade of silk as can be made by the expert workwomen of France.

It will be seen by the estimates given above that silk-culture is not (and it never has been) an exceedingly profitable business, but it adds vast wealth to the nations engaged in it, for the simple reason that it can be pursued by the humblest and poorest, and requires so little outlay. The question of its establishment in the United States is, as I have elsewhere said, "a question of adding to our own productive resources. There are hundreds of thousands of families in the United States to-day who would be most willing to add a few dollars to their annual income by giving light and easy employment for a few months each year to the more aged, to the young, and especially to the women of the family, who may have no other means of profitably employing their time.

"This holds especially true of the people of the Southern States, most of which are pre-eminently adapted to silk-culture. The girls of the farm, who devote a little time each year to the raising of cocoons, may not earn as much as their brothers in the field, but they may earn something, and that something represents an increase of income, because it provides labor to those members of society who at present too often have none that is remunerative. Further, the raising of a few pounds of cocoons each year does not and need not materially interfere with the household and other duties that now engage their time, and it is by each household raising a few pounds of cocoons that silk-culture must, in the end, be carried on in this as it has always been in other countries."

The reader is reminded that the few quotations not otherwise credited are from the author's Fourth Report on the Insects of Missouri (1871). A number of foreign (more particularly French) terms are unavoidable in treating of silk-culture, as they have no actual equivalents in our language. These and the few technical terms used in the manual are made clear in the glossary.

Finally, I take pleasure in acknowledging the assistance given me in the preparation of this new edition by Mr. Philip Walker, who has acted as the chief agent of the division in the sericultural work during the past two years.

C. V. R.

WASHINGTON, D. C., *May*, 1886.

CHAPTER I.

PHYSIOLOGY AND LIFE-HISTORY OF THE SILK-WORM.

The Silk-worm proper, or that which supplies the ordinary silk of commerce, is the larva of a small moth known to scientific men as *Sericaria mori.* It is often popularly characterized as the Mulberry Silk-worm. Its place among insects is with the *Lepidoptera*, or scaly-winged insects, family *Bombycidæ*, or spinners. There are several closely allied species, which spin silk of different qualities, none of which, however, unite strength and fineness in the same admirable proportions as does that of the mulberry species. The latter has, moreover, acquired many useful peculiarities during the long centuries of cultivation it has undergone. It has in fact become a true domesticated animal. The quality which man has endeavored to select in breeding this insect is, of course, that of silk producing, and hence we find that, when we compare it with its wild relations, the cocoon is vastly disproportionate to the size of the worm which makes it or the moth that issues from it. Other peculiarities have incidentally appeared, and the great number of varieties or races of the Silk-worm almost equals those of the domestic dog. The white color of the species, its seeming want of all desire to escape as long as it is kept supplied with leaves, and the loss of the power of flight on the part of the moth, are all undoubtedly results of domestication. From these facts, and particularly from that of the great variation within specific limits to which the insect is subject, it will be evident to all that the following remarks upon the nature of the Silk-worm must necessarily be very general in their character.

The Silk-worm exists in four states—egg, larva, chrysalis, and adult or imago—which we will briefly describe.

DIFFERENT STATES OR STAGES OF THE SILK-WORM.

THE EGG.—The egg of the Silk-worm moth is called by silk-raisers the "seed." It is nearly round, slightly flattened, and in size resembles a turnip seed. Its color when first deposited is yellow, and this color it retains if unimpregnated. If impregnated, however, it soon acquires a gray, slate, lilac, violet, or even dark green hue, according to variety or breed. It also becomes indented. When diseased it assumes a still darker and dull tint.

Near one end a small spot may be observed. This is the *micropyle*, and is the opening through which the fecundating liquid is injected just before the egg is deposited by the female. After fecundation and before deposition the egg of some varieties is covered with a gummy varnish which closes the micropyle and serves to stick the egg to the object upon which it is laid. Other varieties, however, among which may be mentioned the Adrianople whites and the yellows from Nouka, in the Caucasus, have not this natural gum. As the hatching point approaches the egg becomes lighter in color, which is due to the fact that its fluid contents become concentrated, as it were, into the central forming worm, leaving an intervening space between it and the shell, which is semi-transparent. Just before hatching, the worm within becoming more active, a slight clicking sound is frequently heard, which sound is, however, common to the eggs of many other insects. The shell becomes quite white after the worm has made its exit by gnawing a hole through it, which it does at the micropyle. Each female produces on an average from three to four hundred eggs. In the standard ounce of 25 grams* there are about 50,000 eggs of the small Japanese races, 37,500 of the ordinary yellow annual varieties, and from 30,000 to 35,000 in the races with large cocoons. The specific gravity of the eggs is slightly greater than water, Haberlandt having placed it at 1.08.

It has been noticed that the color of the albuminous fluid of the egg corresponds to that of the cocoon, so that when the fluid is white the cocoon produced is also white, and when yellow the cocoon again corresponds.

THE LARVA OR WORM.—The worm goes through from three to four

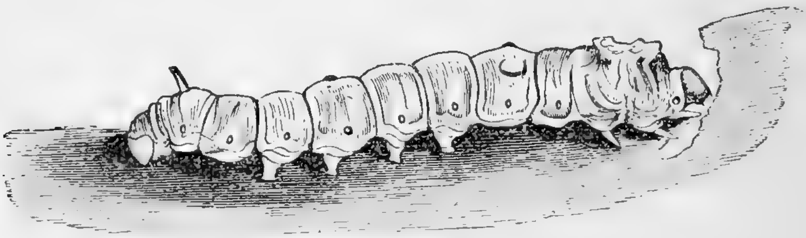

FIG. 1.—Full grown larva or worm (after Riley).

molts or sicknesses, the latter being the normal number. The periods between these different molts are called "ages," there being five of these ages, the first extending from the time of hatching to the end of the first molt, and the last from the end of the fourth molt to the transformation of the insect into a chrysalis.

The time between each of these molts is usually divided as follows: The first period occupies from five to six days, the second but four or five, the third about five, the fourth from five to six, and the fifth from eight to ten. These periods are not exact, but simply proportionate. The time from the hatching to the spinning of the cocoons may, and does, vary all the way from twenty-five to forty days, depending upon the race of the worm, the quality of food, mode of feeding, temperature,

*28⅓ grams = 1 ounce avoirdupois.

etc.; but the same relative proportion of time between molts usually holds true.

The color of the newly-hatched worm is black or dark gray, and it is covered with long, stiff hairs, which, upon close examination, will be found to spring from pale colored tubercles. Different shades of dark gray will, however, be found among worms hatching from the same batch of eggs. After the first molt, and as the worm increases in size, these hairs and tubercles become less noticeable, and the worm gradually gets lighter and lighter, until, in the last stage, it is of a cream-white color. When full grown it presents the appearance of Fig. 1. It never becomes entirely smooth, however, as there are short hairs along the sides, and very minute ones, not noticeable with the unaided eye, all over the body.

The preparation for each molt requires from two to three days of fasting and rest, during which time the worm attaches itself firmly by the abdominal prolegs (the 8 non-articulated legs under the 6th, 7th, 8th, and 9th segments of the body, called prolegs in contradistinction to the 6 articulated true legs under the 1st, 2d, and 3d segments), and holds up the forepart of the body, and sometimes the tail. In front of the first joint a dark, triangular spot is at this time noticeable, indicating the growth of the new head; and when the term of "sickness" is over, the worm casts its old integument, rests a short time to recover strength, and then, freshened, supple, and hungry, goes to work feeding voraciously to compensate for lost time. This so-called "sickness" which preceded the molt was, in its turn, preceded by a most voracious appetite, which served to stretch the skin. In the operation of molting the new head is first disengaged from the old skin, which is then gradually worked back from segment to segment until entirely cast off. If the worm is feeble or has met with any misfortune, the shriveled skin may remain on the end of the body, being held by the anal horn; in which case the individual usually perishes in the course of time. It has been usually estimated that the worm in its growth consumes its own weight of leaves every day it feeds; but this is only an approximation. Yet it is certain that during the last few days before commencing to spin it consumes more than during the whole of its previous worm existence. It is a curious fact, first noted by Quatrefages, that the color of the abdominal prolegs at this time corresponds with the color of the silk which will form the cocoons.

Having attained full growth, the worm is ready to spin up. It shrinks somewhat in size, voids most of the excrement remaining in the alimentary canal; acquires a clear, translucent, often pinkish or amber-colored hue; becomes restless, ceases to feed, and throws out silken threads. The silk is elaborated in a fluid condition in two long, slender, convoluted vessels, one upon each side of the alimentary canal. As these vessels approach the head they become less convoluted and more slender, and finally unite within the spinneret, from which the silk issues in a glutinous state and apparently in a single thread. The glutinous liquid which combines the two, and which hardens immediately on exposure to the air, may, however, be softened in warm water. The worm usually consumes from three to five days in the construction of the cocoon and then passes in three days more, by a final molt, into the chrysalis state.

THE COCOON.—The cocoon (Figs. 2 and 3) consists of an outer lining

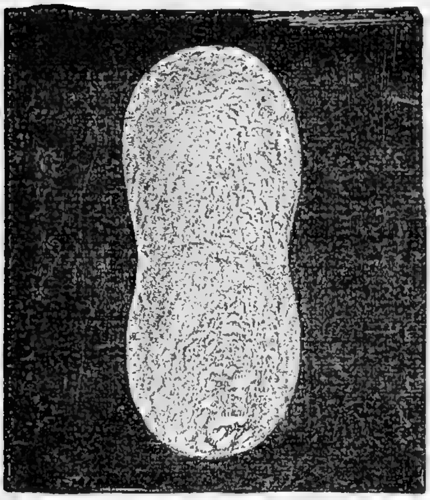

FIG. 2.—Constricted cocoon, with fine texture (original).

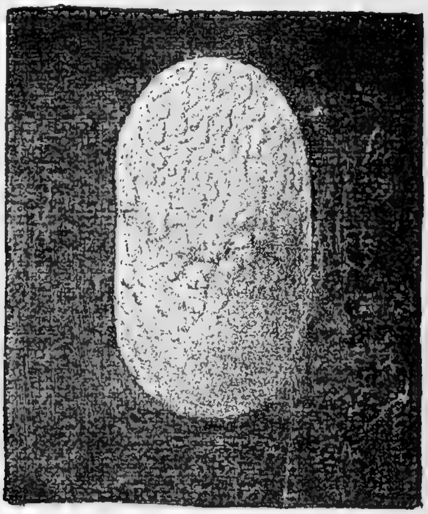

FIG. 3.—Non-constricted cocoon, with coarse texture (original).

of loose silk known as "floss," which is used for carding, and is spun by the worm in first getting its bearings. The amount of this loose silk varies in different breeds. The inner cocoon is tough, strong, and compact, composed of a firm, continuous thread, which is, however, not wound in concentric circles, as might be supposed, but irregularly, in short figure-of-8 loops, first in one place and then in another, so that, in reeling, several yards of silk may be taken off without the cocoon turning around. In form the cocoon is usually oval, and in color yellowish, but in both these features it varies greatly, being either pure silvery-white, cream, or carneous, green, or even roseate.

THE CHRYSALIS.—The chrysalis is a brown, oval body, considerably less in size than the full-grown worm. In the external integument may be traced folds corresponding with the abdominal rings, the wings folded over the breast, the antennæ, and the eyes of the inclosed insect—the future moth. At the posterior end of the chrysalis, pushed closely up to the wall of the cocoon, is the last larval skin, compressed into a dry wad of wrinkled integument. The chrysalis state continues for from two to three weeks, when the skin bursts and the moth emerges.

THE MOTH.—With no jaws, and confined within the narrow space of the cocoon, the moth finds some difficulty in escaping. For this purpose it is provided, in two glands near the obsolete mouth, with a strongly alkaline liquid secretion, with which it moistens the end of the cocoon and dissolves the hard, gummy lining. Then, by a forward and backward motion, the prisoner, with crimped and damp wings, gradually forces its way out; and the exit once effected, the wings soon expand and dry. The silken threads are simply pushed aside, but enough of them get broken in the process to render the cocoons from which the moths escape comparatively useless for reeling.

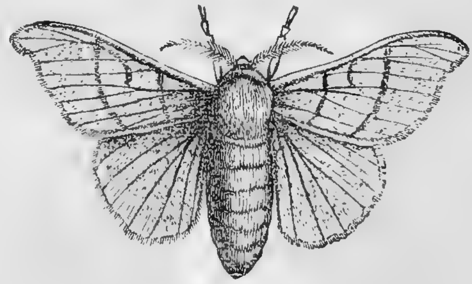
FIG. 4.—Silk-worm moth, male (after Riley).

The moth is of a cream color, with more or less distinct brownish markings across the wings, as in Fig. 4. The males have broader antennæ or feelers than the females, and may be, by this feature, at once distinguished. Neither sex flies, but the male is more active than the female, and may be easily recognized by a constant fluttering motion of the wings, as well as the feature mentioned above. They couple soon after issuing, remaining coupled during several hours, and in a short time after separation the female begins depositing her eggs, whether they have been impregnated or not. Very rarely the unimpregnated eggs have been observed to develop.

VARIETIES OR RACES.

As before stated, domestication has had the effect of producing numerous varieties of the Silk-worm, every different climate into which it has been carried having produced either some changes in the quality of the silk, or the shape or color of the cocoons, or else altered the habits of the worm.

Some varieties produce but one brood in a year; such are known as *Annuals*. Others, known as *Bivoltins*, hatch twice in the course of the year; the first time, as with the Annuals, in the early spring, and the second, eight or ten days after the eggs are laid by the first brood. With Bivoltins the eggs of the second brood only are kept for the next year's crop, as those of the first brood always either hatch or die soon after being laid. The *Trevoltins* produce three annual generations. There are also *Quadrivoltins*, and in Bengal a variety known as *Dacey*, which is said to produce eight generations in the course of a year. Some varieties molt but three times instead of four, especially in warm countries and with Trevoltins. Experiments, taking into consideration the size of the cocoon, quality of silk, time occupied, hardiness, quantity of leaves required, etc., have proved the Annuals to be more profitable than any of the Polyvoltins. The principle difficulties encountered in raising other than the annual races arise from the excessive heat of midsummer, which causes disease, and the deteriorated quality of the leaves as explained in Chapter X. Silk-growers are therefore earnestly advised to attempt but one brood per annum except where, as in some parts of the Pacific coast, the summers are prolonged and equable.

Commercially cocoons are classed as yellow, white, and green, but through the intermingling of races these colors have become merged one into the other, and it is often difficult to define the line of demarkation. The same trouble exists in classifying varieties by the different countries or provinces from which they have originally come. Prior to the Silk-worm plague of twenty years ago in Europe there was a certain degree of exactness in the lines drawn between such races. Then, however, the indigenous races were to a large extent blotted out, and the egg merchants went first to Turkey, then to Asia Minor and Syria, and finally to China and Japan, in search of eggs that should be free from "the malady." Thus it was that there were brought into France and Italy a large number of races foreign to those countries. These were crossed together, and after the researches of Pasteur had made the resuscitation of the native races possible, they were crossed with these as well. Thus the identity of the old varieties was, in many cases, lost, or they obtained different names.

CHAPTER II.

WINTERING AND HATCHING THE EGGS.

As has been said in the last chapter, the egg of the Silk-worm changes color soon after oviposition. During this operation the contents undergo a chemical change, absorbing oxygen and giving off carbonic acid. This absorption of oxygen is very active during the first six days, after which it rapidly declines and continues at a very low rate during the months which precede hatching. The eggs should, therefore, be wintered in such manner that they have plenty of air; otherwise their development will be seriously interfered with. They must not be packed in thick layers, but should be spread out thinly. For these reasons the eggs at this Department are kept through the winter in boxes of perforated tin, the bottoms of which have a surface of 6½ square inches, each box containing not more than one quarter of an ounce of eggs.

The atmosphere in which the eggs are kept should neither be too dry nor too humid. M. Beauvais found a saturation of 50 per cent. to be the most suitable condition of the air, as when it is below that point the liquids of the eggs evaporate so rapidly as to require a highly saturated atmosphere for their incubation. Excessive moisture, on the other hand, will assist the formation of mold, which will quickly injure the contents of the egg. The eggs should be frequently inspected, and whenever such mold is discovered it should be quickly brushed off and the eggs removed to a drier locality.

Under natural conditions the egg undergoes a partial development as soon as laid, as shown by its changing color. After oviposition, and until subjected to cold, the eggs of the annual races are not capable of hatching out. This is the rule, although we often find in a batch of annual eggs a few accidental bivoltins that hatch some fifteen days after they are laid. The number, however, is very slight, and it has been determined that the temperature to which they are submitted in no way alters the result. During this period, which we call prehibernal, the eggs may be kept at any ordinary temperature, however warm, but once they are submitted to the cold of winter a certain change takes place in them, the nature of which has not yet been determined, and their subsequent warming may then result in hatching. As in our climate warm days are quite frequent in late winter, it is very necessary that the eggs be kept below the hatching temperature until the foliage on which the worms are to feed is developing and all danger from late frosts is at an end. The period of hibernation may be lengthened by keeping the eggs in a cool, dry cellar, with a northerly exposure, and in general this will suffice. But in such a case the temperature is more or less variable, and the embryo may be started in its development only to be checked by renewed cold. When kept at a uniform low temperature, after having once been cooled, development is imperceptible, and when afterward exposed to the proper hatching conditions, the resultant worms will prove more vigorous. If possible the temperature should never be allowed to rise above 40° F., but may be allowed to sink below freezing point without injury.

When small lots of eggs are to be wintered, they may be placed in ordinary boxes in the cellar, care being taken to observe the precautions noted above as to ventilation, humidity, and temperature. They should also be protected from rats, mice, ants, and other vermin. But where great quantities are to be stored, it will be well worth while to construct special hibernating boxes, where the requisite conditions may be regulated with nicety and precision.

A great object should be to have them hatch uniformly, and this is best attained by keeping together those laid at one and the same time, and by wintering them, as already recommended, in cellars or hibernating boxes that are cool enough to prevent any embryonic development. They should then, as soon as the leaves of their food-plant have commenced to put forth,* be placed in trays and brought into a well-aired room where the temperature averages about 75° F. If they have been wintered adhering to the cloth on which they were laid, all that it is necessary to do is to spread this same cloth over the bottom of the tray. If, on the contrary, they have been wintered in the loose condition, they must be uniformly sifted or spread over sheets of cloth or paper. The temperature should be kept uniform, and a small stove in the hatching-room will prove very valuable in providing this uniformity. The heat of the room may be increased about 2° each day, and if the eggs have been well kept back during the winter, they will begin to hatch under such treatment on the fifth or sixth day. By no means must the eggs be exposed to the sun's rays, which would kill them in a very short time. As the time of hatching approaches, the eggs grow lighter in color, and then, if the weather be dry, the atmosphere must be kept moist artificially by sprinkling the floor or otherwise, in order to enable the worms to eat through the egg-shell more easily. They also appear fresher and more vigorous with due amount of moisture.

It will be found that eggs which have been subjected to great cold during the winter will require a longer time in their incubation than those which have been kept at a higher temperature, and it is also true, as has been intimated above, that when the atmosphere in which the eggs have been retained has been excessively dry it will require con-

*Too much stress can not be laid on the importance of beginning the rearing of worms as early as possible, so that the excessive heat of summer may be avoided. Beginners are very apt to delay sending for eggs until after the leaves have put out, and there is not only more danger of the hatching of the eggs in transit, but the worms will be maturing during very warm weather.

siderable humidity to cause them to hatch. Such matters must be largely regulated by the experience of the individual raiser.

The desired conditions can be better regulated in specially constructed incubators than in an open room. A simple form of incubator is shown in Fig. 5. It consists of a tin cylinder with a perforated shelf and a

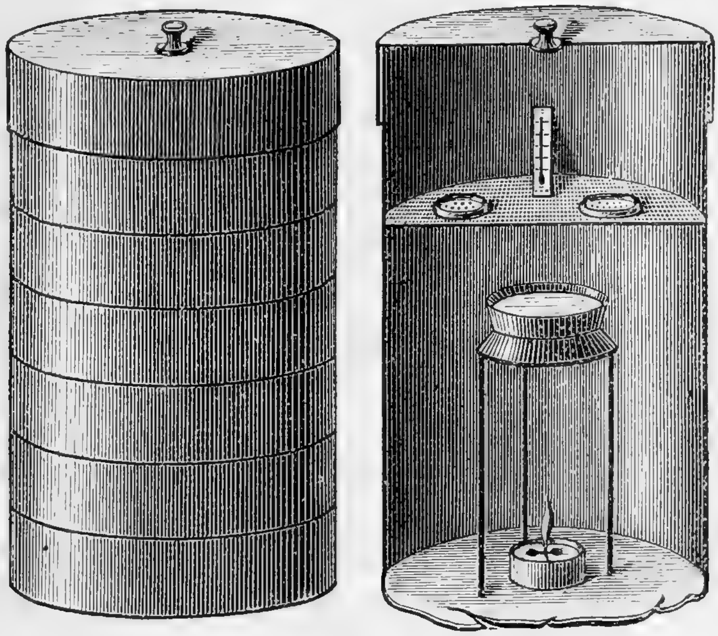

FIG. 5.—Incubator made of tin-ware (after Roman).

movable cover. Under the shelf is placed upon a tripod a small vessel of water, beneath which burns a small night-lamp. This apparatus may be made about eight times the size of the drawing. A similar and simple form of basket-ware incubator is shown in Fig. 6. This possesses

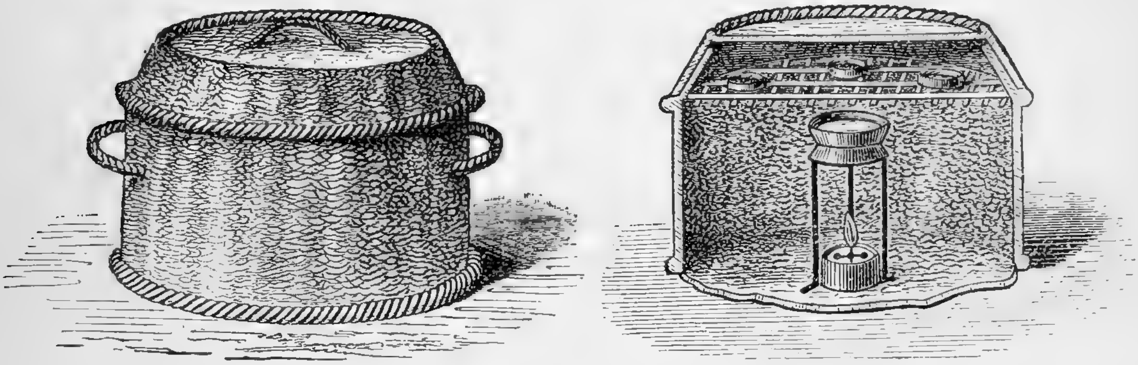

FIG. 6.—Incubator made of basket-ware (after Roman).

the advantage of being permeable to the air and of thus insuring a more complete ventilation for the eggs. Many modifications of these designs will suggest themselves to individuals; amongst others the surrounding of the cylinder of the incubator first described with a jacket, in which hot water may be placed, by means of which the temperature of the interior may be regulated with a considerable degree of nicety.

CHAPTER III.

IMPLEMENTS THAT FACILITATE THE RAISING OF SILK.

The room in which the rearing is to be done should be so arranged that it can be thoroughly and easily ventilated and warmed if desirable. A northeast exposure is the best, and buildings erected for the express purpose should combine these requisites. If but few worms are to be reared, all the operations can be performed in trays upon tables, but in large establishments the room should be arranged with deep and numerous shelves, ranging one above the other from floor to ceiling, as shown in Fig. 7. The width of these shelves should not exceed 5 feet,

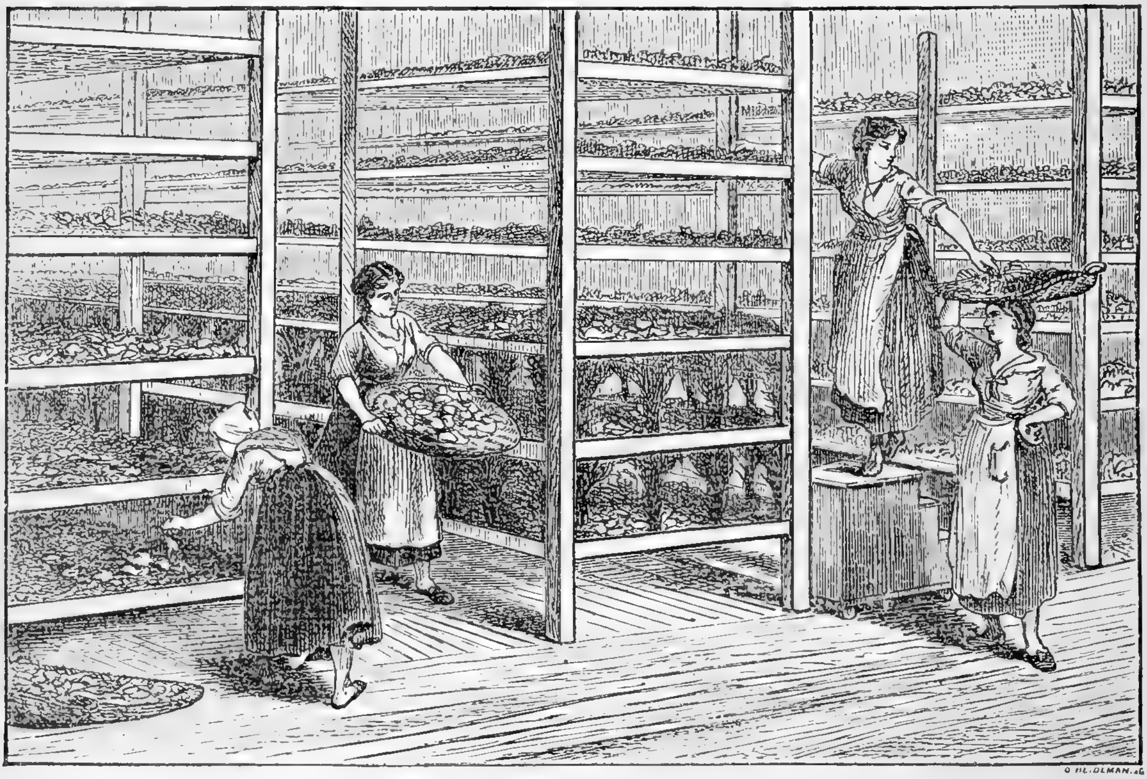

FIG. 7.—A modern magnanerie (after Gobin).

as those in charge must be able to reach from either side to the middle of each table. Bearing this in mind, the dimensions of these tables may be made to suit the room in which the worms are reared. The vertical distance between two shelves should not be less than 20 inches, but if this space is greatly increased it will be found inconvenient to obtain brush of sufficient length to form the arches upon which the cocoons are to be spun.

The form in which the tables are constructed is also immaterial, and should depend upon the resources of the owner. Where canes are abundant, as upon the Mississippi bottom, such a shelf as is shown in

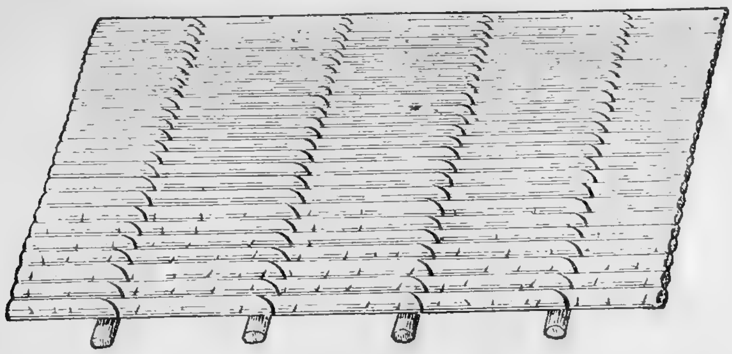

FIG. 8.—Shelf made of canes (after Roman).

Fig. 8 will be found inexpensive and satisfactory. To construct a shelf in this manner, say 5 by 8 feet, there should be selected for cross-pieces four stout canes about one inch through at the small end and 5 feet 4 inches long. Having procured a quantity of smaller canes, 8 feet long, lay out the four cross-pieces some eighteen inches apart, and, placing a cane across them, lash the whole together with stout cord. This is done by having an end of cord attached to each cross-piece, which, after it is carried over the smaller cane, is brought around the cross-piece and fastened by a slip knot, as will be better understood by reference to

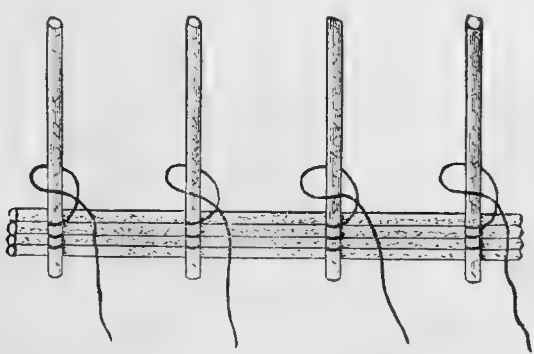

FIG. 9.—Construction of the cane shelf (after Roman).

Fig. 9. The second cane should be placed tip to butt with the first, and so on alternately. Fig. 10 shows a shelf formed with wire-work, which

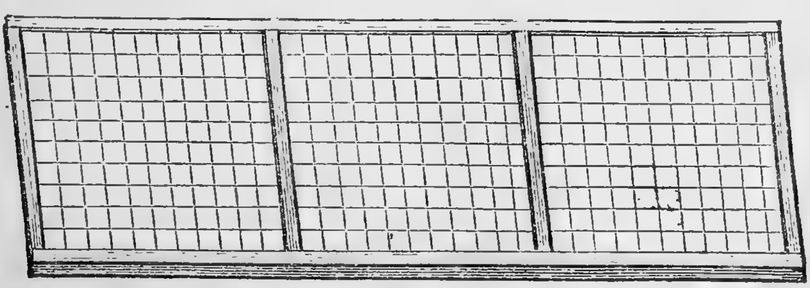

FIG 10. Wire-work shelf (after Roman).

makes a strong and light article. The form shown in Fig. 11 is essentially the same, being covered with wooden slats. Placing these diagonally increases the stiffness and diminishes liability to break.

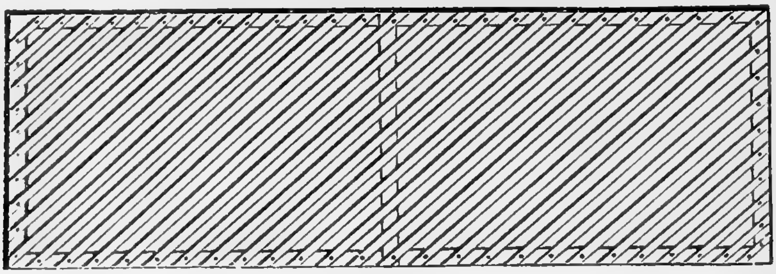

FIG. 11.—Frame covered with slats (original).

Where it is desired to have a neat and convenient standard, upon which a small quantity of worms may be reared, it may be constructed after the manner of that shown in Fig. 12, the shelves being made as

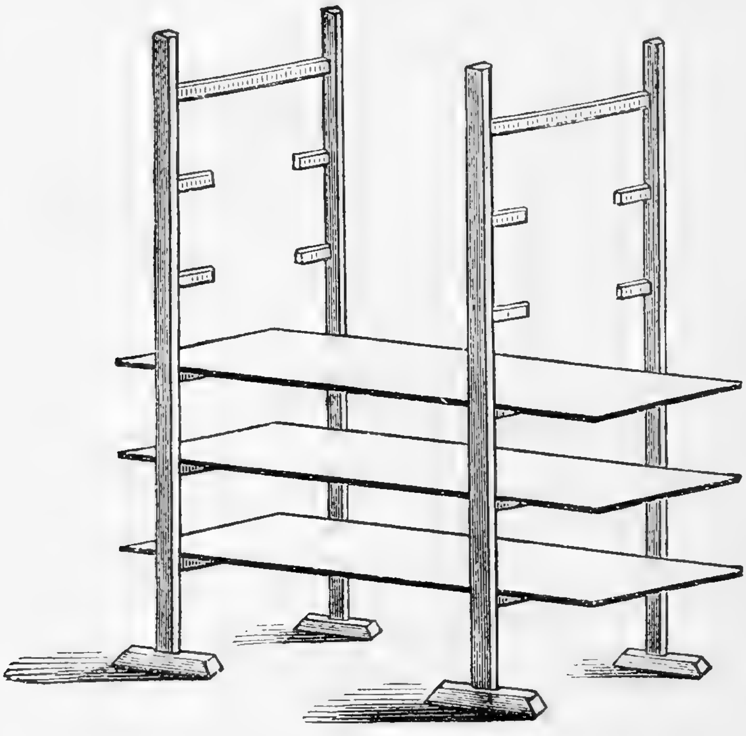

FIG. 12.—Standard for holding shelves (original).

shown in either of Figs. 10 or 11. The principal requisites in the construction of all the above articles are lightness and strength, and the shelves should be so constructed as to permit the free circulation of the air. All wood should be well seasoned, as green wood seems to be injurious to the health of the worms. The shelves above described must be covered with strong brown paper before being used, and it will be found to be more convenient in removing the litter if sheets of the same size as the table are employed.

In rearing Silk-worms great care should be observed in not handling them more than is absolutely necessary, and as, in clearing up the litter made by the larvæ, it is necessary to transport them from one table to another, several schemes have been adopted to accomplish this object. The first transfer made upon the birth of the worms is usually performed with the aid of ordinary mosquito netting, which is lightly laid over the hatching eggs. Upon this can be evenly spread freshly-plucked leaves or buds. The worms will rise through the meshes of the net, and cluster upon the leaves, when the whole net can be easily removed.

This netting has the disadvantage of sagging in the middle and lumping the worms. Netting of a coarser mesh may be used later in rearing, but it should be stretched on light frames. This method of transfer is such a great convenience and time-saver that in France, for many years, paper, stamped by machinery with holes of different sizes, suited to the different ages of the worms, has been used. The material employed is a stout manila paper, and the perforations vary in size, as shown in Fig. 13. I have experienced some difficulty in the

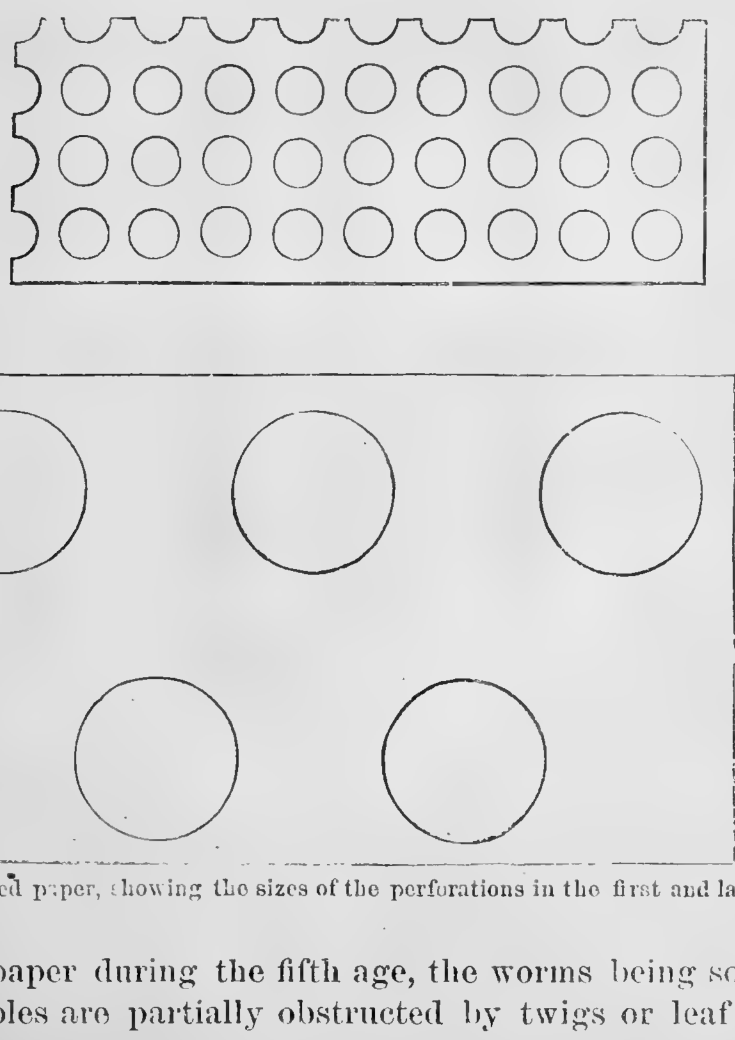

Fig. 13.—Perforated paper, showing the sizes of the perforations in the first and last ages (original)

use of this paper during the fifth age, the worms being so large that when the holes are partially obstructed by twigs or leaf stems they must force themselves through the restricted space, often cutting themselves on the sharp edges of the paper.. This may be avoided by the use, during that age, of a lattice-work tray, such as is shown in Fig. 14.

To prevent this tray from pressing upon the worms beneath, it should be propped up by small blocks placed under the corners.

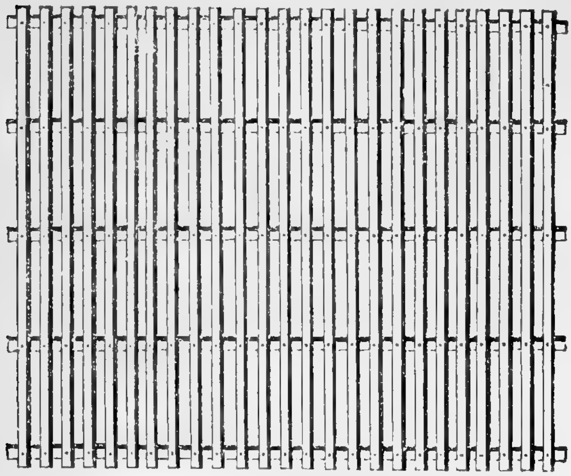

FIG. 14.—Lattice-work transfer tray (original).

When large pieces of perforated paper are used they should be handled by two persons. By cutting them into smaller pieces and using a transfer tray (Fig. 15) one person can perform the necessary work with ease. Such a tray is most conveniently made about 13 by 19 inches inside. When the paper, which should be made about one inch smaller each way, has been covered with leaves, and the worms have come through the perforations in search of their food, the whole may easily be slipped into the transfer tray, and as easily taken from it in depositing the worms on another table.

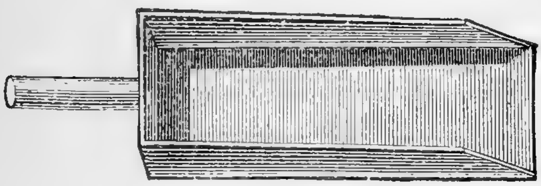

FIG. 15.—Transfer drawer (after Roman).

In gathering leaves for the worms it will be found convenient to employ a bag (Fig. 16), so arranged that it may be attached around the waist like an apron. Two such sacks may be made from an ordinary meal bag.

The worms should be made to spin their cocoons on brush so arranged as to form arches between the shelves, as is shown in Fig. 19.

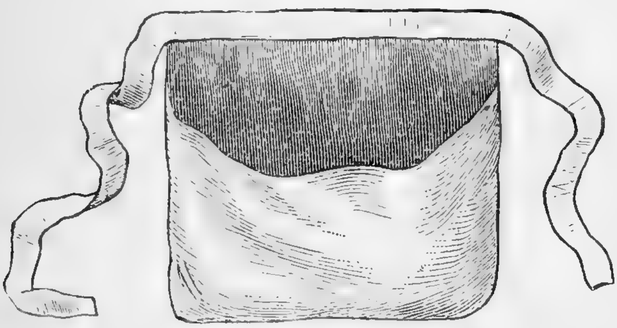

FIG. 16.—Bag for gathering mulberry leaves (after Roman).

For the same object the cocooning ladder shown in Fig. 17 was devised in 1842 by M. Davril. It consists of two central supports, across each side of which (Fig. 18) are nailed small strips of about one-quarter by one-half inch section, $1\frac{1}{2}$ inches apart. The strips on one side are placed opposite the spaces between the strips on the other side. The ladder may be made about 30 by 15 inches, and the central supports about five-eighths inch thick. When in use the ladder is placed slantingly between the tables, with the central supports horizontal.

A thermometer is a very useful adjunct to the appliances above described.

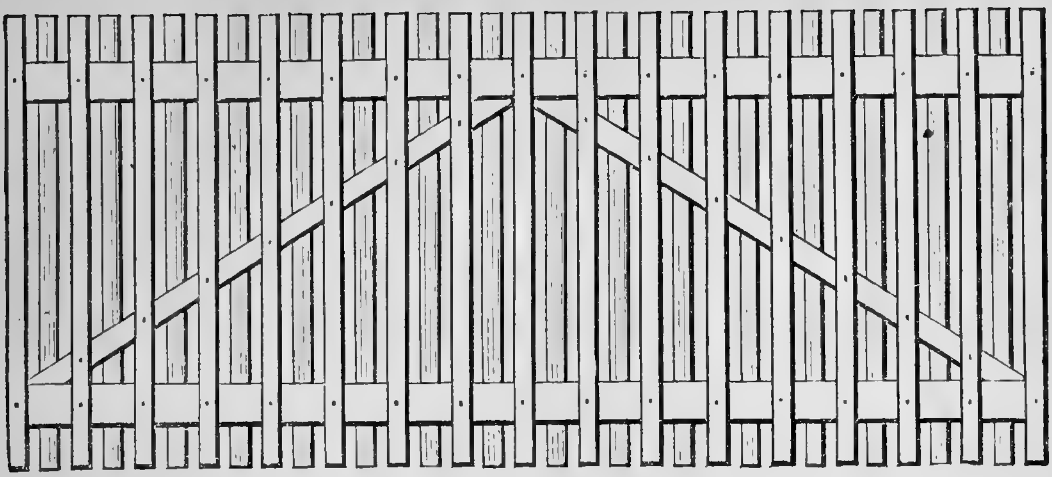

FIG. 17.—The Davril cocooning ladder.

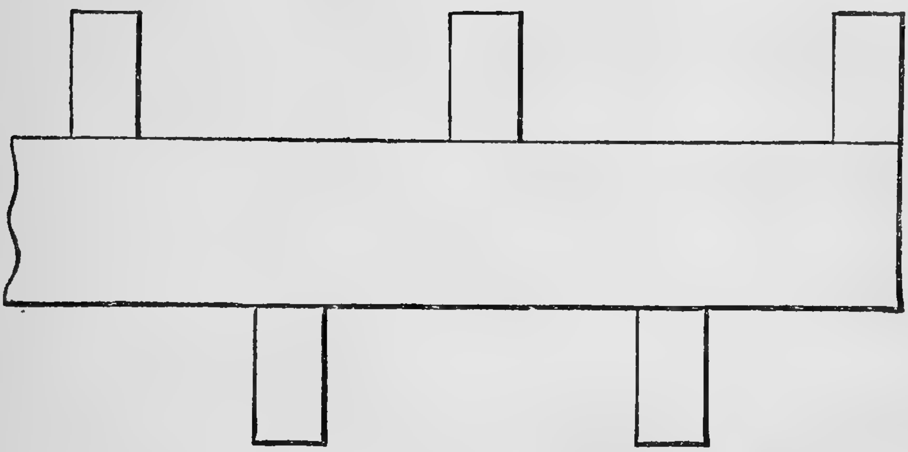

FIG. 18.—Partial end view of the Davril cocooning ladder (full size).

CHAPTER IV.

THE REARING OF SILK-WORMS.

The chief conditions of success in silk raising are (1) the use of good eggs; (2) proper care of the worms.

The means of obtaining pure eggs will be described in the next chapter, and we will here consider the second of the conditions.

Unless new, and especially where the worms raised with them the preceding season have suffered from any disease, all the implements and furniture used should be cleansed and purified by carefully scrubbing in soap and water. The walls of the room may, where convenient, be submitted to the same operation, and covered with a strong coat of whitewash. The room should then be tightly closed and thoroughly fumigated with burning brimstone during an entire day and night. It may then, after being well aired, be used for the rearing of Silk-worms.

The eggs when about to hatch, whether brought to this condition by the systematic processes described in Chapter II, or by ruder methods, should be spread out on clean paper in as thin layers as possible. Over them should be lightly laid small pieces of ordinary mosquito-netting. When the worms begin to appear there should be sparsely scattered over this netting a few buds or finely-cut leaves. The newly born larvæ will at once pass through its meshes in search of food, and the whole can then be easily removed to the table upon which they are to pass their first age.

It is recommended by many to feed the worms while in this age, and, consequently, weak and tender, leaves that have been cut up or hashed, in order to give them more edges to eat upon and to make less work for them. This, however, is hardly necessary with annuals, although it is quite generally practised in France. With the second brood of Bivoltins it might be advisable, inasmuch as the leaves at the season of the year when they appear have attained their full growth and are a little tough for the newly-hatched individuals. In the spring, however, the leaves are small and tender, and nature has provided the young worms with sufficiently strong jaws to cut them.

Many rules have been laid down as to regularity of feeding, and much stress has been put upon it by some writers, most advising four meals a day at regular intervals, while a given number of meals between molts has also been urged; but such definite rules are of but little avail, as so much depends upon circumstances and conditions. The food should, in fact, be renewed whenever the leaves have been devoured, or whenever they have become in the least dry, which, of course, takes place much quicker when young and tender than when mature. This also is an objection to the use of the hashed leaves, as, of course, they dry very quickly. The worms eat most freely early in the morning and late at night, and it would be well to renew the leaves abundantly between 5 and 6 a. m., and between 10 and 11 p. m. Additional meals should be given during the day, according as the worms may seem to need them. It is only by experience that one can learn just what amount of food should be given to the worms. It may prove dangerous to feed them too copiously, as in the first ages the worms may become buried and lost in the litter, while later the massing of food in an attempt to satisfy their ravenous appetites may cause it to ferment and become productive of disease.

Great care should be taken to pick the leaves for the early morning meal the evening before, as when picked and fed with the dew upon them they are more apt to induce disease. Indeed, the rule should be laid down, never to feed wet or damp leaves to your worms. In case the leaves are picked during a rain they should be thoroughly dried before being fed; and on the approach of a storm it is always well to lay in a stock, which should be kept from heating by occasional stirring. Care should also be taken to spread the leaves evenly, so that all may feed alike. During this first and most delicate age the worm requires much care and watching.

As the fifth or sixth day approaches, signs of the first molt begin to be noticed. The worm begins to lose appetite, grows more shiny, and soon the dark spot already described appears above the head. The larva at this time generally wanders to an unencumbered spot where it may shed its skin in quiet and often gets hidden and buried under the superimposed leaves. When the first worms show these signs of molting, food should be given more sparingly and the meals should cease altogether as soon as the most forward worms awaken. When the time for the molt is near, say during the fourth day, it will be well to clear away the litter so that the worms may pass the crisis on a clean bed.

Some will undoubtedly undergo the shedding of the skin much more easily and quickly than others, but no food should be given to these forward individuals until nearly all have completed the molt. This serves to keep the batch together, and the first ones will wait one or even two days without injury from want of food. It is, however, unnecessary to wait for all, as there will always be some few which remain sick after the great majority have cast their skins. These should either be set aside and kept separate, or destroyed, as they are usually the most feeble and most inclined to disease; otherwise the batch will grow more and more irregular in their moltings and the diseased worms will contaminate the healthy ones. It is really doubtful whether the silk raised from these weak individuals will pay for the trouble of rearing them separately, and it will be better perhaps to destroy them. The importance of keeping each batch together, and of causing the worms to molt simultaneously, can not be too much insisted upon as a means of saving time.

As soon as the great majority have molted they should be copiously fed, and, as they grow very rapidly after each molt, and as they must always be allowed plenty of room, it will probably become necessary to divide the batch, and this is readily done at any meal by removing the net or tray when about half of the worms have risen and replacing it by an additional one. The space allotted to each batch should, of course, be increased proportionately with the growth of the worms. The same precautions should be observed in the three succeeding molts as in this first one.

The second and third castings of the skin take place with but little more difficulty than the first, but the fourth is more laborious, and the worms not only take more time in undergoing it, but more often perish in the act. At this molt it is perhaps better to give the more forward individuals a light feed as soon as they have completed the change, inasmuch as it is the last molt and but little is to be gained by the retardation, whereas it is important to feed them all that they will eat, since much of the nutriment given during the last age goes to the elaboration of the silk.

It would, too, be found inconvenient if all the worms were to arrive at the spinning period together, as extra assistance would be required to place the brush on which they spin their cocoons.

At each successive molt the color of the worm has been gradually whitening, until now it is of a decided cream color. Some breeds, however, remain dark, and occasionally there is an individual with zebra-like markings.

As regards the temperature of the rearing-room, great care should be taken to avoid all sudden changes from warm to cold, or *vice versa.* A mean temperature of 75° or 80° F. will usually bring the worms to the spinning-point in the course of 35 days after hatching, but the rapidity of development depends upon a variety of other causes, such as quality of leaf, race of worm, etc. If it can be prevented the temperature should not be permitted to rise very much above 80°, and it is for this reason that a room with a northern or northeastern exposure was recommended as preferable to any other. The air should be kept pure all of the time, and arrangements should be made to secure a good circulation. Great care should be taken to guard against the incursions of ants and other predaceous insects, which would make sad havoc among the worms were they allowed an entrance, and all through the existence of the insect, from the egg to the moth, rats and mice are on the watch for a chance to get at them, and are to be feared almost as much as any other enemy the Silk-worm has.

So much depends upon the conditions of development mentioned above that it is impossible to state the exact quantity of food consumed by the Silk-worm during its life. It will not be far from the truth, however, to place the amount consumed by the issue of an ounce of healthy eggs, which matures in 35 days, at 6½ pounds during the first age, 20 pounds during the second, 65 pounds during the third, 200 pounds during the fourth, and during the fifth and last age 1,250 pounds. This makes a total of between 1,500 and 1,600 pounds. It need hardly be said that the food mentioned must be of the best quality. Were it poor, it would be impossible to give any figures at all.

Too much can not be said in favor of giving the larvæ plenty of room. Every worm should be free to move easily without incommoding its fellows. We should therefore allow the issue of an ounce of eggs during the first age, from 10 square feet at the beginning to 30 square feet at the end of the age, daily extending the space occupied by them by spreading their food over a greater table surface. In the second age, they should spread in the same manner so as to cover from 50 to 75 square feet, in the third from 100 to 160 square feet, and in the fourth from 200 to 320 square feet. Entering the last age, spread over 430 square feet of surface, they should gradually be extended until they occupy, at the spinning period, 640 square feet. It need hardly be said that when the worms have been decimated by disease the surface occupied by them need not be so extensive.

The litter of the worms should be cleared away by the use of netting or perforated paper, before and after each molt, and once at about the middle of the third age. While small, the frass, dung, and detritus dry rapidly, and may (though they should not) be left for several days in a tray with impunity; but he who allows his trays to go uncleaned for more than a day during the two last ages will suffer in the disease and mortality of his worms just as they are reaching the spinning point.

Summed up, the requisites to successful Silk-worm raising are: 1st. Uniformity of age in the individuals of the same tray, so as to insure their molting simultaneously. 2d. No intermission in the supply of fresh food, except during the molting periods. 3d. Plenty of room, so that the worms may not too closely crowd each other. 4th. Fresh air and as uniform temperature as possible. 5th. Cleanliness. The last three are particularly necessary during the fourth and fifth ages.

PREPARATIONS FOR SPINNING.

With eight or ten days of busy feeding, after the last molt, the worms, as we have learned before, will begin to lose appetite, shrink in size, become restless, and throw out silk, and the arches for the spinning of the cocoons must now be prepared. These can be made of twigs of different trees, two or three feet long, set up upon the shelves over the worms, and made to interlock in the form of an arch above them. Interlace these twigs with broom-corn, hemlock, or other well-dried

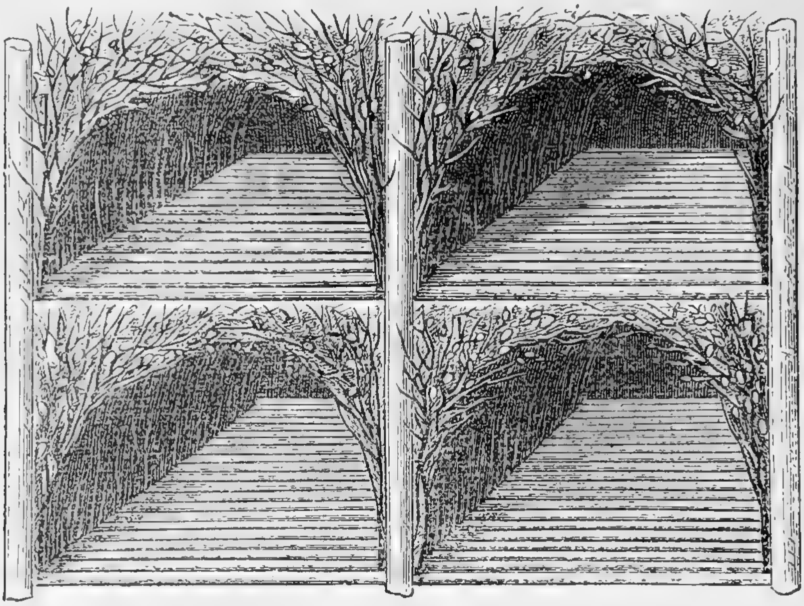

FIG. 19.—Method of constructing arches upon which the cocoons are spun (after Roman).

brush. The feet of each arch should be only about a foot apart. The Davril cocooning ladder, described in Chapter III, may be used with advantage in the place of the brush arches.

The temperature of the room should now be kept above 80°, as the silk does not flow so freely in a cool atmosphere. The worms will immediately mount into the branches and commence to spin their cocoons. They will not all, however, mount at the same time, and those which are more tardy should be fed often, but in small quantities at a time, in order to economize the leaves, as almost every moment some few will quit and mount. There will always be a few which altogether fail to mount, and prefer to spin in their trays. It is best, therefore, after the bulk have mounted, to remove the trays and lay brush carefully over them. The fact that the worms already mounted make a final discharge of soft and semi-fluid excrement before beginning to spin makes this separation necessary, as otherwise the cocoons of the lower ones would be badly soiled.

As the worms begin to spin they should be carefully watched, to guard against two or three of them making what is called a double or treble cocoon, which would be unfit for reeling purposes. Whenever one worm is about to spin up too near another, it should be carefully removed to another part of the arch. In two or three days the spinning will have been completed, and in six or seven the chrysalis will be formed.

GATHERING THE COCOONS.

Eight days from the time the spinning commenced, it will be time to gather the cocoons. The arches should be carefully taken apart, and the spotted or stained cocoons first removed and laid aside. Care should be taken not to stain the clean ones with the black fluids of such worms as may have died and become putrid, for there are always a few of these in every cocoonery. The outer cocoons of loose or floss silk are then removed from the inner cocoons or pods, and the latter sorted according to color, weight, and firmness of texture; those which best resist pressure indicating that the worm has best accomplished its work. Too much care can not be taken to remove the soft or imperfect cocoons, as, if mixed with the firm ones, they would be crushed and soil the others with their contents. The very best of the firm cocoons are now to be chosen as provision for eggs for the next year, unless the raiser prefers buying his eggs to the trouble of caring for the moths and keeping the eggs through the winter. Eggs bought from large establishments are, however, apt to be untrustworthy, and it is well for all silk-raisers to provide their own seed. The precautions to be taken in choosing cocoons for reproduction are set forth in Chapter VI.

Kept at a temperature of about 70° F., new silk cocoons lose, through the giving off of humidity by the chrysalides, a material proportion of their weight. According to Dandolo the loss in 100 pounds during the first ten days amounts to about $7\frac{1}{2}$ per cent.* The amount of humidity in the atmosphere naturally affects this result. The loss continues until the cocoons are thoroughly dry, when it will be found that they have lost two-thirds of their original weight.

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* Dandolo states that 100 pounds of cocoons will suffer the losses indicated by the following table:

	Pounds.
Weight when taken from the brush and after the floss has been removed	100.0
Weight one day after	99.1
Weight two days after	98.2
Weight three days after	97.5
Weight four days after	97.0
Weight five days after	96.6
Weight six days after	96.0
Weight seven days after	95.2
Weight eight days after	94.3
Weight nine days after	93.4
Weight ten days after	92.5

CHAPTER V.

ENEMIES AND DISEASES OF THE SILK-WORM.

As regards the enemies of the Silk-worm but little need be said. It has been generally supposed that no true parasite will attack it, but in China and Japan great numbers of the worms are killed by a disease known as "uji." This is produced by a Tachinid called by Rondani *Ujimyia sericaria*, and the life history of which has been carefully worked up by Prof. C. Sasaki of Japan (Journal Science College, Imp. Un., Tokio, Japan, 1886, Vol. I, part I).

There are, however, several forms of disease against which it is necessary to guard and of which it is therefore necessary that silk-raisers should have an intimate knowledge. Through the multitude of local names given to these diseases abroad, one would suppose that there were as many diseases to which the Silk-worm is subject. But Pasteur, after studying the subject very carefully, concluded that all may be considered as varieties of four principal diseases, viz: the *muscardine*, *pébrine*, *flacherie*, and *grasserie*.*

The *gattine*, one of these varieties, is considered by Pasteur as a mild form of the pébrine,† but Maillot, in a later work,‡ considers it as a species of the flacherie.

These diseases are found to some extent intercurrent, though at all times one (at least one of the first three) has been more prevalent than the others, generally amounting to a plague. So in 1849 we find M. Guérin-Méneville studying, on the part of the French Academy, the then prevalent disease, the muscardine. This was soon followed, in the fifties, by a veritable scourge in which the pébrine was the leading feature, with flaccidity (*flacherie*) quite frequently found. The same learned body appointed Pasteur to study the causes of these diseases, and after two years of patient research he devised a means, which will hereafter be described, of successfully preventing the return of the pébrine. This made way for flaccidity, which is to-day the dread of silk-raisers, for although it does not reach the importance of a plague, its effects are distinctly visible upon the national crops of cocoons in France and Italy, and I have never known it to be absent from worms reared by me almost every year for nearly two decades in this country. The grasserie has never attained any such importance. but occurs in rare instances only.

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* Pasteur, "*Études sur la maladie des vers à soie*," Vol. I, p. 225.

† Pasteur, "*Études*," etc., Vol. I, p. 12.

‡ Maillot, "*Leçons sur le vers à soie du murier*," p. 109.

MUSCARDINE.

The first of these, the *muscardine*, has been more or less destructive in Europe for many years. It is of precisely the same nature as the fungus (*Empusa muscæ*), which so frequently kills the common house-fly, and which sheds a halo of spores, readily seen upon the window-pane, around its victim.

A worm about to die of this disease becomes languid, and the pulsations of the dorsal vessel or heart become insensible. It suddenly dies, and in a few hours becomes stiff, rigid, and discolored; and finally in about a day, a white powder or efflorescence manifests itself, and soon entirely covers the body, developing most rapidly in a warm, humid atmosphere. No outward signs indicate the first stage of the disease, and though it attacks worms of all ages, it is by far the most fatal in the fifth or last age or stage, just before the transformation.

"This disease was proved by Bassi to be due to the development of a fungus (*Botrytis bassiana*) in the body of the worm. It is certainly infectious, the spores, when they come in contact with the body of the worm, germinating and sending forth filaments which penetrate the skin, and, upon reaching the internal parts, give off minute floating corpuscles which eventually spore in the efflorescent manner described. Yet, most silk-worm raisers, including such good authorities as F. E. Guérin-Méneville and Eugène Robert,* who at first implicitly believed in the fungus origin of this disease, now consider that the Botrytis is only the ultimate symptom—the termination of it. At the same time they freely admit that the disease may be contracted by the Botrytis spores coming in contact with worms predisposed by unfavorable conditions to their influence. Such a view implies the contradictory belief that the disease may or may not be the result of the fungus, and those who consider the fungus as the sole cause certainly have the advantage of consistency. Dr. W. B. Carpenter, an eminent microscopist, believes in the fungus origin of the disease, and thinks it entirely caused by floating spores being carried in at the spiracles or breathing orifices of the worm, and germinating in the interior of the body.

Whichever view be held, it appears very clear that no remedies are known, but that care in procuring good eggs, care in rearing the worms, good leaves, pure, even-temperatured atmosphere, and cleanliness are checks to the disease.

As the sole means of disseminating the disease are the spores which only appear several hours after the death of the worm, the most rational means of preventing the spread of muscardine is by carefully taking from the tables all dead worms as soon as they are discovered, and if the disease seems to have gained a foothold in the magnanerie it will be well to remove the litter oftener and give the worms more

* *Guide à l'éleveur de vers à soie.*

space. The spores retain their power of communicating disease for at least three years; hence the importance of cleansing and fumigating as described in the last chapter.

PÉBRINE.

External symptoms.—"The disease, pébrine, shows itself outwardly by the dwindling away of the worms and their inequality of size; eating little, they do not grow as large as when in their normal state. At the end of a few days black spots frequently make their appearance on the skin, resembling punctures or burns; the anal horn, the prolegs, the soft parts between the rings, are especially subject to these spots."*

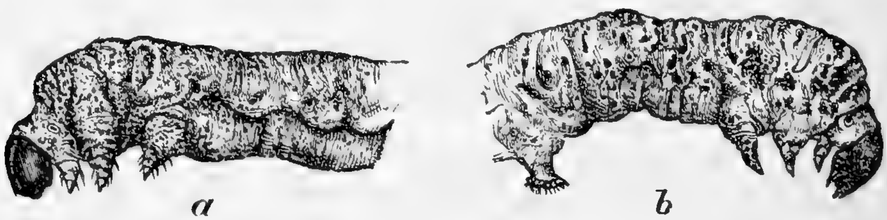

FIG. 20.—Silk-worms spotted with pébrine, twice natural size (after Pa teur).

Fig. 20 "represents, at twice the natural size, the anterior part of the body of sick worms covered with such spots. In one of the worms, *a*, they are just becoming visible, and the eye should be aided by a magnifying glass to render them distinct; the other, *b*, shows them farther advanced, easily recognizable with the naked eye, if the worm be examined with a little attention. Finally, Fig. 21 shows one ring spotted with pébrine, magnified to six diameters. For this cut was chosen a worm bearing two kinds of marks, one with clear-cut edges, the others surrounded with a halo. The first are wounds, the others the true spots belonging to the disease and serving as an indication of its existence, if not always, at least under many circumstances. The halos in question have generally a yellowish tint. They must be observed through a magnifying glass to be well seen."†

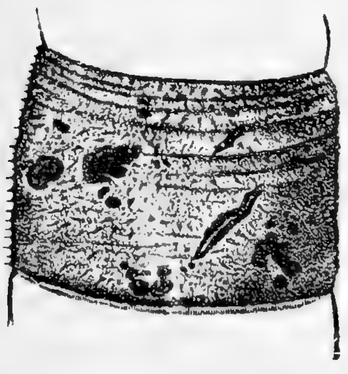

FIG. 21.—Joint of a Silk-worm showing wounds and spots of pébrine, six times natural size (after Pasteur).

These spots disappear with the shedding of the skin at each molt only to reappear again within a few days. Worms bearing them are figured in plate I, A, B, C, and D. In addition to these symptoms it is noticed that the prolegs do not seem to attach themselves easily to objects. In the chrysalis the abdomen is very much swollen and the rings stretched. In a highly-diseased moth the wings are wrinkled as when they emerge

* Maillot, *Leçons*, etc., p. 96.

† Pasteur, *Études*, etc., p. 15.

from the cocoon, and are often covered with bloody pimples, which become black on drying. Part of the body and the wings have a leaden color; but this must not be confounded with a certain natural brownness which some healthy moths exhibit, and which extends over the whole body; but it is only with highly diseased subjects that these exterior signs become visible, and to find the symptoms of the disease we are often obliged to resort to a microscopical examination of the interior of the insect.

Internal symptoms.—"In the interior of the body microscopic observation reveals the presence of innumerable corpuscles of an ovoid shape (Plate II), filling the cells of the walls of the stomach, those of the silk glands, the muscles, the fatty tissues, the skin, the nerves—in a word, all the portions of the body. There are often so many of them that the cells of the silk glands become swollen and white, and appear to the naked eye to be sprinkled over with chalky spots; the silky liquid always remains exempt from this parasite, but it is much less abundant than when the worm is in a healthy state."*

In 1849, M. Guérin-Méneville first noticed these floating corpuscles in the bodies of the diseased worms. They were supposed by him to be endowed with independent life; but their motion was afterwards shown by Filippi to depend on what is known as the Brownian motion, and they are now included in the class *Sporozoa* of the *Protozoa*, and referred by Balbiani to the order *Microsporidiæ.*

These corpuscles are found in the Silk-worm in all its stages—in the egg, larva, chrysalis, and moth. It was for a long time a mooted question as to whether they were the true cause or the mere result of the disease; but the praiseworthy researches of Pasteur have demonstrated that pébrine is entirely dependent upon the presence and multiplication of these corpuscles. The disease is both contagious and infectious, because the corpuscles which have been passed with the excrement or with other secretions of diseased worms may be taken into the alimentary canal of healthy ones when they devour leaves soiled by them, and because it may be inoculated by wounds inflicted by the claws of other worms. The malady may be carried to a distance with the corpusculous dust coming from infected magnaneries, and such dust holds the power of communicating disease from one season to another.

When the "seed" is thus diseased it hatches irregularly and incompletely, and the larvæ often perish before or during the first molt. When the corpuscles are taken into the intestines, as above described, the malady usually becomes apparent, through some of the external symptoms mentioned, at the end of four or five days. M. Pasteur determined that if the worm partook of the soiled food after the fourth molt it would make its cocoon, but that corpuscles would be found in profusion in the chrysalis and moth. If, on the other hand, the worm is thus ex-

* Maillot, *Leçons*, etc., pp. 96, 97.

posed to contagion just before spinning, the chrysalis will show the parasites only during its last days, while they will be abundant in the moth.

From the mother moth the corpuscles pass into the egg and give rise to the diseased "seed" already remarked upon. Disease in the male will not, however, affect its progeny. The egg is formed while the insect is still in the chrysalis state, and it has been ascertained that where the corpuscles become abundant only during the last days of this stage they enter into the seed to a very small degree only, if at all. For this reason eggs are sometimes found to be entirely pure, though the issue of a highly pébrinous parent. The development and multiplication of these corpuscles, though ordinarily very rapid, is insignificant in the egg until the formation of the larva begins. It will be easily understood that, though the parasite may exist in the vitellus of the egg, its detection may be extremely difficult. But when the development of the embryo has commenced, the number of corpuscles grows also, so that just before, or, better still, just after the time of hatching they may be found by hundreds upon a casual observation. Upon a microscopical examination at this time, Vittadini, in 1859, founded his system of selection, examining samples of eggs just at the time of hatching and rejecting those lots which showed the corpuscular disease.

At that epoch it was believed that the corpuscles existed even in the healthy moth when well advanced towards its natural death. But Pasteur showed this theory to be fallacious, proving, as we have said above, that the corpuscle is only present when the moth is diseased. He showed that, where the moth is free from the parasite, the egg, too, would be exempt, and that, as a rule, where the corpuscles exist in the moth, then its issue will probably be corpusculous also. There is, to be sure, even then a chance of its purity, as mentioned above—that is, where the corpuscles become abundant in the chrysalis only after the formation of the egg. But here, too, it is highly probable that the malady will have so affected the general health of the parent as to make her issue more apt to succumb to disease, as in the case of flaccidity. Therefore it is laid down as a rule, and upon this rule the Pasteur system of selection rests, that if, upon microscopical examination of the mother moth, the corpuscles of pébrine are found, then her eggs and issue will also be pébrinous, and should be destroyed.

The details of the Pasteur system of selection will be given in the next chapter.

FLACCIDITY (*flacherie*).

External symptoms.—When, after the worms have passed their fourth molt, and are eating well and regularly, they have all the appearance of perfect health and vigor, and the silk-raiser feels full confidence in the success of his crop, some will often be seen to crawl to the edges of the trays, and lie there languid and without motion. But for the loss of their wonted activity and the cessation of their naturally voracious appetite, one would still think the worms in perfect health, for they yet retain all the outward perfection of form that we have remarked above (Plate I, Fig. G). In color they have, perhaps, become somewhat more rosy, especially if the disease is in a violent form. On touching them, however, we find them soft, and even in this seemingly live condition they are often dead. Had the worms been carefully observed at this time, it would have been seen that the beating of the dorsal vessel was gradually becoming slower, and that it finally stopped altogether. A green drop appears at the mouth and the worm secretes a dirty liquid, which soils the anal orifice and gradually closes it.

Before many hours are passed the skin begins to shrivel and draw in around the fourth and fifth joints of the body, viz: those two lying between the set bearing the legs proper and the set bearing the prolegs (Plate I, Fig. F). Later, at this restricted point, the body begins to turn brown (Plate I, Fig. E), then black, and the whole worm is soon in an advanced state of putrefaction. Then, and even before the death of the worm, a sour odor is perceptible in the magnanerie, due to the fatty volatile acids exuded by the victims to the disease. Should the malady strike the insects at a later period, when they are ready to spin their cocoons, the same languishing air will be observed; they will show a reluctance to crawl up into the arches, and will be seen to gather around their bases, seeking some place which it requires no exertion to attain to spin their cocoons. Many of those which reach the branches stretch themselves out motionless on the twigs and die there. They are to be seen later hanging by their prolegs in different states of putrefaction (Fig. 22). When these symptoms are observed we may be sure that the worms are attacked by flaccidity (*flacherie*).

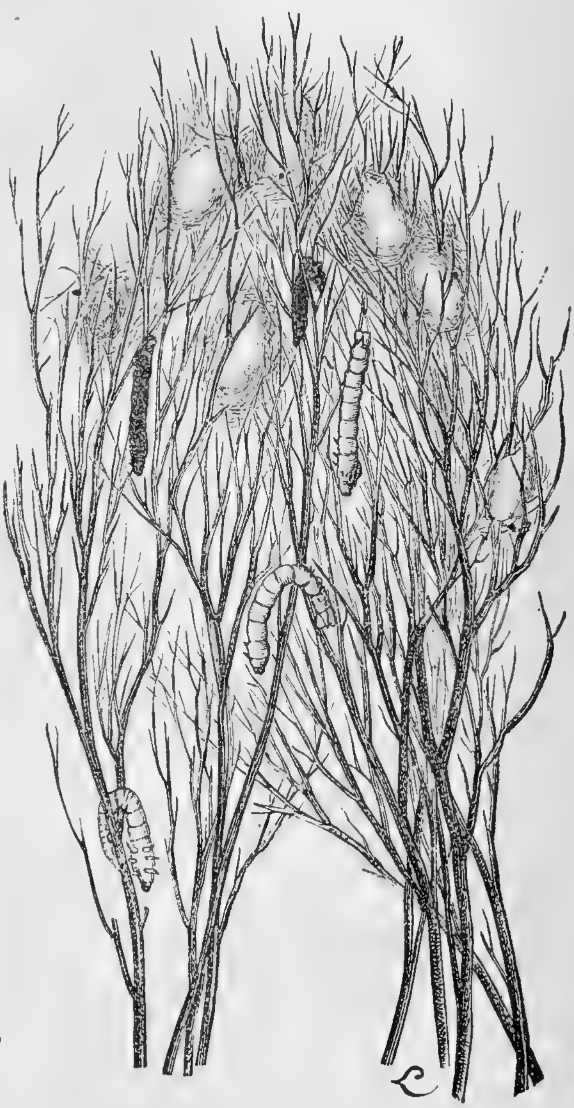

Fig. 22.—Silk-worms at the spinning period, after death by flaccidity (after Pasteur).

Internal symptoms.—A microscopic examination of the intestines of the sick worm will show masses of undigested food, and the coats of the intestines will be found to be opaque. Here, too, the microscope reveals the parasites ordinarily attending putrefaction, chief among which is a bacillus, seen sometimes with and sometimes without a bright nucleus. There also exists a special form of ferment, not unlike that which accompanies the formation of vinegar (*Mycoderma aceti* Pasteur), which is found in short chains, the links of which are almost spherical

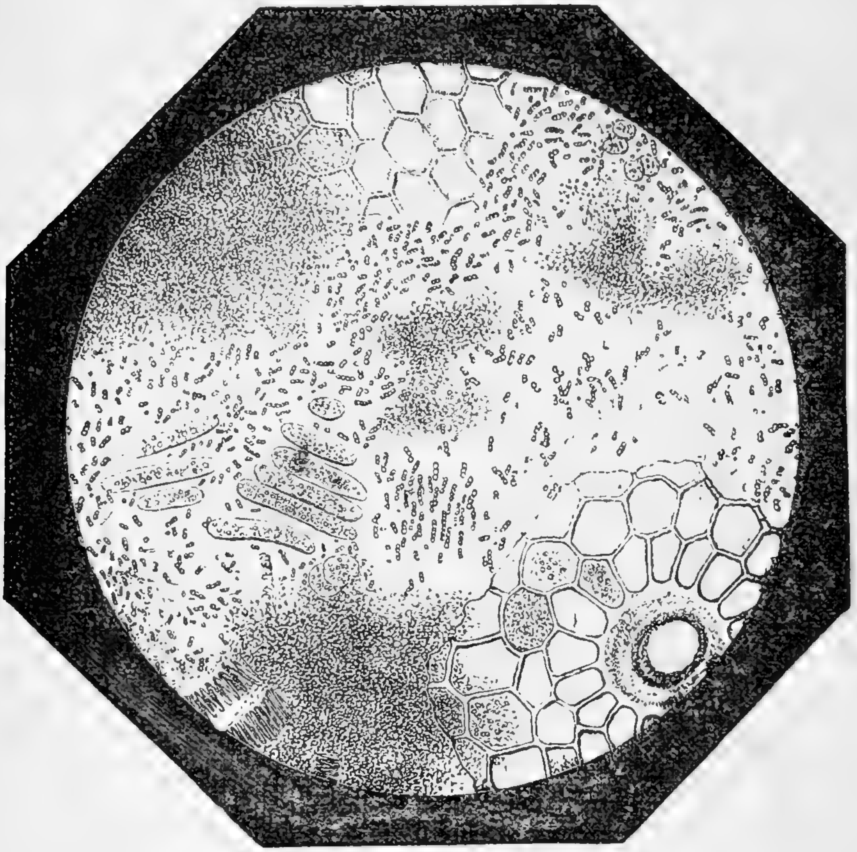

FIG. 23.—Chain ferment, taken from the stomach of a flaccid chrysalis. Magnified 400 times (after Pasteur).

in form (Fig. 23).* These two parasites are sometimes found together and sometimes separately. When the bacillus is abundant death quickly follows its appearance, and the disease, spreading rapidly, will sometimes destroy a whole school in a single day. At times this bacillus appears so short a time before the spinning of the cocoon that the worms are able to mount into the branches, and even make their cocoons and become chrysalides. Then, however, the disease overcomes them, and their putrefaction produces foul cocoons. This case is, however, more rare, and in general the bacillus is not often found in the chrysalis. When the ferment alone appears the disease progresses differently. The worms then show the same languor on the approach of the spinning period, and the same indisposition to make their cocoons; but even then they mount the branches, perform their work of spinning, are transformed into chrysalides, and these into moths which may have a fine appearance. The silk crop may even be exceptionally good; but where this state has existed, when the worm has been without its usual

* The distance from center to center of the links of these chains is about 1 μ (=0.001^{mm}=0.00004 inch).

agility at the spinning time, where it has shown this apparent laziness, then, though the cocoons be of the firmest and the moths the finest, there will exist a weakness, a constitutional debility, that will show itself in the next generation. This is the only way in which flaccidity is hereditary, in this predisposition of the worm to succumb to disease on account of the affection which weakened but which did not kill the parent.

Such are the symptoms attending flaccidity in Silk-worms, and from them M. Pasteur evolved the theory that the disease was caused by the fermentation of the food in the intestinal tube of the larva, which was followed by diarrhea and the closing of the anal orifice, as already mentioned. Confirming this theory of food fermentation is the fact that the same parasite (Fig. 23) which is found in the intestines of flaccid larvæ also exists in a fermented broth of mulberry leaves. Digestion thus arrested, the worm ceases to eat and becomes languid. The gases evolved by the processes described burst the walls of the intestines and cause the death of the victim. Such is the Pasteur theory, followed, as a rule, by the French scientists.

Italians, on the contrary, believe with Verson and Vlacovich, who claim to have observed "that in the flaccid worm the micro-organisms are not at times to be found; that it has been proved that in the beginning there occurs a tumefaction of the membrane of the intestines, and that this membrane, as the disease advances, disappears here and there, and finally altogether. According to them flaccidity consists primarily of a lesion of the membranous walls of the intestines, which would generally be followed by the development and multiplication of the micro-organisms which Pasteur considered the primitive cause of the disease. It is a fact, nevertheless, that all acknowledge, that in most cases flaccidity is accompanied by bacilli and ferments in great numbers in the intestinal tube."*

Flaccidity generally appears after some sudden change in the weather or temperature, as, for instance, a thunder shower, or a hot, heavy day. It is apt, too, to follow the feeding of wet or fermented food. If the shelves go too long without cleaning and begin to mildew; if the worms are too crowded on the table and their natural respiration interfered with, flaccid subjects will soon appear in the school. These, by their unhealthy excrement, soil the food of their neighbors, who quickly follow them in the path of disease. It is thus that flaccidity becomes highly infectious.

No very satisfactory means have been proposed for combating this malady when once it appears. It would be well, on the discovery of the first victims, to take the worms remaining healthy into another apartment and give them more space and plenty of air. Attentive care may then save the crop, though by no means with certainty.

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* Perroncito, *I Parassiti*, p. 35.

To avoid the disease one should carefully follow the fundamental rules already laid down (Chapter IV), though even then circumstances may be against the silk-raiser and the crop be lost through no apparent fault of his.

GRASSERIE.

This disease is of little importance, and has therefore received but little attention from scientists. It is thus described by Maillot:*

"In the middle of a school of worms in good condition it is not rare, as a molt approaches or just before the spinning begins, to find here and there some worms which crawl slowly, and have a shining, stretched, thin skin; the body is of a bright yellow in the yellow, and of a milky white in the white races; a troubled liquid transudes through the skin; soiling the food and the worms over which the diseased subjects pass. * * * A moist, cold, stagnant air seems to favor the occurrence of grasserie. The disease is not contagious, * * * nor does it appear that it can be transmitted by heredity. From this point of view there is nothing to be feared, unless a great number die of the malady, in which case it will be imprudent to use the stock for reproduction."

Victims of this disease should be removed as soon as discovered, as they are apt to crawl into the branches and soil the cocoons spun by other worms.

Prefacing the next chapter we may draw the following conclusions from what has been said: Grasserie is never hereditary, as the victim never dies later than in the chrysalis state, and the disease can never originate in the moth. This is equally true of muscardine, provided the moths be not mingled with worms covered with the spores of the Botrytis. In such a case the moth might also catch the disease and its general debility decrease the vigor of its progeny. Flaccidity is hereditary in an indirect manner, a debility springing from the affection of the parent rendering its issue more apt to succumb to disease. And finally, pébrine is hereditary in its true sense, the corpuscles passing from the mother through the egg to the next generation. In the production of eggs, then, we need look for flaccidity and the pébrine only, the other diseases not entering into the consideration.

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* *Leçons, etc.*, p. 111.

CHAPTER VI.

REPRODUCTION.

It has been said in Chapter IV that the first condition of success in raising Silk-worms is to "procure good eggs." The object of the present chapter is to describe the most approved processes of producing such eggs.

Were it not for the diseases to which the Silk-worm is subject, the old, simple processes of egg production might still be followed, and even now, unless the egg producer is able and ready to undertake the microscopical examination required by the Pasteur system, it is needless to observe the more complex rules for the isolation and examination of the moths.

The simple process formerly employed in all sericultural countries consisted in stringing the cocoons and letting the moths couple, as in the modern process. A sheet was then hung up with the lower edge so turned as to form a trough into which any badly gummed eggs might fall. After uncoupling, the females were placed upon the sheet and permitted to lay their eggs promiscuously. The only precaution taken against disease was in the selection for reproduction of lots of cocoons whose larvæ had shown no signs of any malady, and which were themselves of first quality. From what has been said it will at once be seen that pébrine contracted after the fourth molt and the slow form of flaccidity due to the presence of chain-ferment are not thus guarded against. The modern system has a deeper, more scientific basis, and aims to guard against these.

The Pasteur system of microscopical selection.—As we have seen, pébrine and flaccidity are the only diseases which it is necessary to guard against in selecting eggs. If pébrine or flaccidity have appeared in a positive form in the larvæ, either through the external or internal symptoms described in the last chapter, no further examination need be resorted to, as the stock will evidently be unfit for reproduction. The most important and positive sign of the latter disease to be looked for is languor at the spinning time. If a greater degree of certainty is desired, or if the egg-producer has not had the opportunity of observing the rearing of the worms, a miscroscopical examination of the chrysalis may be resorted to. In flaccidity this examination should be confined to the stomach, where the chain-ferment to be sought for is more easily found. M. Pasteur gives the following directions for extracting this organ:

"Cut away the walls of the thorax of the chrysalis with fine scissors, after the manner shown in Fig. 24, so as to reveal the stomach *s*. Draw this out with a pair of tweezers. The restricted part of the digestive tube, which unites the stomach with the urinal sack *u*, should then be cut. The anterior part of the digestive tube now alone holds the stomach in place, and this easily gives way. Lay the small ball thus withdrawn on a glass slide and scratch away the very soft, fatty envelope which covers the interior. Of this interior substance take a piece as big as the head of a pin, wash it with a drop of distilled water, and, placing it upon a slide with a cover glass over it, examine it with a microscope magnifying about four hundred diameters. With a little experience this work may be done very rapidly. It would be well to take out at the same time the stomachs of, say, twenty chrysalides, and lay them on as many glass slides. * * *

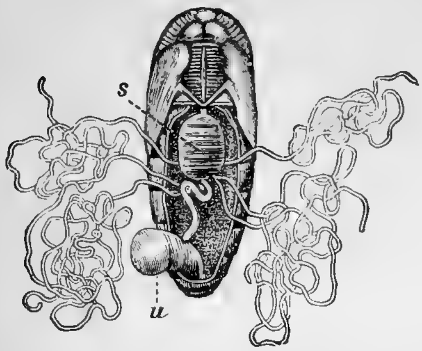

FIG. 24.—Anatomy of the chrysalis, showing method of extracting the stomach (after Pasteur).

"The first few days after the formation of the chrysalis the contents of the stomach are generally very liquid, which makes their extraction inconvenient. It is better to make these observations seven or eight days after the spinning begins, when the matter will be found to have more consistence. * * * Fig. 23, page 38, shows the appearance of the ferment found in flaccid chrysalides under a magnifying power of 400 diameters. It is associated with the débris of leaves, morsels of the trachea, and chlorophyl cells. These matters ordinarily accompany the little ferment in the stomach of the chrysalis, because of the incomplete digestion of the leaf whenever it is submitted to fermentation."*

No parasite indicative of flaccidity has been discovered other than this ferment, which is not found in the adult insect; and if the transformation into the moth is permitted, all opportunity will be lost for detecting the disease.

In pébrine, on the contrary, the corpuscle is found in the moth as well as in the chrysalis. We might, therefore, wait for a final examination of the moth to be made after oviposition. But, in case disease is then found, it will be too late to stifle the cocoons, and the emergence of the moths will have ruined them for certain commercial purposes. For this reason it is important to detect the disease, if it exists, at as early a stage of the work as possible. If the larvæ have shown no external signs of the pébrine, it would be well to microscopically examine a few of the last worms to spin. The corpuscles will be found in these laggards, if anywhere.

Isolation and examination of the moths.—If left to themselves the insects remain in the chrysalis state for from two to three weeks in our ordi-

* Pasteur, *Études*, etc., Vol. I, p. 233.

nary summer weather. Their development may, however, be hastened or retarded by increasing or lowering the temperature. This fact is taken advantage of to obtain a few adult insects which may be microscopically examined before the whole lot becomes fully developed.

I was very much pleased with the method employed by M. Maillot, which I had an opportunity of examining at Montpelier, in 1884, and I here give a description of it in his own words:

"Three or four days before the cocoons are taken from the branches we take, here and there, from the early spinners as well as the late, several hundred cocoons; as, for example, five hundred from a lot of 90 pounds. This sample should be placed in an oven or warm room, where it will be kept day and night at a temperature of from 100° to 110° Fah., and a high degree of humidity. In this way the formation of the moth is hastened. As during this time the cocoons of the lot itself remain at a temperature of from 75° to 90°, and often during the night at even lower temperatures, we shall still have time to stifle them if the lot is discarded, or to string them into chains if, on the contrary, it proves healthy.

"Every two days we take ten chrysalides from the sample and examine them microscopically for corpuscles. If we find them in the first eight or ten days, no matter in how small quantities, we can be sure that the proportion of pebrinous moths will be considerable. When the chrysalides are mature, which is easily seen by their eyes becoming black and the eggs harder to break under the pestle, and also by some of them turning into moths, we proceed to the definite examination. We crush one by one the moths which have come out and the chrysalides which remain and search for corpuscles; the per cent. which is thus found will not differ materially from that which exists in the whole lot."*

The examination of the chrysalides here mentioned may be made in the manner already described when searching for the ferment of flaccidity and at the same time. But if we are looking for the pébrine only we need simply crush the whole chrysalis in the manner hereafter described for the moth.

Proceeding now with stock of which the purity has been ascertained by one or more of the different methods of observation above described, 200 cocoons should be selected for each ounce of eggs that it is desired to produce. In making this selection great care should be exercised in taking only cocoons that are fine in texture and firmly made. This fineness is one of the prerequisites of a first-class cocoon. What is meant by this difference in texture will be seen by an examination of Figs. 2 and 3, page 14, the former being fine and the latter coarse. The firmness of the cocoon, depending as it does on the amount of silk which it contains, is an indication of the vigor of the worm, and another item to be considered in selecting stock for reproduction. Rules have been

*Maillot, *Leçons*, etc., p. 250.

given for the determination of the sex of the inclosed insect, and among them, perhaps the most common, is the assertion that those that are constricted in the middle (Fig. 2) contain males, while those not constricted (Fig. 3) contain females. This, however, may be regarded as an indication rather than a fixed rule, and there are races in which the cocoon is almost uniformly constricted and others where the reverse is true. But this careful selection for sex is comparatively unimportant, and we consider it wiser to choose the cocoons in relation to their firmness and texture, and trust to chance to bring as many male moths as female. Double cocoons, where two worms have spun together, should never be used in egg-making.

The proper cocoons having thus been selected, they should be strung upon stout threads about 3 feet long. Care should be taken not to prick the chrysalides with the needle while passing it through the end of the cocoon in making the chains. These chains should then be hung in a cool, darkened room while waiting for the moths to emerge. They should not be placed near any object which would be soiled by the secretions emitted by the moths on their emergence from their cocoons.

Previous to this emergence there should be prepared for each ounce of eggs to be produced about one hundred small bags of fine muslin (cheese cloth makes a good material), made in the following manner: Cut the cloth in pieces 3 by 6 inches, then fold one end over so as to leave a single edge of about three-quarters of an inch, as shown in Fig.

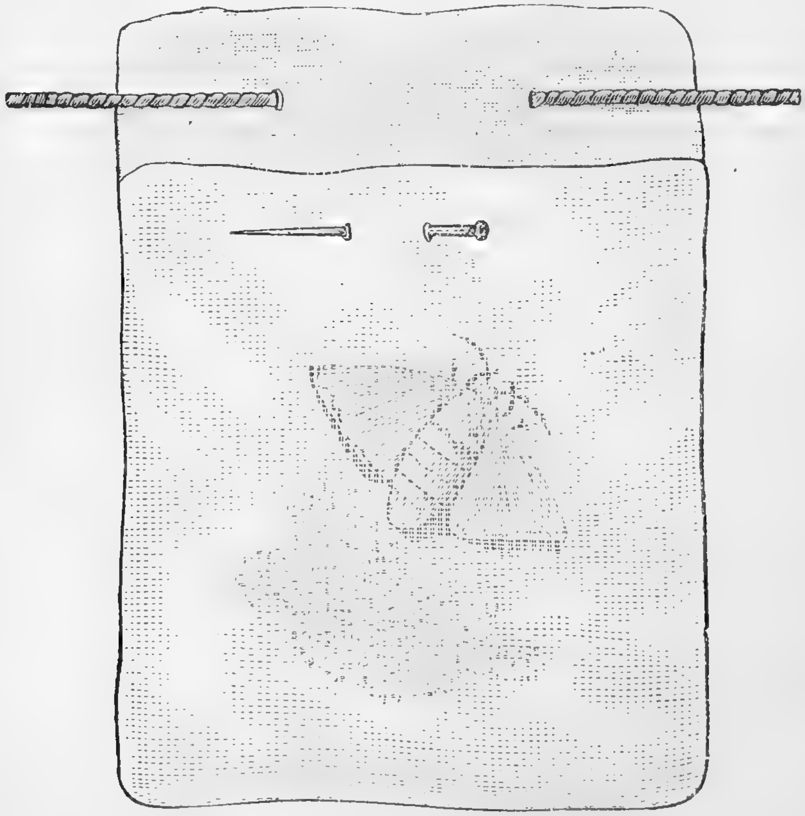

Fig. 25.—Cell used in the Pasteur system of egg-laying (after Roman).

25. This should be sewn up into a bag with the upper end open, and then turned inside out so that the seams will cause the sides to bulge. Thus completed they are called "cells." The cells should be strung

on a cord stretched across the room. Some trouble having been experienced in keeping the moth from crawling out of the cell at either side of the pin, which is the method of closing it shown in the cut, the scheme shown in Fig. 26 was adopted last year in the Department.

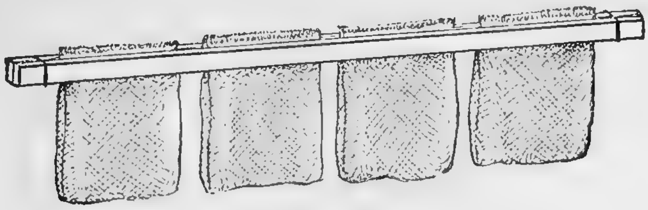

FIG. 26.—Method of clamping cells (original).

This consists in clamping the bags in fours between two sticks of wood, rough sawn, about one-half by one-quarter inch through and 14 inches long. They are bound together by rubber bands and may be laid across parallel wires stretched across the room at about 13 inches apart. M. Pasteur suggests that a simple piece of cloth about four inches square be used instead of the sack. The moth lays her eggs on this and is then retained by being fastened to the cloth, the corner of which is turned up over her and a pin passed through it and over her wings (Fig. 27).

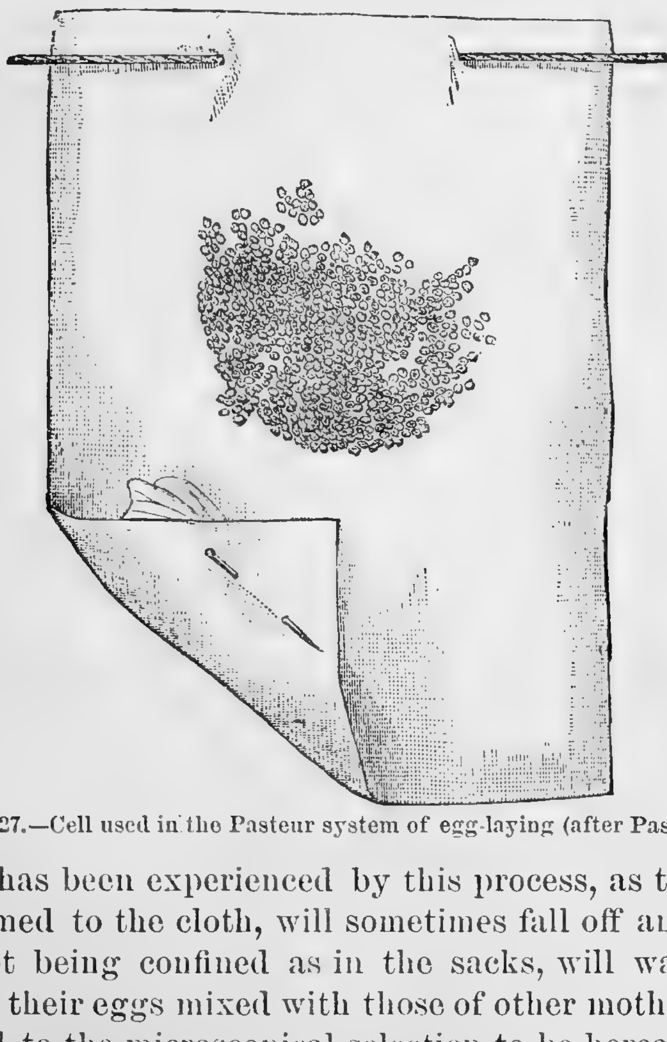

FIG. 27.—Cell used in the Pasteur system of egg-laying (after Pasteur).

Some trouble has been experienced by this process, as the eggs, if not properly gummed to the cloth, will sometimes fall off and be lost, and the moths, not being confined as in the sacks, will wander to other cloths and get their eggs mixed with those of other moths, which would be detrimental to the microscopical selection to be hereafter described. It has the advantage, however, of enabling the microscopist to avoid the labor of turning the sacks.

The moths emerge from the cocoons, as a rule, from 5 to 8 o'clock in the morning. At the latter hour many of them will be found coupled and clinging to the chains. These should be carefully taken by the wings and placed upon a table by themselves, the single moths being placed upon another table where they will couple if the sexes are evenly divided. They should then be transferred to the first table as the fluttering of the male moths is apt to disturb the couples. These should be left together until 4 or 5 o'clock in the afternoon, when they may be separated by drawing them gently apart by the wings. The females should then be placed in the cells or upon the cloths already described, where they will at once commence their egg-laying, completing it in about thirty-six hours. Most of the males may then be thrown away, though it may be wise to keep a few of the more active ones to compensate for any superabundance of females in the issue of the following day. But little difficulty will be encountered in distinguishing the sexes, the males being noticeable by their smaller abdomens, more robust antennæ, and by their greater activity.

When the eggs have been laid, the microscopical examination of the moths should be made with a view to ascertaining whether or no they are afflicted with pébrine. The entire moth should be ground up with a few drops of distilled water* in a small glass mortar (1 ounce is a convenient size). A drop of this water is then taken with a medicine dropper and placed upon a glass slide with a cover glass over it. It is then microscopically examined with a power greater than three hundred diameters. Plate II shows a field very highly charged with the corpuscles of pébrine. When the moths are not examined until some time has elapsed after their death, they will be found to contain other germs peculiar to putrefaction. These do not indicate any disease that would affect the egg or its issue; nor does their presence imply any lack of vigor in the parents. They are simply post-mortem parasites. Great care should be taken in cleansing the mortar, pestle, and other implements before making an examination, by washing them in an abundance of water and rinsing them thoroughly with distilled water. In making the above examination only the corpuscles of pébrine need be looked for. The bacilli and the ferments of flaccidity are rarely found in the moth.

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* The amount remaining in the mortar after rinsing is sufficient.

CHAPTER VII.

CHOKING THE CHRYSALIS.

In most silk-producing countries the parties who raise the cocoons sell them to the reeling establishments before suffocation is necessary, as these establishments have better facilities for this work than are to be found in private families. If, however, the reeling is done by the raiser, or some time must elapse before the cocoons can be sent to a reeling establishment, some means must be used to kill the contained chrysalis before the cocoon is injured for reeling purposes by the egress of the moth. This can be done by stifling them with steam or choking them by dry heat. Steaming is the surest, quickest, and best method, if the facilities are at hand; it can be done at any steam mill. The cocoons are laid upon shelves in a tightly-sealed box and the steam is turned in. Twenty minutes will suffice to do the required work, and the cocoons are then dried in the sun.

The following apparatus has been used by Mr. Walker at the Department:

It consists of a tin reservoir, about one-third filled with water. Slightly above the surface of the water is a movable perforated partition, B, intended to prevent spattering during ebullition. The upper portion contains a perforated pan for holding the cocoons, while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus, over boiling water, for twenty minutes. It will be seen, too, that much the same apparatus may be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should only be subjected to the action of steam. The apparatus is 12 inches in diameter and 13 inches deep, and will stifle from 3 to 4 pounds of cocoons at a time.

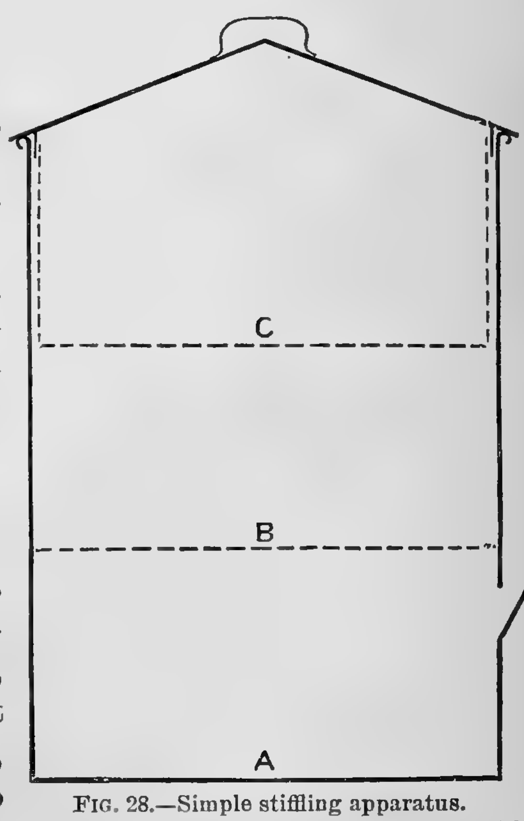

Fig. 28.—Simple stiffling apparatus.

The dry-heat method occupies a much longer time. The cocoons are placed in shallow baskets and slipped on iron drawers into an oven which is kept heated to a temperature of about 200° F. This should not be increased for fear of burning the silk. This operation lasts from two to twenty-four hours. A certain humming noise continues so long as there is any life, and its cessation is an indication that the chrysalides are all dead. Where the choking is well done there is little loss, only about 1 per cent. of the cocoons bursting at the ends. After choking in this manner, the cocoons should be strewn upon long wooden shelves in the shade, with plenty of air, and, for the first few days, frequently stirred. After remaining on these shelves for about two months, with occasional stirring, the chrysalides become quite dry, and the cocoons will preserve indefinitely. They are, however, still subject to the attacks of rats and mice, and the little beetles known as "museum pests," belonging to the genera *Dermestes* and *Anthrenus*, are attracted by the dead chrysalis within and will penetrate the cocoon, injuring it for reeling purposes. In the warm Southern States the dry-heat choking can be accomplished by simple exposure to the sun. Two or three days of such exposure are sufficient. But, as strong wind may annihilate the effect of the sun's warmth, it is good to have for that purpose long boxes, 4 feet wide, sides 6 inches high, to be covered with glass frames. This will increase the heat, and, by absorbing the air of the box, stifle the chrysalis most surely. The glass cover should be slightly raised to permit the escape of the excessive moisture which evaporates from the cocoons, and care should be had to keep out the ants.

CHAPTER VIII.

SILK-REELING.

Spun, reeled, and thrown Silk.—From the cocoon the silk is by different processes transformed into spun or reeled silk. The former is generally made from pierced cocoons or silk waste, and serves in the manufacture of inferior classes of tissues. The method of manufacture consists in cleaning and macerating the raw material, after which it is carded and made into thread somewhat after the manner of cotton. The process of producing reeled silk, which will be hereafter treated at length, consists, in general, of softening the gluten of the cocoons in hot water and then taking the ends of the constituent threads of several of them together and winding these threads from the cocoons upon a reel.

By virtue of the next process of manufacture to which this material is submitted it becomes *thrown silk*. Thrown silk is classified as organzine and tram. It is made either from spun or reeled silk. Tram consists of two or three threads of reeled (or spun) silk twisted together at about 75 to 100 turns per running meter (67.5 to 90 per yard). It is used in making the warp in weaving. Organzine, used in the woof, is produced by twisting two threads together at about 500 to 600 turns per running meter, and then taking two of the threads thus made and twisting them together in the opposite direction at about 400 to 500 turns. It is, in the language of the trade expression, "cable laid."

It is the object of this work to deal only with one of these classes; that is to say, reeled, or, as it is commonly called, raw silk. Although the former name indicates more exactly than the latter the processes to which the raw material has been previously submitted, yet the term "raw silk" has acquired a special meaning by trade usage and applies only to reeled silk.

The process of Silk-reeling.—The cocoons should have been roughly sorted before they were spread out in the cocoonery, the double and feeble specimens having been laid aside. They should now be sorted so that cocoons of the same color and shade may be reeled together, for the use even of cocoons of the same color but of different shades will give a streaked skein of silk. They should, too, be sorted as to their texture. Those of fine texture, among ordinary cocoons, are considered first choice and are used to produce the finest qualities of raw silk. They are more easily unwound than those of coarser texture which are called satiny cocoons. This satinage appears to be due to the fact that the successive layers of the cocoon are insufficiently gummed together. As a result the water penetrates quickly into its center while it is being reeled and causes it to sink to the bottom of the basin, which interferes with the process of unwinding. Towards the end a satiny cocoon comes off in flocks, making a dirty silk.

A comparison of the cocoons shown in the cuts on page 14 may convey an idea of the difference of texture mentioned, Fig. 2 being fine, and Fig. 3 of coarse grain. In addition to the above features some regard must be paid to the reeling of cocoons of the same size together. An extended experience is needed to make a rapid cocoon-sorter, and it is work that should be followed without intermission, that the knack necessary to quickness may not be lost.

The process of reeling cocoons, while extremely simple, is still one that requires an amount of skill to acquire which the experience of several months is necessary. The cocoons are first plunged into boiling water, whereby their gluten is softened in such a manner as to render the unwinding of the filaments an easy matter. This done, they are brushed with a small broom, to the straws of which their fibers become attached. The bundle of filaments is then taken and they are unwound until each cocoon shows but one clean thread. These three operations are called "cooking," "brushing," and "cleansing." All of these operations can be accomplished mechanically.

The elements of the mechanism of all modern silk-reels are essentially the same. They are shown in Fig. 29, and consist, in general, of a basin,

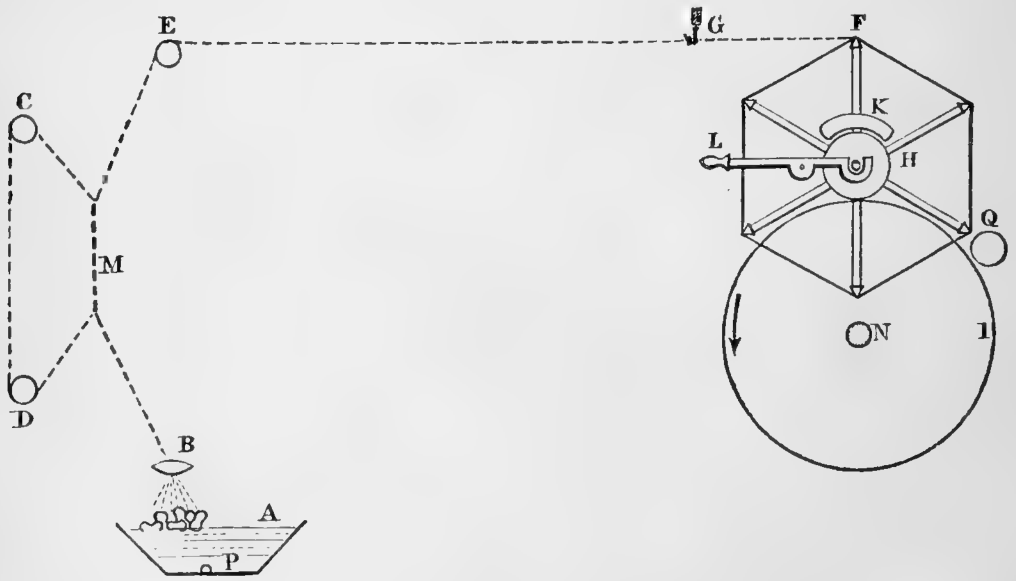

FIG. 29.—Elements of the mechanism of a modern silk reel (original).

A, in which is a perforated steam-pipe, *P*, by means of which the water in the basin may be heated. A few inches above the surface of the water is placed a perforated agate, *B*. The cocoons having undergone the three operations mentioned, the ends of the filaments of four or more of them are twisted together into a thread, which is passed through the hole in the agate. From this it runs through the "croisure" *M*, which will be hereafter explained, and over the guide *E* to the reel at *F*. Between *E* and *F* the thread passes a guide, *G*, moving to and fro (in a line perpendicular to the plane of the paper), which distributes it in a broad band over the surface of the reel. This facilitates the drying of the silk, without which the gluten would bind together the threads of the skein as it does those of the cocoons, and thus ruin its commercial value. In winter it is often necessary to use supplementary means to effect this drying. Perhaps one of the best is by passing a large steam-pipe near the reel, as at *Q*. The shaft of the reel carries at one end a friction-wheel, *H*, which rests on the large friction-wheel *I* that constantly revolves on the shaft *N*, and thus motion is imparted to the reel. In order to stop the reel it is only necessary to raise the wheel *H* from its bearings by means of the lever *L*. This movement presses the wheel against the brake-shoe *K*, and its motion is at once arrested.

As has been said above, the thread is passed between the agate and the reel through the croisure. The making of the croisure consists in twisting the thread around itself or another thread so as to consolidate its constituent filaments and wring the water from it and thus aid in its drying. The mode of the formation of this croisure forms the principal distinguishing mark between the French and Italian systems of reeling. The former is called the "Chambon system." Each reeler manages two threads. These are passed through separate agates, and after being brought together and twisted twenty or thirty times around each other are again separated and passed through guiding eyes to the reel. The other system, called "tavellette,"* consists in passing the thread up over a small pulley *C*, down over another *D*, and then twisting it around itself, as shown at *M*, in Fig. 29, and thence to the reel.

The cocoon filament is somewhat finer in the floss or beginning, thickens at the point of forming the more compact pod, and then very gradually diminishes in diameter until it becomes so fine as to be incapable of standing the strain of reeling. Therefore a thread which is made up of five new filaments becomes so small when the cocoons from which it is drawn are half unwound as to require an addition. This addition might also be made necessary by the rupture of one of the constituent filaments. It is here that the skill of the operator is called into play. When her experience tells her that the thread needs nourishing from either of these causes she takes the end of the filament of one of the cocoons which lie prepared in her basin, and, giving it a slight snap or whiplash movement with the index finger, causes it to wind around or adhere to the running thread of which it from this moment becomes a constituent part. This lancing, as it is called, of the end of the filament, although in hand reeling performed in the manner described, is also accomplished mechanically, several devices having been invented for this purpose.

*The trade name of the small pulley mentioned.

They consist, in general, of a mechanism which causes a small hook to revolve in a horizontal plane about the running thread, and to twist around it any end of the filament that may be placed in the path of the hook. The reeler, seeing that a new filament is needed, holds the end of one in the way of the attaching device and it is automatically caught.

The temperature of the water used while reeling the cocoons varies from 140° to 175° F. The more cocoons have been cooked the lower will be the temperature required. It is customary, however, to work in the neighborhood of the maximum limit. Whenever the silk rises in locks the temperature of the water is known to be too hot, and when it unwinds with difficulty the temperature is, on the contrary, too low. The operator is supplied with a skimmer with which to remove all chrysalides and refuse silk; also, with a basin of cold water, in which to cool her fingers, which are being constantly dipped in the hot basin.

It is highly important that the silk be kept as clean as possible. It lacks cleanness when the filament ends are badly attached in lancing, when the figure 8 loops, of which the cocoon is composed, come off one or more at a time instead of unwinding continuously, or when the thread after breaking is not neatly knotted. All these faults show in weaving and injure the value of the silk.

According to Dandolo the fresh cocoons consist, by weight, of:

	Per cent.
Chrysalides	84.20
Castings	0.45
Silken pods	15.35

It is from this 15.35 per cent. that the reeler draws her silken thread. But a large proportion of even this is lost, so that there is recovered but 8, 9, or rarely 10 per cent. of the original weight of the cocoons. From this it will be seen that it takes from 10 to 12½ pounds of fresh cocoons, or 3⅓ to 4⅙ pounds of dry ones to make a pound of silk. A more usual working average, with good stock, is in the neighborhood of 3¾ pounds of dry cocoons per pound of silk. If cocoons are of poorer quality they necessarily produce less silk and their commercial value falls off in far greater proportion than their power of silk production.

CHAPTER IX.

PHYSICAL PROPERTIES OF REELED SILK.

Certain physical properties are of great importance in determining the commercial value of reeled silk. They are its cleanliness, already mentioned; its mean size; the irregularities in its size; its ductility, or, as it is wrongfully but universally called, its elasticity; its tenacity, and the amount of soluble gum which it contains.

The mean size of a skein is determined in the following manner: One thousand yards of the thread is wound off on a reel, supplied with a counter called an *éprouvette*, and made into a little skein termed an *échevette.* This échevette is then weighed and the number of sixty-fourths of a dram which it is found to equal becomes the size number of the thread. This process is called the sizing, or, colloquially, the "dramming" of silk.

In Europe the same system is employed, but the units are a length of 476 meters (400 old French ells) and a small weight called the *denier.* One dram silk in America is equivalent to a thread of 17$\frac{1}{3}$ deniers in France.

Until recently there has been no means of determining the irregularities in size existing in a silken thread, but manufacturers were content to approximate it by weighing four échevettes per sample skein. The difficulty in making this determination is owing to the fact that the thread is not round, but flattened, being, in fact, in its simple state, two filaments joined into one, and when several of these naturally compound filaments are combined to make a commercial thread the matter becomes still more difficult. Mr. E. W. Serrell, jr., of New York, has, however, overcome these obstacles by relying on another property of a silk filament, which is, that the distance which a given length will stretch under a given tension is inversely proportionate to the mean cross-section of this length. This is the underlying principle of his serigraph, which will now be described. The mode of testing with this machine is as follows: The end of the thread is brought from the reel or bobbin on which it is wound, around a drum (Fig. 30 *A*), thence over

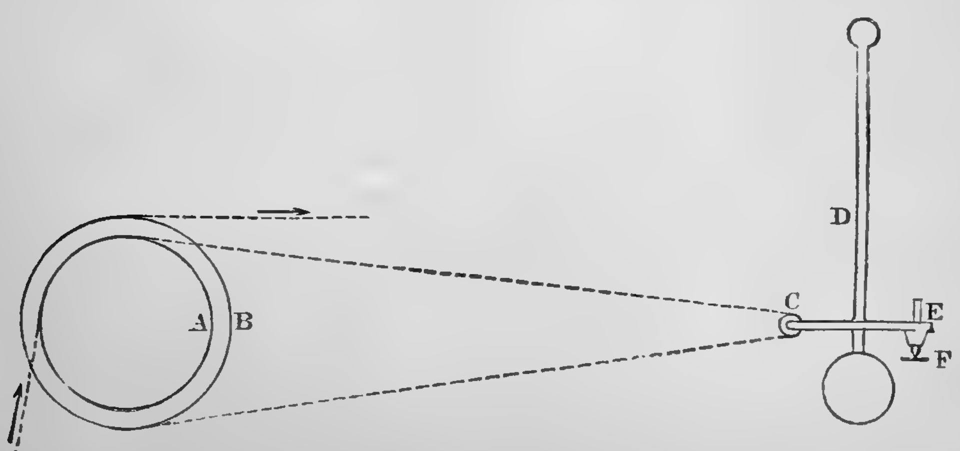

FIG. 30.—The principle of the Serigraph (original).

a pulley, *C*, and back around another drum, *B*, mounted on the same axis as *A*. From the drum *B* it is wound on a reel. The drum *B* is larger than *A*, so that the former winds on the thread somewhat faster than it is paid off by the latter. In thus stretching the thread we apply a force to the pulley *C* tending to draw it from its normal position. This pulley is attached to the base of a pendulum, *D*, which, under the action of the force mentioned, is drawn from the perpendicular. The weight of this pendulum overcoming this applied force to an extent inversely proportional to the mean section of the length of thread submitted to the test, the position of equilibrium taken by the pendulum depends upon that mean section. This length of thread is the piece between the two drums *A* and *B*, and as, through the constant action of the machine, successive lengths of thread occupy the position indicated, the pendulum oscillates through a course which depends upon the irregularities of the thread. These irregularities are graphically recorded by a pencil, *E*, attached to the pendulum, upon a band of paper, *F*, constantly moving under its point. In the commercial form of the machine the mechanism for driving the reel is so constructed as to stop automatically when a standard échevette has been wound upon it, and this échevette may then be sized in the manner above described.

The elasticity and the tenacity of raw silk are determined by the use of the serimeter. This machine is composed of a dynamometer above, a graduated circle indicating the tension corresponding to the point at which the index stops. On the lower extremity of this dynamometer is a knob to which the thread to be tested may be attached. At 50 centimeters below this knob, in the same vertical line, is another knob attached to a counterweight which is on the inside of the case of the instrument and which also bears a pointer moving along a graduated scale on the outside of the case. This weight is held in place by a detent which is terminated on the outside of the case by a faller, on which it is only necessary to press lightly to cause the detent to let go the counterweight and permit its index to slide along the scale; these stop instantly, on the other hand, when the faller is released and retakes its initial position.

The silk thread attached to the two knobs mentioned passes over this faller, and, as it tends to pull it from its normal position, the detent lets go the counterweight and the thread stretches until rupture takes place, when the descent of the counterweight is automatically stopped. It is then only necessary to read the indication of the dynamometer to ascertain the weight which caused the rupture. By doubling the distance passed over by the sliding index, we have the stretch per meter or per cent. of elasticity.

The elasticity or ductility of silk is about 15 to 20 per cent., being nearly four times superior to that of cotton. It is about the same as brass and slightly greater than iron; hair has only half the ductility of silk.

"The tenacity of silk thread is well known; a thread of raw silk of 10 deniers easily supports a weight of 50 grams* without breaking. Direct relations exist between the tenacity of silk, the country in which it originates, its hygrometric state, the processes by which it was reeled, etc. Relations not less interesting may be found between the elasticity and the ductility." †

In the silk which constitutes the cocoon as made by the worm we find three classes of material. They consist of a waxy substance soluble in boiling water, of a gluten soluble in certain acids and alkalies, and especially in a solution of soap, and of the fibrine which constitutes the base of the thread. In the yellow silks there is also a slight quantity of coloring matter. Robinet found from 4 to 5 per cent. of the waxy substance, which, being soluble in boiling water, disappears in the process of reeling. We therefore find in reeled silk the gluten, or, as it is technically called, *grès*, and the fibrine. Before this silk can be properly dyed it is essential that a certain portion of this gluten be removed. This operation is usually performed by boiling it in a solution of soap. At the Conditioning Works at Lyons, France, this boiling off, as it is called, consists of two operations. The silk is first submitted for thirty minutes to ebullition in a solution containing an amount of soap equal in weight to about 25 per cent. of the weight of the silk boiled off. This silk is then wrung, in order to free it from the soap and the dissolved gluten, and then resubmitted to the same operation of boiling. As a result of these tests, it is found that white French silks contain 19.68 per cent. of gluten and the yellow silks 22.84 per cent. Silks coming from Italian filatures contain an amount of gluten slightly in excess of these figures, while the Chinese silks exceed them by more than 2 per cent.

The silk thread is highly hygrometric, containing under ordinary conditions 10 to 12 per cent. of water, while a thread of raw silk is capable of absorbing 21 to 26 per cent. Humidity augments the ductility of silk and slightly diminishes its tenacity.

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* 100,000 times the weight of a piece 50 centimeters long.

† Adrien Perret, "*Monographie de la Condition des Soies de Lyon.*"

CHAPTER X.

FOOD-PLANTS.

The traditional food-plant of the Silk-worm is the Mulberry (botanical genus *Morus*). There are two species of Mulberry indigenous to the United States, namely, the Red Mulberry (*Morus rubra*) and the Small-leaved Mulberry (*Morus parvifolia*), neither of which is suitable Silk-worm food. I have tried in vain to rear the worms upon *rubra*, but they either refuse its leaves entirely or dwindle and soon die upon it. The imported kinds which are most used are the Black (*M. nigra*) and the different varieties of the White (*M. alba*). The first is inferior to the others as Silk-worm food.

The *Moretti*, a variety of the White Mulberry, is profitably grown in the form of a hedge, and the large size of its leaves makes it a very desirable variety.

The *rosea*, *japonica*, and the *multicaulis*, varieties of the same species, are also used with excellent success.

A species of Mulberry new to this country has lately been introduced into the Western States by the Mennonites. This is the Russian Mulberry (*M. tartarica*). It is very hardy and its leaves make excellent Silk-worm food.*

The Mulberry grows readily, being easily propagated by cuttings or layers or from the seed. The white Mulberry, in particular, grows well

*A tree of a genus allied to the Morus is the *Broussonetia papyrifera*, commonly called the Paper Mulberry. It is found quite generally throughout the South, but its foliage is *not* suitable for Silk-worm food. The Paper Mulberry is usually a somewhat larger tree than the Mulberry and its leaves are subject to a considerable diversity of form, being mainly ovate and toothed on the margin; frequently with lobes on one or both sides of the leaf. They are quite rough to the touch on the upper surface, much more so than the Mulberry, and on the under surface they are softly hairy. The trees are of two kinds, male and female. The male tree, early in the spring before its leaves are developed, has tassels something like those of the willow. They soon drop off after shedding pollen. The female flowers then go on developing during the summer until they make small round balls from which, when ripe, the seeds stand out. These seeds are covered with a gummy substance and are very small, being about the size of those of the raspberry. The female trees are little known in this country, as only the male trees have been introduced into the United States.

I refer to this tree because of the frequency with which inquiries are made by Southern correspondents as to whether the Paper Mulberry can be used as Silk-worm food. The tree is very generally used for shade and ornament in Southern cities, where it attracts attention by the gnarled and knotted character of its trunk.

from cuttings, and this is perhaps the readiest and most economical method of planting to secure a stock.

The cuttings should be started in rows, 3 or 4 inches apart, in ground prepared by deep plowing and harrowing. They should be about 6 inches long, and should be cut just before an eye in every case. They should be almost entirely buried. The quickest way to get a supply of leaves is to grow dwarfs. Set out the young trees from the nursery in rows 10 to 15 feet apart and 6 to 8 feet between the rows, and form the crown of the tree by cutting down to a foot or so from the ground. The height of the tree and its form are easily regulated by pruning, and upon this process depend not only the vigorous growth of the tree, but also the ease with which the leaves may be gathered when desired. The pruning may be done in February or March, either every year or every other year.* All dead twigs and dried bark should be removed and the limbs kept as smooth as possible, as this greatly facilitates picking. The best time for planting is in the fall, from frost until December, and in the spring, from March until May.

For growing standard high trees, a practical raiser gives the following directions: The cutting should remain two years in the nursery without pruning. The third year it is cut close to the ground and transplanted. The finest shoot is then allowed to grow, and in good land it will reach a height of 8 or 10 feet in one season. The fourth year it is cut back to 6 feet or thereabouts. Then, the three or four terminal buds only being allowed to grow, all others are removed as often as they appear by passing the hand along the stem.

It must not be forgotten that in the propagation of plants only true species can be reproduced from the seed. The varieties of the White Mulberry mentioned above can only be obtained from cuttings or layers.

The fresh mulberry leaf contains a large amount of water of vegetation, and of certain mineral and organic matters. Of water, it is only necessary that there should be sufficient to enable the worm to easily digest its food, and all that is in excess of this quantity is apt to be injurious and productive of disease. In order to avoid this difficulty, food-trees should be planted in a light loam, and especial care taken to prevent excessive irrigation. It has been found, too, to be important that the tree should be so planted as to receive as much sunlight as possible, experiments having shown that, other conditions being equal, the leaves of such a tree contained but 55 per cent. of water, while in the case of one lighted by the sun until 1 o'clock only there was 64 per cent., and in one which received only diffused light, 73 per cent.

* The better plan is to have two sets of trees, using each set but once in two years. When pruned a tree is then allowed to grow for one year without touching its leaves, which are only picked for the second season. The life of the tree will thus be materially prolonged, and the crop of leaves be more abundant than with annual pickings.

Of the mineral matter contained in the leaf, only certain portions are appropriated by the worm; these are phosphoric and sulphuric acid, potash, and magnesia. Its silica and sulphate and carbonate of lime are not useful in nutrition. In studying the leaf of the Mulberry at different seasons it is found that early in the spring certain varieties possess these nutritive mineral substances to a greater extent than others, but that as the season advances they become less abundant, while the proportion of silica and lime increases. It is important, then, if from this point of view only, that we should rear our Silk-worms as early in the season as possible. A great many experimenters have occupied themselves with the value of the different varieties of Mulberry with a view to ascertaining which would give the best alimentary results under ordinary conditions. As a result, it is generally advised that the seedling White Mulberry be fed at the beginning of an education and the *rosea* during the later ages. The *multicaulis* possesses many of the advantages of these varieties, though less rich in nutritive elements than either of them.

OSAGE ORANGE.—The cultivation of the Osage Orange (*Maclura aurantiaca*) is so well understood in this country that there is no need of giving detailed instructions on the subject. Very generally used as a hedge-plant in those sections of the country which are particularly adapted to silk culture, its leaves may at once be obtained without any special investment of capital. Indeed, as the hedges need trimming, the cutting off of the new year's growth, as the leaves may be wanted for feeding purposes, is a saving rather than an expenditure. Those who use this plant as Silk-worm food must, however, bear in mind that the shoots from a hedgerow become very vigorous and succulent by the time the worms are in the last age. These more milky and succulent terminal leaves should be thrown aside and not used, as they are apt to induce flaccidity and other diseases.

In avoiding these more tender leaves and using only the older and firmer ones, especially when the worms are large, consists the whole secret of the successful rearing of Silk-worms on this plant; and if care be had in this respect, and the same judgment used in selecting from trees or hedges well exposed to sunlight, as suggested for Mulberry, there will be no appreciable difference in the silk crop from Osage Orange as compared with that from Mulberry.

The thorns of this plant make it somewhat more difficult to pick its leaves than those of the Mulberry, and I should not advise its cultivation merely as Silk-worm food.

What is said of the Osage Orange is based upon a very extended experience, and I would not only emphasize the fact of the value of this plant, but also of the necessity of the careful selection of Maclura leaves, especially during the last two ages of the worm. I have found that after the third age time is saved by using the twigs, first taking care to clip off the spines, which is rapidly done by means of a pair of scissors. In using twigs instead of leaves, the tender tips of the current year's growth should be cut off with the spines. I have found this method of feeding to have decided advantages (though contrary to all custom in Europe, where the twigs and branches of the Mulberry are too valuable to be constantly pruned), for it not only allows more air to circulate as the food accumulates, but it gives the worms, as they grow in size, an opportunity of clambering about, which they do not have to the same extent where leaves alone are used. In adding the new meal there is, also, where twigs are used, less danger of the transfer paper pressing injuriously upon the worms beneath.

Should the worms, from whatever cause, hatch before either Mulberry or Osage Orange leaves can be obtained, they may be quite successfully fed, for a few days, upon well-dried lettuce leaves. It will, however, be worse than a waste of time to attempt to feed them entirely on these leaves, or, in fact, on any other plants than the two here recommended.

GLOSSARY OF TERMS USED.

Age: The interval between hatching and first molt, between any two molts, or between the last larval molt and spinning.
Alimentary canal: The food canal; a straight, simple tube, running from one end of the body to the other, and which it is impossible to subdivide into gullet, stomach, and intestine.
Alkaline: Having the opposite reactions to an acid.
Anal horn: The horn upon the posterior end of the body of the worm.
Annuals: Those races which produce but one brood in a year.
Antennæ: The feathery feelers upon the head of the moth.
Bacillus: A microscopical vegetable organism, often causing disease.
Bivoltins: Those races producing two broods in one year.
Bombycidæ: The family of moths, commonly known as "spinners," to which the Silk-worm moth belongs.
Botrytis bassiana: The fungus causing muscardine.
Brin: The French term for a single thread from the cocoon.
Carneous: Flesh-colored.
Choked cocoons: A term applied to those cocoons in which the chrysaiis has been killed.
Chlorophyl: The green coloring matter of leaves.
Chrysalis: The third or restful state of the insect, or that between the worm and the moth, inclosed in the cocoon.
Cocoon: The silken covering with which the worm surrounds itself before passing into the chrysalis state.
Cocoonery: The name applied to a room or building where cocoons are dried after being choked.
Corpuscle: A microscopic parasitic organism causing the disease, pébrine.
Croisure: The twist to which the silk thread is submitted in reeling.
Dacey: A Bengalese race of worms producing eight broods each year.
Detent: A stop which locks and unlocks the wheels in clock-work.
Dorsal vessel: The heart, extending from one end of the body to the other, just under the skin of the back.
Échevette: A small skein of silk of a determined length, the weight of which determines its size number.
Epizootic: A term having the same significance with lower animals as epidemic with man.
Éprouvette: A reel supplied with a counter upon which échevettes are measured.
Faller: A small lever, over which a thread runs, and which, upon the breaking of the thread, falls, thus stopping the mechanism through the action of a detent to which it is attached,
Fil: The French term for the combined threads as they come from the reel.
Ferment: Micro-organism causing fermentation.
Fibrine: An organic compound forming the base of the silk filament.
Filature: The French name for reeling establishment.
Flaccidity: A Silk-worm disease characterized in the text, Chapter V.
Flacherie: The French name for flaccidity.
Floss silk: Silk made from the loose material of the outer cocoon and from pierced cocoons, etc. It is carded and spun like cotton or wool.
Fresh cocoons: Cocoons that have not been choked.
Gattine: An old name for a mild phase of the disease known as pébrine. Maillot thinks that it is a form of flaccidity.
Grasserie: A Silk-worm disease allied to jaundice. It is described in Chapter V.
Green cocoons: A name frequently applied to fresh or unchoked cocoons. Should be avoided, except where it has reference to cocoons of a green color.
Greens: A name applied to those races making cocoons of a greenish tint.
Integument: Skin or outer covering.
Japonica: A variety of the White Mulberry.
Labium: The under lip, upon which is situated the spinneret.
Larva: The second or worm state of the insect.
Lepidoptera: Name of the order to which the Silk-worm belongs.
Lusettes: A name applied to the worms which die from being unable to molt.
Magnanerie: The name applied to the room or building used for the rearing of worms.
Micropyle: The opening in the egg of the Silk-worm moth through which the fecundating liquid enters.
Moretti: A variety of the White Mulberry discovered in 1815 by Professor Moretti, of Pavia.
Mori: The scientific specific name for the Silk-worm.
Morus: The botanical generic name of the Mulberry.
Multicaulis: A variety of the White Mulberry.
Muscardine: A Silk-worm disease of a fungus nature, characterized in the text, Chapter V.

Spinneret: A tube projecting from the lower lip, and through which the silk issues.
Organzine: Highly twisted thrown silk used in the woof in weaving.
Ovipositing: Laying the eggs.
Pébrine: A Silk-worm disease characterized in the text, Chapter V.
Pod: The compact portion of the cocoon, which is used for reeling purposes.
Polyvoltins: A term applied indiscriminately to all races which produce more than one brood in a year.
Pro-legs: The ten non-jointed legs under the sixth, seventh, eighth, ninth, and last joints of the body of the worm.
Psorospermiæ: Scientific name for the floating corpuscles in the bodies of worms affected by pébrine.
Quadrivoltins: Those races which produce four broods in one year.
Raw silk: Silk reeled from the cocoons before being thrown and woven.
Rosea: A variety of the White Mulberry.
Seed: The eggs in bulk.
Sericaria: A generic name proposed by Latreille, and to which the Silk-worm is referred by modern writers.
Sickness: The period of molting.
Spiracles: The breathing-holes of the insect; one row of nine down each side of the body.
Spores: The germinating seed of fungi.
Tavellette: A small pulley used in the Italian system of reeling.
Thrown silk: Silk which has been submitted to the operations following spinning or reeling. It is classed as tram and organzine.
Trachea: The breathing-tube of an insect.
Tram: Slightly twisted thrown silk used in the warp in weaving.
Transformation: The change from one state to another, as from worm to chrysalis or from chrysalis to moth.
Trevoltins: Those races of Silk-worms of which there are three broods in one year.
Vitellus: The yolk of an egg.
Whites: Those varieties having white cocoons.
Yellows: Those varieties having yellow cocoons.

EXPLANATION TO PLATES.

PLATE I.

SILK-WORMS AFFECTED BY PÉBRINE AND FLACCIDITY (AFTER PASTEUR).

A, B, C, D, Silk-worms affected with pébrine, showing the spots of the disease. On the eighth joint of the worm A will be seen a wound which is distinguishable by its clear-cut edges.

E, F, G, worms, after death from flaccidity. G shows the worm just after death, still retaining all of its outward perfection of form. At F the worm has begun to shrivel, while at E the blackening caused by putrefaction is shown.

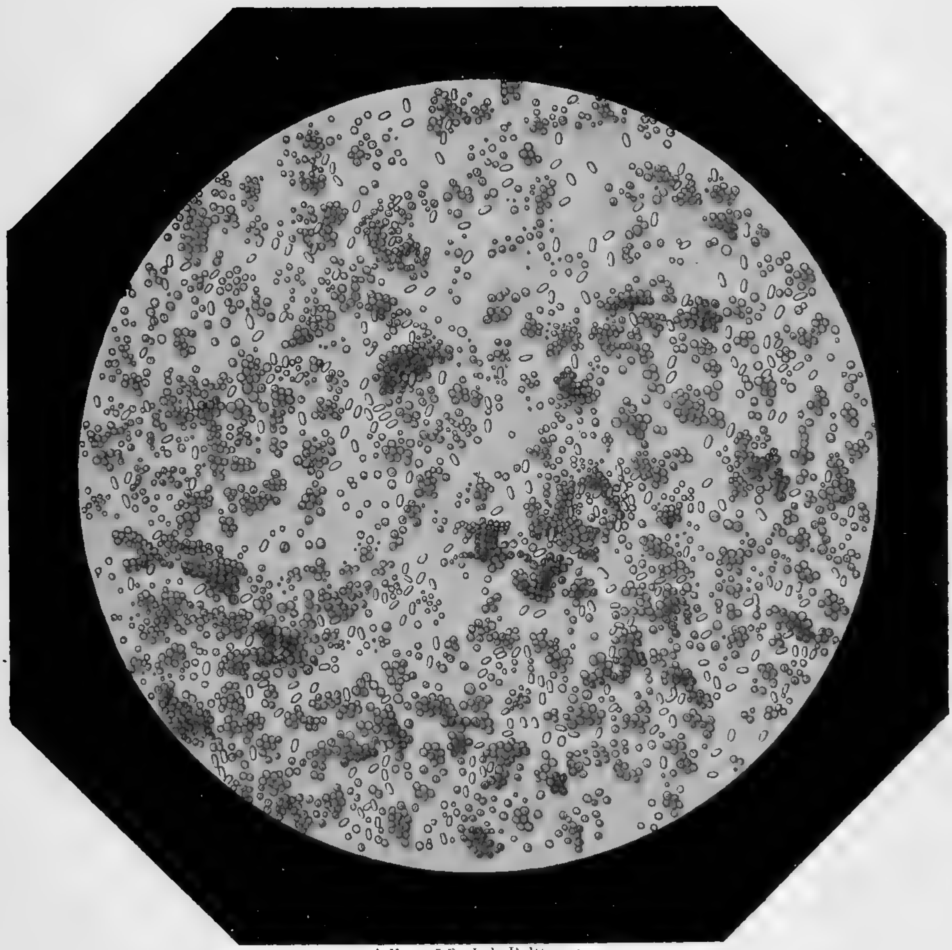
PLATE II.

PÉBRINE CORPUSCLES OF SILK-WORM MOTH HIGHLY MAGNIFIED (AFTER PASTEUR).
(The white ovoid bodies are these corpuscles.)

A.Hoen & Co.Lith. Baltimore

SILKWORMS AFFECTED BY PEBRINE AND FLACCIDITY.

(after PASTEUR)



A. Hoen & Co. Lith. Baltimore

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PEBRINE CORPUSCULES OF SILKWORM MOTH.

highly magnified

(after PASTEUR)

INDEX.

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DIVISION OF ENTOMOLOGY.
BULLETIN No. 9.

THE MULBERRY SILK-WORM;

BEING A

MANUAL OF INSTRUCTIONS

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16136—No. 9

TABLE OF CONTENTS.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 20, 1888.

SIR: The sixth edition of Bulletin No. 9 of this Division, on the Silk-worm, having been exhausted, I have the honor to present for publication a seventh edition, which is little more than a reprint of the sixth, with such slight changes as late experience has suggested.

Respectfully,

C. V. RILEY,
Entomologist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

PREFACE TO THE SECOND EDITION.*

That there exists just now a very general and widespread interest in the subject of silk-culture in the United States is manifest from the recent large increase in the correspondence of the Entomological Division in relation thereto, and from the demand made for this Manual. To avoid the disappointment that is sure to follow exaggerated and visionary notions on the subject, it may be well here to emphasize the facts that the elements of successful silk-culture on a large scale are at the present time entirely wanting in this country; that the profits of silk-culture are always so small that extensive operations by organized bodies must prove unprofitable where capital finds so many more lucrative fields for employment; that extensive silk-raising is fraught with dangers that do not beset less ambitious operations; that silk-culture, in short, as shown in this Manual, is to be recommended only as a light and pleasant employment for those members of the farmer's household who either can not do or are not engaged in otherwise remunerative work.

The want of experience is a serious obstacle to silk-culture in this country; for while, as is shown in the following pages, the mere feeding of a certain number of worms and the preparation of the cocoons for market are simple enough operations, requiring neither physical strength nor special mental qualities, yet skill and experience count for much, and the best results can not be attained without them. In Europe and Asia this experience is traditional and inherited, varying in different sections both as to methods and races of worm employed. With the great variety of soil, climate, and conditions prevailing in this country, experience in the same lines will also vary, but the general principles indicated in this Manual should govern.

The greater value of labor here as compared with labor in the older silk-growing countries has been in the past a most serious obstacle to silk-culture in the United States, but conditions exist to-day that render this obstacle by no means insuperable. In the first place, comparative prices, as so often quoted, are misleading. The girl who makes only twenty or thirty cents a day in France or Italy does as well, because

* This preface was written in 1882, and some passages are omitted which had only a temporary interest and which might be misleading to-day.

of the relatively lower prices of all other commodities there, as she who earns three or four fold as much here. Again, the conditions of life are such in those countries that every woman among the agricultural classes not absolutely necessary in the household, finds a profitable avenue for her labor in field or factory, so that the time given to silk raising must be deducted from other profitable work in which she may be employed. With us, on the contrary, there are thousands—aye, hundreds of thousands—of women who, from our very condition of life, are unable to labor in the field or factory, and have, in short, no means, outside of household duties, of converting labor into capital. The time that such might give to silk-culture would, therefore, be pure gain, and in this sense the cheap-labor argument loses nearly all its force. This holds more particularly true in the larger portion of the South and West, that are least adapted to the production of merchantable dairy products or where bee-keeping and poultry-raising are usually confined to the immediate wants of the household.

The want of a ready market for the cocoons is now, as it always has been, the most serious obstacle to be overcome, and the one to which all interested in establishing silk-culture should first direct their attention. Ignore this, and efforts to establish the industry are bound to fail, as they have failed in the past. A permanent market once established, and the other obstacles indicated will slowly, but surely, vanish as snow before the coming spring. Owing to the prevalence of disease in Europe, there grew up a considerable demand for silk-worm eggs in this country, so that several persons found the production of these eggs quite profitable. Large quantities are yet shipped across the continent from Japan each winter; but this demand is, in its nature, transient and limited, and, with the improved Pasteur method of selection and prevention of disease, silk-raisers are again producing their own eggs in Europe. Silk-culture must depend for its growth, therefore, on the production of cocoons, and these will find no remunerative sale except where the silk can be reeled. I find no reason to change the views expressed relative to the part this Department might take in succoring silk-culture through Congressional aid; for, however just and desirable direct protection to the industry may be by the imposition of an import duty on reeled silk, no such protection has yet been given by Congress, and silk filatures can not be fully and profitably established without some fostering at the start. Under a heavy protective tariff our silk manufactures have rapidly grown in importance and wealth, until, during the year 1881 (according to the reports of W. C. Wyckoff, secretary of the Silk Association of America), raw silk to the value of $11,936,865 and waste silk and cocoons to the value of $769,186 were imported at the ports of New York and San Francisco, while our manufactured goods reached in value between $35,000,000 and $49,000,000. Now, the so-called raw silk thus imported to the value of nearly $12,000,000 is just as much a manufactured article as the woven goods, and its importation free of duty is as much an encouragement to foreign manufacturers and an impediment to home industry as the removal of the duty would be on the woven goods. The aid that Congress, through this Department, should, in my judgment, give to silk-reeling, and thereby to silk-production, may be supplied by private and benevolent means.

*   *   *   *   *   *   *

The obstacles which I have set forth are none of them permanent or insuperable, while we have some advantages not possessed by other countries. One of infinite importance is the inexhaustible supply of Osage Orange (*Maclura aurantiaca*) which our thousands of miles of hedges furnish; another is the greater average intelligence and ingenuity of our people, who will not be content to tread merely in the ways of the Old World, but will be quick to improve on their methods; still another may be found in the more spacious and commodious nature of the barns and outhouses of our average farmers. Every year's experience with the *Maclura* confirms all that I have said of its value as silkworm food. Silk which I have had reeled from a race of worms fed on it, now for eleven consecutive years, is of the very best quality, while the tests made at the recent silk fair at Philadelphia showed that in some instances a less weight of cocoons spun by *Maclura*-fed worms was required for a pound of reeled silk than of cocoons from mulberry-fed worms.

C. V. R.

WASHINGTON, D. C., *February* 20, 1882.

PREFACE TO THE SIXTH EDITION.

The growing interest shown in the culture of silk, in the United States, is attested by the demands upon this Department for copies of this manual, which has hitherto been published as Special Report No. 11. Originally prepared as a brief manual, based on my own experience of the industry in America, the present demands of silk-growers, or rather of those desirous of becoming such, call for some further details, and in elaborating the work it has been thought best to include it among the bulletins of the Division. I have also divided the matter into chapters, and those on the implements which are necessary to, or facilitate, the work; those on diseases, reproduction, reeling, and the physical properties of raw silk embrace essentially new material, parts of Chapters V and VI being from my current annual report not yet distributed.

In Chapter VIII, in speaking of machinery I have omitted the detailed descriptions of special machines given in former editions and explained rather the mechanical principles that should be involved in all. A description of the Serrell Reel would have been very appropriate, but the inventor has been promised by the Commissioner that such should not be made public until all patents are secured. I shall hope to elaborate this chapter in some future edition.

It must not be forgotten that the original manual was never intended as an extended treatise on silk-raising or reeling, but was prepared to give, in a simple and most condensed way, information to those interested, and in a form applicable to the United States. It is gratifying to know that a number of other pamphlets on the Silk-worm have of late years been published, and that this manual has been quite freely used in their preparation. In one instance, in fact, an almost verbatim copy has been published and sold privately. I have found little or no occasion to alter opinions expressed in the manual, but in the present edition have revised the estimates of profits given in the Introduction to the original edition, leaving out those on egg production, because of the changed conditions since 1879, which have rendered such work, as a profitable business, obsolete in this country, and the production of sound and reliable eggs much more difficult and expensive.

Though particular pains were taken to impress upon readers the fact that the estimates of profits in silk-raising were based on definite market prices at that time, and that prices and profits must needs, as in all trades, vary from year to year, and though I especially omitted the cost of food, eggs, special buildings, etc., because the manual was addressed to those who would not have to incur these expenses (and I would not now recommend any one to embark in the industry who did not have these necessaries at command), yet these estimates have been criticised because silk-raisers have been unable to realize, in 1885, the profits which I considered attainable in 1879. For, though sharing the opinion of those directly connected with the silk trade, I then believed that the prices of raw silk and cocoons had reached as low a figure as they ever would, the belief proved subsequently unfounded, for fresh cocoons which in Europe sold in 1879 for 47 cents could be purchased, in 1885, for 35 cents per pound. Again, any estimates must needs be approximate only, as they will vary with the race.

This great alteration in the value of silk products has necessarily impaired the accuracy of the estimates given by me in the first edition of this pamphlet. I have therefore prepared another series of figures which are more nearly accurate to-day than the former ones, and are based on the French yellow race.

PROFITS OF PRODUCING COCOONS: ESTIMATES FOR TWO ADULTS, OR MAN AND WIFE.

Average number of eggs per standard ounce of 25 grams, in ordinary yellow races, 37,500.

Number of fresh cocoons per pound, 300 to 400.

Average reduction in weight for choked cocoons, 66 per cent.

Maximum amount of fresh cocoons from 1 ounce of eggs, 93 to 125 pounds.

Allowing for deaths in rearing—26 per cent. being a large estimate—we thus get as the product of an ounce of eggs 69 to 92 pounds of fresh, or 23 to 31 pounds of choked, cocoons.

Two adults can take charge of the issue of from 1 to 3, say 2, ounces of eggs, which will produce 138 to 184 pounds of fresh, or 46 to 62 pounds of choked cocoons.

Price per pound of fresh cocoons (1885), 35 cents (300 cocoons per pound).

184 pounds of fresh cocoons, at 35 cents, $64.40.

Price per pound of fresh cocoons (1885), 25 cents (400 cocoons per pound).

138 pounds of fresh cocoons, at 25 cents, $34.50.

Price per pound of choked cocoons (1885), 80 cents to $1.15.

Value of above products, choked, $36.80 to $71.30.

APPROXIMATE COST OF REELING.

Estimated product of 6 non-automatic steam reels for the 300 working days of the year—1,200 pounds of reeled silk, and 300 pounds of waste silk.

Cost of production of 1,200 pounds of reeled silk, based on the Government experiments at New Orleans, in 1885:

Value of plant:		
Six reels	$500.00	
One steam engine	600.00	
Shafting and miscellaneous	400.00	
	1,500.00	
Interest and depreciation on plant, 20 per cent. per annum		$300.00
Raw material:		
5,076 pounds of choked cocoons, at $1		5,076.00
Labor (as shown at New Orleans), $1.12½ per pound of silk		1,350.00
Fuel, oil, etc		150.00
Total		6,876.00

Value of the above product:

1,200 pounds reeled silk, at $5.50	$6,600.00
300 pounds waste silk, at $1	300.00
Total	6,900.00

In studying these estimates the reader must, as I have said, bear in mind that the silk industry, like all industries, will have its ups and downs—its periods of buoyancy and depression. For the past few years it has been going through one of the latter. But late last fall an upward tendency was shown in prices for raw silk, which, if they remain firm, can not but influence for the better the value of cocoons.

In the preface to the second edition I mentioned the advantages to be gained by raising Silk-worm eggs, though I called attention to the fact that the market for them was in its nature limited and transient, and that European merchants were again producing their own seed by the aid of the improved Pasteur system of selection. Notwithstanding the facts there stated as to the limited nature of the egg market, silk-raisers have been disappointed, after having produced large quantities of eggs, in not finding a ready sale for them. But though the egg market is important in its place, it will readily be seen that it can be, when in a healthy state, no more extensive than is necessary to supply each season the wants of silk growers. In 1884, in France, about 2½ per cent. of the total crop was employed in the production of eggs. These figures, from a country where silk culture is established, furnish a foundation upon which to estimate. Every pound of cocoons which is sold at the filature puts money into the pockets of the silk-raising class; while every pound used in the production of eggs in excess of the amount actually required robs it of the money that it would otherwise receive. The only way to build up the industry, then, is, as I have so often insisted, to create, by the establishment of filatures, a durable and profitable market for cocoons. The production of eggs is simply an incident of comparatively little importance.

I have shown in said preface that silk-raising on an extensive scale is fraught with so many dangers that it is inadvisable to invest capital in such an enterprise. This is partly due to the fact that a large crop must necessarily be raised with the aid of hired labor, and a consequent investment of cash capital. A large rearing requires a large and (for success) a specially constructed building, which must necessarily lie idle for the greater part of the year. It has been found, too, that the average production of cocoons, per ounce of eggs, is much less for large than for smaller crops. Thus one ounce of eggs of good race will produce one hundred pounds of fresh cocoons; while for every additional ounce the percentage is reduced if the worms are all raised together, until for twenty ounces the average may not exceed 25 pounds of cocoons per ounce. Such is the general experience throughout France, according to Guérin-Méneville, and it shows the importance of keeping the worm in small broods, or of rearing on a moderate scale. As a result we see the great magnaneries disappearing from France and Italy, where in some establishments as many as 60 ounces were at one time annually raised. We find this statement confirmed by looking at the French official statistics for 1884, where it is stated that the cocoons produced in France during that year were raised by over one hundred and forty thousand families, who utilized therefor about two hundred and eighty thousand ounces of eggs, or an average of about two ounces per family.

To beginners I would repeat the advice so often given from this Office, to hatch the first season but a small quantity of eggs; not more than an eighth of an ounce. Experience counts in this as in other industries, and it will be found that, where only a small quantity of worms are being fed, there will be much more time to study their habits and wants. With a year's experience there will be a better chance of profit the second year.

It will not be safe for individuals to rely on reeling their own silk. The art of reeling in modern filatures and with steam appliances has been brought to such perfection that none but skilled reelers can hope to produce a first-class article. Skill comes only after full apprenticeship and practice. The only way in which silk-reeling can be managed profitably at present is where a colony of silk-raisers combine to put up and operate a common filature. Though there is a ready market in the United States for large lots of good silk, it will not be found so easy to dispose of small lots of poorer quality.

Two years ago Congress appropriated $15,000 for the encouragement of silk-culture, and the appropriation was repeated for the present fiscal year. The appropriation was general in its nature, and the method of encouragement left with the Commissioner of Agriculture. In my Annual Reports for 1884 and 1885 details are given as to the work done by the Department under this appropriation, and various questions discussed and conclusions reached as to the outcome of the two years' experience. These need not be repeated here.

Owing to the conviction that the establishment of filatures and their successful operation was the *sine qua non* in putting the industry on a firm basis, a large portion of the money thus appropriated has been devoted to experiments in silk reeling. These experiments have shown that the quality of cocoons produced by American silk-raisers is not yet such as to enable this country to compete with others in the production of raw silk. The quality of a cocoon is most conclusively shown by the quantity of silk which may be unwound from it. A good average result, after the experience of European filatures, is the production of a pound of raw silk from 3.80 pounds of dry cocoons. The Government experiments at New Orleans showed a production of but 1 pound of silk from 4.23 pounds of dry cocoons. The cost of producing silk from a poorer quality of cocoons is proportionately much greater than where the cocoons are of better quality, and the difference is much greater than would be thought possible by one unacquainted with the industry. We have, therefore, much to accomplish from this point of view before we can hope to make the industry a profitable one in the United States. The cocoons which have been received at the Government stations during the past year have been, to a large extent, raised by persons who were inexperienced, and who were thus unable to produce a first-class cocoon. There is an inclination among these very persons to blame the industry if they do not receive, the first season, what they consider an adequate compensation for the time which they have expended upon the work. And yet these same individuals would not expect to be successful in any other enterprise until they had made themselves thoroughly acquainted, by practical experience, with the special work involved. It is not, therefore, surprising that with such a quality of raw material it has been impossible to produce silk without financial loss. Such a loss, in fact, as shown in my annual report as entomologist, for 1885, was incurred as the result of the experiments. We, however, performed these experiments with non-automatic machinery, and that even of an unimproved type. The loss was, however, so small that we have reason to believe that it can be more than counterbalanced by the use of improved plant. Automatic silk-reels are now being placed upon the market, which not only effect a slight saving in the quantity of raw material employed, but also a very large saving in labor, the cost of which in this country is the principal cause of our inability to compete with Europe and Asia. These new reels are also capable of producing, with comparatively unskilled labor, as good a grade of silk as can be made by the expert workwomen of France.

It will be seen by the estimates given above that silk-culture is not (and it never has been) an exceedingly profitable business, but it adds vast wealth to the nations engaged in it, for the simple reason that it can be pursued by the humblest and poorest, and requires so little outlay. The question of its establishment in the United States is, as I have elsewhere said, " a question of adding to our own productive resources. There are hundreds of thousands of families in the United States to-day who would be most willing to add a few dollars to their annual income by giving light and easy employment for a few months each year to the more aged, to the young, and especially to the women of the family, who may have no other means of profitably employing their time.

"This holds especially true of the people of the Southern States, most of which are pre-eminently adapted to silk-culture. The girls of the farm, who devote a little time each year to the raising of cocoons, may not earn as much as their brothers in the field, but they may earn something, and that something represents an increase of income, because it provides labor to those members of society who at present too often have none that is remunerative. Further, the raising of a few pounds of cocoons each year does not and need not materially interfere with the household and other duties that now engage their time, and it is by each household raising a few pounds of cocoons that silk-culture must, in the end, be carried on in this as it has always been in other countries."

The reader is reminded that the few quotations not otherwise credited are from the author's Fourth Report on the Insects of Missouri (1871). A number of foreign (more particularly French) terms are unavoidable in treating of silk-culture, as they have no actual equivalents in our language. These and the few technical terms used in the manual are made clear in the glossary.

Finally, I take pleasure in acknowledging the assistance given me in the preparation of this new edition by Mr. Philip Walker, who has acted as the chief agent of the division in the sericultural work during the past two years.

C. V. R.

WASHINGTON, D. C., *May*, 1886.

CHAPTER I.

PHYSIOLOGY AND LIFE-HISTORY OF THE SILK-WORM.

The Silk-worm proper, or that which supplies the ordinary silk of commerce, is the larva of a small moth known to scientific men as *Sericaria mori.* It is often popularly characterized as the Mulberry Silk-worm. Its place among insects is with the *Lepidoptera*, or scaly-winged insects, family *Bombycidæ*, or spinners. There are several closely allied species, which spin silk of different qualities, none of which, however, unite strength and fineness in the same admirable proportions as does that of the mulberry species. The latter has, moreover, acquired many useful peculiarities during the long centuries of cultivation it has undergone. It has in fact become a true domesticated animal. The quality which man has endeavored to select in breeding this insect is, of course, that of silk producing, and hence we find that, when we compare it with its wild relations, the cocoon is vastly disproportionate to the size of the worm which makes it or the moth that issues from it. Other peculiarities have incidentally appeared, and the great number of varieties or races of the Silk-worm almost equals those of the domestic dog. The white color of the species, its seeming want of all desire to escape as long as it is kept supplied with leaves, and the loss of the power of flight on the part of the moth, are all undoubtedly results of domestication. From these facts, and particularly from that of the great variation within specific limits to which the insect is subject, it will be evident to all that the following remarks upon the nature of the Silk-worm must necessarily be very general in their character.

The Silk-worm exists in four states—egg, larva, chrysalis, and adult or imago—which we will briefly describe.

DIFFERENT STATES OR STAGES OF THE SILK-WORM.

THE EGG.—The egg of the Silk-worm moth is called by silk-raisers the "seed." It is nearly round, slightly flattened, and in size resembles a turnip seed. Its color when first deposited is yellow, and this color it retains if unimpregnated. If impregnated, however, it soon acquires a gray, slate, lilac, violet, or even dark green hue, according to variety or breed. It also becomes indented. When diseased it assumes a still darker and dull tint.

Near one end a small spot may be observed. This is the *micropyle*, and is the opening through which the fecundating liquid is injected just before the egg is deposited by the female. After fecundation and before deposition the egg of some varieties is covered with a gummy varnish which closes the micropyle and serves to stick the egg to the object upon which it is laid. Other varieties, however, among which may be mentioned the Adrianople whites and the yellows from Nouka, in the Caucasus, have not this natural gum. As the hatching point approaches the egg becomes lighter in color, which is due to the fact that its fluid contents become concentrated, as it were, into the central forming worm, leaving an intervening space between it and the shell, which is semi-transparent. Just before hatching, the worm within becoming more active, a slight clicking sound is frequently heard, which sound is, however, common to the eggs of many other insects. The shell becomes quite white after the worm has made its exit by gnawing a hole through it, which it does at the micropyle. Each female produces on an average from three to four hundred eggs. In the standard ounce of 25 grams* there are about 50,000 eggs of the small Japanese races, 37,500 of the ordinary yellow annual varieties, and from 30,000 to 35,000 in the races with large cocoons. The specific gravity of the eggs is slightly greater than water, Haberlandt having placed it at 1.08.

It has been noticed that the color of the albuminous fluid of the egg corresponds to that of the cocoon, so that when the fluid is white the cocoon produced is also white, and when yellow the cocoon again corresponds.

THE LARVA OR WORM.—The worm goes through from three to four

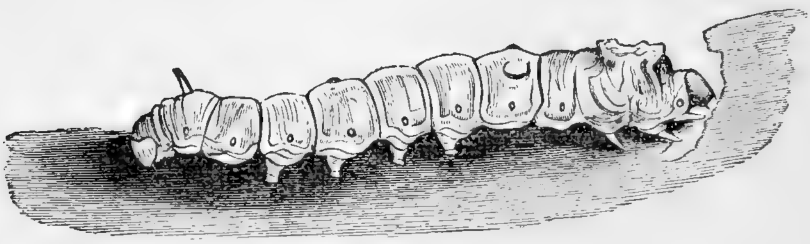

FIG. 1.—Full grown larva or worm (after Riley).

molts or sicknesses, the latter being the normal number. The periods between these different molts are called "ages," there being five of these ages, the first extending from the time of hatching to the end of the first molt, and the last from the end of the fourth molt to the transformation of the insect into a chrysalis.

The time between each of these molts is usually divided as follows: The first period occupies from five to six days, the second but four or five, the third about five, the fourth from five to six, and the fifth from eight to ten. These periods are not exact, but simply proportionate. The time from the hatching to the spinning of the cocoons may, and does, vary all the way from twenty-five to forty days, depending upon the race of the worm, the quality of food, mode of feeding, temperature,

*28½ grams = 1 ounce avoirdupois.

etc.; but the same relative proportion of time between molts usually holds true.

The color of the newly-hatched worm is black or dark gray, and it is covered with long, stiff hairs, which, upon close examination, will be found to spring from pale colored tubercles. Different shades of dark gray will, however, be found among worms hatching from the same batch of eggs. After the first molt, and as the worm increases in size, these hairs and tubercles become less noticeable, and the worm gradually gets lighter and lighter, until, in the last stage, it is of a cream-white color. When full grown it presents the appearance of Fig. 1. It never becomes entirely smooth, however, as there are short hairs along the sides, and very minute ones, not noticeable with the unaided eye, all over the body.

The preparation for each molt requires from two to three days of fasting and rest, during which time the worm attaches itself firmly by the abdominal prolegs (the 8 non-articulated legs under the 6th, 7th, 8th, and 9th segments of the body, called prolegs in contradistinction to the 6 articulated true legs under the 1st, 2d, and 3d segments), and holds up the forepart of the body, and sometimes the tail. In front of the first joint a dark, triangular spot is at this time noticeable, indicating the growth of the new head; and when the term of "sickness" is over, the worm casts its old integument, rests a short time to recover strength, and then, freshened, supple, and hungry, goes to work feeding voraciously to compensate for lost time. This so-called "sickness" which preceded the molt was, in its turn, preceded by a most voracious appetite, which served to stretch the skin. In the operation of molting the new head is first disengaged from the old skin, which is then gradually worked back from segment to segment until entirely cast off. If the worm is feeble or has met with any misfortune, the shriveled skin may remain on the end of the body, being held by the anal horn; in which case the individual usually perishes in the course of time. It has been usually estimated that the worm in its growth consumes its own weight of leaves every day it feeds; but this is only an approximation. Yet it is certain that during the last few days before commencing to spin it consumes more than during the whole of its previous worm existence. It is a curious fact, first noted by Quatrefages, that the color of the abdominal prolegs at this time corresponds with the color of the silk which will form the cocoons.

Having attained full growth, the worm is ready to spin up. It shrinks somewhat in size, voids most of the excrement remaining in the alimentary canal; acquires a clear, translucent, often pinkish or amber-colored hue; becomes restless, ceases to feed, and throws out silken threads. The silk is elaborated in a fluid condition in two long, slender, convoluted vessels, one upon each side of the alimentary canal. As these vessels approach the head they become less convoluted and more slender, and finally unite within the spinneret, from which the silk issues in a glutinous state and apparently in a single thread. The glutinous liquid which combines the two, and which hardens immediately on exposure to the air, may, however, be softened in warm water. The worm usually consumes from three to five days in the construction of the cocoon and then passes in three days more, by a final molt, into the chrysalis state.

THE COCOON.—The cocoon (Figs. 2 and 3) consists of an outer lining

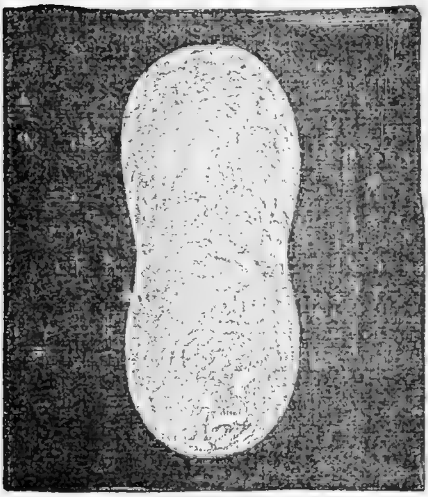

FIG. 2.—Constricted cocoon, with fine texture (original).

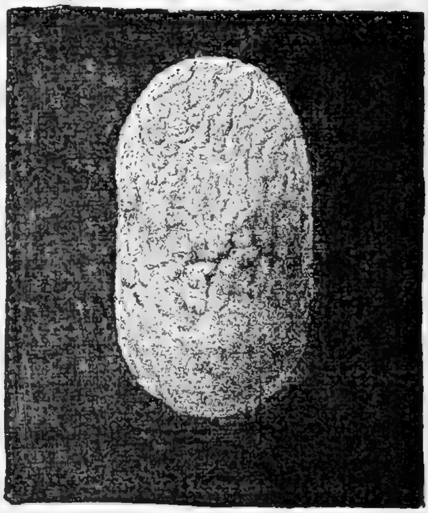

FIG. 3.—Non-constricted cocoon, with coarse texture (original).

of loose silk known as "floss," which is used for carding, and is spun by the worm in first getting its bearings. The amount of this loose silk varies in different breeds. The inner cocoon is tough, strong, and compact, composed of a firm, continuous thread, which is, however, not wound in concentric circles, as might be supposed, but irregularly, in short figure-of-8 loops, first in one place and then in another, so that, in reeling, several yards of silk may be taken off without the cocoon turning around. In form the cocoon is usually oval, and in color yellowish, but in both these features it varies greatly, being either pure silvery-white, cream, or carneous, green, or even roseate.

THE CHRYSALIS.—The chrysalis is a brown, oval body, considerably less in size than the full-grown worm. In the external integument may be traced folds corresponding with the abdominal rings, the wings folded over the breast, the antennæ, and the eyes of the inclosed insect—the future moth. At the posterior end of the chrysalis, pushed closely up to the wall of the cocoon, is the last larval skin, compressed into a dry wad of wrinkled integument. The chrysalis state continues for from two to three weeks, when the skin bursts and the moth emerges.

THE MOTH.—With no jaws, and confined within the narrow space of the cocoon, the moth finds some difficulty in escaping. For this purpose it is provided, in two glands near the obsolete mouth, with a strongly alkaline liquid secretion, with which it moistens the end of the cocoon and dissolves the hard, gummy lining. Then, by a forward and backward motion, the prisoner, with crimped and damp wings, gradually forces its way out; and the exit once effected, the wings soon expand and dry. The silken threads are simply pushed aside, but enough of them get broken in the process to render the cocoons from which the moths escape comparatively useless for reeling.

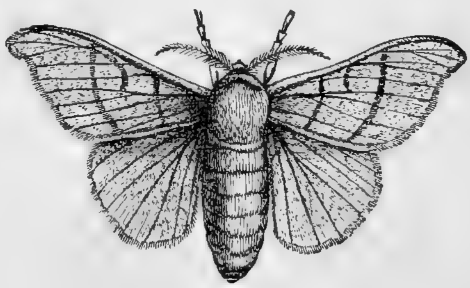

FIG. 4.—Silk-worm moth, male (after Riley).

The moth is of a cream color, with more or less distinct brownish markings across the wings, as in Fig. 4. The males have broader antennæ or feelers than the females, and may be, by this feature, at once distinguished. Neither sex flies, but the male is more active than the female, and may be easily recognized by a constant fluttering motion of the wings, as well as the feature mentioned above. They couple soon after issuing, remaining coupled during several hours, and in a short time after separation the female begins depositing her eggs, whether they have been impregnated or not. Very rarely the unimpregnated eggs have been observed to develop.

VARIETIES OR RACES.

As before stated, domestication has had the effect of producing numerous varieties of the Silk-worm, every different climate into which it has been carried having produced either some changes in the quality of the silk, or the shape or color of the cocoons, or else altered the habits of the worm.

Some varieties produce but one brood in a year; such are known as *Annuals.* Others, known as *Bivoltins*, hatch twice in the course of the year; the first time, as with the Annuals, in the early spring, and the second, eight or ten days after the eggs are laid by the first brood. With Bivoltins the eggs of the second brood only are kept for the next year's crop, as those of the first brood always either hatch or die soon after being laid. The *Trevoltins* produce three annual generations. There are also *Quadrivoltins*, and in Bengal a variety known as *Dacey*, which is said to produce eight generations in the course of a year. Some varieties molt but three times instead of four, especially in warm countries and with Trevoltins. Experiments, taking into consideration the size of the cocoon, quality of silk, time occupied, hardiness, quantity of leaves required, etc., have proved the Annuals to be more profitable than any of the Polyvoltins. The principle difficulties encountered in raising other than the annual races arise from the excessive heat of midsummer, which causes disease, and the deteriorated quality of the leaves as explained in Chapter X. Silk-growers are therefore earnestly advised to attempt but one brood per annum except where, as in some parts of the Pacific coast, the summers are prolonged and equable.

Commercially cocoons are classed as yellow, white, and green, but through the intermingling of races these colors have become merged one into the other, and it is often difficult to define the line of demarkation. The same trouble exists in classifying varieties by the different countries or provinces from which they have originally come. Prior to the Silk-worm plague of twenty years ago in Europe there was a certain degree of exactness in the lines drawn between such races. Then, however, the indigenous races were to a large extent blotted out, and the egg merchants went first to Turkey, then to Asia Minor and Syria, and finally to China and Japan, in search of eggs that should be free from "the malady." Thus it was that there were brought into France and Italy a large number of races foreign to those countries. These were crossed together, and after the researches of Pasteur had made the resuscitation of the native races possible, they were crossed with these as well. Thus the identity of the old varieties was, in many cases, lost, or they obtained different names.

CHAPTER II.

WINTERING AND HATCHING THE EGGS.

As has been said in the last chapter, the egg of the Silk-worm changes color soon after oviposition. During this operation the contents undergo a chemical change, absorbing oxygen and giving off carbonic acid. This absorption of oxygen is very active during the first six days, after which it rapidly declines and continues at a very low rate during the months which precede hatching. The eggs should, therefore, be wintered in such manner that they have plenty of air; otherwise their development will be seriously interfered with. They must not be packed in thick layers, but should be spread out thinly. For these reasons the eggs at this Department are kept through the winter in boxes of perforated tin, the bottoms of which have a surface of 6½ square inches, each box containing not more than one quarter of an ounce of eggs.

The atmosphere in which the eggs are kept should neither be too dry nor too humid. M. Beauvais found a saturation of 50 per cent. to be the most suitable condition of the air, as when it is below that point the liquids of the eggs evaporate so rapidly as to require a highly saturated atmosphere for their incubation. Excessive moisture, on the other hand, will assist the formation of mold, which will quickly injure the contents of the egg. The eggs should be frequently inspected, and whenever such mold is discovered it should be quickly brushed off and the eggs removed to a drier locality.

Under natural conditions the egg undergoes a partial development as soon as laid, as shown by its changing color. After oviposition, and until subjected to cold, the eggs of the annual races are not capable of hatching out. This is the rule, although we often find in a batch of annual eggs a few accidental bivoltins that hatch some fifteen days after they are laid. The number, however, is very slight, and it has been determined that the temperature to which they are submitted in no way alters the result. During this period, which we call prehibernal, the eggs may be kept at any ordinary temperature, however warm, but once they are submitted to the cold of winter a certain change takes place in them, the nature of which has not yet been determined, and their subsequent warming may then result in hatching. As in our climate warm days are quite frequent in late winter, it is very necessary that the eggs be kept below the hatching temperature until the foliage on which the worms are to feed is developing and all danger from late frosts is at an end. The period of hibernation may be lengthened by keeping the eggs in a cool, dry cellar, with a northerly exposure, and in general this will suffice. But in such a case the temperature is more or less variable, and the embryo may be started in its development only to be checked by renewed cold. When kept at a uniform low temperature, after having once been cooled, development is imperceptible, and when afterward exposed to the proper hatching conditions, the resultant worms will prove more vigorous. If possible the temperature should never be allowed to rise above 40° F., but may be allowed to sink below freezing point without injury.

When small lots of eggs are to be wintered, they may be placed in ordinary boxes in the cellar, care being taken to observe the precautions noted above as to ventilation, humidity, and temperature. They should also be protected from rats, mice, ants, and other vermin. But where great quantities are to be stored, it will be well worth while to construct special hibernating boxes, where the requisite conditions may be regulated with nicety and precision.

A great object should be to have them hatch uniformly, and this is best attained by keeping together those laid at one and the same time, and by wintering them, as already recommended, in cellars or hibernating boxes that are cool enough to prevent any embryonic development. They should then, as soon as the leaves of their food-plant have commenced to put forth,* be placed in trays and brought into a well-aired room where the temperature averages about 75° F. If they have been wintered adhering to the cloth on which they were laid, all that it is necessary to do is to spread this same cloth over the bottom of the tray. If, on the contrary, they have been wintered in the loose condition, they must be uniformly sifted or spread over sheets of cloth or paper. The temperature should be kept uniform, and a small stove in the hatching-room will prove very valuable in providing this uniformity. The heat of the room may be increased about 2° each day, and if the eggs have been well kept back during the winter, they will begin to hatch under such treatment on the fifth or sixth day. By no means must the eggs be exposed to the sun's rays, which would kill them in a very short time. As the time of hatching approaches, the eggs grow lighter in color, and then, if the weather be dry, the atmosphere must be kept moist artificially by sprinkling the floor or otherwise, in order to enable the worms to eat through the egg-shell more easily. They also appear fresher and more vigorous with due amount of moisture.

It will be found that eggs which have been subjected to great cold during the winter will require a longer time in their incubation than those which have been kept at a higher temperature, and it is also true, as has been intimated above, that when the atmosphere in which the eggs have been retained has been excessively dry it will require con-

*Too much stress can not be laid on the importance of beginning the rearing of worms as early as possible, so that the excessive heat of summer may be avoided. Beginners are very apt to delay sending for eggs until after the leaves have put out, and there is not only more danger of the hatching of the eggs in transit, but the worms will be maturing during very warm weather.

siderable humidity to cause them to hatch. Such matters must be largely regulated by the experience of the individual raiser.

The desired conditions can be better regulated in specially constructed incubators than in an open room. A simple form of incubator is shown in Fig. 5. It consists of a tin cylinder with a perforated shelf and a

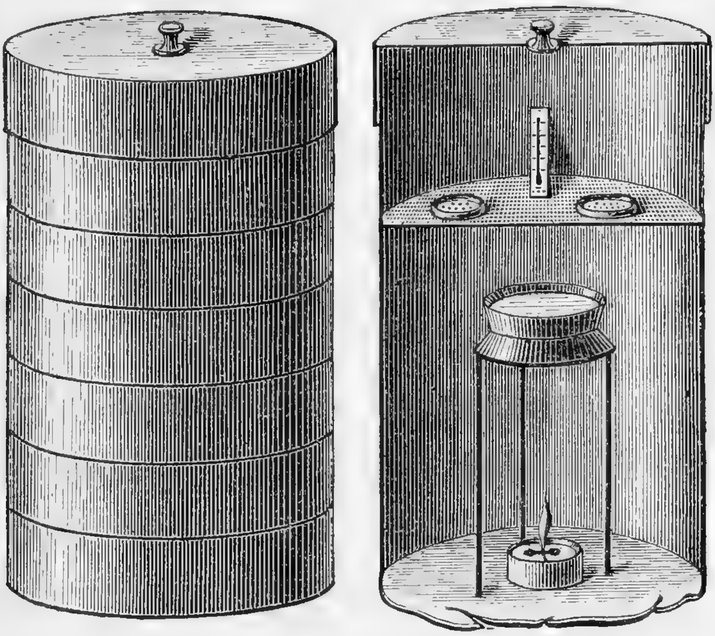

FIG. 5.—Incubator made of tin-ware (after Roman).

movable cover. Under the shelf is placed upon a tripod a small vessel of water, beneath which burns a small night-lamp. This apparatus may be made about eight times the size of the drawing. A similar and simple form of basket-ware incubator is shown in Fig. 6. This possesses

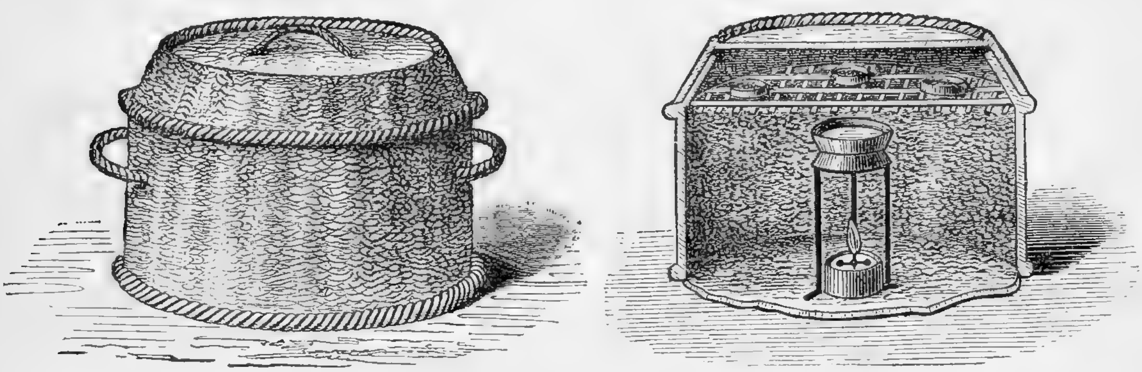

FIG. 6.—Incubator made of basket-ware (after Roman).

the advantage of being permeable to the air and of thus insuring a more complete ventilation for the eggs. Many modifications of these designs will suggest themselves to individuals; amongst others the surrounding of the cylinder of the incubator first described with a jacket, in which hot water may be placed, by means of which the temperature of the interior may be regulated with a considerable degree of nicety.

CHAPTER III.

IMPLEMENTS THAT FACILITATE THE RAISING OF SILK.

The room in which the rearing is to be done should be so arranged that it can be thoroughly and easily ventilated and warmed if desirable. A northeast exposure is the best, and buildings erected for the express purpose should combine these requisites. If but few worms are to be reared, all the operations can be performed in trays upon tables, but in large establishments the room should be arranged with deep and numerous shelves, ranging one above the other from floor to ceiling, as shown in Fig. 7. The width of these shelves should not exceed 5 feet,

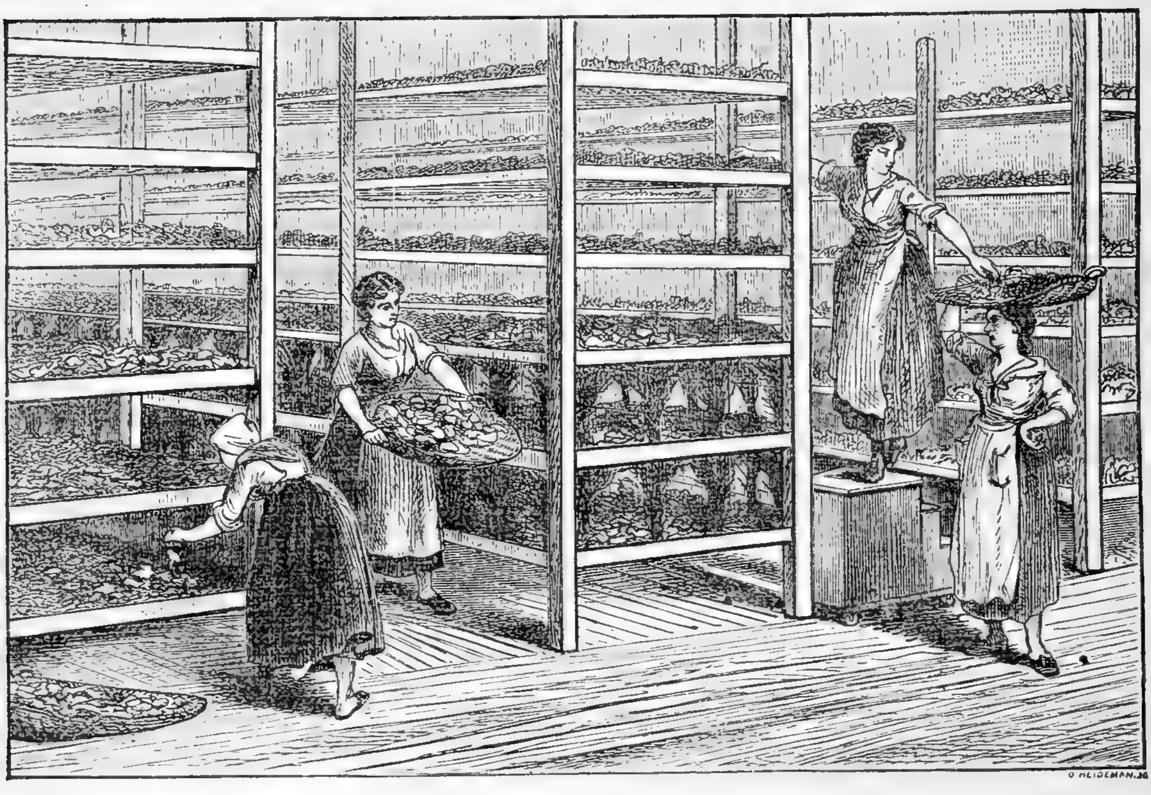

FIG. 7.—A modern magnanerie (after Gobin).

as those in charge must be able to reach from either side to the middle of each table. Bearing this in mind, the dimensions of these tables may be made to suit the room in which the worms are reared. The vertical distance between two shelves should not be less than 20 inches, but if this space is greatly increased it will be found inconvenient to obtain brush of sufficient length to form the arches upon which the cocoons are to be spun.

The form in which the tables are constructed is also immaterial, and should depend upon the resources of the owner. Where canes are abundant, as upon the Mississippi bottom, such a shelf as is shown in

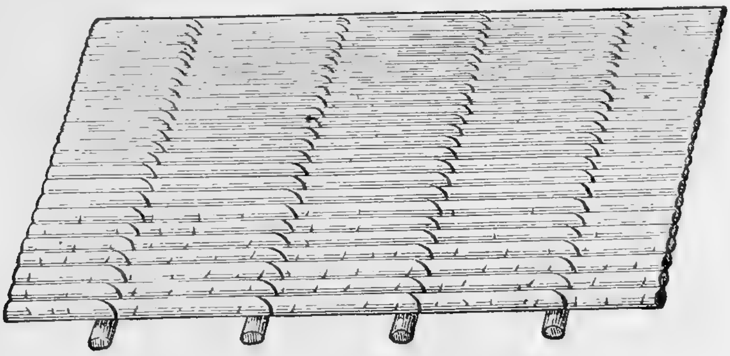

FIG. 8.—Shelf made of canes (after Roman).

Fig. 8 will be found inexpensive and satisfactory. To construct a shelf in this manner, say 5 by 8 feet, there should be selected for cross-pieces four stout canes about one inch through at the small end and 5 feet 4 inches long. Having procured a quantity of smaller canes, 8 feet long, lay out the four cross-pieces some eighteen inches apart, and, placing a cane across them, lash the whole together with stout cord. This is done by having an end of cord attached to each cross-piece, which, after it is carried over the smaller cane, is brought around the cross-piece and fastened by a slip knot, as will be better understood by reference to

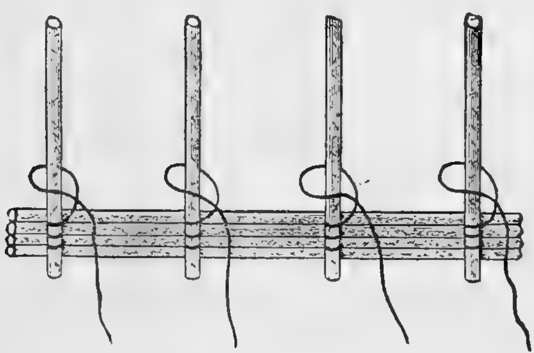

FIG. 9.—Construction of the cane shelf (after Roman).

Fig. 9. The second cane should be placed tip to butt with the first, and so on alternately. Fig. 10 shows a shelf formed with wire-work, which

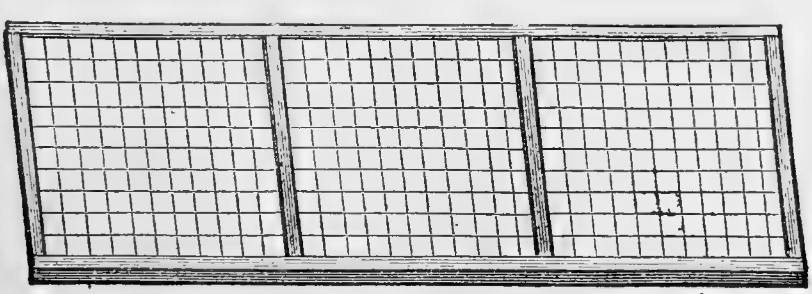

FIG 10. Wire-work shelf (after Roman).

makes a strong and light article. The form shown in Fig. 11 is essentially the same, being covered with wooden slats. Placing these diagonally increases the stiffness and diminishes liability to break.

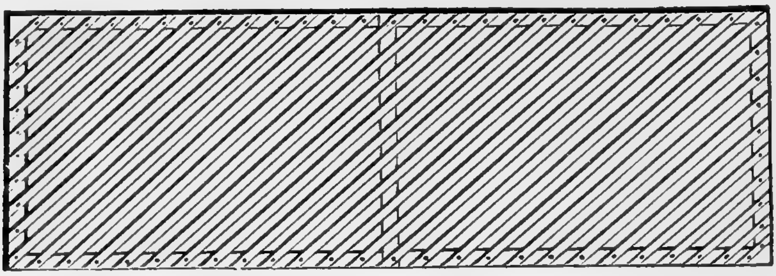

FIG. 11.—Frame covered with slats (original).

Where it is desired to have a neat and convenient standard, upon which a small quantity of worms may be reared, it may be constructed after the manner of that shown in Fig. 12, the shelves being made as

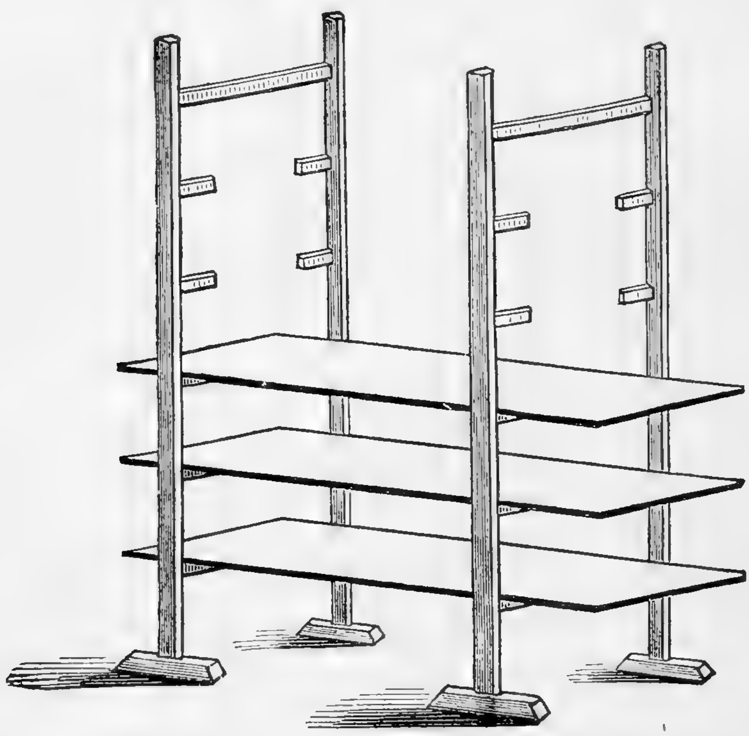

FIG. 12.—Standard for holding shelves (original).

shown in either of Figs. 10 or 11. The principal requisites in tne construction of all the above articles are lightness and strength, and the shelves should be so constructed as to permit the free circulation of the air. All wood should be well seasoned, as green wood seems to be injurious to the health of the worms. The shelves above described must be covered with strong brown paper before being used, and it will be found to be more convenient in removing the litter if sheets of the same size as the table are employed.

In rearing Silk-worms great care should be observed in not handling them more than is absolutely necessary, and as, in clearing up the litter made by the larvæ, it is necessary to transport them from one table to another, several schemes have been adopted to accomplish this object. The first transfer made upon the birth of the worms is usually performed with the aid of ordinary mosquito netting, which is lightly laid over the hatching eggs. Upon this can be evenly spread freshly-plucked leaves or buds. The worms will rise through the meshes of the net, and cluster upon the leaves, when the whole net can be easily removed.

This netting has the disadvantage of sagging in the middle and lumping the worms. Netting of a coarser mesh may be used later in rearing, but it should be stretched on light frames. This method of transfer is such a great convenience and time-saver that in France, for many years, paper, stamped by machinery with holes of different sizes, suited to the different ages of the worms, has been used. The material employed is a stout manila paper, and the perforations vary in size, as shown in Fig. 13. I have experienced some difficulty in the

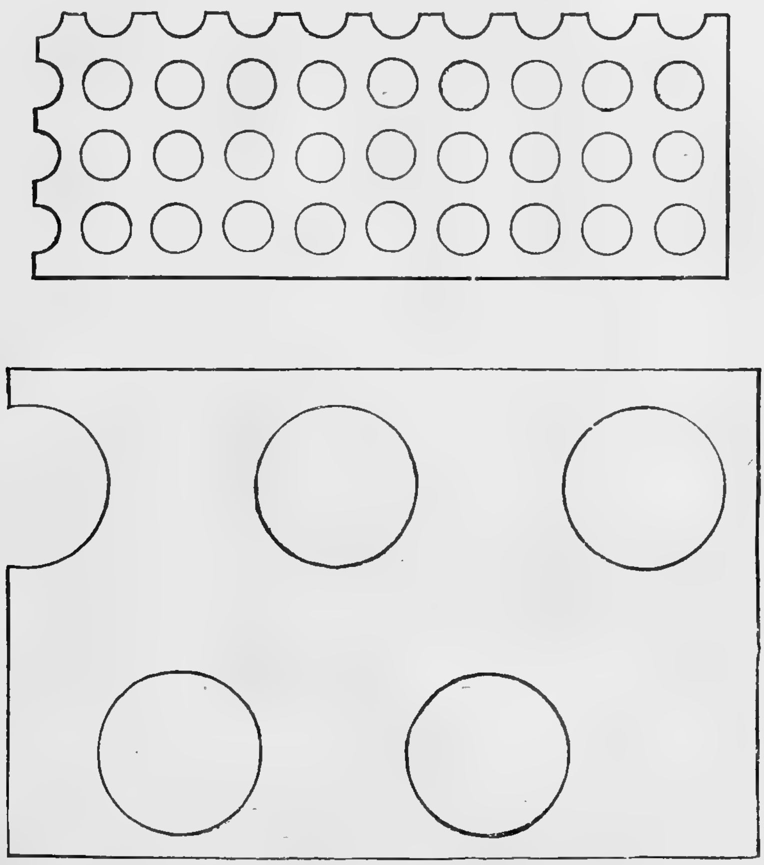

FIG. 13.—Perforated paper, showing the sizes of the perforations in the first and last ages (original)

use of this paper during the fifth age, the worms being so large that when the holes are partially obstructed by twigs or leaf-stems they must force themselves through the restricted space, often cutting themselves on the sharp edges of the paper. This may be avoided by the use, during that age, of a lattice-work tray, such as is shown in Fig. 14.

To prevent this tray from pressing upon the worms beneath, it should be propped up by small blocks placed under the corners.

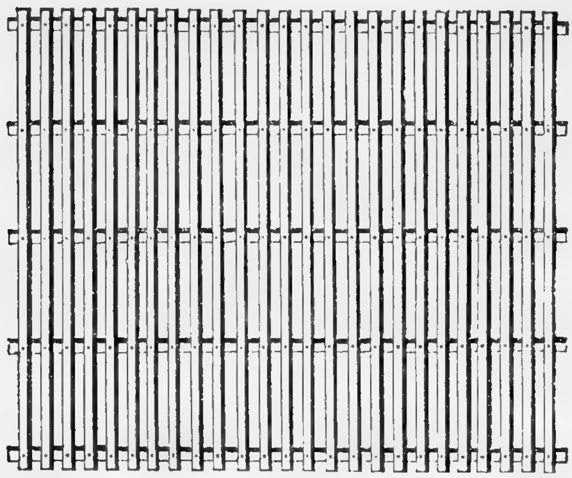

FIG. 14.—Lattice-work transfer tray (original).

When large pieces of perforated paper are used they should be handled by two persons. By cutting them into smaller pieces and using a transfer tray (Fig. 15) one person can perform the necessary work with ease. Such a tray is most conveniently made about 13 by 19 inches inside. When the paper, which should be made about one inch smaller each way, has been covered with leaves, and the worms have come through the perforations in search of their food, the whole may easily be slipped into the transfer tray, and as easily taken from it in depositing the worms on another table.

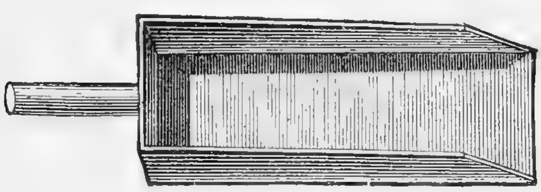

FIG. 15.—Transfer drawer (after Roman).

In gathering leaves for the worms it will be found convenient to employ a bag (Fig. 16), so arranged that it may be attached around the waist like an apron. Two such sacks may be made from an ordinary meal bag.

The worms should be made to spin their cocoons on brush so arranged as to form arches between the shelves, as is shown in Fig. 19.

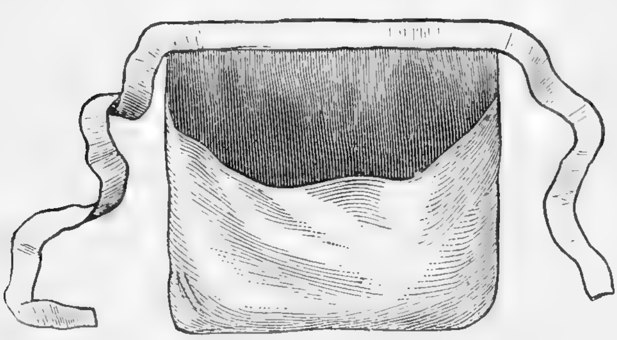

FIG. 16.—Bag for gathering mulberry leaves (after Roman).

For the same object the cocooning ladder shown in Fig. 17 was devised in 1842 by M. Davril. It consists of two central supports, across each side of which (Fig. 18) are nailed small strips of about one-quarter by one-half inch section, $1\frac{1}{2}$ inches apart. The strips on one side are placed opposite the spaces between the strips on the other side. The ladder may be made about 30 by 15 inches, and the central supports about five-eighths inch thick. When in use the ladder is placed slantingly between the tables, with the central supports horizontal.

A thermometer is a very useful adjunct to the appliances above described.

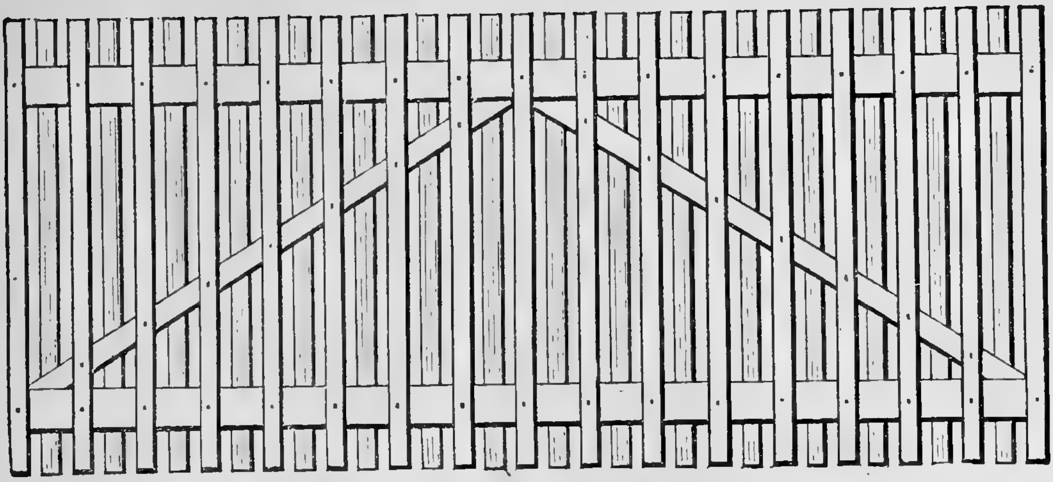

FIG. 17.—The Davril cocooning ladder.

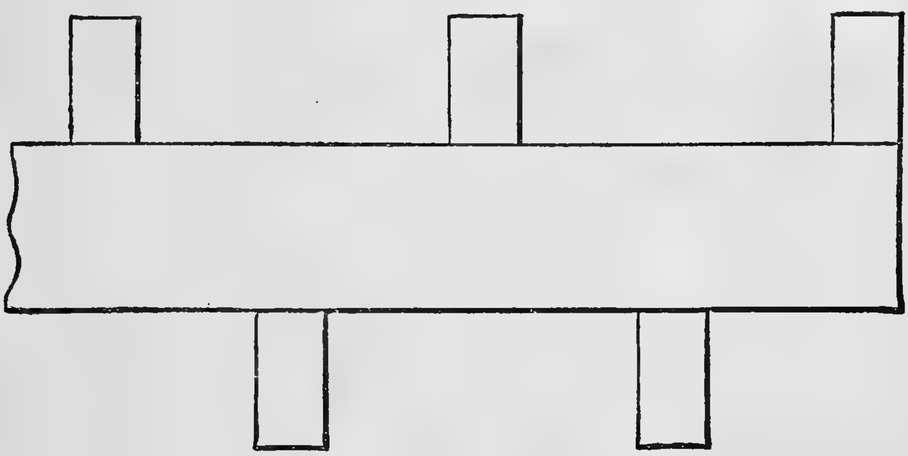

FIG. 18.—Partial end view of the Davril cocooning ladder (full size).

CHAPTER IV.

THE REARING OF SILK-WORMS.

The chief conditions of success in silk raising are (1) the use of good eggs; (2) proper care of the worms.

The means of obtaining pure eggs will be described in the next chapter, and we will here consider the second of the conditions.

Unless new, and especially where the worms raised with them the preceding season have suffered from any disease, all the implements and furniture used should be cleansed and purified by carefully scrubbing in soap and water. The walls of the room may, where convenient, be submitted to the same operation, and covered with a strong coat of whitewash. The room should then be tightly closed and thoroughly fumigated with burning brimstone during an entire day and night. It may then, after being well aired, be used for the rearing of Silk-worms.

The eggs when about to hatch, whether brought to this condition by the systematic processes described in Chapter II, or by ruder methods, should be spread out on clean paper in as thin layers as possible. Over them should be lightly laid small pieces of ordinary mosquito-netting. When the worms begin to appear there should be sparsely scattered over this netting a few buds or finely-cut leaves. The newly born larvæ will at once pass through its meshes in search of food, and the whole can then be easily removed to the table upon which they are to pass their first age.

It is recommended by many to feed the worms while in this age, and, consequently, weak and tender, leaves that have been cut up or hashed, in order to give them more edges to eat upon and to make less work for them. This, however, is hardly necessary with annuals, although it is quite generally practised in France. With the second brood of Bivoltins it might be advisable, inasmuch as the leaves at the season of the year when they appear have attained their full growth and are a little tough for the newly-hatched individuals. In the spring, however, the leaves are small and tender, and nature has provided the young worms with sufficiently strong jaws to cut them.

Many rules have been laid down as to regularity of feeding, and much stress has been put upon it by some writers, most advising four meals a day at regular intervals, while a given number of meals between molts has also been urged; but such definite rules are of but little avail, as so much depends upon circumstances and conditions. The food should, in fact, be renewed whenever the leaves have been devoured, or whenever they have become in the least dry, which, of course, takes place much quicker when young and tender than when mature. This also is an objection to the use of the hashed leaves, as, of course, they dry very quickly. The worms eat most freely early in the morning and late at night, and it would be well to renew the leaves abundantly between 5 and 6 a. m., and between 10 and 11 p. m. Additional meals should be given during the day, according as the worms may seem to need them. It is only by experience that one can learn just what amount of food should be given to the worms. It may prove dangerous to feed them too copiously, as in the first ages the worms may become buried and lost in the litter, while later the massing of food in an attempt to satisfy their ravenous appetites may cause it to ferment and become productive of disease.

Great care should be taken to pick the leaves for the early morning meal the evening before, as when picked and fed with the dew upon them they are more apt to induce disease. Indeed, the rule should be laid down, never to feed wet or damp leaves to your worms. In case the leaves are picked during a rain they should be thoroughly dried before being fed; and on the approach of a storm it is always well to lay in a stock, which should be kept from heating by occasional stirring. Care should also be taken to spread the leaves evenly, so that all may feed alike. During this first and most delicate age the worm requires much care and watching.

As the fifth or sixth day approaches, signs of the first molt begin to be noticed. The worm begins to lose appetite, grows more shiny, and soon the dark spot already described appears above the head. The larva at this time generally wanders to an unencumbered spot where it may shed its skin in quiet and often gets hidden and buried under the superimposed leaves. When the first worms show these signs of molting, food should be given more sparingly and the meals should cease altogether as soon as the most forward worms awaken. When the time for the molt is near, say during the fourth day, it will be well to clear away the litter so that the worms may pass the crisis on a clean bed.

Some will undoubtedly undergo the shedding of the skin much more easily and quickly than others, but no food should be given to these forward individuals until nearly all have completed the molt. This serves to keep the batch together, and the first ones will wait one or even two days without injury from want of food. It is, however, unnecessary to wait for all, as there will always be some few which remain sick after the great majority have cast their skins. These should either be set aside and kept separate, or destroyed, as they are usually the most feeble and most inclined to disease; otherwise the batch will grow more and more irregular in their moltings and the diseased worms will contaminate the healthy ones. It is really doubtful whether the silk raised from these weak individuals will pay for the trouble of rearing them separately, and it will be better perhaps to destroy them. The importance of keeping each batch together, and of causing the worms to molt simultaneously, can not be too much insisted upon as a means of saving time.

As soon as the great majority have molted they should be copiously fed, and, as they grow very rapidly after each molt, and as they must always be allowed plenty of room, it will probably become necessary to divide the batch, and this is readily done at any meal by removing the net or tray when about half of the worms have risen and replacing it by an additional one. The space allotted to each batch should, of course, be increased proportionately with the growth of the worms. The same precautions should be observed in the three succeeding molts as in this first one.

The second and third castings of the skin take place with but little more difficulty than the first, but the fourth is more laborious, and the worms not only take more time in undergoing it, but more often perish in the act. At this molt it is perhaps better to give the more forward individuals a light feed as soon as they have completed the change, inasmuch as it is the last molt and but little is to be gained by the retardation, whereas it is important to feed them all that they will eat, since much of the nutriment given during the last age goes to the elaboration of the silk.

It would, too, be found inconvenient if all the worms were to arrive at the spinning period together, as extra assistance would be required to place the brush on which they spin their cocoons.

At each successive molt the color of the worm has been gradually whitening, until now it is of a decided cream color. Some breeds, however, remain dark, and occasionally there is an individual with zebra-like markings.

As regards the temperature of the rearing-room, great care should be taken to avoid all sudden changes from warm to cold, or *vice versa*. A mean temperature of 75° or 80° F. will usually bring the worms to the spinning-point in the course of 35 days after hatching, but the rapidity of development depends upon a variety of other causes, such as quality of leaf, race of worm, etc. If it can be prevented the temperature should not be permitted to rise very much above 80°, and it is for this reason that a room with a northern or northeastern exposure was recommended as preferable to any other. The air should be kept pure all of the time, and arrangements should be made to secure a good circulation. Great care should be taken to guard against the incursions of ants and other predaceous insects, which would make sad havoc among the worms were they allowed an entrance, and all through the existence of the insect, from the egg to the moth, rats and mice are on the watch for a chance to get at them, and are to be feared almost as much as any other enemy the Silk-worm has.

So much depends upon the conditions of development mentioned above that it is impossible to state the exact quantity of food consumed by the Silk-worm during its life. It will not be far from the truth, however, to place the amount consumed by the issue of an ounce of healthy eggs, which matures in 35 days, at 6½ pounds during the first age, 20 pounds during the second, 65 pounds during the third, 200 pounds during the fourth, and during the fifth and last age 1,250 pounds. This makes a total of between 1,500 and 1,600 pounds. It need hardly be said that the food mentioned must be of the best quality. Were it poor, it would be impossible to give any figures at all.

Too much can not be said in favor of giving the larvæ plenty of room. Every worm should be free to move easily without incommoding its fellows. We should therefore allow the issue of an ounce of eggs during the first age, from 10 square feet at the beginning to 30 square feet at the end of the age, daily extending the space occupied by them by spreading their food over a greater table surface. In the second age, they should spread in the same manner so as to cover from 50 to 75 square feet, in the third from 100 to 160 square feet, and in the fourth from 200 to 320 square feet. Entering the last age, spread over 430 square feet of surface, they should gradually be extended until they occupy, at the spinning period, 640 square feet. It need hardly be said that when the worms have been decimated by disease the surface occupied by them need not be so extensive.

The litter of the worms should be cleared away by the use of netting or perforated paper, before and after each molt, and once at about the middle of the third age. While small, the frass, dung, and detritus dry rapidly, and may (though they should not) be left for several days in a tray with impunity; but he who allows his trays to go uncleaned for more than a day during the two last ages will suffer in the disease and mortality of his worms just as they are reaching the spinning point.

Summed up, the requisites to successful Silk-worm raising are: 1st. Uniformity of age in the individuals of the same tray, so as to insure their molting simultaneously. 2d. No intermission in the supply of fresh food, except during the molting periods. 3d. Plenty of room, so that the worms may not too closely crowd each other. 4th. Fresh air and as uniform temperature as possible. 5th. Cleanliness. The last three are particularly necessary during the fourth and fifth ages.

PREPARATIONS FOR SPINNING.

With eight or ten days of busy feeding, after the last molt, the worms, as we have learned before, will begin to lose appetite, shrink in size, become restless, and throw out silk, and the arches for the spinning of the cocoons must now be prepared. These can be made of twigs of different trees, two or three feet long, set up upon the shelves over the worms, and made to interlock in the form of an arch above them. Interlace these twigs with broom-corn, hemlock, or other well-dried

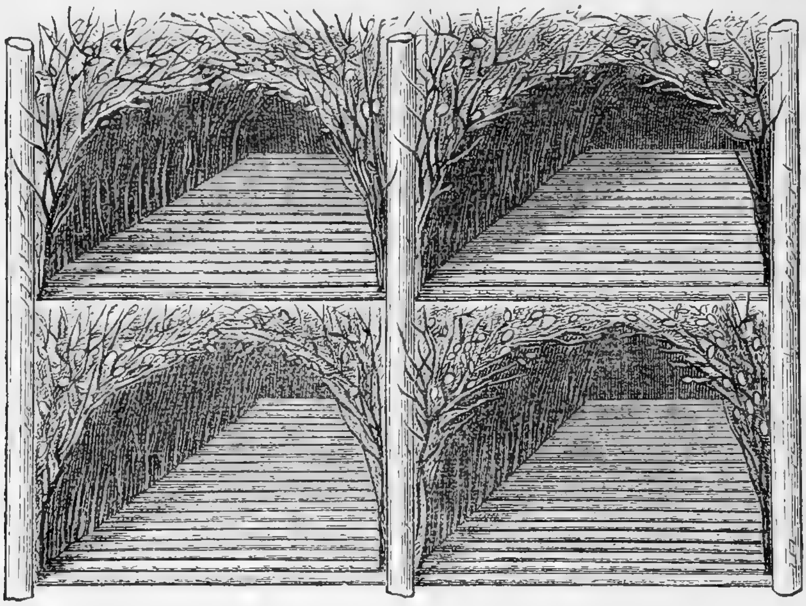

FIG. 19.—Method of constructing arches upon which the cocoons are spun (after Roman).

brush. The feet of each arch should be only about a foot apart. The Davril cocooning ladder, described in Chapter III, may be used with advantage in the place of the brush arches.

The temperature of the room should now be kept above 80°, as the silk does not flow so freely in a cool atmosphere. The worms will immediately mount into the branches and commence to spin their cocoons. They will not all, however, mount at the same time, and those which are more tardy should be fed often, but in small quantities at a time, in order to economize the leaves, as almost every moment some few will quit and mount. There will always be a few which altogether fail to mount, and prefer to spin in their trays. It is best, therefore, after the bulk have mounted, to remove the trays and lay brush carefully over them. The fact that the worms already mounted make a final discharge of soft and semi-fluid excrement before beginning to spin makes this separation necessary, as otherwise the cocoons of the lower ones would be badly soiled.

As the worms begin to spin they should be carefully watched, to guard against two or three of them making what is called a double or treble cocoon, which would be unfit for reeling purposes. Whenever one worm is about to spin up too near another, it should be carefully removed to another part of the arch. In two or three days the spinning will have been completed, and in six or seven the chrysalis will be formed.

GATHERING THE COCOONS.

Eight days from the time the spinning commenced, it will be time to gather the cocoons. The arches should be carefully taken apart, and the spotted or stained cocoons first removed and laid aside. Care should be taken not to stain the clean ones with the black fluids of such worms as may have died and become putrid, for there are always a few of these in every cocoonery. The outer cocoons of loose or floss silk are then removed from the inner cocoons or pods, and the latter sorted according to color, weight, and firmness of texture; those which best resist pressure indicating that the worm has best accomplished its work. Too much care can not be taken to remove the soft or imperfect cocoons, as, if mixed with the firm ones, they would be crushed and soil the others with their contents. The very best of the firm cocoons are now to be chosen as provision for eggs for the next year, unless the raiser prefers buying his eggs to the trouble of caring for the moths and keeping the eggs through the winter. Eggs bought from large establishments are, however, apt to be untrustworthy, and it is well for all silk-raisers to provide their own seed. The precautions to be taken in choosing cocoons for reproduction are set forth in Chapter VI.

Kept at a temperature of about 70° F., new silk cocoons lose, through the giving off of humidity by the chrysalides, a material proportion of their weight. According to Dandolo the loss in 100 pounds during the first ten days amounts to about 7½ per cent.* The amount of humidity in the atmosphere naturally affects this result. The loss continues until the cocoons are thoroughly dry, when it will be found that they have lost two-thirds of their original weight.

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* Dandolo states that 100 pounds of cocoons will suffer the losses indicated by the following table:

	Pounds.
Weight when taken from the brush and after the floss has been removed	100.0
Weight one day after	99.1
Weight two days after	98.2
Weight three days after	97.5
Weight four days after	97.0
Weight five days after	96.6
Weight six days after	96.0
Weight seven days after	95.2
Weight eight days after	94.3
Weight nine days after	93.4
Weight ten days after	92.5

CHAPTER V.

ENEMIES AND DISEASES OF THE SILK-WORM.

As regards the enemies of the Silk-worm but little need be said. It has been generally supposed that no true parasite will attack it, but in China and Japan great numbers of the worms are killed by a disease known as "uji." This is produced by a Tachinid called by Rondani *Ujimyia sericaria*, and the life history of which has been carefully worked up by Prof. C. Sasaki of Japan (Journal Science College, Imp. Un., Tokio, Japan, 1886, Vol. I, part I).

There are, however, several forms of disease against which it is necessary to guard and of which it is therefore necessary that silk-raisers should have an intimate knowledge. Through the multitude of local names given to these diseases abroad, one would suppose that there were as many diseases to which the Silk-worm is subject. But Pasteur, after studying the subject very carefully, concluded that all may be considered as varieties of four principal diseases, viz: the *muscardine*, *pébrine*, *flacherie*, and *grasserie*.*

The *gattine*, one of these varieties, is considered by Pasteur as a mild form of the pébrine,† but Maillot, in a later work,‡ considers it as a species of the flacherie.

These diseases are found to some extent intercurrent, though at all times one (at least one of the first three) has been more prevalent than the others, generally amounting to a plague. So in 1849 we find M. Guérin-Méneville studying, on the part of the French Academy, the then prevalent disease, the muscardine. This was soon followed, in the fifties, by a veritable scourge in which the pébrine was the leading feature, with flaccidity (*flacherie*) quite frequently found. The same learned body appointed Pasteur to study the causes of these diseases, and after two years of patient research he devised a means, which will hereafter be described, of successfully preventing the return of the pébrine. This made way for flaccidity, which is to-day the dread of silk-raisers, for although it does not reach the importance of a plague, its effects are distinctly visible upon the national crops of cocoons in France and Italy, and I have never known it to be absent from worms reared by me almost every year for nearly two decades in this country. The grasserie has never attained any such importance, but occurs in rare instances only.

* Pasteur, "*Études sur la maladie des vers à soie,*" Vol. I, p. 225.

† Pasteur, "*Études,*" etc., Vol. I, p. 12.

‡ Maillot, "*Leçons sur le vers à soie du murier,*" p. 109.

MUSCARDINE.

The first of these, the *muscardine*, has been more or less destructive in Europe for many years. It is of precisely the same nature as the fungus (*Empusa muscæ*), which so frequently kills the common house-fly, and which sheds a halo of spores, readily seen upon the window-pane, around its victim.

A worm about to die of this disease becomes languid, and the pulsations of the dorsal vessel or heart become insensible. It suddenly dies, and in a few hours becomes stiff, rigid, and discolored; and finally in about a day, a white powder or efflorescence manifests itself, and soon entirely covers the body, developing most rapidly in a warm, humid atmosphere. No outward signs indicate the first stage of the disease, and though it attacks worms of all ages, it is by far the most fatal in the fifth or last age or stage, just before the transformation.

"This disease was proved by Bassi to be due to the development of a fungus (*Botrytis bassiana*) in the body of the worm. It is certainly infectious, the spores, when they come in contact with the body of the worm, germinating and sending forth filaments which penetrate the skin, and, upon reaching the internal parts, give off minute floating corpuscles which eventually spore in the efflorescent manner described. Yet, most silk-worm raisers, including such good authorities as F. E. Guérin-Méneville and Eugène Robert,* who at first implicitly believed in the fungus origin of this disease, now consider that the Botrytis is only the ultimate symptom—the termination of it. At the same time they freely admit that the disease may be contracted by the Botrytis spores coming in contact with worms predisposed by unfavorable conditions to their influence. Such a view implies the contradictory belief that the disease may or may not be the result of the fungus, and those who consider the fungus as the sole cause certainly have the advantage of consistency. Dr. W. B. Carpenter, an eminent microscopist, believes in the fungus origin of the disease, and thinks it entirely caused by floating spores being carried in at the spiracles or breathing orifices of the worm, and germinating in the interior of the body.

Whichever view be held, it appears very clear that no remedies are known, but that care in procuring good eggs, care in rearing the worms, good leaves, pure, even-temperatured atmosphere, and cleanliness are checks to the disease.

As the sole means of disseminating the disease are the spores which only appear several hours after the death of the worm, the most rational means of preventing the spread of muscardine is by carefully taking from the tables all dead worms as soon as they are discovered, and if the disease seems to have gained a foothold in the magnanerie it will be well to remove the litter oftener and give the worms more

* *Guide à l'éleveur de vers à soie.*

space. The spores retain their power of communicating disease for at least three years; hence the importance of cleansing and fumigating as described in the last chapter.

PÉBRINE.

External symptoms.—"The disease, pébrine, shows itself outwardly by the dwindling away of the worms and their inequality of size; eating little, they do not grow as large as when in their normal state. At the end of a few days black spots frequently make their appearance on the skin, resembling punctures or burns; the anal horn, the prolegs, the soft parts between the rings, are especially subject to these spots."*

FIG. 20.—Silk-worms spotted with pébrine, twice natural size (after Pa teur).

Fig. 20 "represents, at twice the natural size, the anterior part of the body of sick worms covered with such spots. In one of the worms, *a*, they are just becoming visible, and the eye should be aided by a magnifying glass to render them distinct; the other, *b*, shows them farther advanced, easily recognizable with the naked eye, if the worm be examined with a little attention. Finally, Fig. 21 shows one ring spotted with pébrine, magnified to six diameters. For this cut was chosen a worm bearing two kinds of marks, one with clear-cut edges, the others surrounded with a halo. The first are wounds, the others the true spots belonging to the disease and serving as an indication of its existence, if not always, at least under many circumstances. The halos in question have generally a yellowish tint. They must be observed through a magnifying glass to be well seen."†

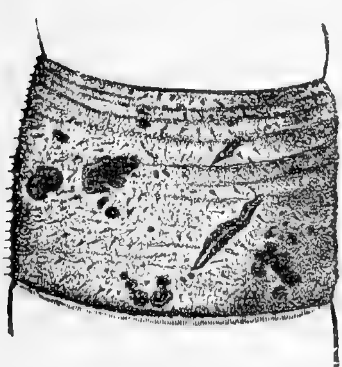

FIG. 21.—Joint of a Silk-worm showing wounds and spots of pébrine, six times natural size (after Pasteur).

These spots disappear with the shedding of the skin at each molt only to reappear again within a few days. Worms bearing them are figured in plate I, A, B, C, and D. In addition to these symptoms it is noticed that the prolegs do not seem to attach themselves easily to objects. In the chrysalis the abdomen is very much swollen and the rings stretched. In a highly-diseased moth the wings are wrinkled as when they emerge

* Maillot, *Leçons*, etc., p. 96. † Pasteur, *Études*, etc., p. 15.

from the cocoon, and are often covered with bloody pimples, which become black on drying. Part of the body and the wings have a leaden color; but this must not be confounded with a certain natural brownness which some healthy moths exhibit, and which extends over the whole body; but it is only with highly diseased subjects that these exterior signs become visible, and to find the symptoms of the disease we are often obliged to resort to a microscopical examination of the interior of the insect.

Internal symptoms.—"In the interior of the body microscopic observation reveals the presence of innumerable corpuscles of an ovoid shape (Plate II), filling the cells of the walls of the stomach, those of the silk glands, the muscles, the fatty tissues, the skin, the nerves—in a word, all the portions of the body. There are often so many of them that the cells of the silk glands become swollen and white, and appear to the naked eye to be sprinkled over with chalky spots; the silky liquid always remains exempt from this parasite, but it is much less abundant than when the worm is in a healthy state."*

In 1849, M. Guérin-Méneville first noticed these floating corpuscles in the bodies of the diseased worms. They were supposed by him to be endowed with independent life; but their motion was afterwards shown by Filippi to depend on what is known as the Brownian motion, and they are now included in the class *Sporozoa* of the *Protozoa*, and referred by Balbiani to the order *Microsporidiæ.*

These corpuscles are found in the Silk-worm in all its stages—in the egg, larva, chrysalis, and moth. It was for a long time a mooted question as to whether they were the true cause or the mere result of the disease; but the praiseworthy researches of Pasteur have demonstrated that pébrine is entirely dependent upon the presence and multiplication of these corpuscles. The disease is both contagious and infectious, because the corpuscles which have been passed with the excrement or with other secretions of diseased worms may be taken into the alimentary canal of healthy ones when they devour leaves soiled by them, and because it may be inoculated by wounds inflicted by the claws of other worms. The malady may be carried to a distance with the corpusculous dust coming from infected magnaneries, and such dust holds the power of communicating disease from one season to another.

When the "seed" is thus diseased it hatches irregularly and incompletely, and the larvæ often perish before or during the first molt. When the corpuscles are taken into the intestines, as above described, the malady usually becomes apparent, through some of the external symptoms mentioned, at the end of four or five days. M. Pasteur determined that if the worm partook of the soiled food after the fourth molt it would make its cocoon, but that corpuscles would be found in profusion in the chrysalis and moth. If, on the other hand, the worm is thus ex-

*Maillot, *Leçons*, etc., pp. 96, 97.

posed to contagion just before spinning, the chrysalis will show the parasites only during its last days, while they will be abundant in the moth.

From the mother moth the corpuscles pass into the egg and give rise to the diseased "seed" already remarked upon. Disease in the male will not, however, affect its progeny. The egg is formed while the insect is still in the chrysalis state, and it has been ascertained that where the corpuscles become abundant only during the last days of this stage they enter into the seed to a very small degree only, if at all. For this reason eggs are sometimes found to be entirely pure, though the issue of a highly pébrinous parent. The development and multiplication of these corpuscles, though ordinarily very rapid, is insignificant in the egg until the formation of the larva begins. It will be easily understood that, though the parasite may exist in the vitellus of the egg, its detection may be extremely difficult. But when the development of the embryo has commenced, the number of corpuscles grows also, so that just before, or, better still, just after the time of hatching they may be found by hundreds upon a casual observation. Upon a microscopical examination at this time, Vittadini, in 1859, founded his system of selection, examining samples of eggs just at the time of hatching and rejecting those lots which showed the corpuscular disease.

At that epoch it was believed that the corpuscles existed even in the healthy moth when well advanced towards its natural death. But Pasteur showed this theory to be fallacious, proving, as we have said above, that the corpuscle is only present when the moth is diseased. He showed that, where the moth is free from the parasite, the egg, too, would be exempt, and that, as a rule, where the corpuscles exist in the moth, then its issue will probably be corpusculous also. There is, to be sure, even then a chance of its purity, as mentioned above—that is, where the corpuscles become abundant in the chrysalis only after the formation of the egg. But here, too, it is highly probable that the malady will have so affected the general health of the parent as to make her issue more apt to succumb to disease, as in the case of flaccidity. Therefore it is laid down as a rule, and upon this rule the Pasteur system of selection rests, that if, upon microscopical examination of the mother moth, the corpuscles of pébrine are found, then her eggs and issue will also be pébrinous, and should be destroyed.

The details of the Pasteur system of selection will be given in the next chapter.

FLACCIDITY (*flacherie*).

External symptoms.—When, after the worms have passed their fourth molt, and are eating well and regularly, they have all the appearance of perfect health and vigor, and the silk-raiser feels full confidence in the success of his crop, some will often be seen to crawl to the edges of the trays, and lie there languid and without motion. But for the loss of their wonted activity and the cessation of their naturally voracious appetite, one would still think the worms in perfect health, for they yet retain all the outward perfection of form that we have remarked above (Plate I, Fig. G). In color they have, perhaps, become somewhat more rosy, especially if the disease is in a violent form. On touching them, however, we find them soft, and even in this seemingly live condition they are often dead. Had the worms been carefully observed at this time, it would have been seen that the beating of the dorsal vessel was gradually becoming slower, and that it finally stopped altogether. A green drop appears at the mouth and the worm secretes a dirty liquid, which soils the anal orifice and gradually closes it.

Before many hours are passed the skin begins to shrivel and draw in around the fourth and fifth joints of the body, viz: those two lying between the set bearing the legs proper and the set bearing the prolegs (Plate I, Fig. F). Later, at this restricted point, the body begins to turn brown (Plate I, Fig. E), then black, and the whole worm is soon in an advanced state of putrefaction. Then, and even before the death of the worm, a sour odor is perceptible in the magnanerie, due to the fatty volatile acids exuded by the victims to the disease. Should the malady strike the insects at a later period, when they are ready to spin their cocoons, the same languishing air will be observed; they will show a reluctance to crawl up into the arches, and will be seen to gather around their bases, seeking some place which it requires no exertion to attain to spin their cocoons. Many of those which reach the branches stretch themselves out motionless on the twigs and die there. They are to be seen later hanging by their prolegs in different states of putrefaction (Fig. 22). When these symptoms are observed we may be sure that the worms are attacked by flaccidity (*flacherie*).

Fig. 22.—Silk-worms at the spinning period, after death by flaccidity (after Pasteur).

Internal symptoms.—A microscopic examination of the intestines of the sick worm will show masses of undigested food, and the coats of the intestines will be found to be opaque. Here, too, the microscope reveals the parasites ordinarily attending putrefaction, chief among which is a bacillus, seen sometimes with and sometimes without a bright nucleus. There also exists a special form of ferment, not unlike that which accompanies the formation of vinegar (*Mycoderma aceti* Pasteur), which is found in short chains, the links of which are almost spherical

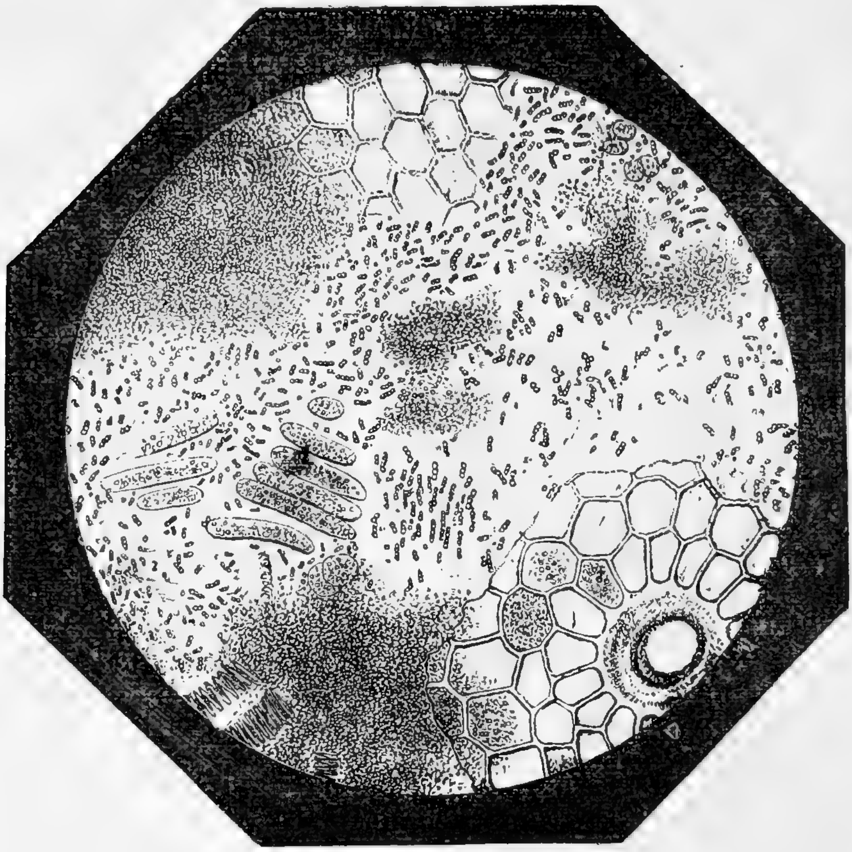

Fig. 23.—Chain ferment, taken from the stomach of a flaccid chrysalis. Magnified 400 times (after Pasteur).

in form (Fig. 23).* These two parasites are sometimes found together and sometimes separately. When the bacillus is abundant death quickly follows its appearance, and the disease, spreading rapidly, will sometimes destroy a whole school in a single day. At times this bacillus appears so short a time before the spinning of the cocoon that the worms are able to mount into the branches, and even make their cocoons and become chrysalides. Then, however, the disease overcomes them, and their putrefaction produces foul cocoons. This case is, however, more rare, and in general the bacillus is not often found in the chrysalis. When the ferment alone appears the disease progresses differently. The worms then show the same languor on the approach of the spinning period, and the same indisposition to make their cocoons; but even then they mount the branches, perform their work of spinning, are transformed into chrysalides, and these into moths which may have a fine appearance. The silk crop may even be exceptionally good; but where this state has existed, when the worm has been without its usual

* The distance from center to center of the links of these chains is about 1 μ ($=0.001^{mm}=0.00004$ inch).

agility at the spinning time, where it has shown this apparent laziness, then, though the cocoons be of the firmest and the moths the finest, there will exist a weakness, a constitutional debility, that will show itself in the next generation. This is the only way in which flaccidity is hereditary, in this predisposition of the worm to succumb to disease on account of the affection which weakened but which did not kill the parent.

Such are the symptoms attending flaccidity in Silk-worms, and from them M. Pasteur evolved the theory that the disease was caused by the fermentation of the food in the intestinal tube of the larva, which was followed by diarrhea and the closing of the anal orifice, as already mentioned. Confirming this theory of food fermentation is the fact that the same parasite (Fig. 23) which is found in the intestines of flaccid larvæ also exists in a fermented broth of mulberry leaves. Digestion thus arrested, the worm ceases to eat and becomes languid. The gases evolved by the processes described burst the walls of the intestines and cause the death of the victim. Such is the Pasteur theory, followed, as a rule, by the French scientists.

Italians, on the contrary, believe with Verson and Vlacovich, who claim to have observed "that in the flaccid worm the micro organisms are not at times to be found; that it has been proved that in the beginning there occurs a tumefaction of the membrane of the intestines, and that this membrane, as the disease advances, disappears here and there, and finally altogether. According to them flaccidity consists primarily of a lesion of the membranous walls of the intestines, which would generally be followed by the development and multiplication of the micro-organisms which Pasteur considered the primitive cause of the disease. It is a fact, nevertheless, that all acknowledge, that in most cases flaccidity is accompanied by bacilli and ferments in great numbers in the intestinal tube."*

Flaccidity generally appears after some sudden change in the weather or temperature, as, for instance, a thunder shower, or a hot, heavy day. It is apt, too, to follow the feeding of wet or fermented food. If the shelves go too long without cleaning and begin to mildew; if the worms are too crowded on the table and their natural respiration interfered with, flaccid subjects will soon appear in the school. These, by their unhealthy excrement, soil the food of their neighbors, who quickly follow them in the path of disease. It is thus that flaccidity becomes highly infectious.

No very satisfactory means have been proposed for combating this malady when once it appears. It would be well, on the discovery of the first victims, to take the worms remaining healthy into another apartment and give them more space and plenty of air. Attentive care may then save the crop, though by no means with certainty.

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* Perroncito, *I Parassiti*, p. 35.

To avoid the disease one should carefully follow the fundamental rules already laid down (Chapter IV), though even then circumstances may be against the silk-raiser and the crop be lost through no apparent fault of his.

GRASSERIE.

This disease is of little importance, and has therefore received but little attention from scientists. It is thus described by Maillot:*

"In the middle of a school of worms in good condition it is not rare, as a molt approaches or just before the spinning begins, to find here and there some worms which crawl slowly, and have a shining, stretched, thin skin; the body is of a bright yellow in the yellow, and of a milky white in the white races; a troubled liquid transudes through the skin; soiling the food and the worms over which the diseased subjects pass. * * * A moist, cold, stagnant air seems to favor the occurrence of grasserie. The disease is not contagious, * * * nor does it appear that it can be transmitted by heredity. From this point of view there is nothing to be feared, unless a great number die of the malady, in which case it will be imprudent to use the stock for reproduction."

Victims of this disease should be removed as soon as discovered, as they are apt to crawl into the branches and soil the cocoons spun by other worms.

Prefacing the next chapter we may draw the following conclusions from what has been said: Grasserie is never hereditary, as the victim never dies later than in the chrysalis state, and the disease can never originate in the moth. This is equally true of muscardine, provided the moths be not mingled with worms covered with the spores of the Botrytis. In such a case the moth might also catch the disease and its general debility decrease the vigor of its progeny. Flaccidity is hereditary in an indirect manner, a debility springing from the affection of the parent rendering its issue more apt to succumb to disease. And finally, pébrine is hereditary in its true sense, the corpuscles passing from the mother through the egg to the next generation. In the production of eggs, then, we need look for flaccidity and the pébrine only, the other diseases not entering into the consideration.

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* *Leçons, etc.*, p. 111.

CHAPTER VI.

REPRODUCTION.

It has been said in Chapter IV that the first condition of success in raising Silk-worms is to "procure good eggs." The object of the present chapter is to describe the most approved processes of producing such eggs.

Were it not for the diseases to which the Silk-worm is subject, the old, simple processes of egg production might still be followed, and even now, unless the egg producer is able and ready to undertake the microscopical examination required by the Pasteur system, it is needless to observe the more complex rules for the isolation and examination of the moths.

The simple process formerly employed in all sericultural countries consisted in stringing the cocoons and letting the moths couple, as in the modern process. A sheet was then hung up with the lower edge so turned as to form a trough into which any badly gummed eggs might fall. After uncoupling, the females were placed upon the sheet and permitted to lay their eggs promiscuously. The only precaution taken against disease was in the selection for reproduction of lots of cocoons whose larvæ had shown no signs of any malady, and which were themselves of first quality. From what has been said it will at once be seen that pébrine contracted after the fourth molt and the slow form of flaccidity due to the presence of chain-ferment are not thus guarded against. The modern system has a deeper, more scientific basis, and aims to guard against these.

The Pasteur system of microscopical selection.—As we have seen, pébrine and flaccidity are the only diseases which it is necessary to guard against in selecting eggs. If pébrine or flaccidity have appeared in a positive form in the larvæ, either through the external or internal symptoms described in the last chapter, no further examination need be resorted to, as the stock will evidently be unfit for reproduction. The most important and positive sign of the latter disease to be looked for is languor at the spinning time. If a greater degree of certainty is desired, or if the egg-producer has not had the opportunity of observing the rearing of the worms, a miscroscopical examination of the chrysalis may be resorted to. In flaccidity this examination should be confined to the stomach, where the chain-ferment to be sought for is more easily found. M. Pasteur gives the following directions for extracting this organ:

"Cut away the walls of the thorax of the chrysalis with fine scissors, after the manner shown in Fig. 24, so as to reveal the stomach *s*. Draw this out with a pair of tweezers. The restricted part of the digestive tube, which unites the stomach with the urinal sack *u*, should then be cut. The anterior part of the digestive tube now alone holds the stomach in place, and this easily gives way. Lay the small ball thus withdrawn on a glass slide and scratch away the very soft, fatty envelope which covers the interior. Of this interior substance take a piece as big as the head of a pin, wash it with a drop of distilled water, and, placing it upon a slide with a cover glass over it, examine it with a microscope magnifying about four hundred diameters. With a little experience this work may be done very rapidly. It would be well to take out at the same time the stomachs of, say, twenty chrysalides, and lay them on as many glass slides. * * *

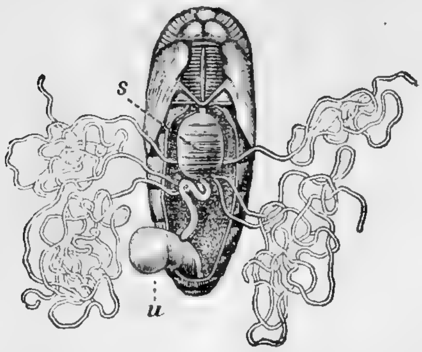

FIG. 24.—Anatomy of the chrysalis, showing method of extracting the stomach (after Pasteur).

"The first few days after the formation of the chrysalis the contents of the stomach are generally very liquid, which makes their extraction inconvenient. It is better to make these observations seven or eight days after the spinning begins, when the matter will be found to have more consistence. * * * Fig. 23, page 38, shows the appearance of the ferment found in flaccid chrysalides under a magnifying power of 400 diameters. It is associated with the débris of leaves, morsels of the trachea, and chlorophyl cells. These matters ordinarily accompany the little ferment in the stomach of the chrysalis, because of the incomplete digestion of the leaf whenever it is submitted to fermentation."*

No parasite indicative of flaccidity has been discovered other than this ferment, which is not found in the adult insect; and if the transformation into the moth is permitted, all opportunity will be lost for detecting the disease.

In pébrine, on the contrary, the corpuscle is found in the moth as well as in the chrysalis. We might, therefore, wait for a final examination of the moth to be made after oviposition. But, in case disease is then found, it will be too late to stifle the cocoons, and the emergence of the moths will have ruined them for certain commercial purposes. For this reason it is important to detect the disease, if it exists, at as early a stage of the work as possible. If the larvæ have shown no external signs of the pébrine, it would be well to microscopically examine a few of the last worms to spin. The corpuscles will be found in these laggards, if anywhere.

Isolation and examination of the moths.—If left to themselves the insects remain in the chrysalis state for from two to three weeks in our ordi-

* Pasteur, *Études*, etc., Vol. I, p. 233.

nary summer weather. Their development may, however, be hastened or retarded by increasing or lowering the temperature. This fact is taken advantage of to obtain a few adult insects which may be microscopically examined before the whole lot becomes fully developed.

I was very much pleased with the method employed by M. Maillot, which I had an opportunity of examining at Montpelier, in 1884, and I here give a description of it in his own words:

"Three or four days before the cocoons are taken from the branches we take, here and there, from the early spinners as well as the late, several hundred cocoons; as, for example, five hundred from a lot of 90 pounds. This sample should be placed in an oven or warm room, where it will be kept day and night at a temperature of from 100° to 110° Fah., and a high degree of humidity. In this way the formation of the moth is hastened. As during this time the cocoons of the lot itself remain at a temperature of from 75° to 90°, and often during the night at even lower temperatures, we shall still have time to stifle them if the lot is discarded, or to string them into chains if, on the contrary, it proves healthy.

"Every two days we take ten chrysalides from the sample and examine them microscopically for corpuscles. If we find them in the first eight or ten days, no matter in how small quantities, we can be sure that the proportion of pebrinous moths will be considerable. When the chrysalides are mature, which is easily seen by their eyes becoming black and the eggs harder to break under the pestle, and also by some of them turning into moths, we proceed to the definite examination. We crush one by one the moths which have come out and the chrysalides which remain and search for corpuscles; the per cent. which is thus found will not differ materially from that which exists in the whole lot."*

The examination of the chrysalides here mentioned may be made in the manner already described when searching for the ferment of flaccidity and at the same time. But if we are looking for the pébrine only we need simply crush the whole chrysalis in the manner hereafter described for the moth.

Proceeding now with stock of which the purity has been ascertained by one or more of the different methods of observation above described, 200 cocoons should be selected for each ounce of eggs that it is desired to produce. In making this selection great care should be exercised in taking only cocoons that are fine in texture and firmly made. This fineness is one of the prerequisites of a first-class cocoon. What is meant by this difference in texture will be seen by an examination of Figs. 2 and 3, page 14, the former being fine and the latter coarse. The firmness of the cocoon, depending as it does on the amount of silk which it contains, is an indication of the vigor of the worm, and another item to be considered in selecting stock for reproduction. Rules have been

*Maillot, *Leçons*, etc., p. 250.

given for the determination of the sex of the inclosed insect, and among them, perhaps the most common, is the assertion that those that are constricted in the middle (Fig. 2) contain males, while those not constricted (Fig. 3) contain females. This, however, may be regarded as an indication rather than a fixed rule, and there are races in which the cocoon is almost uniformly constricted and others where the reverse is true. But this careful selection for sex is comparatively unimportant, and we consider it wiser to choose the cocoons in relation to their firmness and texture, and trust to chance to bring as many male moths as female. Double cocoons, where two worms have spun together, should never be used in egg-making.

The proper cocoons having thus been selected, they should be strung upon stout threads about 3 feet long. Care should be taken not to prick the chrysalides with the needle while passing it through the end of the cocoon in making the chains. These chains should then be hung in a cool, darkened room while waiting for the moths to emerge. They should not be placed near any object which would be soiled by the secretions emitted by the moths on their emergence from their cocoons.

Previous to this emergence there should be prepared for each ounce of eggs to be produced about one hundred small bags of fine muslin (cheese cloth makes a good material), made in the following manner: Cut the cloth in pieces 3 by 6 inches, then fold one end over so as to leave a single edge of about three-quarters of an inch, as shown in Fig.

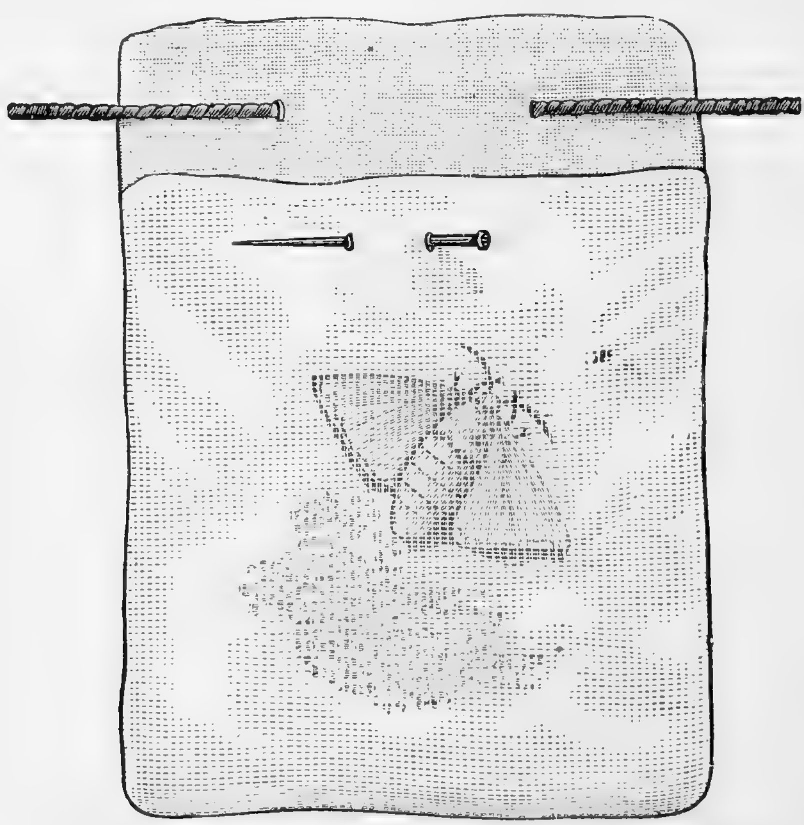

Fig. 25.—Cell used in the Pasteur system of egg-laying (after Roman).

25. This should be sewn up into a bag with the upper end open, and then turned inside out so that the seams will cause the sides to bulge. Thus completed they are called "cells." The cells should be strung

on a cord stretched across the room. Some trouble having been experienced in keeping the moth from crawling out of the cell at either side of the pin, which is the method of closing it shown in the cut, the scheme shown in Fig. 26 was adopted last year in the Department.

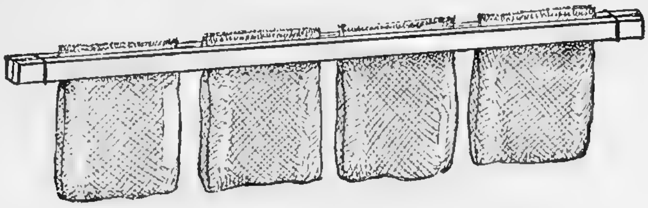

FIG. 26.—Method of clamping cells (original).

This consists in clamping the bags in fours between two sticks of wood, rough sawn, about one-half by one-quarter inch through and 14 inches long. They are bound together by rubber bands and may be laid across parallel wires stretched across the room at about 13 inches apart. M. Pasteur suggests that a simple piece of cloth about four inches square be used instead of the sack. The moth lays her eggs on this and is then retained by being fastened to the cloth, the corner of which is turned up over her and a pin passed through it and over her wings (Fig. 27).

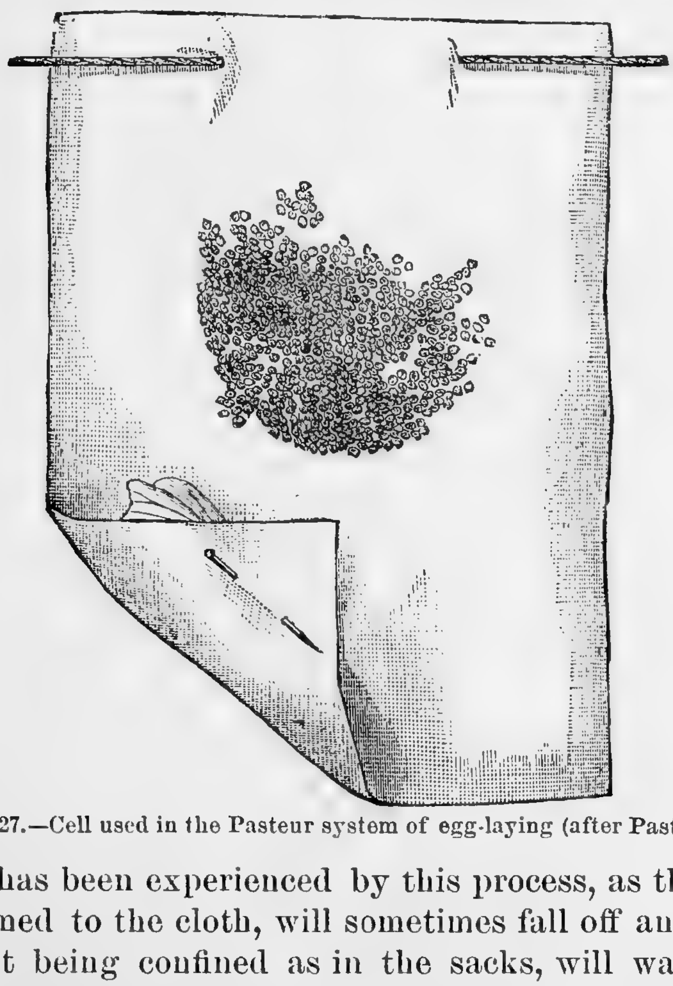

FIG. 27.—Cell used in the Pasteur system of egg-laying (after Pasteur).

Some trouble has been experienced by this process, as the eggs, if not properly gummed to the cloth, will sometimes fall off and be lost, and the moths, not being confined as in the sacks, will wander to other cloths and get their eggs mixed with those of other moths, which would be detrimental to the microscopical selection to be hereafter described. It has the advantage, however, of enabling the microscopist to avoid the labor of turning the sacks.

The moths emerge from the cocoons, as a rule, from 5 to 8 o'clock in the morning. At the latter hour many of them will be found coupled and clinging to the chains. These should be carefully taken by the wings and placed upon a table by themselves, the single moths being placed upon another table where they will couple if the sexes are evenly divided. They should then be transferred to the first table as the fluttering of the male moths is apt to disturb the couples. These should be left together until 4 or 5 o'clock in the afternoon, when they may be separated by drawing them gently apart by the wings. The females should then be placed in the cells or upon the cloths already described, where they will at once commence their egg-laying, completing it in about thirty-six hours. Most of the males may then be thrown away, though it may be wise to keep a few of the more active ones to compensate for any superabundance of females in the issue of the following day. But little difficulty will be encountered in distinguishing the sexes, the males being noticeable by their smaller abdomens, more robust antennæ, and by their greater activity.

When the eggs have been laid, the microscopical examination of the moths should be made with a view to ascertaining whether or no they are afflicted with pébrine. The entire moth should be ground up with a few drops of distilled water* in a small glass mortar (1 ounce is a convenient size). A drop of this water is then taken with a medicine dropper and placed upon a glass slide with a cover glass over it. It is then microscopically examined with a power greater than three hundred diameters. Plate II shows a field very highly charged with the corpuscles of pébrine. When the moths are not examined until some time has elapsed after their death, they will be found to contain other germs peculiar to putrefaction. These do not indicate any disease that would affect the egg or its issue; nor does their presence imply any lack of vigor in the parents. They are simply post-mortem parasites. Great care should be taken in cleansing the mortar, pestle, and other implements before making an examination, by washing them in an abundance of water and rinsing them thoroughly with distilled water. In making the above examination only the corpuscles of pébrine need be looked for. The bacilli and the ferments of flaccidity are rarely found in the moth.

* The amount remaining in the mortar after rinsing is sufficient.

CHAPTER VII.

CHOKING THE CHRYSALIS.

In most silk-producing countries the parties who raise the cocoons sell them to the reeling establishments before suffocation is necessary, as these establishments have better facilities for this work than are to be found in private families. If, however, the reeling is done by the raiser, or some time must elapse before the cocoons can be sent to a reeling establishment, some means must be used to kill the contained chrysalis before the cocoon is injured for reeling purposes by the egress of the moth. This can be done by stifling them with steam or choking them by dry heat. Steaming is the surest, quickest, and best method, if the facilities are at hand; it can be done at any steam mill. The cocoons are laid upon shelves in a tightly-sealed box and the steam is turned in. Twenty minutes will suffice to do the required work, and the cocoons are then dried in the sun.

The following apparatus has been used by Mr. Walker at the Department:

It consists of a tin reservoir, about one-third filled with water. Slightly above the surface of the water is a movable perforated partition, B, intended to prevent spattering during ebullition. The upper portion contains a perforated pan for holding the cocoons, while all is tightly closed by a cover. Cocoons may be thoroughly stifled by exposure in this apparatus, over boiling water, for twenty minutes. It will be seen, too, that much the same apparatus may be contrived by the use of a deep kettle, into which is set an ordinary colander full of cocoons. It is well to avoid, however, so filling the kettle with water that it will splash upon the cocoons in boiling, as they should only be subjected to the action of steam. The apparatus is 12 inches in diameter and 13 inches deep, and will stifle from 3 to 4 pounds of cocoons at a time.

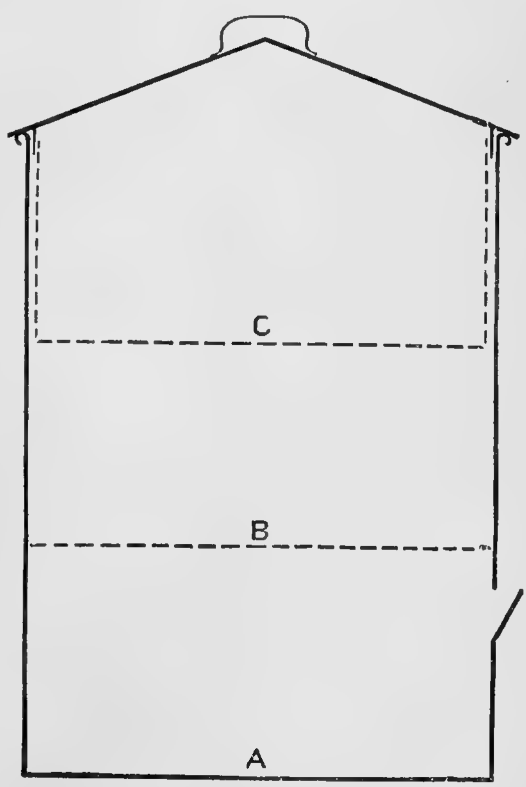

FIG. 28.—Simple stiffling apparatus.

The dry-heat method occupies a much longer time. The cocoons are placed in shallow baskets and slipped on iron drawers into an oven which is kept heated to a temperature of about 200° F. This should not be increased for fear of burning the silk. This operation lasts from two to twenty-four hours. A certain humming noise continues so long as there is any life, and its cessation is an indication that the chrysalides are all dead. Where the choking is well done there is little loss, only about 1 per cent. of the cocoons bursting at the ends. After choking in this manner, the cocoons should be strewn upon long wooden shelves in the shade, with plenty of air, and, for the first few days, frequently stirred. After remaining on these shelves for about two months, with occasional stirring, the chrysalides become quite dry, and the cocoons will preserve indefinitely. They are, however, still subject to the attacks of rats and mice, and the little beetles known as "museum pests," belonging to the genera *Dermestes* and *Anthrenus*, are attracted by the dead chrysalis within and will penetrate the cocoon, injuring it for reeling purposes. In the warm Southern States the dry-heat choking can be accomplished by simple exposure to the sun. Two or three days of such exposure are sufficient. But, as strong wind may annihilate the effect of the sun's warmth, it is good to have for that purpose long boxes, 4 feet wide, sides 6 inches high, to be covered with glass frames. This will increase the heat, and, by absorbing the air of the box, stifle the chrysalis most surely. The glass cover should be slightly raised to permit the escape of the excessive moisture which evaporates from the cocoons, and care should be had to keep out the ants.

CHAPTER VIII.

SILK-REELING.

Spun, reeled, and thrown Silk.—From the cocoon the silk is by different processes transformed into spun or reeled silk. The former is generally made from pierced cocoons or silk waste, and serves in the manufacture of inferior classes of tissues. The method of manufacture consists in cleaning and macerating the raw material, after which it is carded and made into thread somewhat after the manner of cotton. The process of producing reeled silk, which will be hereafter treated at length, consists, in general, of softening the gluten of the cocoons in hot water and then taking the ends of the constituent threads of several of them together and winding these threads from the cocoons upon a reel.

By virtue of the next process of manufacture to which this material is submitted it becomes *thrown silk*. Thrown silk is classified as organzine and tram. It is made either from spun or reeled silk. Tram consists of two or three threads of reeled (or spun) silk twisted together at about 75 to 100 turns per running meter (67.5 to 90 per yard). It is used in making the warp in weaving. Organzine, used in the woof, is produced by twisting two threads together at about 500 to 600 turns per running meter, and then taking two of the threads thus made and twisting them together in the opposite direction at about 400 to 500 turns. It is, in the language of the trade expression, "cable laid."

It is the object of this work to deal only with one of these classes; that is to say, reeled, or, as it is commonly called, raw silk. Although the former name indicates more exactly than the latter the processes to which the raw material has been previously submitted, yet the term "raw silk" has acquired a special meaning by trade usage and applies only to reeled silk.

The process of Silk-reeling.—The cocoons should have been roughly sorted before they were spread out in the cocoonery, the double and feeble specimens having been laid aside. They should now be sorted so that cocoons of the same color and shade may be reeled together, for the use even of cocoons of the same color but of different shades will give a streaked skein of silk. They should, too, be sorted as to their texture. Those of fine texture, among ordinary cocoons, are considered first choice and are used to produce the finest qualities of raw silk. They are more easily unwound than those of coarser texture which are called satiny cocoons. This satinage appears to be due to the fact that the successive layers of the cocoon are insufficiently gummed together. As a result the water penetrates quickly into its center while it is being reeled and causes it to sink to the bottom of the basin, which interferes with the process of unwinding. Towards the end a satiny cocoon comes off in flocks, making a dirty silk.

A comparison of the cocoons shown in the cuts on page 14 may convey an idea of the difference of texture mentioned, Fig. 2 being fine, and Fig. 3 of coarse grain. In addition to the above features some regard must be paid to the reeling of cocoons of the same size together. An extended experience is needed to make a rapid cocoon-sorter, and it is work that should be followed without intermission, that the knack necessary to quickness may not be lost.

The process of reeling cocoons, while extremely simple, is still one that requires an amount of skill to acquire which the experience of several months is necessary. The cocoons are first plunged into boiling water, whereby their gluten is softened in such a manner as to render the unwinding of the filaments an easy matter. This done, they are brushed with a small broom, to the straws of which their fibers become attached. The bundle of filaments is then taken and they are unwound until each cocoon shows but one clean thread. These three operations are called "cooking," "brushing," and "cleansing." All of these operations can be accomplished mechanically.

The elements of the mechanism of all modern silk-reels are essentially the same. They are shown in Fig. 29, and consist, in general, of a basin,

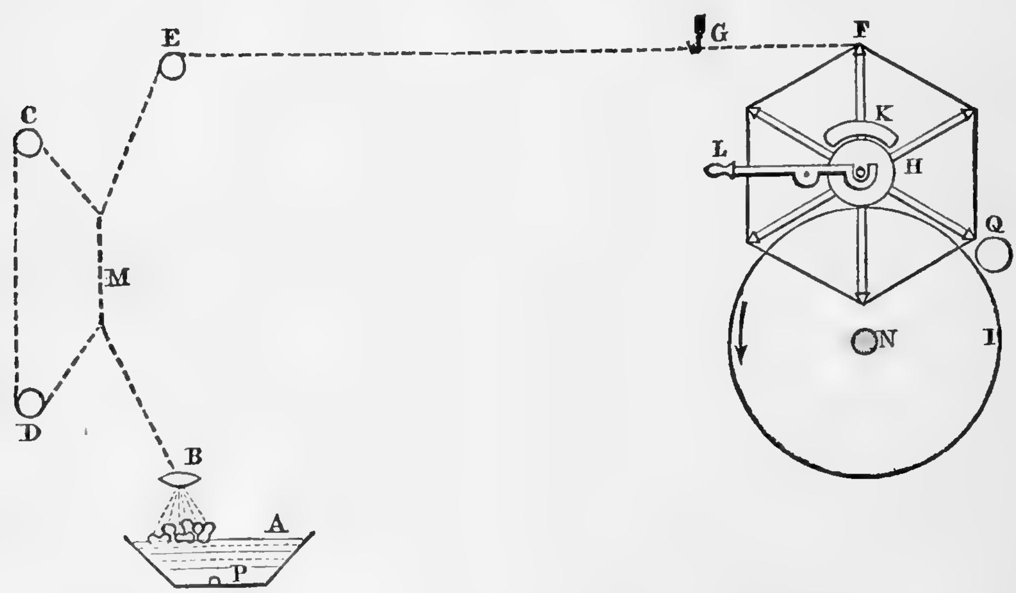

FIG. 29.—Elements of the mechanism of a modern silk reel (original).

A, in which is a perforated steam-pipe, *P*, by means of which the water in the basin may be heated. A few inches above the surface of the water is placed a perforated agate, *B*. The cocoons having undergone the three operations mentioned, the ends of the filaments of four or more of them are twisted together into a thread, which is passed through the hole in the agate. From this it runs through the "croisure" *M*, which will be hereafter explained, and over the guide *E* to the reel at *F*. Between *E* and *F* the thread passes a guide, *G*, moving to and fro (in a line perpendicular to the plane of the paper), which distributes it in a broad band over the surface of the reel. This facilitates the drying of the silk, without which the gluten would bind together the threads of the skein as it does those of the cocoons, and thus ruin its commercial value. In winter it is often necessary to use supplementary means to effect this drying. Perhaps one of the best is by passing a large steam-pipe near the reel, as at *Q*. The shaft of the reel carries at one end a friction-wheel, *H*, which rests on the large friction-wheel *I* that constantly revolves on the shaft *N*, and thus motion is imparted to the reel. In order to stop the reel it is only necessary to raise the wheel *H* from its bearings by means of the lever *L*. This movement presses the wheel against the brake-shoe *K*, and its motion is at once arrested.

As has been said above, the thread is passed between the agate and the reel through the croisure. The making of the croisure consists in twisting the thread around itself or another thread so as to consolidate its constituent filaments and wring the water from it and thus aid in its drying. The mode of the formation of this croisure forms the principal distinguishing mark between the French and Italian systems of reeling. The former is called the "Chambon system." Each reeler manages two threads. These are passed through separate agates, and after being brought together and twisted twenty or thirty times around each other are again separated and passed through guiding eyes to the reel. The other system, called "tavellette,"* consists in passing the thread up over a small pulley *C*, down over another *D*, and then twisting it around itself, as shown at *M*, in Fig. 29, and thence to the reel.

The cocoon filament is somewhat finer in the floss or beginning, thickens at the point of forming the more compact pod, and then very gradually diminishes in diameter until it becomes so fine as to be incapable of standing the strain of reeling. Therefore a thread which is made up of five new filaments becomes so small when the cocoons from which it is drawn are half unwound as to require an addition. This addition might also be made necessary by the rupture of one of the constituent filaments. It is here that the skill of the operator is called into play. When her experience tells her that the thread needs nourishing from either of these causes she takes the end of the filament of one of the cocoons which lie prepared in her basin, and, giving it a slight snap or whiplash movement with the index finger, causes it to wind around or adhere to the running thread of which it from this moment becomes a constituent part. This lancing, as it is called, of the end of the filament, although in hand reeling performed in the manner described, is also accomplished mechanically, several devices having been invented for this purpose.

*The trade name of the small pulley mentioned.

They consist, in general, of a mechanism which causes a small hook to revolve in a horizontal plane about the running thread, and to twist around it any end of the filament that may be placed in the path of the hook. The reeler, seeing that a new filament is needed, holds the end of one in the way of the attaching device and it is automatically caught.

The temperature of the water used while reeling the cocoons varies from 140° to 175° F. The more cocoons have been cooked the lower will be the temperature required. It is customary, however, to work in the neighborhood of the maximum limit. Whenever the silk rises in locks the temperature of the water is known to be too hot, and when it unwinds with difficulty the temperature is, on the contrary, too low. The operator is supplied with a skimmer with which to remove all chrysalides and refuse silk; also, with a basin of cold water, in which to cool her fingers, which are being constantly dipped in the hot basin.

It is highly important that the silk be kept as clean as possible. It lacks cleanness when the filament ends are badly attached in lancing, when the figure 8 loops, of which the cocoon is composed, come off one or more at a time instead of unwinding continuously, or when the thread after breaking is not neatly knotted. All these faults show in weaving and injure the value of the silk.

According to Dandolo the fresh cocoons consist, by weight, of:

	Per cent.
Chrysalides	84.20
Castings	0.45
Silken pods	15.35

It is from this 15.35 per cent. that the reeler draws her silken thread. But a large proportion of even this is lost, so that there is recovered but 8, 9, or rarely 10 per cent. of the original weight of the cocoons. From this it will be seen that it takes from 10 to 12½ pounds of fresh cocoons, or 3⅓ to 4⅙ pounds of dry ones to make a pound of silk. A more usual working average, with good stock, is in the neighborhood of 3¾ pounds of dry cocoons per pound of silk. If cocoons are of poorer quality they necessarily produce less silk and their commercial value falls off in far greater proportion than their power of silk production.

CHAPTER IX.

PHYSICAL PROPERTIES OF REELED SILK.

Certain physical properties are of great importance in determining the commercial value of reeled silk. They are its cleanliness, already mentioned; its mean size; the irregularities in its size; its ductility, or, as it is wrongfully but universally called, its elasticity; its tenacity, and the amount of soluble gum which it contains.

The mean size of a skein is determined in the following manner: One thousand yards of the thread is wound off on a reel, supplied with a counter called an *éprouvette*, and made into a little skein termed an *échevette*. This échevette is then weighed and the number of sixty-fourths of a dram which it is found to equal becomes the size number of the thread. This process is called the sizing, or, colloquially, the "dramming" of silk.

In Europe the same system is employed, but the units are a length of 476 meters (400 old French ells) and a small weight called the *denier*. One dram silk in America is equivalent to a thread of $17\frac{1}{3}$ deniers in France.

Until recently there has been no means of determining the irregularities in size existing in a silken thread, but manufacturers were content to approximate it by weighing four échevettes per sample skein. The difficulty in making this determination is owing to the fact that the thread is not round, but flattened, being, in fact, in its simple state, two filaments joined into one, and when several of these naturally compound filaments are combined to make a commercial thread the matter becomes still more difficult. Mr. E. W. Serrell, jr., of New York, has, however, overcome these obstacles by relying on another property of a silk filament, which is, that the distance which a given length will stretch under a given tension is inversely proportionate to the mean cross-section of this length. This is the underlying principle of his serigraph, which will now be described. The mode of testing with this machine is as follows: The end of the thread is brought from the reel or bobbin on which it is wound, around a drum (Fig. 30 *A*), thence over

FIG. 30.—The principle of the Serigraph (original).

a pulley, *C*, and back around another drum, *B*, mounted on the same axis as *A*. From the drum *B* it is wound on a reel. The drum *B* is larger than *A*, so that the former winds on the thread somewhat faster than it is paid off by the latter. In thus stretching the thread we apply a force to the pulley *C* tending to draw it from its normal position. This pulley is attached to the base of a pendulum, *D*, which, under the action of the force mentioned, is drawn from the perpendicular. The weight of this pendulum overcoming this applied force to an extent inversely proportional to the mean section of the length of thread submitted to the test, the position of equilibrium taken by the pendulum depends upon that mean section. This length of thread is the piece between the two drums *A* and *B*, and as, through the constant action of the machine, successive lengths of thread occupy the position indicated, the pendulum oscillates through a course which depends upon the irregularities of the thread. These irregularities are graphically recorded by a pencil, *E*, attached to the pendulum, upon a band of paper, *F*, constantly moving under its point. In the commercial form of the machine the mechanism for driving the reel is so constructed as to stop automatically when a standard échevette has been wound upon it, and this échevette may then be sized in the manner above described.

The elasticity and the tenacity of raw silk are determined by the use of the serimeter. This machine is composed of a dynamometer above, a graduated circle indicating the tension corresponding to the point at which the index stops. On the lower extremity of this dynamometer is a knob to which the thread to be tested may be attached. At 50 centimeters below this knob, in the same vertical line, is another knob attached to a counterweight which is on the inside of the case of the instrument and which also bears a pointer moving along a graduated scale on the outside of the case. This weight is held in place by a detent which is terminated on the outside of the case by a faller, on which it is only necessary to press lightly to cause the detent to let go the counterweight and permit its index to slide along the scale; these stop instantly, on the other hand, when the faller is released and retakes its initial position.

The silk thread attached to the two knobs mentioned passes over this faller, and, as it tends to pull it from its normal position, the detent lets go the counterweight and the thread stretches until rupture takes place, when the descent of the counterweight is automatically stopped. It is then only necessary to read the indication of the dynamometer to ascertain the weight which caused the rupture. By doubling the distance passed over by the sliding index, we have the stretch per meter or per cent. of elasticity.

The elasticity or ductility of silk is about 15 to 20 per cent., being nearly four times superior to that of cotton. It is about the same as brass and slightly greater than iron; hair has only half the ductility of silk.

"The tenacity of silk thread is well known; a thread of raw silk of 10 deniers easily supports a weight of 50 grams* without breaking. Direct relations exist between the tenacity of silk, the country in which it originates, its hygrometric state, the processes by which it was reeled, etc. Relations not less interesting may be found between the elasticity and the ductility." †

In the silk which constitutes the cocoon as made by the worm we find three classes of material. They consist of a waxy substance soluble in boiling water, of a gluten soluble in certain acids and alkalies, and especially in a solution of soap, and of the fibrine which constitutes the base of the thread. In the yellow silks there is also a slight quantity of coloring matter. Robinet found from 4 to 5 per cent. of the waxy substance, which, being soluble in boiling water, disappears in the process of reeling. We therefore find in reeled silk the gluten, or, as it is technically called, *grès*, and the fibrine. Before this silk can be properly dyed it is essential that a certain portion of this gluten be removed. This operation is usually performed by boiling it in a solution of soap. At the Conditioning Works at Lyons, France, this boiling off, as it is called, consists of two operations. The silk is first submitted for thirty minutes to ebullition in a solution containing an amount of soap equal in weight to about 25 per cent. of the weight of the silk boiled off. This silk is then wrung, in order to free it from the soap and the dissolved gluten, and then resubmitted to the same operation of boiling. As a result of these tests, it is found that white French silks contain 19.68 per cent. of gluten and the yellow silks 22.84 per cent. Silks coming from Italian filatures contain an amount of gluten slightly in excess of these figures, while the Chinese silks exceed them by more than 2 per cent.

The silk thread is highly hygrometric, containing under ordinary conditions 10 to 12 per cent. of water, while a thread of raw silk is capable of absorbing 21 to 26 per cent. Humidity augments the ductility of silk and slightly diminishes its tenacity.

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* 100,000 times the weight of a piece 50 centimeters long.

† Adrien Perret, "*Monographie de la Condition des Soies de Lyon.*"

CHAPTER X.

FOOD-PLANTS.

The traditional food-plant of the Silk-worm is the Mulberry (botanical genus *Morus*). There are two species of Mulberry indigenous to the United States, namely, the Red Mulberry (*Morus rubra*) and the Small-leaved Mulberry (*Morus parvifolia*), neither of which is suitable Silk-worm food. I have tried in vain to rear the worms upon *rubra*, but they either refuse its leaves entirely or dwindle and soon die upon it. The imported kinds which are most used are the Black (*M. nigra*) and the different varieties of the White (*M. alba*). The first is inferior to the others as Silk-worm food.

The *Moretti*, a variety of the White Mulberry, is profitably grown in the form of a hedge, and the large size of its leaves makes it a very desirable variety.

The *rosea*, *japonica*, and the *multicaulis*, varieties of the same species, are also used with excellent success.

A species of Mulberry new to this country has lately been introduced into the Western States by the Mennonites. This is the Russian Mulberry (*M. tartarica*). It is very hardy and its leaves make excellent Silk-worm food.*

The Mulberry grows readily, being easily propagated by cuttings or layers or from the seed. The white Mulberry, in particular, grows well

*A tree of a genus allied to the Morus is the *Broussonetia papyrifera*, commonly called the Paper Mulberry. It is found quite generally throughout the South, but its foliage is *not* suitable for Silk-worm food. The Paper Mulberry is usually a somewhat larger tree than the Mulberry and its leaves are subject to a considerable diversity of form, being mainly ovate and toothed on the margin; frequently with lobes on one or both sides of the leaf. They are quite rough to the touch on the upper surface, much more so than the Mulberry, and on the under surface they are softly hairy. The trees are of two kinds, male and female. The male tree, early in the spring before its leaves are developed, has tassels something like those of the willow. They soon drop off after shedding pollen. The female flowers then go on developing during the summer until they make small round balls from which, when ripe, the seeds stand out. These seeds are covered with a gummy substance and are very small, being about the size of those of the raspberry. The female trees are little known in this country, as only the male trees have been introduced into the United States.

I refer to this tree because of the frequency with which inquiries are made by Southern correspondents as to whether the Paper Mulberry can be used as Silk-worm food. The tree is very generally used for shade and ornament in Southern cities, where it attracts attention by the gnarled and knotted character of its trunk.

from cuttings, and this is perhaps the readiest and most economical method of planting to secure a stock.

The cuttings should be started in rows, 3 or 4 inches apart, in ground prepared by deep plowing and harrowing. They should be about 6 inches long, and should be cut just before an eye in every case. They should be almost entirely buried. The quickest way to get a supply of leaves is to grow dwarfs. Set out the young trees from the nursery in rows 10 to 15 feet apart and 6 to 8 feet between the rows, and form the crown of the tree by cutting down to a foot or so from the ground. The height of the tree and its form are easily regulated by pruning, and upon this process depend not only the vigorous growth of the tree, but also the ease with which the leaves may be gathered when desired. The pruning may be done in February or March, either every year or every other year.* All dead twigs and dried bark should be removed and the limbs kept as smooth as possible, as this greatly facilitates picking. The best time for planting is in the fall, from frost until December, and in the spring, from March until May.

For growing standard high trees, a practical raiser gives the following directions: The cutting should remain two years in the nursery without pruning. The third year it is cut close to the ground and transplanted. The finest shoot is then allowed to grow, and in good land it will reach a height of 8 or 10 feet in one season. The fourth year it is cut back to 6 feet or thereabouts. Then, the three or four terminal buds only being allowed to grow, all others are removed as often as they appear by passing the hand along the stem.

It must not be forgotten that in the propagation of plants only true species can be reproduced from the seed. The varieties of the White Mulberry mentioned above can only be obtained from cuttings or layers.

The fresh mulberry leaf contains a large amount of water of vegetation, and of certain mineral and organic matters. Of water, it is only necessary that there should be sufficient to enable the worm to easily digest its food, and all that is in excess of this quantity is apt to be injurious and productive of disease. In order to avoid this difficulty, food-trees should be planted in a light loam, and especial care taken to prevent excessive irrigation. It has been found, too, to be important that the tree should be so planted as to receive as much sunlight as possible, experiments having shown that, other conditions being equal, the leaves of such a tree contained but 55 per cent. of water, while in the case of one lighted by the sun until 1 o'clock only there was 64 per cent., and in one which received only diffused light, 73 per cent.

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* The better plan is to have two sets of trees, using each set but once in two years. When pruned a tree is then allowed to grow for one year without touching its leaves, which are only picked for the second season. The life of the tree will thus be materially prolonged, and the crop of leaves be more abundant than with annual pickings.

Of the mineral matter contained in the leaf, only certain portions are appropriated by the worm; these are phosphoric and sulphuric acid, potash, and magnesia. Its silica and sulphate and carbonate of lime are not useful in nutrition. In studying the leaf of the Mulberry at different seasons it is found that early in the spring certain varieties possess these nutritive mineral substances to a greater extent than others, but that as the season advances they become less abundant, while the proportion of silica and lime increases. It is important, then, if from this point of view only, that we should rear our Silk-worms as early in the season as possible. A great many experimenters have occupied themselves with the value of the different varieties of Mulberry with a view to ascertaining which would give the best alimentary results under ordinary conditions. As a result, it is generally advised that the seedling White Mulberry be fed at the beginning of an education and the *rosea* during the later ages. The *multicaulis* possesses many of the advantages of these varieties, though less rich in nutritive elements than either of them.

OSAGE ORANGE.—The cultivation of the Osage Orange (*Maclura aurantiaca*) is so well understood in this country that there is no need of giving detailed instructions on the subject. Very generally used as a hedge plant in those sections of the country which are particularly adapted to silk culture, its leaves may at once be obtained without any special investment of capital. Indeed, as the hedges need trimming, the cutting off of the new year's growth, as the leaves may be wanted for feeding purposes, is a saving rather than an expenditure. Those who use this plant as Silk-worm food must, however, bear in mind that the shoots from a hedgerow become very vigorous and succulent by the time the worms are in the last age. These more milky and succulent terminal leaves should be thrown aside and not used, as they are apt to induce flaccidity and other diseases.

In avoiding these more tender leaves and using only the older and firmer ones, especially when the worms are large, consists the whole secret of the successful rearing of Silk-worms on this plant; and if care be had in this respect, and the same judgment used in selecting from trees or hedges well exposed to sunlight, as suggested for Mulberry, there will be no appreciable difference in the silk crop from Osage Orange as compared with that from Mulberry.

The thorns of this plant make it somewhat more difficult to pick its leaves than those of the Mulberry, and I should not advise its cultivation merely as Silk-worm food.

What is said of the Osage Orange is based upon a very extended experience, and I would not only emphasize the fact of the value of this plant, but also of the necessity of the careful selection of Maclura leaves, especially during the last two ages of the worm. I have found that after the third age time is saved by using the twigs, first taking care to clip off the spines, which is rapidly done by means of a pair of scissors. In using twigs instead of leaves, the tender tips of the current year's growth should be cut off with the spines. I have found this method of feeding to have decided advantages (though contrary to all custom in Europe, where the twigs and branches of the Mulberry are too valuable to be constantly pruned), for it not only allows more air to circulate as the food accumulates, but it gives the worms, as they grow in size, an opportunity of clambering about, which they do not have to the same extent where leaves alone are used. In adding the new meal there is, also, where twigs are used, less danger of the transfer paper pressing injuriously upon the worms beneath.

Should the worms, from whatever cause, hatch before either Mulberry or Osage Orange leaves can be obtained, they may be quite successfully fed, for a few days, upon well-dried lettuce leaves. It will, however, be worse than a waste of time to attempt to feed them entirely on these leaves, or, in fact, on any other plants than the two here recommended.

GLOSSARY OF TERMS USED.

Age: The interval between hatching and first molt, between any two molts, or between the last larval molt and spinning.
Alimentary canal: The food canal; a straight, simple tube, running from one end of the body to the other, and which it is impossible to subdivide into gullet, stomach, and intestine.
Alkaline: Having the opposite reactions to an acid.
Anal horn: The horn upon the posterior end of the body of the worm.
Annuals: Those races which produce but one brood in a year.
Antennæ: The feathery feelers upon the head of the moth.
Bacillus: A microscopical vegetable organism, often causing disease.
Bivoltins: Those races producing two broods in one year.
Bombycidæ: The family of moths, commonly known as "spinners," to which the Silk-worm moth belongs.
Botrytis bassiana: The fungus causing muscardine.
Brin: The French term for a single thread from the cocoon.
Carneous: Flesh-colored.
Choked cocoons: A term applied to those cocoons in which the chrysalis has been killed.
Chlorophyl: The green coloring matter of leaves.
Chrysalis: The third or restful state of the insect, or that between the worm and the moth, inclosed in the cocoon.
Cocoon: The silken covering with which the worm surrounds itself before passing into the chrysalis state.
Cocoonery: The name applied to a room or building where cocoons are dried after being choked.
Corpuscle: A microscopic parasitic organism causing the disease, pébrine.
Croisure: The twist to which the silk thread is submitted in reeling.
Dacey: A Bengalese race of worms producing eight broods each year.
Detent: A stop which locks and unlocks the wheels in clock-work.
Dorsal vessel: The heart, extending from one end of the body to the other, just under the skin of the back.
Échevette: A small skein of silk of a determined length, the weight of which determines its size number.
Epizootic: A term having the same significance with lower animals as epidemic with man.
Éprouvette: A reel supplied with a counter upon which échevettes are measured.
Faller: A small lever, over which a thread runs, and which, upon the breaking of the thread, falls, thus stopping the mechanism through the action of a detent to which it is attached,
Fil: The French term for the combined threads as they come from the reel.
Ferment: Micro-organism causing fermentation.
Fibrine: An organic compound forming the base of the silk filament.
Filature: The French name for reeling establishment.
Flaccidity: A Silk-worm disease characterized in the text, Chapter V.
Flacherie: The French name for flaccidity.
Floss silk: Silk made from the loose material of the outer cocoon and from pierced cocoons, etc. It is carded and spun like cotton or wool.
Fresh cocoons: Cocoons that have not been choked.
Gattine: An old name for a mild phase of the disease known as pébrine. Maillot thinks that it is a form of flaccidity.
Grasserie: A Silk-worm disease allied to jaundice. It is described in Chapter V.
Green cocoons: A name frequently applied to fresh or unchoked cocoons. Should be avoided, except where it has reference to cocoons of a green color.
Greens: A name applied to those races making cocoons of a greenish tint.
Integument: Skin or outer covering.
Japonica: A variety of the White Mulberry.
Labium: The under lip, upon which is situated the spinneret.
Larva: The second or worm state of the insect.
Lepidoptera: Name of the order to which the Silk-worm belongs.
Lusettes: A name applied to the worms which die from being unable to molt.
Magnanerie: The name applied to the room or building used for the rearing of worms.
Micropyle: The opening in the egg of the Silk-worm moth through which the fecundating liquid enters.
Moretti: A variety of the White Mulberry discovered in 1815 by Professor Moretti, of Pavia.
Mori: The scientific specific name for the Silk-worm.
Morus: The botanical generic name of the Mulberry.
Multicaulis: A variety of the White Mulberry.
Muscardine: A Silk-worm disease of a fungus nature, characterized in the text, Chapter V.

Spinneret: A tube projecting from the lower lip, and through which the silk issues.
Organzine: Highly twisted thrown silk used in the woof in weaving.
Ovipositing: Laying the eggs.
Pébrine: A Silk-worm disease characterized in the text, Chapter V.
Pod: The compact portion of the cocoon, which is used for reeling purposes.
Polyvoltins: A term applied indiscriminately to all races which produce more than one brood in a year.
Pro-legs: The ten non-jointed legs under the sixth, seventh, eighth, ninth, and last joints of the body of the worm.
Psorospermiæ: Scientific name for the floating corpuscles in the bodies of worms affected by pébrine.
Quadrivoltins: Those races which produce four broods in one year.
Raw silk: Silk reeled from the cocoons before being thrown and woven.
Rosea: A variety of the White Mulberry.
Seed: The eggs in bulk.
Sericaria: A generic name proposed by Latreille, and to which the Silk-worm is referred by modern writers.
Sickness: The period of molting.
Spiracles: The breathing-holes of the insect; one row of nine down each side of the body.
Spores: The germinating seed of fungi.
Tavellette: A small pulley used in the Italian system of reeling.
Thrown silk: Silk which has been submitted to the operations following spinning or reeling. It is classed as tram and organzine.
Trachea: The breathing-tube of an insect.
Tram: Slightly twisted thrown silk used in the warp in weaving.
Transformation: The change from one state to another, as from worm to chrysalis or from chrysalis to moth.
Trevoltins: Those races of Silk-worms of which there are three broods in one year.
Vitellus: The yolk of an egg.
Whites: Those varieties having white cocoons.
Yellows: Those varieties having yellow cocoons.

EXPLANATION TO PLATES.

PLATE I.

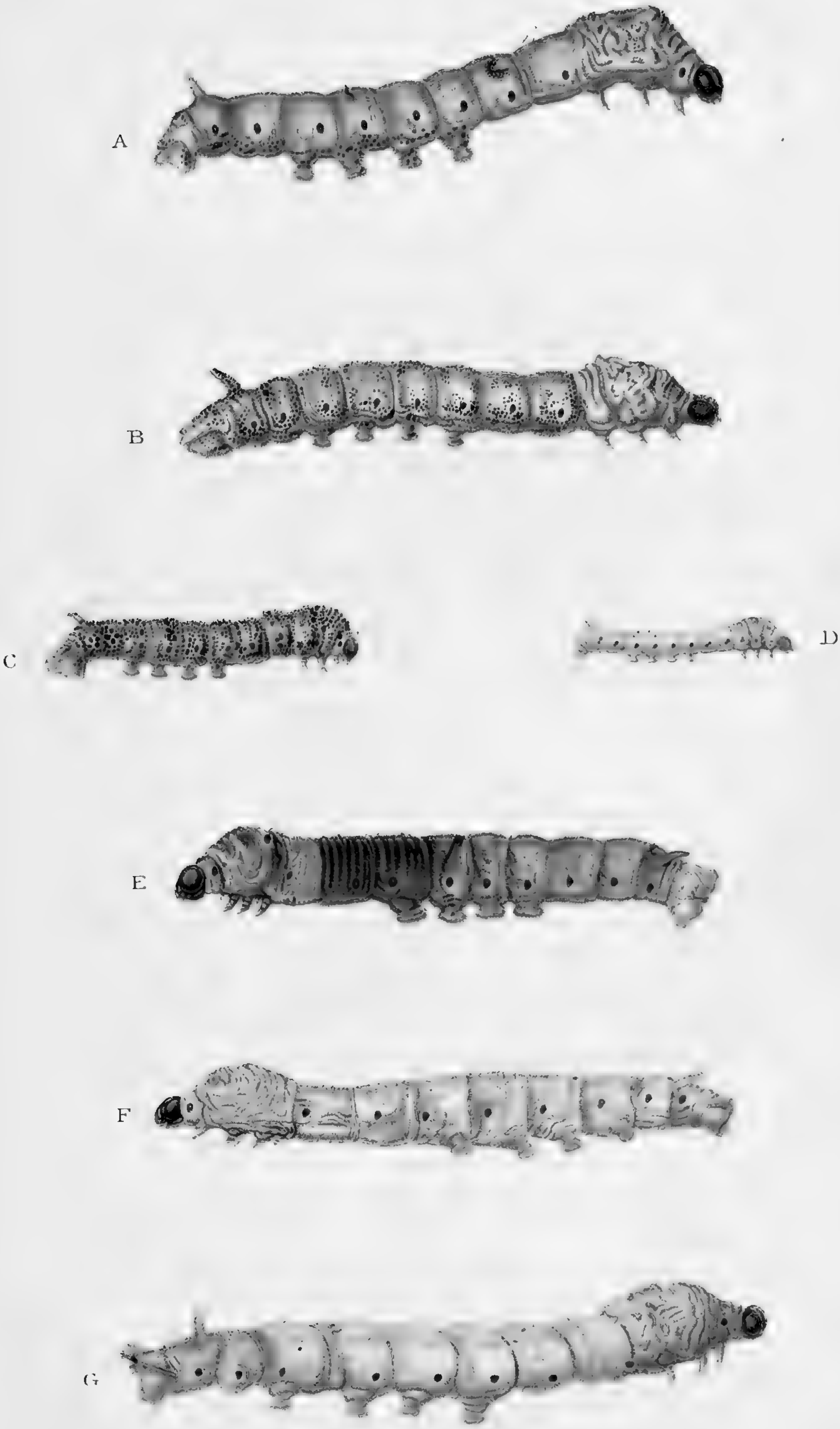
SILK-WORMS AFFECTED BY PÉBRINE AND FLACCIDITY (AFTER PASTEUR).

A, B, C, D, Silk-worms affected with pébrine, showing the spots of the disease. On the eighth joint of the worm A will be seen a wound which is distinguishable by its clear-cut edges.

E, F, G, worms, after death from flaccidity. G shows the worm just after death, still retaining all of its outward perfection of form. At F the worm has begun to shrivel, while at E the blackening caused by putrefaction is shown.

PLATE II.

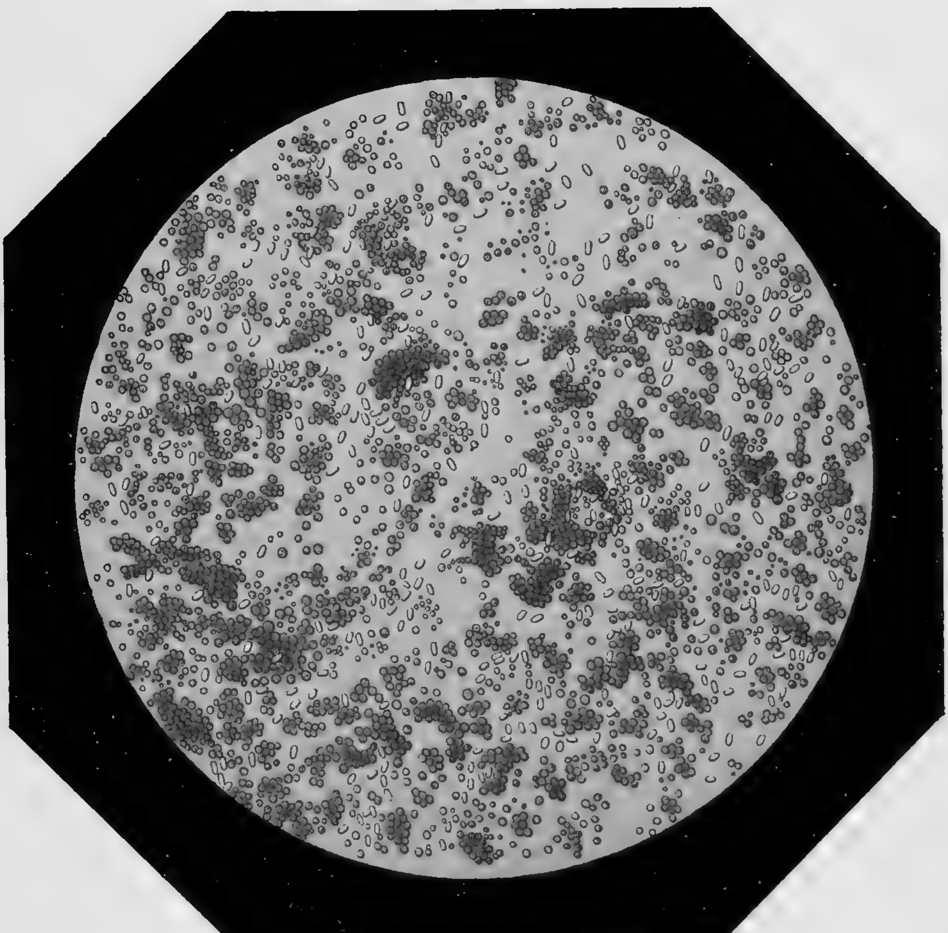
PÉBRINE CORPUSCLES OF SILK-WORM MOTH HIGHLY MAGNIFIED (AFTER PASTEUR).
(The white ovoid bodies are these corpuscles.)



A. Hoen & Co. Lith. Baltimore.

SILKWORMS AFFECTED BY PEBRINE AND FLACCIDITY.

([illegible] PASTEUR)



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PEBRINE CORPUSCULES OF SILKWORM MOTH

highly magnified

(after PASTEUR)

INDEX.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 10.

OUR SHADE TREES AND THEIR INSECT DEFOLIATORS.

BEING A CONSIDERATION OF THE FOUR MOST INJURIOUS SPECIES WHICH AFFECT THE TREES OF THE CAPITAL; WITH MEANS OF DESTROYING THEM.

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CONTENTS.

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DIVISION OF ENTOMOLOGY,
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SIR: I have the honor to submit for publication Bulletin No. 10 of this Division, being an account of the more important insects which defoliate our shade trees. While of interest to other sections of the country, it has been prepared primarily to supply the constant demand for information by residents of the National Capital. In the series of Bulletins of this Division it takes the place of one on "Bird Migration in the Mississippi Valley," announced a year ago, and which, since the creation of the separate Division of Ornithology and Mammalogy, I have thought best to leave out of the series from the Entomological Division, especially as Dr. Merriam, the Ornithologist, has greatly amplified it.

Respectfully,

C. V. RILEY,
Entomologist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION.

Though all four of the insects considered in this Bulletin have been studied in years gone by and have been treated of in various publications, yet some facts of interest are recorded here for the first time. The article on the Elm Leaf-beetle is reproduced from Bulletin No. 6, which has been for some time out of print. Those on the Bag-worm and on the Tussock-moth are condensed from our First Report as State Entomologist of Missouri, published in 1868, and from later writings, and that on the Fall Web-worm is made up from the Third Report of that series for 1870, but contains much that is new and especially applicable to the District of Columbia, the quoted portions being taken in advance from our forthcoming report to the Department. The Bulletin concludes with some facts and suggestions which are also of local interest and have been elicited by the exceptional concern shown by the people of Washington in the caterpillar nuisance. Some portions of this part of the Bulletin have been given for publication to the Washington *Evening Star*.

In treating of the means of preventing the injury and of preserving the foliage of our trees we have gone into details as to the most important means in considering the first species, or the Elm Leaf-beetle, so as to avoid repetition, and later, in connection with the fourth species or Fall Web-worm, referred briefly to other methods.

C. V. R.

SHADE TREES AND THEIR INSECT DEFOLIATORS.

FOUR PRINCIPAL LEAF-EATERS.

There are four insects principally concerned in the defoliation of the shade trees in the city of Washington. They are: (1) The Imported Elm Leaf-beetle (*Galeruca xanthomelæna*); (2) the Bag-worm (*Thyridopteryx ephemeræformis*); (3) the White-marked Tussock-moth (*Orgyia leucostigma*); and (4) the Fall Web-worm (*Hyphantria cunea*).

THE IMPORTED ELM LEAF-BEETLE.

(*Galeruca xanthomelæna** Schrank.)

The depredations of this pest have now become widely extended throughout the Northeastern States, rendering almost worthless and unsightly those most valuable shade trees of our cities—the elms. As its injuries are so far unknown in the Mississippi Valley, the blighted appearance of the elms on the Department grounds in midsummer, and especially of the European varieties, at once attracted our attention when we first came to Washington, and a series of experiments was begun with a view of checking the ravages of the insect. The excellent opportunites thus offered for experiment and study have since been improved, and, with some prefatory passages in relation to the history and habits of the beetle, we will give the practical results reached.

AN IMPORTATION FROM EUROPE.

This beetle has done great mischief in the Old World, especially in Germany and France, and it is very important that the public know the best method of coping with it here. According to Glover, it was imported as early as 1837. Its distribution was formerly confined to limited areas near the coast, and its earlier attacks were notably about Baltimore and New Jersey.

HABITS AND NATURAL HISTORY.

The general characteristics of this insect have been pretty well studied abroad. Mr. E. Heeger† has given an excellent account of its life-history, with a detailed description of the larva and figures illus-

* This is the *Galeruca cratægi* Först., and *G. calmariensis* Fabr. In Crotch's Check-list it appears as *Galerucella xanthomelæna*.

† Seventieth contribution to the natural history of insects. Sitzungsberichte der kais. Ac. Wiss., Wien, 1858, vol. 29.

trating larva and pupa, and anatomical details. More recently M. Maurice Girard* has given a rather poor wood-cut illustration of the insect and its work, with the leading facts concerning its nomenclature and natural history as observed in Europe. Biological notes on the insect have also been given by Leinweber† and Kollar.‡

FIG. 1.—*Galeruca xanthomelana*; *a*, eggs; *b*, larvæ; *c*, adult; *e*, eggs (enlarged); *f*, sculpture of eggs; *g*, larva (enlarged): *h*, side view of greatly enlarged segment of larva; *i*, dorsal view of same; *j*, pupa (enlarged); *k*, beetle (enlarged); *l*, portion of elytron of beetle (greatly enlarged).

In our country the life-history of the insect and its injury have been referred to by Harris, Fitch, Morris, Walsh, and ourselves, while the agricultural papers contain numerous references to the injury inflicted by the insect. The perfect beetle has often been described in systematic works on Coleoptera.

For these reasons we deem it unnecessary to enter here into a detailed description of the beetle and its earlier stages, but content ourselves with pointing out the more obvious characters, alluding to such facts of the life-history as are necessary to a full understanding of the nature of the remedies to be applied for this pest.

The eggs are deposited in an upright position upon the under side of the leaves (Fig. 1 *a*), always in a group, consisting generally of two, rarely three, more or less irregular rows. The individual eggs are close

* Note sur la Galéruque de l'orme, Bull. d'Insectologie Agricole, VIII, pp. 113–116.
† Verhandlungen zoöl.-bot., Ges., Wien, 1856, VI, Sitzb., pp.74, 75.
‡ *Op. cit.*, 1858, VIII, pp.29, 30.

together in each group (Fig. 1 *e*, magnified), and so firmly fastened to the leaf that they can only be detached with great care without breaking the thin and brittle shell. The number of eggs in each group varies from four or five to twenty or more. Very rarely only three eggs are seen in one group, but we never found less than that number. The egg itself is oblong, oval, obtusely, but not abruptly, pointed at tip, of straw-yellow color, its surface being opake and beautifully and evenly reticulated, each mesh forming a regular hexagon, as shown, highly magnified, in Fig. 1 *f*. The form of the eggs is not quite constant, some of them, especially those in the middle of a large group, being much narrower than others. The duration of the egg-state is about one week.

The general shape of the larva is very elongate, almost cylindrical, and distinctly tapering posteriorly in the early stages, but less convex, and of nearly equal width when mature. The general color of the young larva is yellowish-black, with the black markings comparatively larger and more conspicuous, and with the hairs arising from these markings much longer and stiffer than in the full-grown larva. With each consecutive molt the yellow color becomes more marked, the black markings of less extent and of less intense color, and the hairs much shorter, sparser, and lighter in color. A nearly full-grown larva is represented in Fig. 1 *g*, and in this the yellow color occupies a wide dorsal stripe and a lateral stripe each side. The head (excepting the mouth parts and anterior margin of the front), the legs (excepting a ring around the trochanters), and the posterior portion of the anal segment, are always black. The first thoracic segment has two large black spots on the disk, of varying extent, and often confluent. The following segments (excepting the anal segment) are dorsally divided by a shallow transverse impression into two halves, and the black markings on these halves are arranged as follows: Two transversal dorsal markings, usually confluent, as shown in our figure; two round and sublateral spots; the tips of the lateral tubercles are also black. The abdominal joints of the ventral surface have each a transverse medial mark, and two round sublateral spots of black color. Stigmata visible as small umbilicate spots between outer sublateral series of dorsal markings and lateral tubercles. The yellow parts of the upper side are opake, but those of the under side shining. The black markings are polished, piliferous, and raised above the remaining portions of the body.

The larvæ are destructive to the foliage from the month of May until August. They have about two weeks of active life between the egg and pupa states. During this time they prey upon the leaves, which become skeletonized, leaving the venation, and commonly a certain portion of the flesh of the leaf, which becomes rust-brown. They undergo four molts, respectively observed at Washington on July 15 (at hatching) 20, 23, and 29 (pupation). When full grown they descend to the ground and change to pupa under whatever shelter is near to the base of the tree.

The pupa (Fig. 1 *j*) is of a brighter color than the larva, oval in shape, and strongly convex dorsally. It is sparsely covered with moderately long but very conspicuous black bristles, irregularly arranged on head and thorax, but in a transverse row on each following segment. The pupa state lasts about from 6–10 days.

The perfect beetle (Fig. 1 *c*, natural size; *k* magnified) resembles somewhat in appearance the well known striped cucumber-beetle (*Diabrotica vittata*), but is at once distinguished by the elytra not being striate-punctate but simply rugose, the sculpture under high magnifying being represented in Fig. 1 *l*. The color of the upper side is pale yellow or yellowish-brown, with the following parts black: on the head a frontal (often wanting) and a vertical spot; three spots on the thorax; on the elytra a narrow stripe along the suture, a short, often indistinct scutellar stria each side, and a wider humeral stripe not reaching the tip. Under side black, pro and mesosternum and legs yellow, femora with a black apical spot. Upper and under side covered with very fine, short, silky hairs. In newly-hatched individuals the black markings have a greenish tint; the humeral stripe varies in extent.

The beetle assists the larva in its destructive work, but, as usual in such cases, the damage done by the perfect insect is small when compared with that done by the larva. There are three or four annual generations of the insect, according to the character of the season. In the month of September the beetles prepare for hibernation, seeking shelter in hollow trees, in the ground, under old leaves, &c., and remain dormant until the following spring.

REMEDIES.

M. Girard says:

There is no other means of destruction than to jar the branches over cloths to collect the larvæ and adults which fall. It is also possible when they are on the ground to distribute on them boiling water or steam, or even quick-lime or solution of sulphocarbonate of potassium.

In our own country much more has been accomplished toward practically combating this insect.

In the U. S. Agricultural Report of 1867, Glover suggested the use of oil and tar gutters and other barriers surrounding the base or the body of the tree, devices similar to those used against the canker-worm and codling-moth. He then and afterward (1870) recommended "to place around each tree small, tight, square boxes or frames, a foot or 18 inches in height, sunk in the earth; the ground within the inclosure to be covered with cement, and the top edge of each frame to be covered with broad, projecting pieces of tin, like the eaves of a house or the letter T, or painted with some adhesive or repellant substance, as tar, &c. The larvæ descending the tree, being unable to climb over the inclosure, would change into helpless pupæ within the box, where they could daily be destroyed by thousands. Those hiding within the crevices of the bark of the trunk could easily be syringed from their hiding places." (U. S. Agricultural Report, 1870, pp. 73, 74.) These boxes were carefully tested at this Department, and they worked as described. While coal-tar and other adhesives were recommended, we have found scalding-hot water most convenient for destroying the insects that accumulate in the inclosure or upon the ground elsewhere. Where branches are low and droop near the ground some of the larvæ descend the wrong way and fall off, but shade trees should not be allowed to grow in this low, drooping manner, and under all ordinary circumstances, where the branches are not severely jarred to encourage the insects to drop, the larvæ will descend by the trunk and become captured in the devices here noticed.

Mr. Glover regarded the pupa state as the most favorable in which to kill the insect, as it can then be easily crushed or scalded. Concerning the tobacco treatment he adds that "syringing the trees with strong tobacco water has been tried with some good effect, but the larvæ not touched by the fluid are merely knocked down by the concussion, and, if nearly ready to change into pupæ, effect their transformation where they fall."

In this connection we cannot do better than quote what we published in 1880* in reply to certain statements by Dr. J. L. Le Conte, as follows:

Anent *Galeruca xanthomelæna*, which is becoming more destructive each successive year to the shade elms in our northern towns, a correspondent mentions the following facts:

1. The trees are not all attacked at the same time, but the insect seems to break out from a center, gradually destroying the more remote trees, so that isolated trees remain comparatively free.

2. After applying a band (saturated with fish-oil, petroleum, &c.) to some trees which were about half denuded, found hundreds of the worms stopped both in ascending and descending the trees.

He also propounded the following query:

3. Do the beetles hibernate in the ground, so that they can be poisoned, or are they perpetuated only by the eggs on the trees:

Allow me to add the following subjects for investigation as necessary to the devising of proper remedies against this foreign invader:

4. How soon do the insects appear in the spring; how rapidly do they propagate; and what time is passed in each stage of development?

5. Are the larvæ and beetles eaten by insectivorous birds, or are they protected by offensive secretions, as is the case with *Doryphora 10-lineata*, *Orgyia leucostigma*, and several other noxious insects?

6. What proportion of the brood hibernates, and in what stage, pupa or perfect insect, and where?

If the materials for furnishing answers to these questions are not yet within your reach, will you kindly direct the attention of some of your trusty observers to the subject, so that persons interested in the preservation of the shade trees which are so justly esteemed may be properly instructed as to the measures to be adopted during the next summer.

Very truly, yours,

J. L. LE CONTE,
Philadelphia, Pa.

The above inquiries were received from our esteemed correspondent some time since, and we employ them as a ready means of giving our experience with the beetle.

For the benefit of the general reader it may be remarked that the natural history of this Elm Leaf-beetle is quite similar to that of the well-known Colorado Potato-beetle and of the Grape-vine Flea-beetle. The only deviation in the Elm Leaf-beetle is in the mode of pupation, which rarely takes place in the ground, unless this be very friable, but at the base of the tree or under any shelter that may present itself near the trees, such as old leaves, grass, &c.

(1) The phenomenon here described is doubtless due to the gradual increase in spring from one or more females.

(3 and 6) Like most, if not all, *Chrysomelidæ*, the Elm Leaf-beetle hibernates in the perfect state. As places suitable for hibernation abound, any attempt to successfully

* *American Entomologist*, December, 1880, p. 291.

fight this pest in winter time, with a view of preventing its ravages the subsequent season, will prove fruitless. A large proportion of the hibernating beetles doubtless perish, since the insect is comparatively scarce in the earlier part of the season.

(4 and 5) The beetles fly as soon as spring opens, and we have observed the first larvæ early in May, in Washington, D. C., or some time after the elm leaves are fully developed. The ravages of the insect begin to be apparent with the second generation of larvæ, which appear in June.

In 1878 we made many notes and experiments on the species, and the development of the third and most injurious generation occupied about one month. The numerous pupæ, which in the latter part of August were to be found under the trees, were mostly destroyed that year, partly by continuous wet weather prevailing at the time, partly by the many enemies of the insect. Among these there are *Platynus punctiformis* and *Quedius molochinus*, which feed on the full-grown larvæ when these retire for pupation, and also on the pupæ. The larva of a *Chrysopa* (probably *C. rufilabris*) feeds upon the eggs of the *Galeruca; Reduvius novenarius* sucks both beetles and larvæ on the leaves, while *Mantis carolina* preys upon the beetle. Of the numerous other insects found among the pupæ under the trees, *e. g. Tachyporus jocosus*, sundry spiders, myriapods, &c., several are doubtless enemies of the *Galeruca*, though we have, as yet, no proof of the fact. Many birds were observed on the trees infested by the beetles, but the English sparrow, which was the most numerous, did not feed on the insect in any stage of growth.

The only method of warfare against this pest recommended by European writers is to jar the larvæ down onto sheets, and then in one way or another to destroy them. This may answer for young trees, but is then tedious and but partial. We found that the quickest and most satisfactory way of destroying the insect and protecting the trees was by the use of Paris green and water in the manner frequently recommended in these columns, and London purple will evidently prove just as effectual and cheaper. The syringing cannot be done from the ground except on very young trees, though a good fountain pump will throw a spray nearly 30 feet high. Larger trees will have to be ascended by means of a ladder and the liquid sprinkled or atomized through one of the portable atomizers, like Peck's, which is fastened to the body and contains 3 gallons of the liquid.

The mode of pupation of the insect under the tree, on the surface of the ground, beneath whatever shelter it can find, or in the crevices between the earth and the trunk, enables us to kill vast numbers of the pupæ and transforming larvæ by pouring hot water over them. We found that even Paris-green water poured over them also killed. If the trees stand on the sidewalk of the streets the larvæ will go for pupation in the cracks between the bricks or at the base of the tree, where they can also be killed in the same way. This mode of destruction is, take it all in all, the next most satisfactory one we know of, though it must be frequently repeated.

(2) We have largely experimented with a view of intercepting and destroying the larvæ in their descent from the tree. Troughs, such as are used tor canker-worms, tarred paper, felt bands saturated with oil, are all good and the means of destroying large numbers. Care must be taken, however, that the oil does not come in contact with the trees, as it will soon kill them, and when felt bandages are used there should be a strip of tin or zinc beneath them. The trouble with all these intercepting devices, however, is that many larvæ let themselves drop down direct from the tree and thus escape destruction.

In conclusion we would remark that it is highly probable that Pyrethrum powder stirred up in water might be successfully substituted for arsenical poisons, but experiments in this direction have not yet been made. From experiments we have made with dry, unmixed powder, we found that it affects very quickly the larva, pupa, and the perfect insect, but in order to be applied on a large scale and on large trees the powder must of course be mixed in water. There is, however, no danger in the judicious use of the arsenical liquids upon shade trees.

MORE RECENT EXPERIENCE AT THE DEPARTMENT.

The more recent experience in the destruction of this Galeruca on the Department grounds may now be summed up, the experiments having been intrusted to Dr. Barnard.

Past History of the Elms in question.—According to Mr. William Saunders, of this Department, these trees have been annually attacked by the European Elm Leaf-beetle since they were planted ten years ago, and about one year in three the injury has been severe, resulting in their defoliation, while in other years, as in 1879 and 1880, there appeared comparatively none. In some seasons a second or autumnal set of leaves appeared after the trees had been stripped, and in certain of these instances the second crop of leaves became eaten; but in all cases he thinks the lives of the trees have not seemed to be endangered and they soon repaired the damage done. His belief is also that the pest did not become gradually worse and worse through the series of years during which it has been observed by him, still he regards the attack of 1882 as worse than any known to him before on these trees or others, and he has noticed the effects of this insect since 1850, first in its earliest ravages about Baltimore, and later elsewhere.

Condition and Characteristics of the Grove in 1882 *and* 1883.—However it may be for the past history or future desirability of certain trees in the grove, in 1882 many exhibited various grades of feebleness, and some had dying branches. Indeed, a few of them had a very unhealthy aspect the previous year also. Of course it can be claimed that their unhealthy condition is due to other causes than the insects; and it should be remembered that most are foreign species, each often represented in two or more of its varieties. Here all grow on level ground, whereas in a state of nature some belong to mountainous localities; others to the damp climate of England, &c. Therefore, many of them are growing under abnormal conditions. They exhibit much variety in the relative abundance, size, form, and texture of the leaves. There is also great diversity in the density and form of branching.

Extent of Injury in 1882 *and* 1883.—All the varieties and species of elms in this grove, without exception, were preyed upon by the pest in 1882 and 1883. The insect, however, showed decided preferences for certain individual trees, varieties, or species, stripping some completely before doing more than very slight harm to the leaves of others, the former becoming completely eaten in midsummer, the latter not until toward the close of the season, or remaining only slightly damaged until then. In 1882 the leaves were eaten faster than they could be developed, and the insect continued abundant enough to prevent a second crop of foliage until in November, when it became too cold for the leaves and active insects to exist.

On these grounds the southeast side of each tree has suffered more than the northwest half. This peculiarity has been very strongly pronounced this year, 1883, on all the trees affected, and upon some examples far more markedly than upon others. This one-sidedness is especially apparent in the trees which were the most severely eaten. Some trees show the southeast side completely devoured, but the northwest side only half consumed and comparatively green. Such are average cases.

The inferences have been, that the shade, dampness, and coolness of the tree on the northwest side during the morning is too unhealthy for the favorable development of the larvæ or of the eggs deposited there; but whether this be true or not, the insect probably prefers to deposit chiefly in the middle of the forenoon, and on that part of the tree which is then warmest. This would give a greater number of the eggs at the outset on the southeast side, as observation seems to confirm, and since the young larvæ do not migrate to any noteworthy extent, the one-sidedness described would result, whether the northwest side were unhealthy or not. The former explanation is most probably the correct one, as we have noticed that the insect is less injurious during very wet summers.

Preferences of the Elm-beetles for certain Varieties and Species of Elms.—The American Slippery Elm does not occur in this grove, but only one native species, the common American Elm, *Ulmus americana.* This is practically free from the ravages of the beetle, on which account it may be preferred to the European species. It is tall, and has gracefully arched branches, making it as ornamental as any European kind, yet as a shade tree it does not equal the *U. montana* of the Old World. The latter has a broader, denser crown, but the attack on it is considerable, enough to leave the choice in favor of the American species.

U. montana seems the best European species grown here for shade, since the other foreign elms here cultivated are not dense enough. This applies to *U. campestris*, *U. suberosa*, *U. effusa*, and *U. parvifolia* (*siberica*). The last named is not attacked as much as the American. The young larvæ cannot develop on it, but die quite soon, without growing, and they gnaw the leaves very little. The other foreign species mentioned are seriously eaten; the severest attack being upon the *U. campestris*, the favorite food of this insect.

As early as June 25, in 1883, this species was completely eaten and brown in our grove, at which date the *U. montana* examples retained more than half their verdure; in some individuals nearly all; and the common American elm was perfectly green. The *U. campestris* is one of the poorest elms for shade, and its total abolishment throughout the entire country would probably lessen the assault on *U. montana* to a comparatively unobjectionable extent. This measure should be instituted against the pest, and for the sake of the other species of elms.

Effects of arsenical Poisons on Insect and Plant.—Species of elms are somewhat differently affected by the poison. When treated alike there is always manifest some difference in the susceptibility of different elms to the corrosive effects of the poison. Even individuals of the same species or variety are differently impaired. As a rule, those which suit the insect best are injured most by the poison, and those which resist the insect most withstand the poison best. The latter have coarser foliage with a darker green color and more vigorous general growth; the former have more delicate foliage, lighter in color and weight, apparently less succulent.

Certain elms of the species *U. campestris* and other species which were overpoisoned, and shed most of their leaves in consequence, in the last of June, 1883, sent out a profuse new growth of leaves and twigs. The foliage fell gradually for three weeks, and this was somewhat promoted by the succeeding rains.

The larvæ move from place to place so seldom that if the leaves are imperfectly poisoned from the mixture being weakly diluted, or from its application only in large, scattered drops, which are much avoided by the larvæ, they are not killed off thoroughly for several days, and in all cases it requires considerable time to attain the full effect of the poison. This result appears on the plant and on the insect. After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned, each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown, dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. The latter may not all drop from the effects of poison, but the coloration referred to is without doubt generally from the caustic action. The poison not only produces the local effects from contact action on the parts touched by it, but following this there appears a more general effect, manifest in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable, no leaf-eater thrives upon the foliage. Slight overpoisoning seems to have a tonic or invigorating effect on the tree.

Preventive Effects of the Poison.—In this grove the elms that were poisoned in 1882 were attacked in the spring of 1883 less severely than were those which were not poisoned the previous year. This would seem to imply that the insects deposit mostly on the trees nearest to where they develop, and are only partially migratory before ovipositing. The attack afterward became increased, probably by immigration and the new generation, so that later in the season the trees were mostly infested to the usual extent.

In the region of Washington *a preventive application of poison should be made* before the last of May or first of June, when the eggs are being deposited and before they hatch. This will prevent the worms from ever getting a start. By the preventive method the tree escapes two kinds of injury; first, that directly from the eating by the insect; second, that which follows indirectly from the deleterious effects of the poison on the plant, for its caustic effect is much greater where the leaves have been so gnawed that the poison comes in contact with the sap.

Treatment with London purple.—Already early in June the insect appears plentiful. On June 7, 1882, it was at work on all the trees, and its clusters of eggs were numerous beneath the leaves. Some of the trees had half of the leaves considerably gnawed and perforated by larvæ of all sizes, and by the adults. At this date fifteen trees, constituting the south part of the grove, were treated.

Preparation of the Poison.—London purple (one-half pound), flour (3 quarts), and water (barrel, 40 gallons) were mixed, as follows: A large galvanized iron funnel of thirteen quarts capacity, and having a cross-septum of fine wire gauze, such as is used for sieves, also having vertical sides, and a rim to keep it from rocking on the barrel, was used. About three quarts of cheap flour were placed in the funnel and washed through the wire gauze by water poured in. The flour in passing through is finely divided, and will diffuse in the water without appearing in lumps. The flour is a suitable medium to make the poison adhesive. The London purple is then placed upon the gauze and washed in by the remainder of the water until the barrel is filled. In other tests the flour was mixed dry with the poison powder, and both were afterward washed through together with good results. It is thought that by mixing in this way less flour will suffice. Three-eighths of a pound of London purple to one barrel of water may be taken as a suitable percentage. Three-eighths of an ounce may be used as an equivalent in one bucketful of water. The amount of this poison was reduced to one-fourth of a pound to the barrel with good effect, but this seems to be the minimum quantity, and to be of value it must be applied in favorable weather and with unusual thoroughness. With one-half or three-fourths of a pound to the barrel, about the maximum strength allowable is attained, and this should be applied only as an extremely fine mist, without drenching the foliage.

Effects of the Mixture.—The flour seems to keep the poison from taking effect on the leaf, preventing to some extent the corrosive injury which otherwise obtains when the poison is coarsely sprinkled or too strong. It also renders the poison more permanent. On the leaves, especially on the under surfaces, the London purple and flour can be seen for several weeks after it has been applied, and the insect is not only destroyed, but is prevented from reappearing, at least for a long period. By poisoning again, a few weeks later, the insect is deterred with greater certainty for the entire season. By being careful to administer the poison before the insect has worked, and, above all, to diffuse the spray finely but not in large drops, no harm worth mentioning will accrue to the plant from the proportion of poison recommended. The new growth, that developed after the first poisoning, was protected by one-fourth of a pound to the barrel in 1882. From midsummer until autumn the unpoisoned half of the grove remainded denuded of foliage, while the poisoned half retained its verdure. The little damage then appearing in the protected part was mostly done before the first treatment. Eggs were laid abundantly throughout the season. Many of these seemed unhealthy and failed to develop, probably because they were poisoned. Many hatched, but the young larvæ soon died. The eggs were seldom deposited on the young leaves that were appearing after the poison was applied, but were attached to the developed leaves, and here the larvæ generally got the poison to prevent their attack upon the aftergrowth. Still the young leaves became perforated to some extent. The adults, which fly from tree to tree, appeared plentifully without much interruption throughout the season, and often several could be seen feeding on each tree. Possibly many of these may have become poisoned before depositing the eggs.

The efficiency of London purple being established, it will generally be preferred to other arsenicals, because of its cheapness, better diffusibility, visibility on the foliage, &c. As the effects of the poisons commonly do not appear decidedly for two or three days after their administration, the importance of the preventive method of poisoning in advance cannot be too strongly urged. As the effect is slow in appearing, impatient parties will be apt to repoison on the second or third day, and thus put on enough to hurt the plant when the effect does come. Much depends on dryness or wetness of the weather; but good effects may be expected by the third or fourth day.

London purple seems to injure the plant less than Paris green.

Treatment with Paris green.—In 1883 the Paris green was first applied on the 29th of May, at which date the eggs were extremely abundant and hatching rapidly on the leaves. Paris green, flour, and water were mixed by the means previously employed with London purple and already described. The mixture was applied to the north part of the same grove of elms. Thus far experience shows that the Paris green is effective against the insect, but that this poison injures the plant more than does the London purple.

Three-fourths of a pound of Paris green to a barrel (36 or 40 gallons) of water, with 3 quarts of flour, may be regarded as a poison mixture of medium or average strength for treating elms against these beetles, and the indications thus far are that the amount of Paris green should not be increased above one pound or be diminished much below one-half a pound in this mixture. To a bucketful of water three-fourths of an ounce of Paris green may be used. The action of this poison is slow but severe, and varies much with the weather. Thus far the results of tests have been varied so much by the weather and different modes of preparation and application that they will be repeated. When used strong enough to cauterize the leaves the poisonous action upon the plant may be observed to continue for several weeks.

Mechanical Means of applying the Poison.—When many trees were to be sprayed a cart or wagon was employed to haul the poison in a large barrel provided with a stirrer, force-pump, skid, &c. The following brief account of the skid, mixer, barrel, and pump may be reproduced here from our last Annual Report [for 1882]:

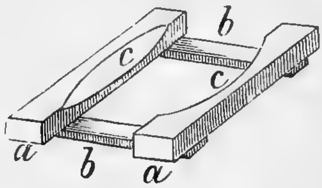

FIG. 2.—*Barrel rest or skid; two coupling cleats, b b: two side rests, a a; chamfered concave, c c.*

The skid is a simple frame to hold the horizontal barrel from rolling, and consists of two pieces (Fig. 2 *a a*) of wood, about the length of the barrel, and in section about 3 by 4 inches, joined parallel, apart from each other, by two cleats, *b b*. The inner upper angles may be cut to match the curve of the barrel, as at *c c*. The barrel being placed upon this frame is next to be filled.

A good device for mixing the poison thoroughly with the water and for filling the barrel is shown in section in Fig. 3. It consists of a large funnel that will hold a bucketful, and has cylindrical sides, *g g*, that rest conformant on the barrel. In this is a gauze or finely perforated diaphragm, or septum, *d*, and a funnel base, *t t*, with its spout, *p*, inserted through the bung.

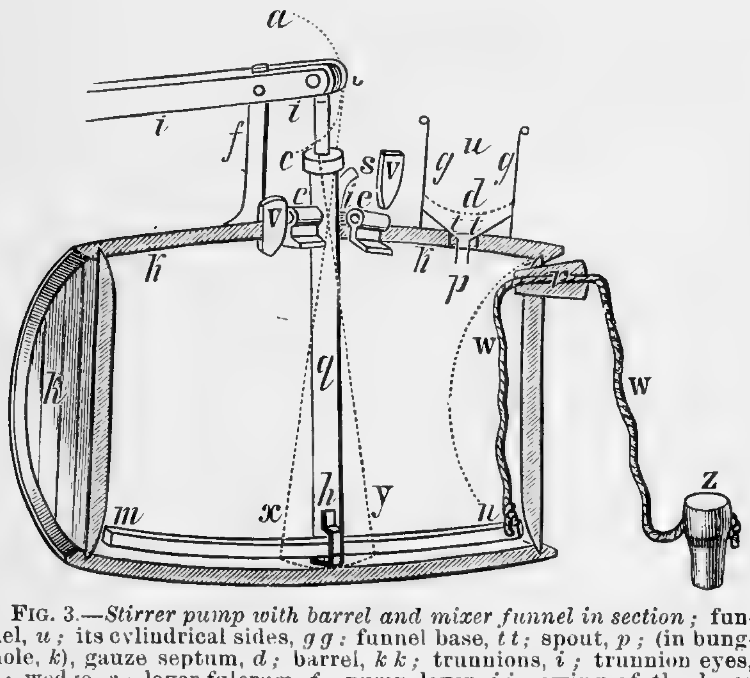

FIG. 3.—*Stirrer pump with barrel and mixer funnel in section;* funnel, *u;* its cylindrical sides, *g g;* funnel base, *t t;* spout, *p;* (in bung-hole, *k*), gauze septum, *d;* barrel, *k k;* trunnions, *i;* trunnion eyes, *e;* wedge, *v;* lever-fulcrum, *f;* pump lever, *i i;* swing of the lever head and piston top, *a b c;* cylinder packing cap, *c;* cylinder, *q;* its swing, *x y;* stirrer loop or eye, *h;* stirrer bar, *m n;* rope, *w w;* bung, *r z.*

By reference to Fig. 3, the barrel, *k*, will be seen in section, and some of its details, together with those of the pump and stirrer, may be noticed. The fulcrum, *f*, has a foot below, screwed to the barrel. Through its top is a pivot, *o*, on which tilts the pump-lever, *l*, which is similarly hinged at *b* to the top of the piston-rod, *t*. The pump-cylinder, *g*, is also hung upon trunnions, *i*, projecting into eyes. In this illustration the eyes, *e e*, have each a neck fitting in a slot cut through the stave, oppositely from the side of the bung-hole, and beneath the stave is a foot on the eye-piece. Its neck is so short that the eye is held down firmly against the top of the stave, while the foot is as tight against its under surface. The length of its eye-piece is a little less than the diameter of the bung-hole, into which it may be inserted to be driven latterly into the slot. The slot is longer than the eye-piece, so the latter may be driven away from the bung-hole for a distance greater than the length of the trunnion pivot. Then the pump being inserted, until these pivots come opposite the eyes, the latter may be driven back as sockets over the pivots, which play in them when the pump is worked. To hold these eyes toward the pump and upon the trunnions a wedge, *r*, is driven in the slot beyond each eye-piece. Thus the pump is easily attached or removed, and its union with the barrel is strong and firm. Perchance it be desired that this pump-hole be bunged, the side slots may be wedged to make the barrel tight.

The parts of the pump being hung as described, the hinge, *b*, forms a toggle-joint, and in its action causes the pump to oscillate on its trunnions, its basal end swinging wider than its top, as indicated by the dotted line from *x* to *y*. Upon the extremity of this swinging end is a loop, *h*, through which is passed the stirrer-bar, *m n*, made to sweep back and forth in the lower side of the barrel, thus to agitate and mix the substances considerably during the operation of the pump, every stroke of the handle causing one or two strokes of the stirrer.

The method of inserting and extricating the stirrer-bar is as follows It is raised with the pump until the end, *m*, comes opposite the bung-hole, *x*, through which the bar may be pulled out by the cord, *w*, which is attached to the end, *n*, and also preferably to the bungs *r* and *z*, as shown. Through the same hole the bar may be inserted. This stirring device is the simplest in construction and operation of any yet contrived. While working as it does with reference to the concavity of the barrel it is perfectly effective.

The pump is double-acting and very powerful, giving strong pressure to disperse the liquid far and finely, for, with the eddy-chamber nozzle used, the greater the pressure the finer is the liquid atomized. A block or other catch may be fixed on the side of the barrel to fit against the skid and prevent the barrel from rocking therein, as might otherwise happen when it is nearly empty if much power is applied. About one pailful of poisoned water was sprayed upon each tree. When only two or three trees were to be treated an Aquapult or other bucket-pump was used to force the poison from a bucket carried by hand. The Paris-green mixture needs to be almost constantly stirred, as this poison precipitates quickly; but with London purple the agitation is only occasionally necessary.

Connected with either pump is a long, flexible pipe, with its distal part stiff, and serving as a long handle whereby to hold its terminal nozzle beneath the branches or very high up at a comfortable distance from the person managing it. Parts of one form of this extension pipe are shown in Figs. 4 and 5.

To the pump spout is attached the long, 2-ply, flexile hose, *h h*, of ¼-inch caliber. Its considerable length, 12 feet or more, allows the nozzle to be carried about the tree without moving the pump. Beyond its flexile part the hose, *h*, passes through a bamboo pole, *b*, from which the septa have been burned out by a hot iron rod. At the distal end of the pole the hose terminates in a nozzle, *n* or *m*. When the nozzle is in its natural position, *m*, the spray, *z*, is thrown straight ahead, and this suits well for spraying very high branches, but for spraying the under surfaces of the lower parts of the tree it is necessary that the nozzle discharge laterally from the pipe, and this is accomplished with a nozzle having a direct discharge by bending it to one side. The nozzle, *n*, and spray, *s*, are directed laterally, and the nozzle, *n*, is maintained in this position by a metallic hook or eye, *v*, having a crooked stem inserted at the side of the hose in the end of the pole. Where the side spray is permanently desired, the metallic stem is inserted inside the hose and connected with the base of the nozzle, or the tubular stem of the nozzle is given the desired crook. For small trees the simpler extension pipe shown in Fig. 5 is satisfactory The metallic tube, *t*, several feet in length, is used as the stiff part, *t*, connected with the hose, *h*. One longer metallic pipe, having telescopic sections made tight by outside segments of rubber tubing, has also been employed, and is a very desirable extension pipe. Where only low end-spraying is to be done, as upon small trees, &c., the eddy-chamber nozzle (Fig. 6) is set upon such a pipe, or upon its own stem, so as to discharge at right angles therefrom; but a diagonal position of the chamber, *n*, on its stem, *i*, throws the spray, *s*, at an intermediate angle between the right angle and a direct line, by which, without any readjustment, the spray, *s*, can be directed higher or lower, beneath the foliage or above. For general use, this kind of nozzle is the best. It consists of a shallow, circular, metal-chamber (Fig. 6, *c*), soldered to a short piece of metal tubing, *a*, as an inlet. The inlet passage, *x*, penetrates the wall of the chamber tangentially, admitting the fluid eccentrically, and causing it to rotate rapidly in the chamber. The outlet consists of a small hole, *s*, drilled in the exact center of the face, *e*, of the chamber, and through this outlet the fluid is driven perpendicularly to the plane of rotation in the chamber, and converted into a very fine spray. For a full description of this nozzle the reader is referred to our report as Entomologist to the Department of Agriculture for the years 1881–'82, p. 162. With ordinary force-pump pressure the discharge-hole of the nozzle is about one sixteenth of an inch in diameter for misty sprays with particles invisibly small. Rather than use the larger, coarser sprays, which were usually employed in these tests, it is better to use the finest spray. The spray falling upon the extension pipe soon accumulates enough to flow down the pole and wet the hands. To prevent this a wrapping washer of leather or other flange

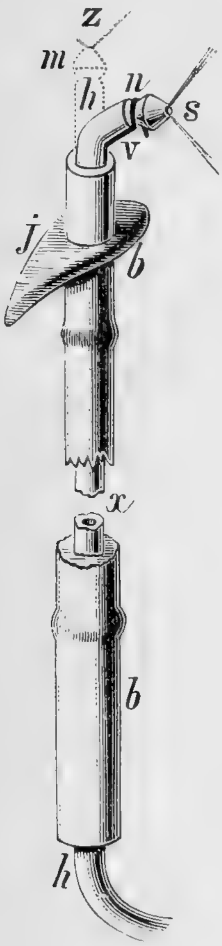

FIG. 4.—*Parts of hose-pole device for spraying trees*; bamboo pole, *b b*; drip washer, *j*; hose, *h x*; side hook, *v*; eddy chamber nozzle, *n m*; spray, *z s*.

FIG. 5.—*Metallic hand pipe with diagonal nozzle*: hose, *h*; metallic pipe, *t*; diagonal eddy chamber nozzle, *n*; its removable face, *i*; spray, *s*.

may surround the pole proximally from the spray, and the drip will drop off from its margin. Such an arrangement is indicated at J in Fig. 4. While one person operates the pump, another, standing in the vehicle or upon the ground, directs the spray by the stiff part of the pipe. Thus the operator can not only spray higher and lower with convenience, but he can, to a great extent, move the spray from place to place without leaving his own position and without moving the vessel of poison with the pump.

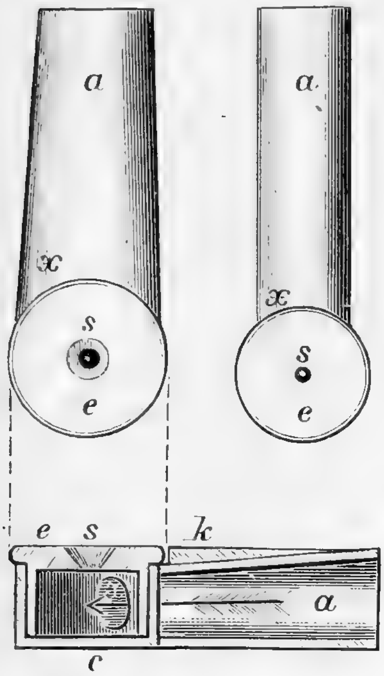

FIG. 6.—*Eddy-chamber nozzle*, natural size; face view and section.

The hose and bamboo combination was conceived of, and used as the lightest, long, stiff tube practicable for these purposes, and it has answered admirably. A similar pole, with a metallic tube in its interior, with a nozzle, not producing the very fine mist desired, and lacking the side discharge, &c., was afterward learned of as being used in California. (See Agricultural Department Report, 1881-'82, p. 208.)

By the apparatus used, when everything is prepared, a tree can be sprayed quickly, and a large grove is treated in a short time. It is equally adapted for forestry use in general, and likewise available for poisoning on fruit trees, when not in fruit, while the shorter style of extension-pipe is convenient for underspraying all kinds of low plants.

THE BAG-WORM.

(*Thyridopteryx ephemeræformis* Haw.)

Although this species was not particularly destructive to our shade-trees in 1886, and in numbers greatly inferior to the Fall Web-worm and the Tussock-moth, yet in 1879 it was much more formidable, and at irregular intervals becomes a great pest where not properly dealt with, especially in more southern States. For the past two or three years it has been on the increase in special localities in Washington, and should be carefully looked after.

HABITS AND NATURAL HISTORY.

The Eggs.—During winter time the dependent sacs or bags of this species may be seen hanging on the twigs of almost every kind of tree. If they happen to be on coniferous trees, and they are usually more abundant on these than on deciduous trees, they are not infrequently mistaken for the cones. In reality they are the coverings spun by our worm, and they serve not only as a protection to it, but also to the eggs. Upon cutting open the larger of these bags in winter time they will be found to contain the shell of a chrysalis (technically called the puparium), which is filled with numerous small yellow eggs (Fig. 7 *e*). Each of these is a little over 1 millimeter in length, obovate in form, and surrounded by a delicate, fawn-colored, silky down. In this condition the eggs remain from fall throughout the winter and early spring.

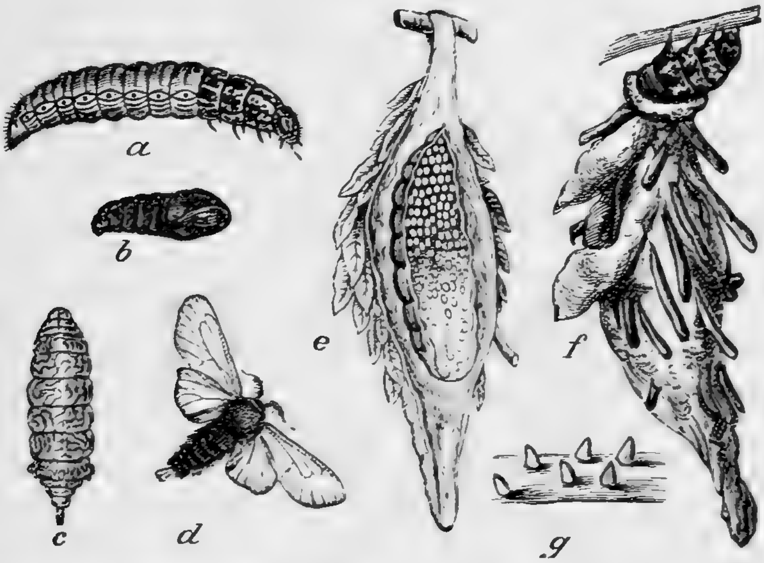

FIG. 7.—*Thyridopteryx ephemeræformis: a.* larva; *b.* male chrysalis; *c.* female moth; *d.* male moth; *e.* follicle and puparium cut open to show eggs; *f.* full grown larva with bag; *g.* young larvæ with their conical upright coverings; all natural size.

The Larva and its Bag.—About the middle of May in this latitude the eggs hatch into small but active larvæ, which at once commence to construct a portable case or bag in which to live. The way in which this bag is prepared is curious (Fig. 8). The young larva crawls on a leaf and,

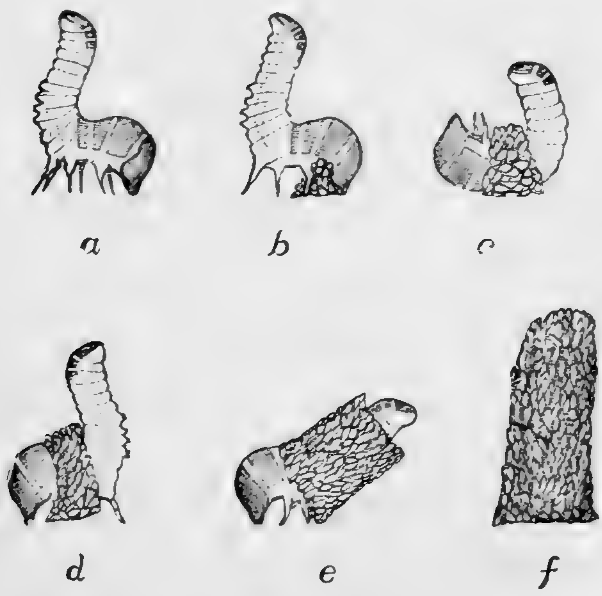

FIG. 8.—*Thyridopteryx ephemeræformis.* How the young larva prepares its bag.

gnawing little bits from the surface, fastens these together with fine silk spun from its mouth. Continually adding to the mass, the larva finally produces a narrow, elongate band, which is then fastened at both ends onto the surface of the leaf by silky threads. Having secured itself from falling down by some threads, it now straddles this band and, bending its head downward (Fig. 8 *b*), makes a dive under it, turns a complete somersault and lies on its back, held down by the band (Fig. 8 *c*). By a quick turning movement the larva regains its feet, the band now extending across its neck (Fig. 8 *d*). It then adds to the band at each end until the two ends meet, and they are then fastened together so as to form a kind of narrow collar which encircles the neck of the worm. Far from resting, it now busies itself by adding row after row to the anterior or lower end of the collar, which thus rapidly grows in girth and is pushed further and further over the maker (Fig. 8 *e*). The inside of this bag is now carefully lined with an additional layer of silk, and the larva now marches off, carrying the bag in an upright position (Fig. 7 *g* and Fig. 8 *f*). When in motion or when feeding, the head and thoracic segments protrude from the lower end of the bag, the rest of the body being bent upward and held in this position by the bag. As the worms grow they continue to increase the bags from the lower end and they gradually begin to use larger pieces of leaves, or bits of twigs or any other small objects for ornamenting the outside. Thus the bags will differ according to the different kind of tree or shrub upon which the larva happens to feed; those found on coniferous trees being ornamented with the filiform pine leaves, usually arranged lengthwise on the bag, while those on the various deciduous trees are more or less densely and irregularly covered with bits of leaves interspersed with pieces of twigs. When kept in captivity the worms are very fond of using bits of cork, straw, or paper, if such are offered to them. When the bags, with the growth of the larva, get large and heavy, they are no longer carried, but allowed to hang down (Fig. 7 *f*). The worms undergo four molts, and at each of these periods they close up the mouth of their bags to remain within until they have cast their skin and recovered from this effort. The old skin, as well as the excrement, is pushed out through a passage which is kept open by the worms at the extremity of the bag.

The young larva is of a nearly uniform brown color, but when more full-grown that portion of the body which is covered by the bag is soft, of light-brown color and reddish on the sides, while the head and thoracic joints are horny and mottled with dark-brown and white (Fig. 7 *a*). The numerous hooks with which the small, fleshy prolegs on the middle and posterior part of the body are furnished, enable the worm to firmly cling to the silken lining of the bag, so that it can with difficulty be pulled out.

The bag of the full-grown worm (Fig. 7, *f*) is elongate-oval in shape, its outlines being more or less irregular on account of the irregularities in the ornamentation above described: The silk itself is extremely tough and with difficulty pulled asunder.

The larvæ are poor travelers during growth, and though, when in great numbers, they must often wander from one branch to another, they rarely leave the tree upon which they were born unless compelled to do so by hunger through the defoliation of the tree. When full-grown, however, they develop a greater activity, especially when very numerous, and, letting themselves down by a fine silken thread, travel fast enough across sidewalks or streets and often for a considerable distance until they reach another tree, which they ascend. This migratory desire is instinctive; for should the worms remain on the same tree they would become so numerous as to necessarily perish for want of food.

Pupation.—The bags of the worms which are to produce male moths attain rather more than an inch in length, while those which produce females attain nearly double this size. When ready to transform, the larva firmly secures the anterior end of the bags to a twig or branch, and instinct leads it to reject for this purpose any deciduous leaf or leaf-stem with which it would be blown down by the winds. The inside of the bag is then strengthened with an additional lining of silk, and the change to chrysalis is made with their heads always downward. The chrysalis is of a dark-brown color, that of the male (Fig. 7, *b*) being only half the size of that of the female (Fig. 7, *e* and Fig. 9, *a*).

The Imago or perfect Insect.—After a lapse of about three weeks from pupation a still greater difference between the two sexes becomes apparent. The male chrysalis works its way to the lower end of the bag

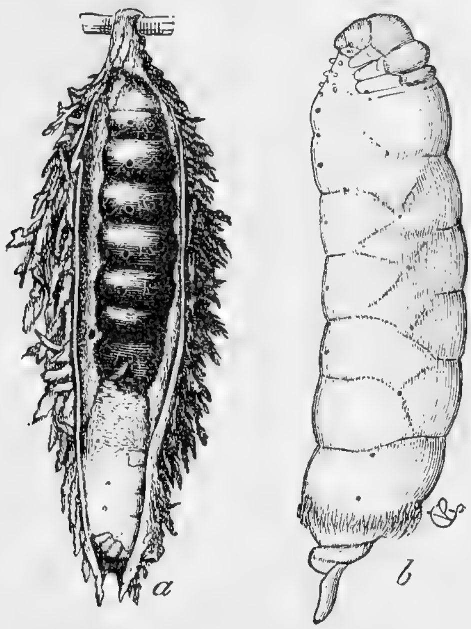

FIG. 9.—*Thyridopteryx ephemeræformis*: *a*, Follicle cut open to show the manner in which the female works from her puparium and reaches the end of the bag, natural size; *b*, female extracted from her case, enlarged.

and half way out of the opening at the extremity. Then its skin bursts and the imago appears as a winged moth with a black, hairy body and glassy wings (Fig. 7, *d*). It is swift of flight, and, owing to its small size and transparent wings, is rarely observed in nature. The life-duration of this sex is also very short. The female imago is naked (save a ring of pubescence near the end of the body of yellowish-white color), and entirely destitute of legs and wings (Fig. 7, *c*, and Fig. 9, *b*). She pushes her way partly out of the chrysalis, her head reaching to the lower end of the bag, where, without leaving the same, she awaits the approach of the male. The manner in which the chrysalis shell is elongated and reaches to the end of the bag is shown in Fig. 9, *a*, and an enlarged side view of the female showing the details of structure shown at *b*, in the same figure. The extensility of the male genitalia, which permits him to reach the female within her bag, is set forth in the accompanying Fig. 10, where the parts are shown at rest, *c* and *d*,

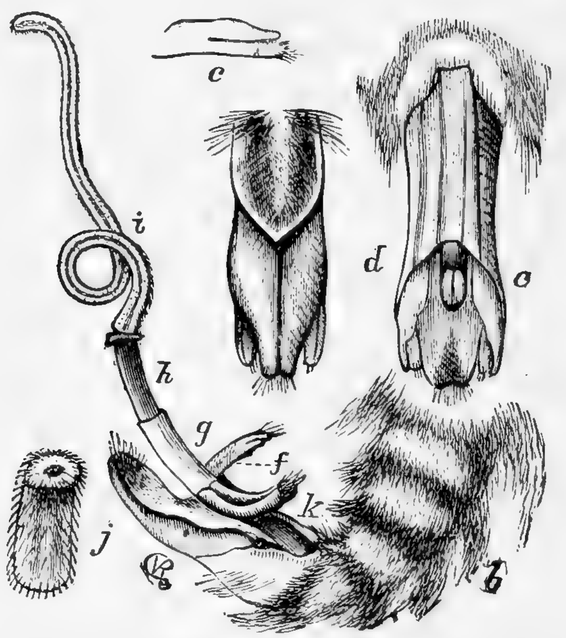

FIG. 10.—*Thyridopteryx ephemeræformis*: *b*, The end of male abdomen from the side, showing genitalia extended; *c*, genitalia in repose ventral view; *d*, do., dorsal view enlarged.

and in action, *b*. Fertilization being accomplished, the female works her way back within the chrysalis skin and fills it with eggs, receding as she does so toward the lower end of the bag, where, having completed the work of oviposition, she forces, with a last effort, her shrunken body out of the opening, drops exhausted to the ground, and perishes. When the female has withdrawn the slit at the head of the puparium and the elastic opening of the bag close again, and the eggs thus remain securely protected till they are ready to hatch the ensuing spring.

GEOGRAPHICAL DISTRIBUTION.

The Bag-worm occurs most frequently in the more southern portion of the Middle States and in the Southern States, but seems to be absent from the Peninsula of Florida. Within these limits it extends from the Atlantic to Texas, and reaches the less timbered region west of the

Mississippi. Northward, it is occasionally found in New York and even Massachusetts, but so rarely and locally restricted that neither Dr. Harris nor Dr. Fitch mention it in their publications on economic entomology. Wherever it occurs it prefers the gardens and parks within or near the cities, being much less abundant in the woods remote from cities, and this dependence upon the vicinity of human civilization is more marked in this species than in any of the others here treated of.

FOOD-PLANTS.

The Bag-worm is known to feed on a large number of trees and shrubs, but has a predilection for certain kinds of coniferous trees, notably the Red Cedar and Arbor Vitæ, and as these evergreens are much less able to stand the loss of their foliage than the deciduous trees, the worms are much more dangerous to the former than to the latter. The Hard Maples are, as a rule, avoided by the worms, and it is also quite noticeable that they are not particularly fond of oak leaves and those of the Paulonias. The Ailanthus trees are also generally exempt from their attacks, either on account of the unpleasant taste of the leaves, or perhaps on account of the compound nature of the leaves, the worms fastening their bags to the leaf stems which fall to the ground in Fall. With these exceptions,* the worms, when sufficiently numerous, do great damage to most other kinds of trees used in our cities as shade and park trees.

ENEMIES.

The Bag-worm is so well protected in all its stages that no insectivorous bird nor predaceous insect is known to attack it. In spite of

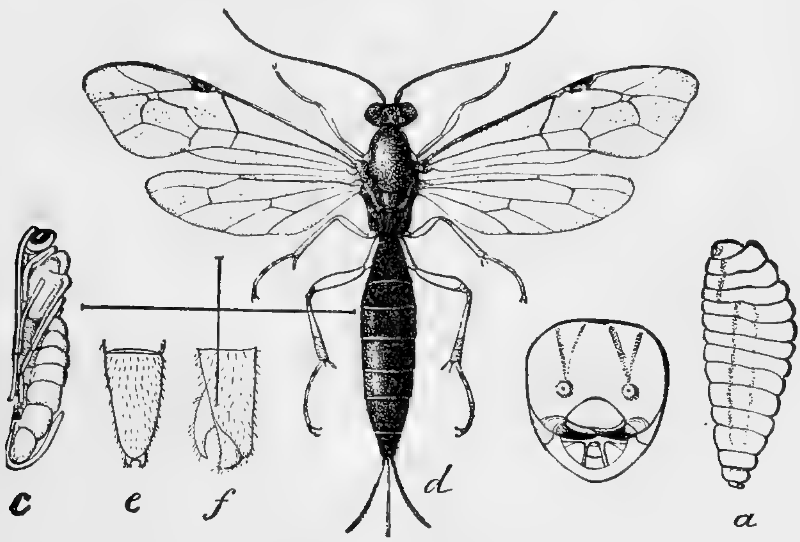

FIG. 11.—*Pimpla conquisitor: a*, larva; *b*, head of do from front; *c*, pupa; *d*, adult female (hair line indicating natural size); *e*, end of male abdomen from above; *f*, same from the side—all enlarged.

the absence of predaceous enemies, the Bag-worm suffers from the attacks of at least six true parasites, while two others, which may be

* The China trees of our Southern cities are entirely exempt from the worms.

primary but are probably secondary, are reared from the bags. Three of these are Ichneumonids, viz: (1) *Pimpla conquisitor* Say (Fig. 11); (2) *Pimpla inquisitor* Say, and (3) *Hemiteles thyridopterigis* Riley (Fig. 12).

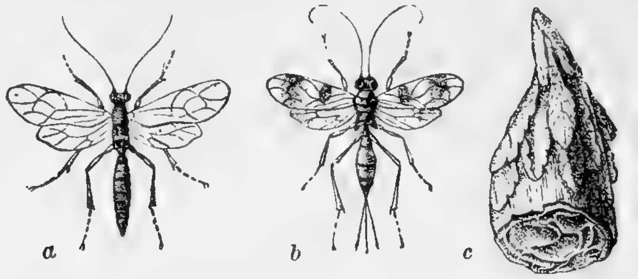

FIG. 12.—*Hemiteles thyridopterigis*: *a*, male; *b*, female; *c*, sack of bag-worm cut open, showing cocoons of parasite, natural size.

Of these, the last-named is most abundantly bred, and we have always considered it as the most important parasite of the Bag-worm. The past season, however, we have ascertained that three species of the genus *Hemiteles*, viz: *H. utilis*, and two undescribed species, are unquestionably secondary parasites, and this renders it quite likely that *H. thyridopterigis* may also be secondary, or, in other words, a parasite of one of the true parasites of the Bag-worm. It is a question, however, which only the most careful study, with abundant material, can decide, as the law of unity of habit in the same genus finds many exceptions in insect life. The other parasites are as follows: (4) *Chalcis ovata* Say. This parasite is a very general feeder on Lepidopterous larvæ, and we have bred it from seven widely different species. (5) *Spilochalcis mariæ* (Riley). This species, while parasitic on Thyridopteryx, is more partial to the large silk-spinning caterpillars, as we have reared it from the cocoons of all of our large native Silk-worms. (6) *Pteromalus* sp. This undescribed Chalcid is found very abundantly in the Bags, but may be a secondary parasite. (7) *Dinocarsis thyridopterygis* Ashmead.* This parasite was bred from the Bags in Florida by Mr. William H. Ashmead, who believes it to be parasitic on the eggs. (8) *Tachina* sp. We have bred a large bluish Tachinid from the Bags. Its eggs are commonly attached to the Bags externally, near the neck, and the young larvæ, on hatching, work their way into the case. They frequently fail, however, to reach the Bag-worm.

* Mr. Ashmead's description (Canadian Entomologist, XVIII, No. 5, p. 97, May, (1886), shows that this species cannot belong to *Dinocarsis*, as limited by Mayr.

THE WHITE-MARKED TUSSOCK-MOTH.

(*Orgyia leucostigma* Smith & Abbot.)

HABITS AND NATURAL HISTORY.

The Eggs.—During the month of June, and more especially late in fall and throughout the winter, glistening white objects may be seen on the trunks and the larger branches of trees, or in the corners of the fences near by, or on bunches of dead leaves hanging on the tree (see Fig. 13 *a*). Upon examination these masses will be found to be glued on to a cocoon of dirty gray color, and to consist of numerous perfectly round, cream-white eggs, which are partly covered by a glistening-white froth

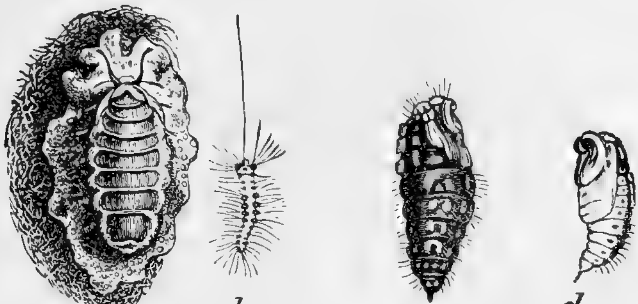

FIG. 13.—*Orgyia leucostigma*: *a*, female on cocoon. *b*, larva, *c*, female pupa; *d*, male pupa.

or spittle-like matter. In one of these egg-masses which we received from Kansas we have counted as many as 786 eggs, while from another mass we obtained upward of 400 young caterpillars.

Development and Characters of the Larva.—In the latitude of Saint Louis, Mo., and Washington the eggs begin to hatch about the middle of May, and the newly-born caterpillar, not quite 3 millimeters in length, is of dull whitish-gray color, with the under side paler, the upper side being covered with rather long hairs and tufts of a dark-brown color. In two days from hatching small orange spots begin to appear along

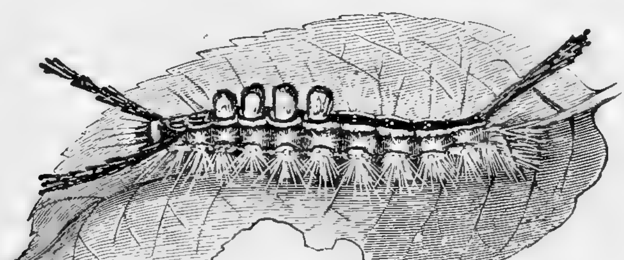

FIG. 14.—*Orgyia leucostigma*: female caterpillar

the back, and on the seventh day the first molt takes place, to be followed at intervals of six days each by the second and third molts. The changes that take place during this time in the appearance of the caterpillar are remarkable, and after the third molt it is a beautiful object and of striking appearance (Fig. 14). The head and two little elevated spots situated on joints 9 and 10, are bright vermilion red; the back is velvety black with two bright yellow subdorsal lines, and another yellow line each side along the lower sides. The whole body is thinly clothed with long pale yellow hairs, originating from small wart-like elevations. Four cream-colored or white dense brushes of hair are in a row on the middle of the fourth, fifth, sixth, and seventh dorsal joints, while from each side of the head arises a long plume-like tuft of black hair projecting forward and outward. A similar plume projects upwards from the last dorsal joint. The hairs composing these plumes are coarse, barbed, knobbed, and arranged in sets of unequal length, thus giving the plumes a turbinate appearance.

Habits of the Larva.—The young caterpillars scatter all over the tree soon after hatching. When disturbed they make free use of a fine silken thread, which they spin, and by which they let themselves down. The full-grown larvæ are often seen to change quarters and travel from one branch to another, or from one tree to another. Their rather quiet way of moving contrasts strongly with the nervous movements of the Fall Web-worm.

Pupation.—Six days after the third molt a portion of the larvæ spin up; all these produce male moths. The female caterpillars, which up to this time have been undistinguishable from the male caterpillars, undergo a fourth (and, as it appears from more recent experience, in some instances even a fifth) molt and acquire twice the size of the male caterpillar. This last, when full-grown, measures about 20 millimeters in length. The cocoon spun by the male caterpillar is of whitish or yellowish color and sufficiently thin to show the insect within. It consists of two layers, the hairs of the tufts and brushes of the caterpillar being interwoven with the outer layer. The female cocoon is correspondingly larger, of gray color, and much more solid and denser than the male cocoon. The male chrysalis (Fig. 13 *d*), which is soon formed within the cocoon, is of brownish color, sometimes whitish on the ventral side, and covered on the back and sides with fine white hairs. The female chrysalis (Fig. 13 *c*) is much larger than the male, and otherwise differs, especially in lacking the wing-sheaths and in having on the three first segments after the head transverse, flattened protuberances composed of scales, which are much less visible in the male. The duration of the pupa state is less than a fortnight.

The Imago.—The male (Fig. 15) is a winged moth with feathery antennæ and very hairy fore legs. The general color is ashy-gray, the front wings being crossed by undulated bands of darker shade, with two black markings on the outer edge near the tip and a white spot on the inner edge also near the tip. He may frequently be seen sitting on the trunks of trees or on the shady side of houses, &c., as he rests during the day and flies only after dusk, often being attracted by light. The female (Fig. 13 *a*) is totally different from the male in appear-

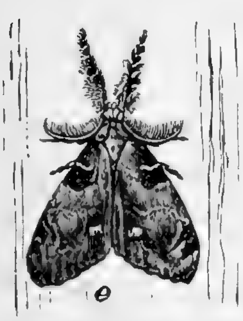

FIG. 15.—*Orgyia leucostigma*: male.

ance and resembles a hairy worm rather than a moth, since she possesses the merest rudiments of wings. She is of a pale gray color, the antennæ being short and not feathered, the legs rather slender and not covered with long hairs. She has consequently no power of flight, and is barely able to walk. After working her way out of the chrysalis and cocoon she takes her place on the outside of the latter and patiently awaits the approach of the male. Here she also deposits and protects her eggs in the manner already mentioned, after which she drops exhausted to the ground and perishes. The white mass covering the eggs is at first viscous, but soon dries, becoming brittle, and is impervious to water.

Hibernation.—The species hibernates normally in the egg state, but occasionally a living chrysalis may be found in winter time. On January 30, 1874, we received from Mr. Hunter Nicholson, from Knoxville, Tenn., a newly-hatched female, and this had, no doubt, prematurely issued from a hibernating chrysalis. This is, however, quite exceptional, and the different climatic conditions to which the species is subjected in its wide distribution do not seem to alter the normal mode of hibernation.

Number of Annual Generations.—In the latitude of Washington the species is two-brooded, the imagos of the first generation appearing in the first part of June, those of the second generation in September and October. On several occasions we have found, however, that a portion of the caterpillars from one and the same batch of eggs would be feeding while the rest had already transformed to imagos. The result of this retardation and irregularity in development is that caterpillars may be found continuously throughout the season from June till October, and that there is, consequently, no distinct dividing line between the two generations. In the more northern States the species is single-brooded, the caterpillars appearing in the months of July and August.

FOOD-PLANTS.

This caterpillar has most often been referred to by writers on economic entomology as injurious to fruit trees, such as Plum, Pear, and more particularly the Apple; but it also attacks a great many shade trees, and has been for many years particularly injurious to the elms and the soft or silver maples in some of our larger New England cities. It has also a predilection for old or large trees.

NATURAL ENEMIES AND PARASITES.

The fact that the caterpillar makes no effort to conceal itself shows that it enjoys immunity from enemies, and notably from birds. In fact, the American Yellow-billed Cuckoo, the Baltimore Oriole, and the Robin are the only birds which have been observed to feed upon the larvæ. Predaceous insects are also not particularly fond of this hairy caterpillar, the well-known Wheel-bug (*Prionidus cristatus*, see Fig. 16) and a few other Soldier-bugs being the only species which occasionally suck its juices. Nocturnal birds, and especially bats, will, no doubt, devour many of the male moths flying about after dusk, but the destruction of

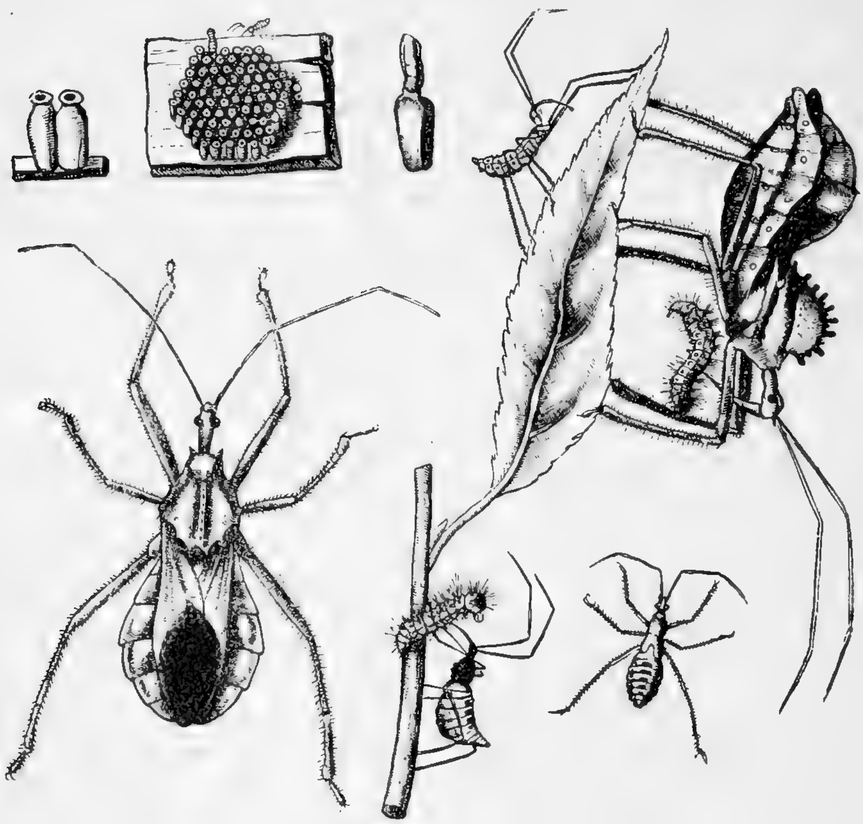

FIG. 16.—*Prionidus cristatus:* eggs, larvæ, and full-grown specimens.

a portion of the males has no appreciable influence on the decrease of the worms of the next generation. The egg-masses appear to be effectually protected by the froth-like covering, as neither bird nor predaceous insect has been observed to destroy them.

While the list of enemies that devour the species is thus small, that of the parasites is fortunately quite large, and it is due to their influence that the caterpillars are not permanently injurious. There are several true parasites of this insect. Fitch described one species which he bred in considerable numbers from the larva, as *Trichogramma? orgyiæ*, but a perusal of his account indicates plainly that this parasite is an *Eulophus*. He also described a closely-related insect as *Trichogramma? fraterna* and gave it as a very probable parasite of *Orgyia*. There is, however, not the slightest evidence of such parasitism and this insect must in future be excluded from the list of parasites of the Orgyia larvæ. We have reared from this insect *Pimpla inquisitor*, and an undetermined Tachinid fly, and have had from the larva the cocoons of a Microgaster which has not been reared to the imago. We have also bred a true egg-parasite of the genus *Telenomus*, two distinct species of the genus *Pteromalus* from the larvæ, and Mr. Lintner has sent us a specimen of a species of *Tetrastichus* which is probably parasitic upon one of the *Pteromali*. Further characterization of these species we defer to another occasion.

GEOGRAPHICAL DISTRIBUTION.

This species is widely distributed in North America east of the more timberless regions of the West, extending northward as far as Canada and southward well into the Southern States. It is most abundant in the Middle and New England States, but it is a noticeable fact that wherever it occurs it is more frequent within our cities, or in gardens and orchards near by, than in the woods remote from human habitation.

THE FALL WEB-WORM.

(*Hyphantria cunea*, Drury.)

"This insect has from time to time attracted general attention by its great injury to both fruit and shade trees. Many authors have written about it, and consequently it has received quite a number of different names. The popular name 'Fall Web-worm,' first given to it by Harris, in his 'Insects injurious to Vegetation,' is sufficiently appropriate as indicating the season when the webs are most numerous. The term is, however, most expressive for the New England and other Northern States, where the insect is single-brooded, appearing there during August and September, while in more southern regions it is double-brooded. In our Third Missouri Report we have first called attention to its double-broodedness at Saint Louis, and we find that it is invariably two-brooded at Baltimore and Washington. Except in seasons of extreme increase, however, the first brood does no widespread damage, while the fall brood nearly always attracts attention.

"We have decided to call attention to this insect somewhat in detail in this report, because of its exceptional prevalence and injury in the Atlantic States during the year 1886, and because it became a public nuisance in the city of Washington, and the District Commissioners have formally requested information from us on the subject."

NATURAL HISTORY.

Limitation of Broods.—"At Washington we may say in general that the first brood appears soon after the leaves have fully developed, and numerous webs can be found about the first of June, while the second brood appears from the middle of July on through August and September. In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The species invariably hibernates in the chrysalis state within its cocoon, and the issuing of the first brood of moths is, as a consequence, tolerably regular as to time, *i. e.*, they will be found issuing and flying slowly about during the evening, and more particularly at night, during the whole month of May, the bulk of them early or late in the month, according as the season may be early or late. They couple and oviposit very soon after issuing, and in ordinary seasons we may safely count on the bulk of the eggs being laid by the end of May. During the month of June the moths become scarcer and the bulk of them have perished by the middle of that month, while the webs of the caterpillars become more and more conspicuous. The second brood of moths begins to appear in July, and its occurrence extends over a longer period than is the case with the first or spring brood. The second brood of caterpillars may be found from the end of July to the end of September, hatching most extensively, however, about the first of August.

"In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The following general remarks upon the different stages refer to Washington and localities where the same conditions hold:

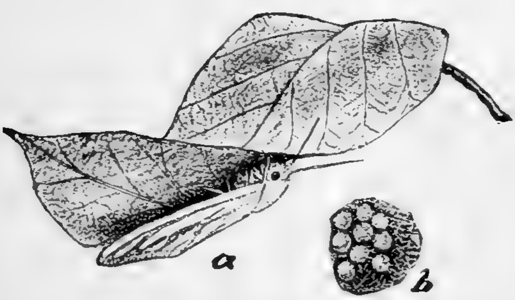

FIG. 17.—*Hyphantria cunea*: *a*, moth in position on leaf laying eggs, side view; *b*, eggs enlarged.

The Eggs (Fig. 17, *b*).—"The female moth deposits her eggs in a cluster on a leaf, sometimes upon the upper and sometimes on the lower side, usually near the end of a branch. Each cluster consists of a great many eggs, which are deposted close together and in regular rows, if the surface of the leaf permits it. In three instances those deposited by a single female were counted. The result was 394, 427, and 502, or on an average 441 eggs. But in addition to such large clusters, each female will deposit eggs in smaller and less regular patches, so that at least 500 eggs may be considered as the real number produced by a single individual. The egg, measuring 0.4 millimeters, is of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give it under a magnifying lens the appearance of a beautiful golden thimble. As the eggs approach the time of hatching this color disappears and gives place to a dull leaden hue.

"The interval between the time of depositing and hatching of the eggs for the first brood varies considerably, and the latter may be greatly retarded by inclement weather. Usually, however, not more than ten days are consumed in maturing the embryo within. The eggs of the summer brood seldom require more than one week to hatch.

"Without check the offspring of one female moth might in a single season (assuming one-half of her progeny to be female and barring all checks) number 125,000 caterpillars in early fall—enough to ruin the shade-trees of many a fine street.

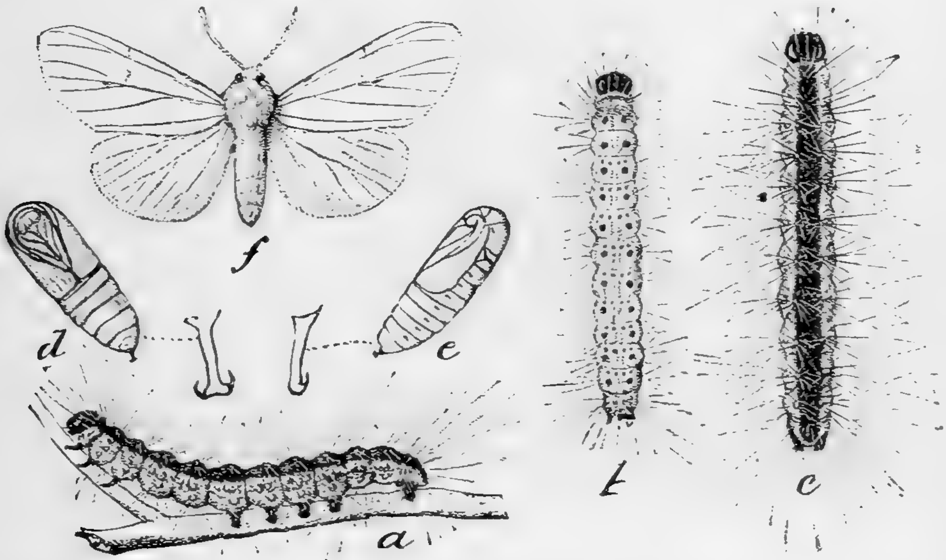

FIG. 18.—*Hyphantria cunea:* *a*, dark larva, seen from side; *b*, light larva from above; *c*, dark larva from above; *d*, pupa from below; *e*, pupa from side; *f*, moth.

The Larva (Fig. 18, *a*, *b*, and *c*).—"The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head, and with quite sparse hairs. When full grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is, however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact, nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker with browner hairs than the spring generation.

"As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes quite bulky, and, as it is filled with brown and skeletonized leaves and other discolored matter, as well as with their old skins, it becomes quite an unpleasant feature in our public thoroughfares and parks. The caterpillars always feed underneath these webs; but as soon as they approach maturity, which requires about one month, they commence to scatter about, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food-supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time.

"When the young caterpillars are forced to leave their webs they do not drop suddenly to the ground, but suspend themselves by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both old and young ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger.

Pupa and Cocoon.—"Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground; in some cases even the empty cocoons of other moths.* The angles of tree-boxes, the rubbish collected around the base of trees and other like shelter are employed for this purpose, while the second brood prefer to bury themselves just under the surface of the ground, provided that the earth be soft enough for that purpose. The cocoon itself is thin and almost transparent, and is composed of a slight web of silk intermixed with a few hairs, or mixed with sand if made in the soil.

"The pupa (Fig. 18, *d* and *e*) is of a very dark-brown color, smooth and polished, and faintly punctate; it is characterized by a swelling or bulging about the middle. It is 0.60 inch long and 0.23 inch broad in the middle of its body, or where it bulges a little all round.

The Moth (Fig. 18, *b*).—"The moths vary greatly, both in size and coloration. They have, in consequence of such variation, received

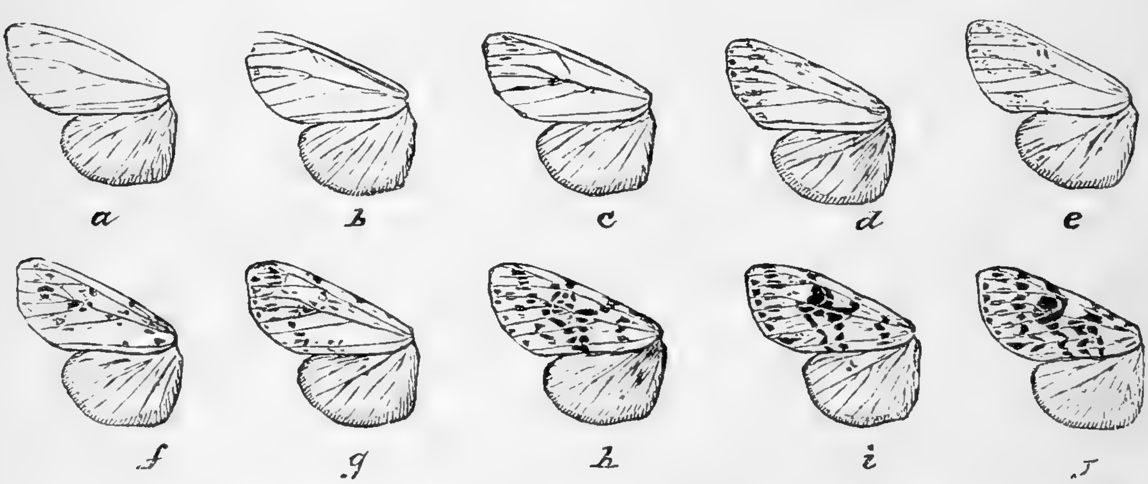

FIG. 19.—*Hyphantria cunea: a–j*, wings of a series of moths, showing the variations from the pure white form to one profusely dotted with black and brown.

many names, such as *cunea* Drury, *textor* Harr., *punctata* Fitch, *punctatissima* Smith (Fig. 19). But there is no doubt, as proven from frequent

* We have known the substantial cocoon of *Cerura* to be used for this purpose.

breeding of specimens, that all these names apply to the very same insect, or at most to slight varieties, and that Drury's name *cunea*, having priority, must be used for the species.

"The most frequent form observed in the vicinity of Washington is white, with a very slight fulvous shade; it has immaculate wings, tawny-yellow front thighs, and blackish feet; in some specimens the tawny thighs have a large black spot, while the shanks on the upper surface are rufous. In many all the thighs are tawny yellow, while in others they have scarcely any color. Some specimens (often reared from the same lot of larvæ) have two tolerably distinct spots on each front wing—one at base of fork on the costal nerve and one just within the second furcation of the median nerve. Other specimens, again, have their wings spotted all over and approach the form *punctatissima*, described as the "Many-spotted Ermine-moth" of the Southern States. The wings of the moths expand from 1¼ inches to 1⅝ inches. The male moth, which is usually a little smaller, has its antennæ doubly feathered beneath, and those of the female possess instead two rows of minute teeth.

"The pupa state lasts from six to eight days for the summer brood, while the hibernating brood, however, requires as many months, according to the latitude in which they occur.

INJURY DONE IN 1886.

"During the past year the city of Washington, as well as its vicinity, was entirely overrun by the caterpillars. With the exception of trees and plants the foliage of which was not agreeable to the taste of this insect, all vegetation suffered greatly. The appended list of trees, shrubs, and other plants shows that comparatively few kinds escaped entirely. The fine rows of shade trees which grace all the streets and avenues appeared leafless, and covered with throngs of the hairy worms. Excepting on the very tall trees, in which the highest branches showed a few leaves too high for the caterpillars to reach, not a vestige of foliage could be seen. The trees were not alone bare, but were still more disfigured by old and new webs made by the caterpillars, in which bits of leaves and leaf-stems, as well as the dried frass, had collected, producing a very unpleasant sight. The pavements were also constantly covered with this unsightly frass, and the empty skins of the various molts the caterpillars had to undergo were drifted about with every wind, and collected in masses in corners and tree-boxes. The parks fared a little better. Because of the great variety of trees planted there some escaped entirely, while others showed the effect of the united efforts of so many hungry caterpillars, only in a more or less severe degree. The grassy spots surrounding the different groups of trees had also a protective influence, since the caterpillars do not like to travel over grass, except when prompted by a too ravenous hunger. The rapid increase of this insect is materially assisted by the peculiar method of selecting shade trees for the city. Each street has, in many cases, but one kind of shade tree; rows of them extend for miles, and the trees are planted so close together that their branches almost interlace. Thus there is no obstacle at all for the rapid increase and distribution of the caterpillars. If different kinds of trees had been planted, so as to alternate, less trouble might be experienced. Plate I shows a view of Fourteenth street, taken in late September, which illustrates this point; the poplars on the west side being completely defoliated as far as the eye can reach, while the maples on the east are almost untouched.

"As long as the caterpillars were young, and still small, the different communities remained under cover of their webs, and only offended the eye. But as soon as they reached maturity, and commenced to scatter—prompted by the desire to find suitable places to spin their cocoons and transform to pupæ—matters became more unpleasant, and complaints were heard from all those who had to pass such infested trees. In many localities no one could walk without stepping upon caterpillars; they dropped upon every one and everything; they entered flower and vegetable gardens, porches and verandas, and the house itself, and became, in fact, a general nuisance.

"The chief damage done to vegetation was confined to the city itself, although the caterpillars extended some distance into the surrounding country. There, however, they were more local, and almost entirely confined to certain trees, and mainly so to the White Poplar and the Cottonwood. Along the Baltimore and Potomac Railroad tracks these trees were defoliated as far as five miles from the Capitol. In Georgetown the caterpillars were equally noxious, but in the adjoining forests but very few webs could be seen.

"The proportionate injury to any given species of tree is to some extent a matter of chance, and in some respects a year of great injury, as 1886, is not a good year to study the preferences of a species, because when hard pressed for food the caterpillars will feed upon almost any plant, though it is questionable whether they can mature and transform on those which they take to only under the influence of such absolute necessity. Again, the preference shown for particular trees is more the result of the preference of the parent moth than of its progeny in a case of so general a feeder as the Fall Web-worm. We had a very good illustration of this in Atlantic City last autumn. The caterpillars were exceedingly abundant during autumn along this portion of the Atlantic coast, especially on the trees above named. We studied particularly their ways upon one tree that was totally defoliated by September 11. The bulk of the caterpillars were then just through their last molt, though others were of all ages illustrating different hatchings. There was an instinctive migration of these larvæ of all sizes, and the strength of their food habits once acquired from birth upon a particular tree was well illustrated. At first the worms passed over various adjacent plants, like honeysuckles, roses, &c., the leaves of which they freely devour if

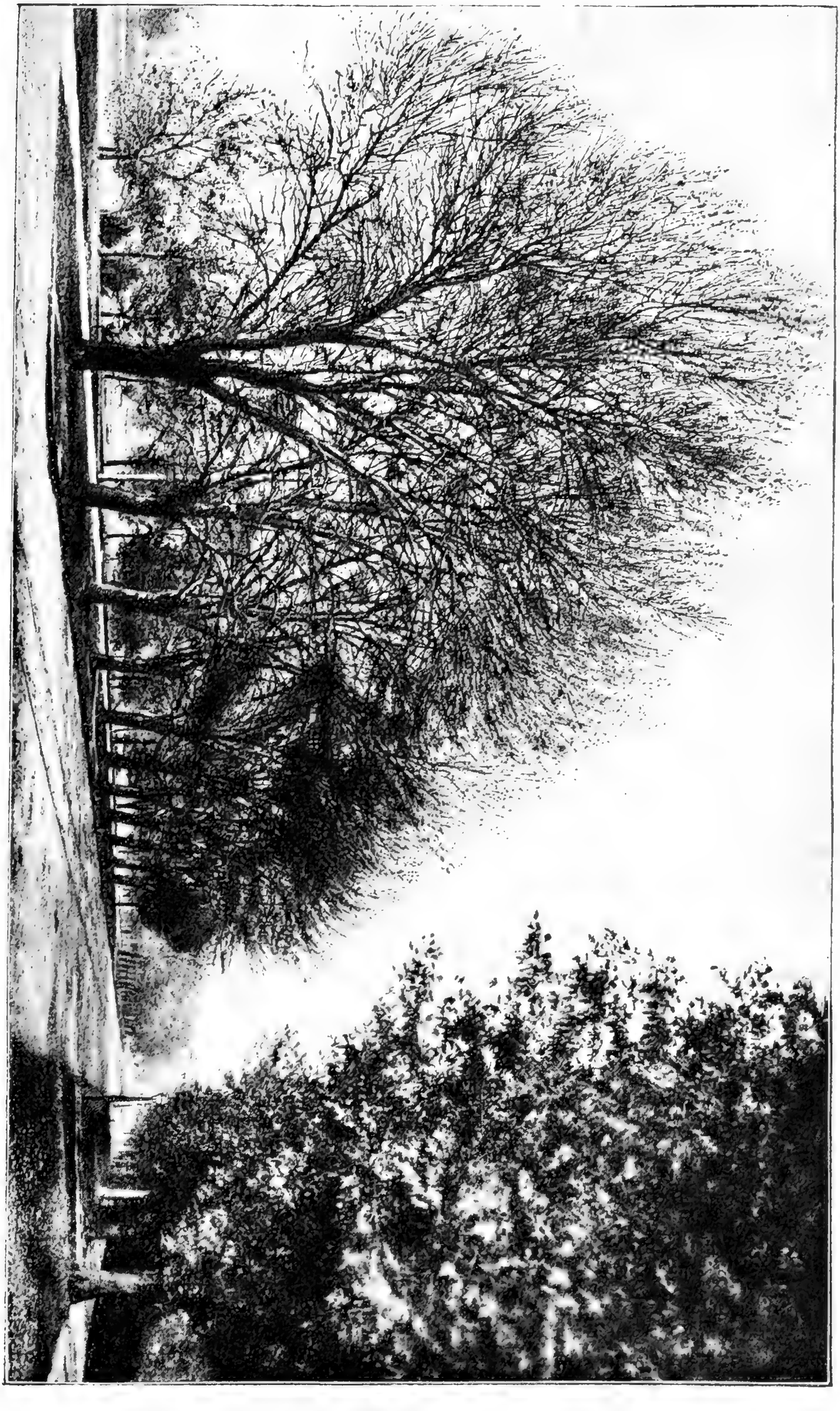

Plate I.—Trees Defoliated by the Web-worm.

hatched upon them, but as the migrating swarm became pressed with hunger they finally fell upon these, and even upon plants like the Peach, and Ailanthus, which ordinarily are passed over. They would pounce upon any food, and a rotten apple placed in their way was soon literally swarming with them and sucked dry.

"In a general way it may be stated that conifers, grapes, and most herbaceous plants are free from their attacks, and it is very doubtful whether the species can mature upon them.

"The list of plants which follows is arranged according to the relative damage to the foliage in the city of Washington. The three first named are most subject to attack, and, in fact, are almost always defoliated.

PROPORTIONATE INJURY TO DIFFERENT PLANTS AND SHADE TREES.

"The damage done in the city of Washington was exceptional, but so was also the general damage throughout the New England States, if not throughout the country. In New England the greater predilection which the species showed for Poplar, Cottonwood, and the ranker growing Willows was everywhere manifest, and so much was this the case that the destruction of the first brood on these trees would have substantially lessened the damage to other trees."

Plants marked 1 have lost from 75 to 100 per cent. of their foliage.
Plants marked 2 have lost from 50 to 75 per cent. of their foliage.
Plants marked 3 have lost from 25 to 50 per cent. of their foliage.
Plants marked 4 have lost from 0 to 25 per cent. of their foliage.
Plants marked with two figures have shown the relative immunity or injury indicated by both, the variation being in individual trees.

1. *Negundo aceroides* Mœnch. (Box Elder.)
1. *Populus alba* L. (European White Poplar.)
1. *Populus monilifera* Aiton. (Cottonwood.)
1–2. *Populus balsamifera* L. (Balsam Poplar.)
1–2. *Populus tremuloides* Mich'x. (Amercan Aspen.)
1–2. *Fraxinus americana* L. (White Ash.)
1–2. *Fraxinus excelsior* L. (European Ash.)
1–2. *Sambucus canadensis* L. (Elder.)
1–2. *Pyrus* species. (Cultivated Pear and Apple.)
1–2. *Prunus avium* and *cerasus* L. (Cherries.)
1–4. *Syringa vulgaris* L. (Lilac.)
1–4. *Ilex* spec. (Holly.)
2. *Platanus occidentalis* L. (Sycamore.)
2. *Salix* species. (Willow.)
2. *Tilia americana* L. (American Linden.)
2. *Tilia europæa* L. (European Linden.)
2. *Populus dilatata* Ait. (Lombardy Poplar.)
2. *Ulmus americana* L. (American White Elm.)
2–3. *Ulmus fulva* Mich. (Slippery Elm.)
2–3. *Prunus armeniaca* L. (Apricot.)
2–3. *Alnus maritima* Muhl. (Alder.)
2–3. *Betula alba,* L. (White Birch.)
2–3. *Viburnum* species. (Haw or Sloe.)
2–3. *Lonicera* species. (Honeysuckles.)
2–3. *Prunus americana* Marsh. (Wild Red Plum.)
2–3. *Celtis occidentalis* L. (Hackberry.)
2–3. *Rosa* species. (Rose.)
2–3. *Gossypium album* Ham. (Cotton.)
2–3. *Cephalanthus occidentalis* L. (Button Bush.)
2–4. *Convolvulus* spec. (Morning Glory.)

2–4. *Acer saccharinum* Wang. (Sugar Maple.)
2–4. *Geranium* species. (Geranium.)
3. *Betula nigra* L. (Red Birch.)
3. *Tecoma radicans* Juss. (Trumpet Creeper.)
3. *Symphoricarpus racemosus.* Mich'x. (Snowberry.)
3. *Larix europæa,* Del. (European Larch.)
2. *Corylus americana,* Walt. (Hazelnut.)
3. *Quercus alba* L. (White Oak.)
3. *Diospyros virginiana* L. (Persimmon.)
3. *Carya* species. (Hickory.)
3. *Juglans* species. (Walnut.)
3. *Wistaria sinensis* Del. (Chinese Wisteria.)
3. *Wistaria frutescens* D. C. (Native Wisteria.)
3. *Amelanchier canadensis* T. & G. (Shad-bush.)
3. *Cratægus* species. (Haw.)
3. *Rubus* species. (Blackberry.)
3. *Spiræa* species. (Spiræa.)
3. *Ribes* species. (Currant and Gooseberry.)
3. *Staphylea trifolia* L. (Bladder Nut.)
3–4. *Cydonia vulgaris* Pers. (Quince.)
3–4. *Asimina triloba* Dun. (Papaw.)
3–4. *Berberis canadensis* Pursh. (Barberry.)
3–4. *Catalpa bignonioides* Walt. (Indian bean.)
3–4. *Catalpa speciosa* Ward. (Bignonia.)
3–4. *Euonymus atropurpureus* Jaeg. (Burning Bush.)
3–4. *Cupressus thyoides* L. (White Cedar.)
3–4. *Juniperus virginiana* L. (Red Cedar.)
3–3. *Cornus florida* L. (Flowering Dogwood.)
3–4. *Cornus alternifolia* L. (Alternate-leaved Dogwood.)
3–4. *Carpinus americana* Mich'x. (Hornbeam.)
3–4. *Castanea americana* Mich'x. (American Chestnut.)
3–4. *Castanea pumila* Mich'x. (Chinquapin.)
3–4. *Ostrya virginica* Willd. (Hop Hornbeam.)
3–4. *Quercus coccinea* Wang. (Scarlet Oak.)
3–4. *Quercus phellos* L. (Willow Oak.)
3–4. *Quercus prinus* L. (Chestnut Oak.)
3–4. *Quercus rubra* L. (Red Oak.)
3, 4. *Diospyros kaki* L. (Japan Persimmon.)
3–4. *Buxus sempervirens* L. (Common Box.)
3–4. *Hamamelis virginica* L. (Witch Hazel.)
3–4. *Sassafras officinale* Ness. (Sassafras.)
3–4. *Cercis canadensis* L. (Red Bud.)
3–4. *Hibiscus syriacus* L. (Tree Hibiscus.)
3–4. *Rhamnus alnifolius* L'Her. (Alder-leaved Buckthorn.)
3–4. *Prunus virginiana* L. (Choke Cherry.)
3–4. *Persica vulgaris* Mill. (Peach.)
3–4. *Æsculus hippocastanum* L. (Horse Chestnut.)
3–4. *Paulownia imperialis* Seeb. (Cigar Tree.)
3–4. *Ailanthus glandulosus* Daf. (Tree of Heaven.)
3–4. *Maclura aurantiaca* Nutt. (Osage Orange.)
3–4. *Ampelopsis quinquefolia.* Virginia Creeper.)
3–4. *Clematis* species. (Clematis.)
3–4. *Trifolium* spec. (Clover.)
3–4. *Helianthus* spec. (Sunflower.)
3–4. *Jasminum* spec. (Jesamine.)
3–4. *Ficus carica* L. (Fig.)
4. *Rhus cotinus* L. (Smoke Tree.)
4. *Pinus* spec. (Pine.)
4. *Taxus* spec. (Yew.)
4. *Nyssa multiflora* Wangerh. (Sour Gum.)
4. *Fagus ferruginea* Ait. (Beech.)
4. *Kalmia* spec. (Laurel.)
4. *Rhododendron* spec. (Rhododendron.)
4. *Ricinus communis* L. (Castor-oil Plant.)
4. *Liquidambar styraciflua* L. (Sweet Gum.)
4. *Gleditschia triacanthos* L. (Honey Locust.)
4. *Gymnocladus canadensis,* Lamb. (Kentucky Coffee Tree.)
4. *Robinia pseudacacia* L. (Locust.)
4. *Liriodendron tulipifera* L. (Tulip Tree.)
4. *Magnolia* spec. (Magnolia.)
4. *Chionanthus virginicus* L. (Fringe Tree.)
4. *Ligustrum vulgare* L. (Privet.)

4. *Zanthoxylum americanum* M. (Prickly Ash.)
4. *Acer dasycarpum* Ehrh. (White or Silver Maple.)
4. *Acer rubrum* Wangert. (Red Maple.)
4. *Æsculus flava*, Ait. (Sweet Buckeye.)
4. *Æsculus glabra* Willd. (Ohio Buckeye.)
4. *Morus rubra* L. (Red Mulberry.)

"Trees in the vicinity of the White Poplar and Cottonwood suffered most. Even trees usually not injured, as, for instance, the Sugar Maple, are often badly defoliated when in such contiguity.

"This list contains a number of plants not usually injured by these caterpillars. In some cases the injury was due to the fact that twigs containing the web, with its occupants, had been pruned from the tree and thrown near plants, instead of being at once burned or otherwise destroyed.

"In other cases the injury is due to the peculiar position of the plant injured, *i. e.*, under a tree infested by the caterpillars. These when fully grown commence to scatter, and dropping upon the plants underneath the tree so defoliate it without actually making their home upon it. The great number thus dropping from a large tree will soon defoliate any smaller plant, even if each caterpillar takes but a mouthful by way of trial. Thus Holly, a plant not usually eaten by these insects, soon becomes denuded. Other plants unpalatable or even obnoxious to the caterpillars are sometimes destroyed by the multitudes in their search for more suitable food.

"Hungry caterpillars leaving a denuded tree in search of food wander in a straight line to the next tree, sometimes a distance of 25 feet, showing that they possess some keen sense to guide them. If such a tree offers unsuitable food, they still explore it for a long time before deserting it. In this manner two columns of wandering caterpillars are formed, which frequently move in opposite directions.

PECULIAR EFFECT OF DEFOLIATION UPON SOME PLANTS.

"During the early part of October many trees, mainly apple and pear, which had been entirely denuded of their foliage by the caterpillars, showed renewed activity of growth. Some had a few scattered flowers upon them, others had one or two branches clothed with flowers, while in some few cases the whole tree appeared white. It looked as if the trees were covered with snow, since they lacked the green foliage usually seen with the blossoms in spring. Some few flowers were also observed upon badly defoliated cherry-trees. Even as late as the middle of November, owing perhaps also to the pleasantly warm weather, some few flowers could be observed upon some imported plants belonging to the genus *Spiræa* and upon the Chinese Red-apple. All these plants usually blossom early in spring. The caterpillars having entirely defoliated the trees produced thus an artificial period of rest, or winter, which was followed by unseasonable budding and flowering. Such a result often follows summer denudation by any insect, and we have referred to some remarkable cases in our previous writings.*

ENEMIES OF THE WEB-WORM OTHER THAN INSECTS.

"The caterpillars have comparatively few enemies belonging to the vertebrate animals. This is not owing to any offensive odor or to any other means of defense, but is entirely due to their hairiness. Chickens, and even the omniverous ducks, do not eat them; if offered to the former they pick at these morsels, but do not swallow them.

"The English sparrow has, in this case at least, not proven of any assistance whatever. Indeed, as before stated, its introduction and multiplication has greatly favored the increase of the worms.

"The 'pellets' of a Screech-owl (*Scops asio*) found in the vicinity of Baltimore, Md., and examined by Mr. Luggar, consisted apparently almost entirely of the hairs of these caterpillars, proving that this useful bird has done good service.

"Perhaps the statement may be of interest, that this little owl is getting much more common in the vicinity of such cities, in which the English sparrow has become numerous, and that the imported birds will find in this owl as bold an enemy as the Sparrow-hawk is to them in Europe, and even more dangerous, since its attacks are made towards dusk, at a time when the sparrow has retired for the night and is not as wide awake for ways and means to escape.

"If our two cuckoos, the black-billed as well as the yellow-billed species, could be induced to build their nests within the city limits or in our parks, we should gain in them two very useful friends, since they feed upon hairy caterpillars.

"The common toad (*Bufo americana*) has eaten great numbers of these caterpillars, as shown by dissections made by Mr. Lugger, and it should be carefully protected instead of being tormented or killed by boys or even grown people. The toad is always a useful animal and ought to be introduced in all gardens and parks.

"The following species of spiders were observed to eat the caterpillars, viz, *Marpessa undata* Koch and *Attus* (*Phydippus*) *tripunctatus*. Neither species builds a web, but obtains its prey by boldly leaping upon it; they are, in consequence of such habits, frequently called Tiger-spiders. The former was exceedingly common last year, more so than for many previous years, thus plainly indicating that the species did not suffer for lack of food. This species is usually found upon the trunks of trees, and is there well protected by its color, which is like that of the bark. It hides in depressions and cracks of the bark, and, jumping upon the passing game, or, cat-like, approaching it from behind, it thrusts its poisonous fangs into the victim, which soon dies and is sucked dry. The *Attus* has similar habits, but is still more cautious; it usually hides

* See Eighth Report on the Insects of Missouri, p. 121.

under loose bark. Both spiders are wonderfully active, and kill large numbers of caterpillars. Their large flat egg-masses can be found during the winter under dead bark and in cracks. Both species hibernate in silken nests in similar localities."

PREDACEOUS INSECT ENEMIES.

The caterpillars of this moth have quite a number of external enemies, which slay large numbers of them. The well-known Rear-horse (*Mantis carolina*, see Fig. 20) seems to be very fond of the caterpillars.

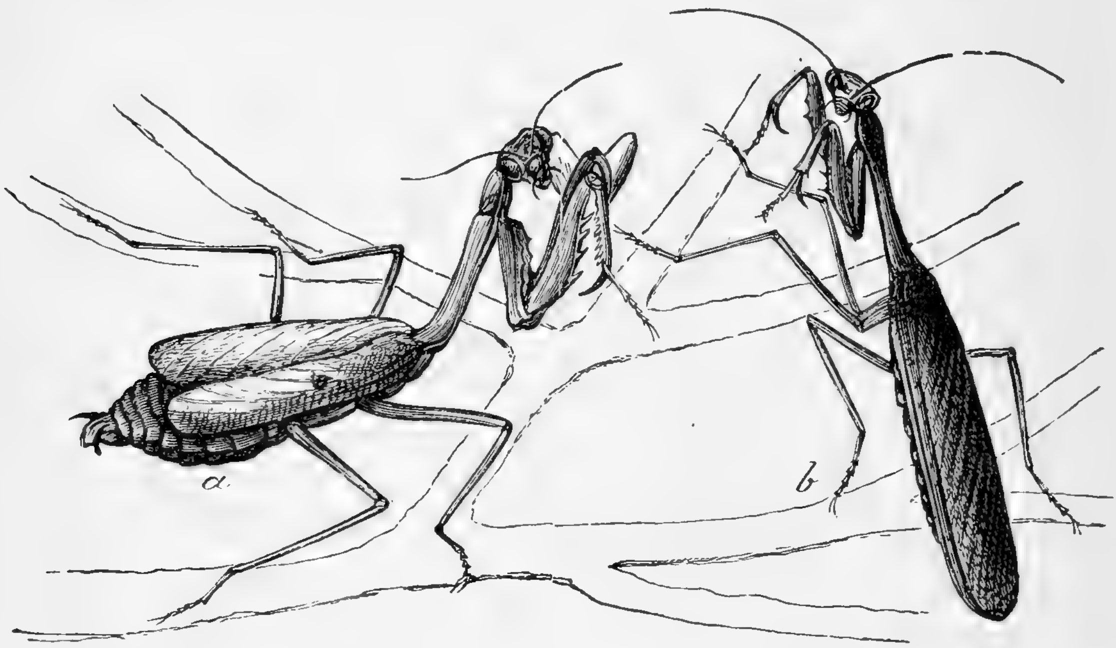

FIG. 20.—*Mantis carolina: a*, female; *b*, male.

The so-called Wheel-bug (*Prionidus cristatus*, see Fig. 16) has proved to be one of our best friends in reducing the numbers of the caterpillars. This insect was formerly by no means very common in cities, but of late years it has greatly increased in numbers, and is now a well-known feature in all our public parks and such streets as possess shade-trees. Outside of the city it is rarely met with; nor does it extend much farther north than Washington. It is, like the Mantis, in all its stages a voracious feeder upon insects, slaying alike beneficial and noxious ones. The bright red larvæ and pupæ, also carnivorous, are seen in numbers during the summer; they usually remain together until hunger forces them to scatter. They assist each other in killing larger game, and are to this extent social. The Wheel-bug could be observed almost anywhere last summer, usually motionless, stationed upon the trunk of trees, waiting for the approach of an insect. If one comes near, it quite leisurely inserts its very poisonous beak, and sucks the life-blood of its victim. When this becomes empty it is hoisted up in the air, as if to facilitate the flow of blood, until eventually it is thrown away as a mere shriveled skin. The appetite of the Wheel-bug is remarkable, whenever chances offer to appease it to the fullest extent. Frequently, however, times go hard with it, and notwithstanding it is very loth to change a position once taken, it is sometimes forced to seek better hunting grounds, and takes to its wings. The Wheel-bug has been observed to remain for days in the same ill-chosen position, for instance upon the walls of a building, waiting patiently for something to turn up. It is slow in all its motions, but withal very observant of everything occurring in its neighborhood, proving without doubt great acuteness of senses. It does not seem to possess any enemies itself, and a glance at its armor will indicate the reason for this unusual exemption.* During warm weather this bug possesses a good deal of very searching curiosity, and a thrust with its beak, filled with poison, is very painful indeed. Boys call it the Blood-sucker, a misnomer, since it does not suck human blood. The eggs are laid during the autumn in various places, but chiefly upon smooth surfaces of the bark of tree-trunks, and frequently in such a position as to be somewhat protected against rain by a projecting branch. The female bug always selects places the color of which is like that of the eggs, so they are not easy to see, notwithstanding their large size.

"*Euschistus servus* Say, is another hemipterous insect that preys upon the caterpillar of *H. cunea*, and in a similar manner to the Wheel-bug. It is a much smaller, but also a very useful insect.

"*Podisus spinosus* Dall (Fig. 21), in all its stages was quite numerous during the caterpillar plague. Its brightly-colored larvæ and pupæ (Fig. 22) were usually found in small numbers together; but as they grew older they become more solitary in their habits. All stages of this insect frequent the trunk and branches of trees, and are here actively engaged in feeding upon various insects. As soon as one of the more mature larvæ or a pupa has impaled its prey, the smaller ones crowd about to obtain their share. But the lucky captor is by no means willing to divide with the others, and he will frequently project his beak forward, thus elevating the caterpillar into the air away from the others. The habit of carrying their food in such a difficult position has perhaps been acquired simply to prevent others from sharing it. A wonderful strength is necessary to perform such a feat, since the caterpillar is sometimes many times as heavy as the bug itself. The greediness of this bug was well illustrated in the following observations: A pupa of *P. spinosus* had impaled a caterpillar, and was actively engaged in sucking it dry; meanwhile a Wheel-bug utilized a favorable opportunity and impaled the pupa, without forcing the same to let go the

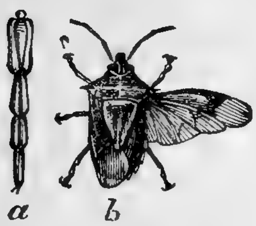

FIG. 21.—*Podisus spinosus*: *a*, enlarged beak; *b*, bug, with right wings expanded.

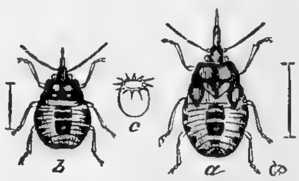

FIG. 22.—*Podisus spinosus*: *a*, pupa; *b*, larva; *c*, egg.

* The eggs of the Wheel-bug are pierced, however, by a little egg-parasite—*Eupelmus reduvii* Howard.

caterpillar. The elasticity of the beak (Fig. 21*a*) of these bugs must be very great; they can bend it in any direction, and yet keep it in sucking operation. The poison contained in the beak must act very rapidly, since caterpillars impaled by it squirm but for a very short time, and then become quiet."

FUNGUS DISEASES OF THE WEB-WORM.

"The first brood of these caterpillars showed in some quite well-defined localities the indications of a fungus disease. This did not become, however, as general as later in the season, when it prevailed everywhere; yet it could be observed that the contagion had started from certain points. In such localities almost all the caterpillars were diseased and large numbers of the dead were huddled together as in life. But when investigated their bodies were hard and dry, and would readily crumble to pieces when pressed, producing an odor like that of some mushrooms. Only full-grown, or rather caterpillars in their last larval stage, were thus affected. The dry remains had retained the original shape, and, if killed but recently by the fungus, their color as well. Before dying the caterpillars had fastened themselves very securely to trunks, twigs, and leaves of various trees, somewhat like the common house-fly, that dies by a similar disease in large numbers during September in our houses, and produces around itself such a characteristic halo of white spores. Caterpillars infested by the incipient stages of this disease wander about aimlessly and at an irregular speed; often they halt for some time, then squirm about frantically to start again, and frequently in an opposite direction to the one they were going before. If such a diseased caterpillar is confined to a glass jar and observed it is soon seen that a white mealy substance gradually grows out of all the soft spaces between their segments, which eventually covers the whole insect, leaving generally only the black head and tips of hairs visible. Before long many spores are scattered about, forming a circle of white dust around the caterpillar, and, if not arrested by an obstruction in its expulsion, the halo thus formed is quite regular and about 2 inches in diameter. Outdoors this white dust is but seldom observed, because even the slightest draft of air will carry it away and drift it about. Even the white mealy substance adhering to the caterpillar itself is usually swept away, and the victims look very much like healthy caterpillars; but they darken with time and eventually drop to the ground. The magnifying glass, however, still reveals some spores adhering to the hairs, upon the underside, and upon the bark or leaf of the tree in their immediate neighborhood.

"This fungus kills caterpillars even after they have made their cocoons. Nor does the pupa escape. In the latter case the spores form a white crest over every suture of the thoracic segments; the abdominal segments, however, remain free from it. Evidently the caterpillars were nearly full-grown when attacked by the disease, and possessed vigor enough to transform into pupæ; later the fungus grew, and, pressing the chitinous portion of the pupa apart, forced its way to the air to fructify.

"Plants not usually eaten by the caterpillars, as well as others not eaten at all, have upon them the largest numbers of caterpillars killed by the fungus, provided that they grow in the vicinity of suitable food-plants. Perhaps unsuitable food, predisposing the caterpillars for any disease, is one of the causes of the innumerable host killed by this fungus.

"The white cocoons of a parasite (*Apanteles hyphantriæ* Riley) of this caterpillar were in some cases observed to be covered with similar spores of a fungus. Opening such cocoons it was seen that the spores were not simply blown upon the silk and there retained, but that they came from the victim within, and had forced their way through the very dense silken covering."

Experiments to obtain percentage of diseased caterpillars.

Experiment I:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) at random in one of our public parks. They were imprisoned in large glass jars and daily supplied with suitable food.

Result, October 18, 1886:

11 apparently healthy pupæ.
3 deformed pupæ.
18 yellow cocoons of *Meteorus hyphantriæ.*
9 dead pupæ, killed by fungus or otherwise.
84 dead caterpillars, killed by fungus or otherwise.

125

In the earth of the jar were found 17 pupæ of Tachina flies, leaving 67 caterpillars and 9 pupæ killed by the fungus, or 61 per cent.

Experiment II:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) from a trunk of a Soft Maple tree (unsuitable food) and treated as above.

Result, October 18, 1886:

8 apparently healthy pupæ.
1 deformed pupa.
7 yellow cocoons of *Meteorus hyphantriæ.*
3 dead pupæ, killed by fungus or otherwise.
104 dead caterpillars, killed by fungus or otherwise.
2 cocoons containing Tachina larvæ.

125

In the earth of the jar were found 28 pupæ of Tachina flies, leaving 76 caterpillars and 3 pupæ killed by fungus, or 63 per cent.

In both experiments it has been assumed that each Tachina fly had killed one caterpillar.

On November 15, 1886, the jars were again investigated, and it was found that a number of the pupæ had been killed by the fungus since October 18, 1886, and that in fact all the remaining ones did not look healthy. The percentage of death by the fungus in the two experiments was thus increased to 63 per cent. in Experiment I and to 67 per cent. in Experiment II.

TRUE PARASITES OF THE WEB-WORM.

Telenomus bifidus Riley.—A single egg of the moth of *H. textor* is a very small affair, yet it is large enough to be a world for a little parasite (Fig. 23), which undergoes all its transformations within it, and

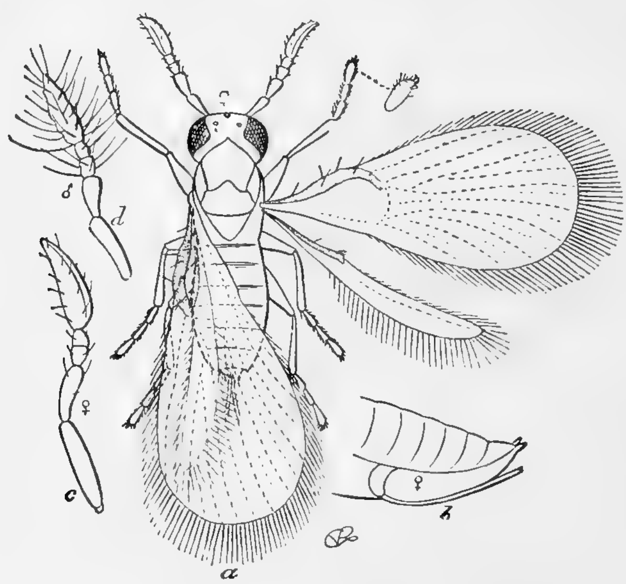

FIG. 23.—An egg-parasite: *a*, female; *b*, tip of female abdomen; *c*, female antenna; *d*, male antenna (all greatly enlarged).

finds there all the food and lodgment required for the short period of its life. In several instances batches of eggs of this moth were parasitized, and instead of producing young caterpillars they brought forth the tiny insects of this species. The batches of parasitized eggs were found July 27 upon the leaves of Sunflower, and August 18 upon leaves of Willow; judging from these dates it was the second brood of moths that had deposited them. There can be no doubt, however, that eggs produced by moths emerging from their cocoons in early spring had been parasitized as well. The female *Telenomus* was also observed, August 2, busily engaged in forcing its ovipositor into the eggs, and depositing therein. The female insect is so very intent upon its work that it is not easily disturbed, and one can pluck a leaf and apply a lens without scaring it away. The eggs soon hatch inside the large egg of the moth, and the larvæ produced soon consume the contents. This egg-parasite is a very useful friend, nipping the evil in the bud, so to speak.

Meteorus hyphantriæ, Riley.—"This parasite (Fig. 24) has performed very good services during the caterpillar plague, and has done much to check any further increase of the Web-worm. During the earlier part of the summer this insect was not very numerous, but sufficient proofs in the form of empty cocoons were observed to indicate at least one earlier brood. Towards the end of September, and as late as the 15th of October, very numerous cocoons of a second brood were formed; they could be found in all situations to which the caterpillar itself had access. But the great majority of them were suspended from the trunks and branches of trees, and chiefly from near the base of the trunk. Each cocoon represents the death of one nearly full-grown caterpillar, since the latter harbors but one larva of the parasite.* A careful watch was kept to see how such a suspended cocoon was formed, but in vain. Once a larva had just started to make a cocoon, but it was prevented from finishing it by a secondary parasite, and it died. Another larva had already spun the rough outside cocoon, but became detached and dropped out of the lower orifice, and commenced a new one. The larva, suspended by the mandibles, evidently spins at first loose, irregular, horizontal loops around its body, until a loose cradle is formed. The silk secreted for this purpose hardens very rapidly when exposed to the air. When secure inside this cradle it lets go its hold with the mandibles, and finishes the soft inside cocoon in the usual manner. If the larva has dropped to the ground it still makes an outer loose cocoon, but the silken threads are thicker and much more irregular. In cocoons made during a high wind the threads that suspend them are much longer, reaching sometimes the length of 4 inches; the more normal length varies from 1½ to 2 inches.

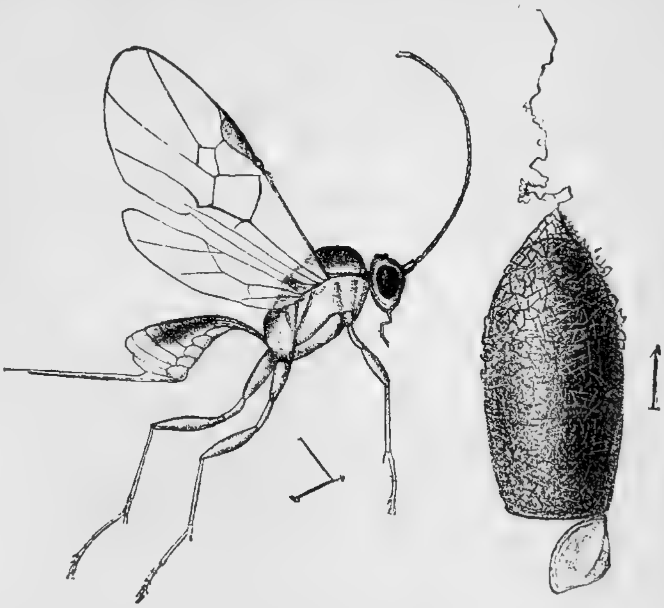

FIG. 24.—*Meteorus hyphantriæ*: *a*, female; *b*, cocoon (enlarged).

"To find out the length of time which this insect occupies in maturing inside the cocoon, 44 freshly-made cocoons were put in a glass jar. With a remarkable regularity but ten days were consumed by the insect in changing from the larval to the winged form. The winged *Meteorus* issues through a perfectly round hole at the lower end of the

* In only one instance the cocoon of this parasite was found inside that of its host.

cocoon by gnawing off and detaching a snugly-fitting cap. There are several secondary parasites of the *Meteorus* which we may mention later, and they always leave the cocoon of their host by smaller holes cut through the sides. Most of the adults had issued by the first of November, but it is possible that some may remain in their cocoons until spring.

"In order to obtain the proportion between the *Meteorus* raised from cocoons and its parasites, *i. e.* secondary parasites of *Hyphantria*, 450 cocoons were confined in a glass jar the latter part of September. Up to the first week in November only 70 specimens of *Meteorus* were bred from these cocoons, the rest giving out secondary parasites, which continued to issue up to date of writing (December 20, 1886). Thus, only 16 per cent. of the cocoons produced the primary, while 84 per cent. produced secondary parasites.

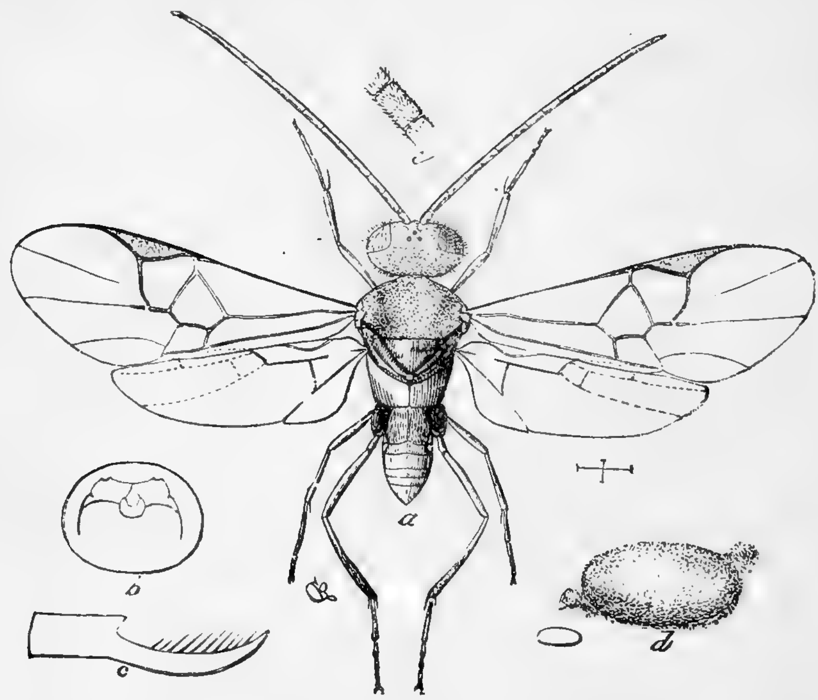

FIG. 25.—An *Apanteles*: *a*, female fly; *b*, outline of head of larva in position to show the chitinized parts of the mouth, the mandibles not visible, being withdrawn; *c*, one of its mandibles as seen within the head of a mounted specimen; *d*, cocoon; *e*, joint of antenna—all enlarged: natural size of *a* and *d* in hair-line.

Apanteles hyphantriæ Riley (Fig. 25).—"This insect was about as numerous as the *Perilitus communis*, and did equally good service in preventing a further increase of the caterpillars. It appeared somewhat earlier in the season, and killed only half-grown caterpillars. From the numerous old and empty cocoons in early summer it was plainly seen that a first brood had been quite numerous, and that from these cocoons mainly *Apanteles* had been bred, and not, as during the autumn, mostly secondary parasites. The white silky cocoon is formed almost under the middle of a half-grown caterpillar, and is fastened securely to the object its host happened to rest upon, and but slightly to the host itself, which is readily carried to the ground by wind and rain, and can therefore only be found in position in the more sheltered places, such as cracks and fissures of the bark of trees. But one *Apanteles* is found in a caterpillar, so that each white cocoon indicates, like a tombstone, the death of a victim. In some places, and notably upon the trunks of poplars, these cocoons were so numerous as to attract attention; it seemed as if the trunk had been sprinkled with whitewash. But notwithstanding such vast numbers, but two specimens of the architects of these neat cocoons were raised; all the rest had been parasitized by secondary parasites.* It is barely possible, however, that some specimens may hibernate in their cocoons, since numbers of them have as yet (December 20, 1886) not revealed any insects. The winged *Apanteles* leaves the cocoon by a perfectly round orifice in the front, by cutting off a little lid, which falls to the ground. Its parasites, however, leave by small holes cut through the sides. These secondary parasites were very common late in September and early in October, and busily engaged in inserting their ovipositors through the tough cocoon into their victim within. It seems as if the cocoons formed early in the season were on an average a little smaller than those formed later.

"The cocoons of this *Apanteles* are of a uniform white color, but exceptionally a distinctly yellowish cocoon is found. From these yellow cocoons nothing has so far been bred, but since, as we have elsewhere shown,† the color of the cocoon may vary in the same species, it is probable that the variation here referred to is not specific.

"Not quite one-half of 1 per cent. produced parasites of various kinds.

"*Limneria pallipes* Provancher.—In addition to the two Hymenopterous parasites treated of, a third one has been very numerous, and has done much good in reducing the numbers of caterpillars. This, an Ichneumonid and a much larger insect, does not form an exposed cocoon like that of the other parasites described. Yet a little attention will soon reveal large numbers of them. Upon the trunks of various trees, but chiefly upon those of the poplars and sugar maples, small colonies of caterpillars, varying in numbers from four to twelve, could be observed, which did not show any sign of life. When removed from the tree they appeared contracted, all of the same size, and pale or almost white. A closer inspection would reveal the fact that the posterior portion of the caterpillar had shrunken away to almost nothing, whilst the rest was somewhat inflated and covered with an unchanged but bleached skin, retaining all the hairs in their normal position. Opening one of these inflated skins, a long, cylindrical, brown cocoon would be exposed; this is the cocoon of the *Limneria* under consideration. As numbers of such inflated skins would always occur together, it was clearly seen that the same parent *Limneria* had oviposited in all of them. Most of the cocoons were found in depressions of the rough bark or other protected places. Single ones were but rarely met with. The Hyphantria larva in dying had very securely fastened all its legs into the crevices of the bark, so that neither wind nor rain could easily dislodge them. Only half-grown caterpillars had thus been killed. Many of these inflated skins showed

* There are a number of these secondary parasites, but as they are still issuing we shall not treat of them in detail in the present article.

† Notes on North American Microgasters, p. 7 (author's edition).

in the early part of October a large hole of exit in their posterior and dorsal ends, from which the ichneumons had escaped. Trying to obtain winged specimens of this parasite one hundred and forty of these cocoons—and only such as were not perforated in any way—were collected and put in a glass jar. Only a single female was produced from all up to time of writing, whilst very large numbers of secondary parasites issued from October 11 till the 20th of November, and doubtless others will appear during the spring of 1887, because some of these inflated skins show as yet no holes of exit.

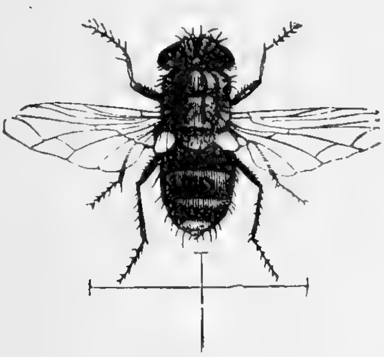

FIG. 26.—A Tachina-fly.

"*Tachina* sp. (Fig. 26.)—The parasites of *H. cunea* described so far all belong to the order Hymenoptera, which furnishes the greatest number of them. But the fly now to be described is fully as useful as any of the others.

"Tachina-flies are very easily overlooked, because they resemble large house-flies, both in appearance and in flight, and their presence out of doors is not usually noticed on that account. Yet they play a very important role, living as they do in their larval state entirely in insects. During the caterpillar plague such flies were often seen to dart repeatedly at an intended victim, buzz about it, and quickly disappear. If the caterpillar thus attacked was investigated, from one to four yellowish-white, ovoid, polished, and tough eggs would be found, usually fastened upon its neck, or some spot where they could not readily be reached. These eggs are glued so tightly to the skin of the caterpillar that they cannot easily be removed. Sometimes as many as seven eggs could be counted upon a single caterpillar, showing a faulty instinct of the fly or flies, because the victim is not large enough to furnish food for so many voracious maggots. If the victim happens to be near a molt, it casts its skin with the eggs and escapes a slow but sure death. But usually the eggs hatch so soon that the small maggots have time to enter the body of the caterpillar, where they soon reach their full growth, after which they force their way through the skin and drop to the ground, into which they enter to shrink into a brown, tun-like object (known technically as the coarctate pupa), which contains the true pupa. The caterpillar, tormented by enemies feeding within it, stops feeding and wanders about for a long time until it dies. As a rule not more than two maggots of this fly mature in their host, and generally but one. The caterpillar attacked by a Tachina-fly is always either fully grown or nearly so.

"Tachina-flies abounded during the whole term of the prevalence of the caterpillars. But it is impossible to state positively whether they were all bred from them or not, since the many species of this genus of flies resemble each other so closely that a very scrutinizing investigation would have been necessary to settle such a question. But there is no doubt that they were very numerous during the summer. Some maggots obtained from caterpillars kept for this purpose in breeding jars changed to the fly in six days; others appeared in twenty-three days, and still others, obtained at about the same time, are still under ground, where they will hibernate. The maggots of these flies do not, however, always enter the ground, as some were found inside cocoons made by caterpillars among rubbish above ground."*

SUMMARY OF THE HABITS OF THE FOUR SPECIES.

It follows from the above that we have to deal with four very different insects, each of them requiring modification in treatment, especially so far as winter work is concerned. Here, as in every other case in dealing with injurious insects, correct knowledge of the habits of the species to be dealt with must necessarily precede intelligent action, else we shall be apt to err, as did the authorities of our neighboring city, Baltimore, many years ago, by incurring a great deal of unnecessary expense without producing any beneficial result. Their blunder is historical. Observing that the elm trees around Cambridge, Mass., suffered from defoliation and were effectually protected by troughs of oil around the trunk, they ordered similar troughs of oil to be placed around their trees in Baltimore, which were also being defoliated. In Cambridge, however, the insect involved was the Spring Canker Worm (*Paleacrita vernata*), which has a wingless female that issues from the ground early in spring, and is effectually prevented by the oil troughs from ascending the trees; whereas the trees in Baltimore were suffering from the Galeruca, which we have just described, and which has ample wings in both sexes.

1. The imported Elm Leaf-beetle is a small yellowish beetle, about a quarter of an inch long, and marked with two longitudinal dark stripes on the back. It passes the winter in the beetle state in holes and crevices in the bark of trees, in fences and tree-boxes, in barns and outhouses, &c., and the eggs are laid on the young leaves of elms in April and May. The eggs are yellowish, elongate, and pointed, and are laid on end upon the leaves in groups of from five to twenty or more. The resulting worm feeds on the leaves, gradually skeletonizing and gnawing holes through them. The larvæ molt four times and transform to pupæ at the surface of the ground under grass and stones. There are several broods, and the worms are pretty constantly at work through the months of June, July, and August.

This is an imported insect, is confined to the Elm (genus *Ulmus*), has a predilection for the European Elm and for trees in cities, and the female flies long distances.

2. The Bag-worm is one of our commonest native American insects, and its bags hang from the smaller limbs of our shade trees so as to be

*Just as this bulletin is going to press we have discovered another primary parasite in the old Department collection. It belongs to the genus *Euplectrus*, and is near *E. platyhypenæ* Howard.

easily seen, especially in winter when the leaves have fallen. These bags are made by the larva or worm which lives within them. The female moth is wingless, and only leaves the bag in which she passed her larval and pupal life after she has deposited her eggs in her empty chrysalis skin or puparium. She then falls to the ground and perishes. The eggs remain in the bag all winter and hatch in spring into young worms, which scatter and at once make new bags, which increase with their growth and protect them from the attacks of birds.

The male moth is a small, black, hairy-bodied creature, with ample transparent wings, and escapes from the chrysalis after it is partially worked out of the hind end of the bag. This worm is a very general feeder, but is, on the whole, more injurious to evergreens than to deciduous trees.

This species has several insect parasites.

3. The White-marked Tussock-moth has a very beautiful hairy larva or caterpillar marked with black and yellow and red. The female cocoons are to be found during the winter on the trees and upon neigboring fences and tree-boxes, and each cocoon is plastered with a number of eggs, protected by a white, frothy, glutinous covering. The eggs hatch in spring and the young worms feed upon the fresh leaves. The males spin their cocoons after three molts and the females after four. The moths issue in July, pair and lay eggs for a second brood of worms, which in turn transform and bring forth moths in October, the eggs from which hibernate. The male moth is active, with ample wings, which are brown, with a conspicucus white spot, while the female is pale and wingless, and only crawls out of her cocoon to lay her eggs thereon and die. This species is never found on evergreens, and is chiefly injurious to elms and maples, and prefers large and old trees to young ones because of the greater shelter which they offer for its cocoons. In Washington it is yet chiefly confined to our parks, and it has not begun to be as injurious as in cities like Philadelphia and Baltimore, where the trees are older and larger. Two probable egg-parasites and seven parasites of larva and pupa are known to me.

4. The Fall Web worm passes the winter in the pupa state. The cocoons are found during the winter principally at the surface of the ground, mixed with dirt and rubbish, or in cracks and crevices of tree boxes, in fences, and under door steps and basement walls. The first moths issue from these cocoons in May, and lay their eggs in flat batches on the under side of the leaves. The young worms feed preferably in company, webbing first one and then several leaves together, and gradually extending their sphere of action until a large part of the tree becomes involved. The worms become full grown in July and spin cocoons, from which a second generation of moths issue early in August and lay eggs, from which the worms hatch, so they are once more in force by the latter part of August. This is the species which did the damage last year. The parent moth is white, with a varying number

of spots; is winged in both sexes; and the female prefers to oviposit on Box Elder (*Negundo aceroides*), the Poplars, Cottonwoods, Ashes, and Willows. The worm feeds, however, on many other trees, but not upon Conifers. It has numerous enemies and parasites.

REMEDIES AND PREVENTIVE MEASURES.

WINTER WORK.

The preventive measures that can be taken during winter time vary according to the species to be dealt with. For No. 1, or the Galeruca, which is confined to the Elms, no treatment of the trees themselves or of the boxes; in fact, no treatment that can well be given in the winter season will avail much in destroying the insect in its hibernating retreats, because the parent beetle finds shelter in all sorts of out-of-the-way places. It flies long distances, especially upon awakening from its winter torpor, so that it may be attracted to the trees from regions into which it is practically impossible to effectually pursue and detect it.

With No. 2, the Thyridopteryx, on the contrary, effective work can be done during the winter time or when the trees are bare. The bags which contain the hibernating eggs, and which are very easily detected, then may be gathered or pruned and burned. This work may be so easily done that there is no excuse for the increase of this species. Where intelligent action is possible the bags were better collected and heaped together in some open inclosure away from trees, rather than burned. By this means most of the parasites will in time escape, while the young Bag-worms, which will in time hatch and which have feeble traveling power, must needs perish from inability to reach proper food.

Much can also be done with No. 3, the Orgyia, because it also hibernates in the egg state upon the female cocoons upon the trunks and in all sorts of recesses.

In regard to No. 4, the Hyphantria, which is the species we are more particularly dealing with, something also may be done in the winter time by systematic clearing away of the cocoons from the sheltered places in which they may be found. These hibernating retreats are, however, so numerous about our houses and our grounds, that complete destruction of all cocoons becomes an impossibility.

ONE SIMPLE PREVENTIVE REMEDY FOR ALL.

It so happens, fortunately, that there is one thoroughly simple, cheap and efficacious remedy applicable to all four of these tree depredators. From the natural history facts already given it is clear that they all begin their work very much at the same season or as soon as the leaves are fairly developed, and arsenical mixtures properly sprayed on the trees about the middle of May and repeated once or twice at intervals of a fortnight later in the season, will prove an effectual protection to trees of all kinds. This can be done at small expense, and will prove the salvation of the trees. An apparatus can be readily constructed, such as has been used on the grounds of the Department of Agriculture, on a sufficiently large scale to economize time and labor. It should consist of a water tank mounted on a cart and furnished with a strong force pump operated by one man and furnished with two sets of rubber tubing of a sufficient length (a hose reel can be constructed on top of the cart), each hose supported by a bamboo extension pole with a cyclone nozzle at tip. With such an apparatus as this three men could drive along the streets and thoroughly spray two trees simultaneously; while if it were found advisable, four independent tubes and four men to work them could be employed with a sufficiently powerful pump, and thus expedite the work. The details of the more important devices connected with this tank-cart are given in considering the Galeruca. The bamboo "extension pole" is used simply to stiffen the rubber hose and to enable the operator to elevate the spraying nozzle into the center of the tree and spray to a so much greater height. The same result can be accomplished by means of a brass rod, in sections, and this has the advantage of superior strength, and will consequently carry a heavier nozzle or a bunch of nozzles at the end.

The "Cyclone" or "Eddy-chamber" nozzle (see Fig. 6) is better suited for work of this kind on small trees than any yet in use. It is small, simple, cheap, will not clog, and gives an admirable spray. A combination nozzle may be made of several of these which will be readily supported by the section rod and will throw a more profuse spray.

The arsenical compound known as London purple is, as already shown, perhaps preferable to white arsenic or Paris green in that it is not so liable to burn the leaves while its color enables one to readily distinguish poisoned from non-poisoned trees. Moreover it is very cheap. From one-quarter to three-quarters of a pound of this substance should be used to a barrel of water, and with this quantity of water it is best to mix three quarts of cheap or damaged flour which will serve both to render the mixture adhesive to the leaves and also to lessen the tendency of the poison to burn the leaves. Three-quarters of a pound to the barrel may prove too strong a mixture for delicate and susceptible young trees, and it will be best for general application to make the amount from three-eighths to one-half pound to the barrel. Paris green will require a somewhat heavier dose—say from one-half to 1 pound per barrel of water.

A number of other means have been tried and are more or less effectual in destroying these defoliators. Such are the application of various other insecticides, particularly an emulsion of milk and kerosene, the burning of the webs (in case of the web-worm) by thrusting a lighted torch, made of various patterns, into the webs; but after full trial, nothing has been found more satisfactory than the arsenical mixtures here recommended. They have the advantage over all other means that they kill directly the worms begin feeding, and at the same time have a preventive influence. Properly sprayed on the under side of the leaves so as to adhere, they are not easily washed off, and they not only kill, without injury to the tree, all the worms at the time upon such tree, but all those which may hatch upon such tree for a number of days and even weeks subsequently.

We are satisfied that with two or three special tanks, such as we have built at the Department of Agriculture, and a gang of three men to each, the trees of the city could be easily protected at a nominal cost beyond labor, and that two sprayings, one about the middle of May and one the first week in June, will effectually prevent the repetition of any such nuisance as that we suffered from last summer. Each gang of three men could properly protect in the neighborhood of from three hundred to five hundred medium-sized trees per day, and in ordinary seasons and in dealing with the web-worm it would only be necessary to poison such trees as are preferred by the insect.

We may here with propriety describe, as supplementary to the general consideration of machinery on pp. 19–22, two recently-invented machines which could be used to advantage in this work.

The first is the invention of Mr. A. H. Nixon, of Dayton, Ohio, and will answer very well for the spraying of arsenical solutions. The cyclone nozzle, with all its advantages on small or medium-sized trees, is not so well adapted for spraying very high trees, and Mr. Nixon's nozzle and several others which might be mentioned have an advantage in that they throw a spray to a greater height or distance, in a more powerful and narrower stream, which nevertheless breaks up into a floating spray.

We have personally tested Mr. Nixon's nozzle and find it is a very satistactory one. Mr. W. B. Alwood, the agent of the Division at Columbus, Ohio, in a report upon it, writes:

"The necessity of a good apparatus for spraying tobacco in a packing-house led Mr. Nixon to experiment with many different kinds of apparatus, until at most by accident he discovered that a jet of water projected against a wire gauze of proper sized mesh held at a certain distance would produce a perfect spray. He was several years in working up a scheme to utilize this newly discovered fact, and then succeeded very imperfectly, but produced an apparatus which found quite common use in his and other tobacco warehouses in the Miami Valley.

"However, some three years ago he conceived the notion of perfecting his nozzle and bringing it into shape for practical utility on a force-pump. In this I think he has succeeded most admirably. Several styles of apparatus have been made by him for using his nozzle in practical work both in doors and out. Those designed for outdoor work have especial reference to the destruction of insects. How useful these may prove I would not venture an opinion, not having had a chance to use them in actual work, but of the fact that his nozzle will produce spray as fine or as coarse as can possibly be desired there is not the possibility of a doubt, and this, too, without any waste of liquid.

"The pump used on his machines is a single cylinder double action force-pump of extremely simple mechanism and of great power and durability.

"The nozzle (in which lies all the mechanism which he can really call his own invention) is very simple. It consists of a brass nipple three-quarters to 1 inch in length, pierced by a small hole varying in diameter according to the amount of spray desired. This nipple screws on to the discharge pipe and on its outer end is screwed a chamber three-quarters to 1 inch in diameter and 3 inches long. These dimensions have been determined by experiment. The nipple and chamber are made of brass. On the outer end of the chamber is soldered a wire gauze varying in size of mesh to suit size of orifice in nipple.

"The nipples tested by me were as follows:

No. 1. One sixty-fourth inch orifice projected spray 10 feet in straight line; discharged pint of liquid in 20 seconds; pressure could not be measured, but I think was 75 to 100 pounds in all the tests. Spray floated like mist.

No. 2. One thirty-second inch orifice projected spray little farther and little coarser; discharged 1 pint in 15 seconds.

No. 3. Five sixty-fourths inch orifice projected spray 18 feet; discharged 1 pint in 8 seconds; spray coarser than previous, but floated well in the air.

No. 4. One-eighth inch orifice projected spray 25 feet; discharged 1 pint in 5 seconds; still coarser, but fell in perfect mist, completely wetting soil.

"The apparatus tested by me was really yet in the experimental stage but gave very satisfactory results.

"The special features which commend this nozzle are that it is very simple, discharges spray farther in a straight line than any apparatus ever tested by me, and the capacity is practically unlimited.

"The complete machines which Mr. Nixon had made and were tested by me were as follows:

"No. 1. Sulky cart, drawn by horse, which also furnished motive power to pump by gearing from wheel. This machine as timed by me was capable of going over 21 acres of ground in eight consecutive hours, and completely spraying any low crop. Tank holds 70 gallons; pump arranged inside and so rigged with safety valve that pressure could be made to suit requirements of the nozzle used. This machine could also be used as a hand-pump by throwing out of gear and putting on a lever.

"No. 2. Is a hand machine on trucks with a small rest wheel in front. Tank holds 40 gallons and can be used for all ordinary purposes of spraying beds and lawns; also mounted in a wagon would be very serviceable for spraying orchards.

"No. 3. Is a small machine, 15-gallon tank, intended for use indoors."

The second machine is the invention of Mr. John Bowles, of Washington, D. C., and is used for the purpose of vaporizing naphtha of grade 77. Experiments made by Mr. Bowles and witnessed by Mr. Howard with this machine upon the Web-worm were successful in killing the worms, leaving the foliage uninjured. Fig. 27 shows the machine in section. Mr. Bowles' description is as follows:

"The mechanism employed for the purpose of applying the oil in the form of spray consists, essentially, of an oil-compresser, combined with an air-compresser, so that both may be actuated by the same effort, the leverage being adjusted so that the greater pressure may be applied to the oil-compresser, and the communicating together of the streams of oil and air at a nozzle for their discharge.

The form of machine shown meets these requirements. S is an oil-tank, that, for convenience, may be mounted on wheels. P is a bellows, attached to the tank, and actuated by the board *h*, by means of the handle, V, being pivoted to the top of the tank at U. An oil-pump is shown, within the chamber of the bellows, having a suction pipe, *s*, extending into the oil, and a discharge-pipe, *w*, connecting with the oil-pipe E, while the air discharged from the bellows passes through the air-pipe D, the oil-pipe being within the air-pipe, and both pipes meeting at the point of discharge, at the nozzle. The plunger or piston of the oil-pump is actuated by a rod

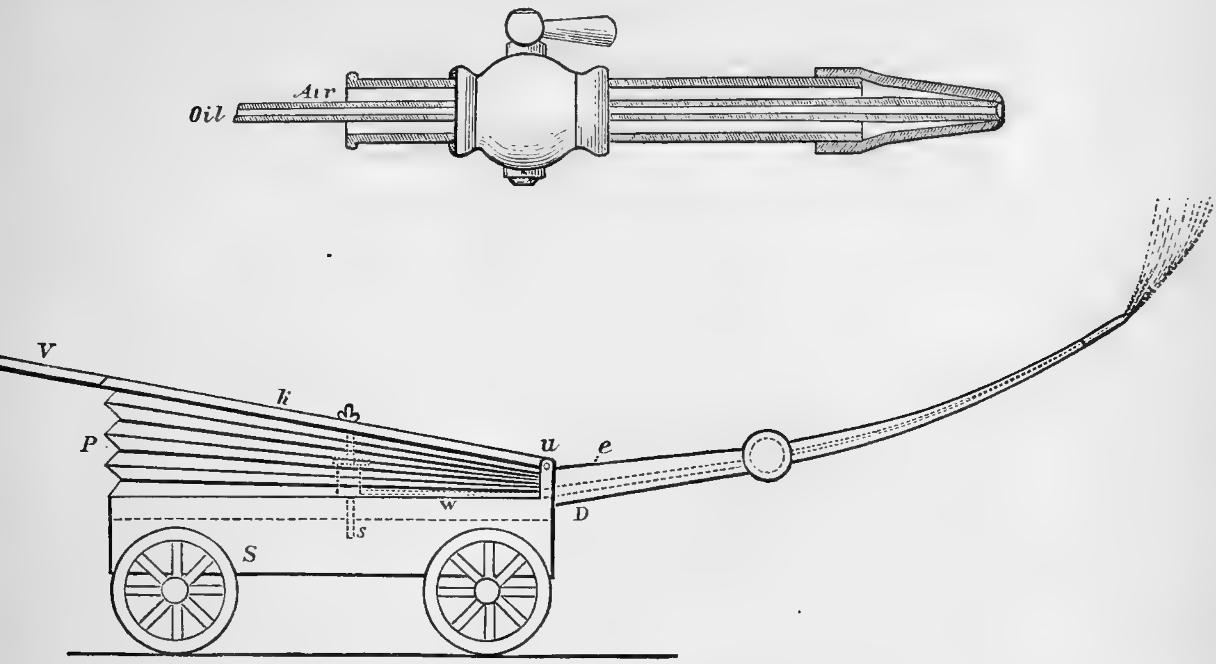

Fig. 27.—Atomizing machine invented by John Bowles, Washington, D. C.

pivoted to the board *h*, at a point that will give the oil-compresser such increased leverage as may be demanded for its proper discharge.

PRUNING AND BURNING.

The old and well-tried remedies of pruning or burning, or pruning and burning, will answer every purpose against the Web-worm in ordinary seasons, where it is thoroughly done and over a whole neighborhood. It must, however, be done upon the first appearance of the webs on the trees, and not, as was done by the Parking Commission of this city last season, after the first brood of worms had attained their full growth and many had already transformed to pupæ. The nests at that time had assumed large proportions, and their removal entire injured the appearance of many young trees. Then, too, they were piled upon an open wagon, which was dragged for many hours around the streets, permitting a large proportion of the worms to escape.

On the first appearance of the webs, which should be looked for with care, they should be cut off or burned off, and if cut off they should be burned at once. The "tree pruners," manufactured for the trade and well known to all gardeners, answer the purpose admirably.

The customary method of burning the nests is by means of rags saturated with kerosene or coal-tar and fastened to the tip of a long pole. An old sponge has been substituted to advantage for the rags, but probably the best substitute for this purpose is a piece of porous brick. In a pointed communication published in the *Evening Star*, of August 21, Major Key, agent of the Humane Society, thus describes the making of a brick torch: "Take a piece of soft brick, commonly termed salmon brick, trim it to an egg shape; then take two soft wires, cross them over this brick, wrapping them together around the opposite side so as to firmly secure it; now tie this end to a long stick, such as the boys get at the planing mills, by wrapping around it; then soak the brick in coal-oil, light it with a match, and you are armed with the best and cheapest weapon known to science. Holding this brick torch under the nests of caterpillars will precipitate to the sidewalk all the worms on one or two trees at least from one soaking of the brick, and it can be repeated as often as necessary. Then use a broom to roll them under it and the work will be done, the controversy ended, and the tree saved."

Asbestos may also be used to advantage, and a little thorough work with some simple torch *at the right time* will in nearly every case obviate the necessity of the more expensive remedies later in the season, when the worms of the first brood have grown larger or when the second brood has appeared.

MULCHING.

After a bad caterpillar year, a little judicious raking together of leaves and rubbish around the trunks of trees which have been infested, at the time when the worms of the second brood are about full-grown and before they commence to wander, will result in the confinement of a large proportion of the pupæ to these limited spaces, where, with a little hot water or a match, they can readily be destroyed during the winter. Many of the caterpillars, of course, reach the ground by dropping purposely or falling accidentally from the branches, but the great majority descend by the trunk, and, finding the covenient shelter for pupation ready at the foot of the tree, go no farther. This has been tested on the Department grounds the past season, and is mentioned as a method of riddance supplementary only to others.

INFLUENCE OF TREE-BOXES.

However necessary it may be in cities to protect trees, by means of tree-boxes, against bodily injury, chiefly committed by mischievous boys and loafers, such protection should only be afforded for a limited time, or long enough for the growing tree to attain a sufficient thickness to prevent its being broken by any ordinary accident. After such a thickness has been reached the boxes ought to be discarded. They are unnatural, and both injurious to the tree and unpleasant to the eye. A great number of trees are forever injured by such boxes, and the great increase of some kinds of insects is solely due to them. For instance, the Maple Bark-borer (*Trochilium acerni*) is almost solely confined to the injured bark of maple trees protected by boxes, and is scarcely ever found in normally growing trees. Such tree-boxes furnish good shelters for the formation of cocoons, and afford winter quarters for many noxious insects. The Web-worm under consideration makes excellent use of them. A small Box Elder, with a trunk of about 4 inches in diameter—a tree strong enough to thrive without protection—had been inclosed by the usual form of a wooden tree-box. This was removed, and the inside of the box and the collected rubbish in it was carefully investigated by one of our assistants, Mr. Otto Lugger. This is the result: 74 cocoons of *H. cunea*; 43 egg-masses of *Orgyia leucostigma*; 4 cocoons of *Acronycta americana*, and 1 pupa of *Datana rubicunda*, besides innumerable old and empty pupal skins of these and other insects. It is to be added in this connection that this tree grew in a park in Baltimore, and was not as badly infested as trees in Washington.

A young tree in a tree-box ought to be firmly fastened at the top to all sides of the box, and this by means of flexible bands, to be renewed from time to time. In this manner a high wind would be prevented from producing any friction of the trunk or branches against the edges of the box. After the tree attains a size of 2 inches in diameter the tree-box ought to be removed, and the members of the city police should be instructed to pay especial attention to their further necessary protection. The shelter afforded by the wooden tree-boxes is, in my judgment, the prime reason why the Web-worm has become such a great nuisance in Washington. They should either be discarded entirely after the trees have attained a trunk diameter of 4 inches, and heavy penalties enacted for hitching horses or for in any way cutting or defacing the trunk; or, what would perhaps be safer, and certainly very much less objectionable, they should be replaced as soon as possible by round iron ones like those now in use on Fifteenth street, between New York avenue and K street. These will afford less shelter for cocoons, and are in every way less objectionable.

WHITEWASHING OF TRUNKS.

Whitewash covers a multitude of sins; but sins should not be covered up, they should be eradicated, which a simple whitewashing will not do. A whitewashed tree is an eyesore, and whole rows of them, or even groves in parks treated in such a way, produce a sight to be deplored by all people admiring the beauty of nature. One is forcibly reminded of a grave-yard when walking through some of the Washington streets after sunset; the white trunks glisten like the broken shafts in an old cemetery. If the trunks of trees must be covered with lime at all, why not choose at least a color more in harmony with nature, the color of the bark for instance? There is no necessity, however, in Washington to whitewash the trunks of our shade trees. As a protection against flat and round-headed borers (species of *Chrysobothris* and *Saperda*) it is of value when a certain proportion of arsenic is mixed with it; but the principle "what is sauce for the goose is sauce for the gander" does not apply in this instance, and as a remedy for the Web-worm it is practically useless. Only one of the insects mentioned can be in any way be lessened by this practice, and that is the species that Washingtonians are just now least concerned with, viz, the Orgyia.

It is very questionable whether the whitewash will destroy its eggs, but there is every reason to believe that the friction of the brush and the disengaging of many of the cocoons will cause the destruction of a certain number. On our larger trees the greater number of these cocoons are never reached by such whitewashing, because they are upon the higher limbs. The Web-worm cannot be affected by the practice, as the hibernating chrysalids and cocoons are not found upon the trunks. As against these negative results of whitewashing, however, we must put the injurious results that follow indirectly; because a great many of the enemies of the defoliators are destroyed by whitewashing. This is particularly the case with the egg-masses of spiders and many of the softer and more delicate cocoons of parasites.

BIRDS: THE ENGLISH SPARROW.

All four of these insects have a certain immunity from the attacks of birds: No. 1 by virtue of an offensive odor; No. 2 by the protection of its bag; Nos. 3 and 4 by the protection afforded by the hairs of the caterpillars, which are also mixed into their cocoons. A few native birds we have seen occasionally feed upon Nos. 3 and 4, but the English sparrow, to which, being emphatically a city bird, we should look for help, has never been known to attack any of them. In fact, we noticed and announced many years ago that in some of the northern cities (as Boston and Philadelphia) the increase of the Orgyia was indirectly a result of the increase of the English sparrow, which feeds in the breeding season upon smooth worms less harmful to our trees, and thus gives better opportunity for the rejected Orgyia to increase, a result still further promoted by the habit of driving away the native birds which the English sparrow is known to have. The same reasoning will hold true in respect of the Web-worm; and, putting all sentiment aside, we may safely aver that this bird is an impediment rather than an aid in preserving our trees from their worst insect defoliators. There is every reason to believe that the Bag-worm is carried, when young, from tree to tree upon the claws and legs of the bird, and its dissemination is thus aided and its destruction rendered more difficult; while the yellow suspended cocoons of the *Meteorus hyphantriæ* (the most important of the parasites of the Web-worm) are sought by the sparrow, probably being mistaken for grains of wheat.

While our feathered friends, owing to the sparrow's pugnacity. are now things of the past, and can only be seen in the spring when they pass through the cities in their migrations to more peaceable nesting places, yet something might be done to encourage their stay. Nesting places might be provided for them not alone by bird-boxes, which, good in themselves, are at once occupied by the English sparrow; they must be afforded safer and natural quarters. This has been successfully achieved in portions of Europe and by the following very simple methods: First, a number of low but dense trees and bushes, forming in themselves fine-looking groups, are surrounded by dense and thorny hedges, to prevent cats and other enemies of birds from entering the inclosed space. Second, in the crotches of taller trees, and chiefly in the first crotch, bundles of thorny branches are fastened in such a way as to prevent cats from climbing above them. Such bundles would not look well during the winter, but they could then be removed to be replaced by fresh ones in the early spring. A broad strip ot tin would, perhaps, answer the same purpose, but would not, at first, be as attractive to the birds themselves. A strict law against the use of slings, stones, and other weapons in the hands of the boys must, of course, be strictly enforced. In a very short time birds of various kinds will discover the safety of such places, and utilize them. Even if these birds should not alone avail against the ravages of insects, they would do good service, and their presence would pay for the little trouble of an invitation to them.

THE FUTURE OF OUR TREES—PRUNING.

Before closing this article it may be well to call attention to another danger from which our shade trees are threatened in the future. We refer to the reckless and almost cruel pruning which has in the past been indulged in, and which, if we are rightly informed by Mr. Saunders, the Parking Commission find it very difficult to prevent. No one looking to the future of our shade trees can have witnessed without indignation the gangs of careless men who periodically go through our streets cutting, hacking, and lopping indiscriminately and without intelligence the limbs of the trees until they have become on many of the older streets deformed and unsightly objects. The result of senseless pruning is easily seen on some of these older streets as compared with the trees in our parks which have been more often left alone and more intelligently pruned. Street shade trees should be pruned from below and not lopped off from the top, so that in the future there will result a tall straight trunk, not intercepting the view of the buildings from the street and yet furnishing the desired shade and beauty. The trees of such cities as Cambridge, New Haven, Saratoga, &c., may be cited by comparison with what ours are fast becoming. But there is another side to this question which justifies us in calling attention to it in this connection. To use the language of our Seventh Report on the Insects of Missouri, published in 1874, in treating of the Flat-headed Borer (*Chrysobothris femorata*), one of the most destructive borers of our trees: "Many a fine orchard tree, and many more city shade trees, receive their death shock from the reckless sawing off of limbs without effort being made to heal the wounds by coating with grafting wax, clay, or other protecting substances. Around such an unprotected sawed limb, as around the frustrum of a felled tree, the rain and other atmospheric in-fluences soon begin their work of causing decay between the bark and the solid wood; and this is but the forerunner of greater injury by insects which are attracted to the spot, and which, though hidden meanwhile from view, soon carry the destruction from the injured to the non-injured parts."

There is, in fact, more danger that our trees in future (especially the Soft Maple) will begin to fall and perish from the ravages of Borers, as a result of reckless pruning, than that they will ever be seriously or permanently injured by leaf-eaters. These last, as we have seen, may be overcome, but the Borers are not only more deadly but more difficult to manage.

TREES WHICH ARE UNINJURED.

I have already indicated a few of the trees which are most subject to injury from this Web-worm. There is also quite a list of trees which are either very little affected or are never attacked, and in this connection it may be well to mention a few of these which are, not only on this account but in every other way, desirable for shade trees and should be strongly urged upon the Parking Commissioners as substitutes for those, like the Box Elders, which are so seriously affected. In this list of desirable trees which have immunity I would mention:

Tulip tree (*Liriodendron tulipifera* L.).
Sweet Gum (*Liquidambar styraciflua* L.).
Sweet Buckeye (*Æsculus flava*, Ait).
Ohio Buckeye (*Æsculus glabra*, Willd.).
The Maples (*Acer rubrum*, *A. saccharinum*, *A. pseudoplatanus*, and *A. dasycarpum*).
Honey Locust (*Gleditschia triacanthus* L.).
Kentucky Coffee Tree (*Gymnocladus canadensis*, Lamb).
Sour Gum (*Nyssa multiflora*, Wangerh.).
Beech (*Fagus ferruginea*, Ait).
Yews (*Taxus* spec.).

GOOD AND BAD EFFECTS OF OUR TREES.

The beauty of Washington is very greatly enhanced by its shade trees, and the Parking Commission deserve very great credit for the gigantic work they have carried out in the last fifteen years. But while these trees are and ought to be in the future an unending source of pleasure and healthfulness, yet here, as is so often the case, the good has some corresponding evil. This last, however, may be easily avoided. We hear much of malarial troubles in Washington, and the Potomac flats come in for nearly the entire blame. During the month of October our streets are constantly covered with fallen leaves from our shade trees, eddying and whirling about and carried by every heavy rain into the sewer traps. Now, however vigilant the authorities may be during the heat of summer in cleaning out these traps, at the approach of cold weather the necessity for their frequent cleaning is supposed to be removed. As a consequence of this, vast masses of black, decomposing, and reeking leaves are left to fester during the late fall and early winter, and even through the whole winter, sending forth their injurious and insidious emanations from every street corner. From personal experience we are convinced that this is a source of much sickness hitherto almost entirely overlooked, and it behooves the authorities to have the traps on all the tree-planted streets thoroughly cleaned out immediately after the trees have become essentially bare.

PROSPECTS THE COMING SEASON.—CONCLUSION.

From the habits of the Orgyia as compared with the Web-worm there is good reason to believe that the former will become in the future more and more numerous and more and more of a nuisance, just as it has become the most grievous pest in Boston and Philadelphia and other cities where the trees are older. As to the prospects of a repetition of the Web-worm nuisance the coming season, the probabilities are that it will be very much less troublesome than it was in 1886. It is almost a universal rule in insect life that abnormal increase of a plant-feeding species is followed by a sudden check. This is due to two causes: *First*, the great multiplication of the parasites and natural enemies of the species which such undue increase permits; *secondly*, to the greater feebleness and tendency to disease resulting from insufficient food, which is a very general accompaniment of such undue increase. From the diseased condition in which the bulk of the last generation of the Web-worm was found, and from the great increase in its parasites that we know to have taken place from actual observation, we may safely expect exceptional immunity the present year.

SOURCE OF ILLUSTRATIONS.

Plates I and II are from photographs. Figures 1, 2, 3, 4, 5, 6, and 11 are republished from former Government reports by the author Figures 7, 12, 13, 14, 15, 20, 21, 22, and 26 are from the author's Reports on the Insects of Missouri. Figures 9, 10, and 25 are from other miscellaneous papers by the author. Figure 8 is from Hubbard, and figure 16 is from Glover; while figures 17, 18, 19, 23, 24, and 27 were drawn for this Bulletin and for our Annual Report as Entomologist to the Department of Agriculture for 1886.

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 10.
(SECOND, REVISED EDITION.)

OUR SHADE TREES AND THEIR INSECT DEFOLIATORS.

BEING A CONSIDERATION OF THE FOUR MOST INJURIOUS SPECIES WHICH AFFECT THE TREES OF THE CAPITAL; WITH MEANS OF DESTROYING THEM.

BY

C. V. RILEY,
ENTOMOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

Compliments of

Norman J. Colman,

Commissioner of Agriculture

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CONTENTS.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 15, 1887.

SIR: I have the honor to submit for publication Bulletin No. 10 of this Division, being an account of the more important insects which defoliate our shade trees. While of interest to other sections of the country, it has been prepared primarily to supply the constant demand for information by residents of the National Capital. In the series of Bulletins of this Division it takes the place of one on "Bird Migration in the Mississippi Valley," announced a year ago, and which, since the creation of the separate Division of Ornithology and Mammalogy, I have thought best to leave out of the series from the Entomological Division, especially as Dr. Merriam, the Ornithologist, has greatly amplified it.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION TO THE FIRST EDITION.

Though all four of the insects considered in this Bulletin have been studied in years gone by and have been treated of in various publications, yet some facts of interest are recorded here for the first time. The article on the Elm Leaf-beetle is reproduced from Bulletin No. 6, which has been for some time out of print. Those on the Bag-worm and on the Tussock-moth are condensed from our First Report as State Entomologist of Missouri, published in 1868, and from later writings, and that on the Fall Web-worm is made up from the Third Report of that series for 1870, but contains much that is new and especially applicable to the District of Columbia, the quoted portions being taken in advance from our forthcoming report to the Department. The Bulletin concludes with some facts and suggestions which are also of local interest and have been elicited by the exceptional concern shown by the people of Washington in the caterpillar nuisance. Some portions of this part of the Bulletin have been given for publication to the Washington *Evening Star*.

In treating of the means of preventing the injury and of preserving the foliage of our trees we have gone into details as to the most important means in considering the first species, or the Elm Leaf-beetle, so as to avoid repetition, and later, in connection with the fourth species or Fall Web-worm, referred briefly to other methods.

C. V. R.

SHADE TREES AND THEIR INSECT DEFOLIATORS.

FOUR PRINCIPAL LEAF-EATERS.

There are four insects principally concerned in the defoliation of the shade trees in the city of Washington. They are: (1) The Imported Elm Leaf-beetle (*Galeruca xanthomelæna*); (2) the Bag-worm (*Thyridopteryx ephemeræformis*); (3) the White-marked Tussock-moth (*Orgyia leucostigma*); and (4) the Fall Web-worm (*Hyphantria cunea*).

THE IMPORTED ELM LEAF-BEETLE.

(*Galeruca xanthomelæna** Schrank.)

The depredations of this pest have now become widely extended throughout the Northeastern States, rendering almost worthless and unsightly those most valuable shade trees of our cities—the elms. As its injuries are so far unknown in the Mississippi Valley, the blighted appearance of the elms on the Department grounds in midsummer, and especially of the European varieties, at once attracted our attention when we first came to Washington, and a series of experiments was begun with a view of checking the ravages of the insect. The excellent opportunites thus offered for experiment and study have since been improved, and, with some prefatory passages in relation to the history and habits of the beetle, we will give the practical results reached.

AN IMPORTATION FROM EUROPE.

This beetle has done great mischief in the Old World, especially in Germany and France, and it is very important that the public know the best method of coping with it here. According to Glover, it was imported as early as 1837. Its distribution was formerly confined to limited areas near the coast, and its earlier attacks were notably about Baltimore and New Jersey.

HABITS AND NATURAL HISTORY.

The general characteristics of this insect have been pretty well studied abroad. Mr. E. Heeger† has given an excellent account of its life-history, with a detailed description of the larva and figures illus-

* This is the *Galeruca cratægi* Först., and *G. calmariensis* Fabr. In Crotch's Checklist it appears as *Galerucella xanthomelæna*.

† Seventieth contribution to the natural history of insects. Sitzungsberichte der kais. Ac. Wiss., Wien, 1858, vol. 29.

trating larva and pupa, and anatomical details. More recently M. Maurice Girard* has given a rather poor wood-cut illustration of the insect and its work, with the leading facts concerning its nomenclature and natural history as observed in Europe. Biological notes on the insect have also been given by Leinweber† and Kollar.‡

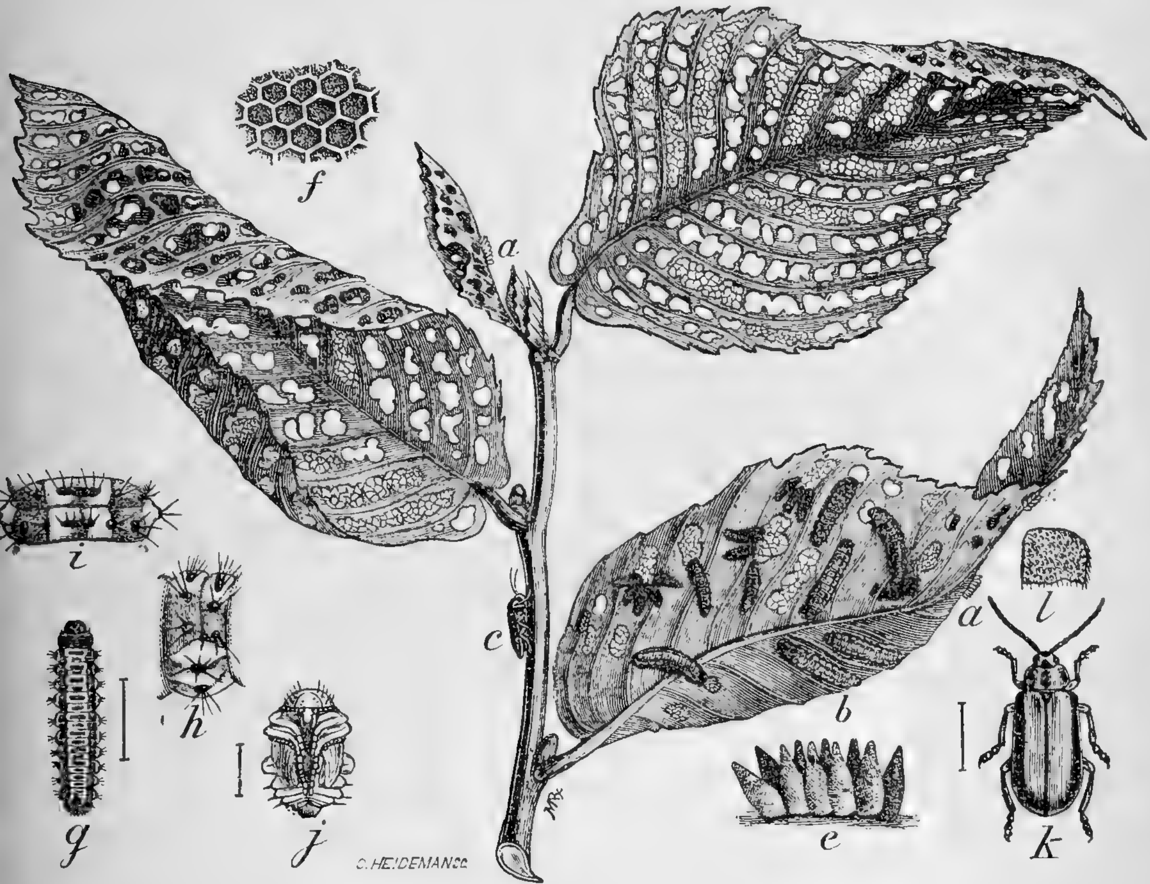

FIG. 1.—*Galeruca xanthomelana; a*, eggs; *b*, larvæ; *c*, adult; *e*, eggs (enlarged); *f*, sculpture of eggs; *g*, larva (enlarged): *h*, side view of greatly enlarged segment of larva; *i*, dorsal view of same; *j*, pupa (enlarged); *k*, beetle (enlarged); *l*, portion of elytron of beetle (greatly enlarged).

In our country the life-history of the insect and its injury have been referred to by Harris, Fitch, Morris, Walsh, and ourselves, while the agricultural papers contain numerous references to the injury inflicted by the insect. The perfect beetle has often been described in systematic works on Coleoptera.

For these reasons we deem it unnecessary to enter here into a detailed description of the beetle and its earlier stages, but content ourselves with pointing out the more obvious characters, alluding to such facts of the life-history as are necessary to a full understanding of the nature of the remedies to be applied for this pest.

The eggs are deposited in an upright position upon the under side of the leaves (Fig. 1 *a*), always in a group, consisting generally of two, rarely three, more or less irregular rows. The individual eggs are close

* Note sur la Galéruque de l'orme, Bull. d'Insectologie Agricole, VIII, pp. 113–116.

† Verhandlungen zoöl.-bot., Ges., Wien, 1856, VI, Sitzb., pp.74, 75.

‡ *Op. cit.*, 1858, VIII, pp.29, 30.

together in each group (Fig. 1 *e*, magnified), and so firmly fastened to the leaf that they can only be detached with great care without breaking the thin and brittle shell. The number of eggs in each group varies from four or five to twenty or more. Very rarely only three eggs are seen in one group, but we never found less than that number. The egg itself is oblong, oval, obtusely, but not abruptly, pointed at tip, of straw-yellow color, its surface being opake and beautifully and evenly reticulated, each mesh forming a regular hexagon, as shown, highly magnified, in Fig. 1 *f*. The form of the eggs is not quite constant, some of them, especially those in the middle of a large group, being much narrower than others. The duration of the egg-state is about one week.

The general shape of the larva is very elongate, almost cylindrical, and distinctly tapering posteriorly in the early stages, but less convex, and of nearly equal width when mature. The general color of the young larva is yellowish-black, with the black markings comparatively larger and more conspicuous, and with the hairs arising from these markings much longer and stiffer than in the full-grown larva. With each consecutive molt the yellow color becomes more marked, the black markings of less extent and of less intense color, and the hairs much shorter, sparser, and lighter in color. A nearly full-grown larva is represented in Fig. 1 *g*, and in this the yellow color occupies a wide dorsal stripe and a lateral stripe each side. The head (excepting the mouth parts and anterior margin of the front), the legs (excepting a ring around the trochanters), and the posterior portion of the anal segment, are always black. The first thoracic segment has two large black spots on the disk, of varying extent, and often confluent. The following segments (excepting the anal segment) are dorsally divided by a shallow transverse impression into two halves, and the black markings on these halves are arranged as follows: Two transversal dorsal markings, usually confluent, as shown in our figure; two round and sublateral spots; the tips of the lateral tubercles are also black. The abdominal joints of the ventral surface have each a transverse medial mark, and two round sublateral spots of black color. Stigmata visible as small umbilicate spots between outer sublateral series of dorsal markings and lateral tubercles. The yellow parts of the upper side are opake, but those of the under side shining. The black markings are polished, piliferous, and raised above the remaining portions of the body.

The larvæ are destructive to the foliage from the month of May until August. They have about two weeks of active life between the egg and pupa states. During this time they prey upon the leaves, which become skeletonized, leaving the venation, and commonly a certain portion of the flesh of the leaf, which becomes rust-brown. They undergo four molts, respectively observed at Washington on July 15 (at hatching) 20, 23, and 29 (pupation). When full grown they descend to the ground and change to pupa under whatever shelter is near to the base of the tree.

The pupa (Fig. 1 *j*) is of a brighter color than the larva, oval in shape, and strongly convex dorsally. It is sparsely covered with moderately long but very conspicuous black bristles, irregularly arranged on head and thorax, but in a transverse row on each following segment. The pupa state lasts about from 6–10 days.

The perfect beetle (Fig. 1 *c*, natural size; *k* magnified) resembles somewhat in appearance the well known striped cucumber-beetle (*Diabrotica vittata*), but is at once distinguished by the elytra not being striate-punctate but simply rugose, the sculpture under high magnifying being represented in Fig. 1 *l*. The color of the upper side is pale yellow or yellowish-brown, with the following parts black: on the head a frontal (often wanting) and a vertical spot; three spots on the thorax; on the elytra a narrow stripe along the suture, a short, often indistinct scutellar stria each side, and a wider humeral stripe not reaching the tip. Under side black, pro and mesosternum and legs yellow, femora with a black apical spot. Upper and under side covered with very fine, short, silky hairs. In newly-hatched individuals the black markings have a greenish tint; the humeral stripe varies in extent.

The beetle assists the larva in its destructive work, but, as usual in such cases, the damage done by the perfect insect is small when compared with that done by the larva. There are three or four annual generations of the insect, according to the character of the season. In the month of September the beetles prepare for hibernation, seeking shelter in hollow trees, in the ground, under old leaves, &c., and remain dormant until the following spring.

REMEDIES.

M. Girard says:

There is no other means of destruction than to jar the branches over cloths to collect the larvæ and adults which fall. It is also possible when they are on the ground to distribute on them boiling water or steam, or even quick-lime or solution of sulphocarbonate of potassium.

In our own country much more has been accomplished toward practically combating this insect.

In the U. S. Agricultural Report of 1867, Glover suggested the use of oil and tar gutters and other barriers surrounding the base or the body of the tree, devices similar to those used against the canker-worm and codling-moth. He then and afterward (1870) recommended "to place around each tree small, tight, square boxes or frames, a foot or 18 inches in height, sunk in the earth; the ground within the inclosure to be covered with cement, and the top edge of each frame to be covered with broad, projecting pieces of tin, like the eaves of a house or the letter T, or painted with some adhesive or repellant substance, as tar, &c. The larvæ descending the tree, being unable to climb over the inclosure, would change into helpless pupæ within the box, where they could daily be destroyed by thousands. Those hiding within the crevices of the bark of the trunk could easily be syringed from their hiding places." (U. S. Agricultural Report, 1870, pp. 73, 74.) These boxes were carefully tested at this Department, and they worked as described. While coal-tar and other adhesives were recommended, we have found scalding-hot water most convenient for destroying the insects that accumulate in the inclosure or upon the ground elsewhere. Where branches are low and droop near the ground some of the larvæ descend the wrong way and fall off, but shade trees should not be allowed to grow in this low, drooping manner, and under all ordinary circumstances, where the branches are not severely jarred to encourage the insects to drop, the larvæ will descend by the trunk and become captured in the devices here noticed.

Mr. Glover regarded the pupa state as the most favorable in which to kill the insect, as it can then be easily crushed or scalded. Concerning the tobacco treatment he adds that "syringing the trees with strong tobacco water has been tried with some good effect, but the larvæ not touched by the fluid are merely knocked down by the concussion, and, if nearly ready to change into pupæ, effect their transformation where they fall."

In this connection we cannot do better than quote what we published in 1880* in reply to certain statements by Dr. J. L. Le Conte, as follows:

Anent *Galeruca xanthomelæna*, which is becoming more destructive each successive year to the shade elms in our northern towns, a correspondent mentions the following facts:

1. The trees are not all attacked at the same time, but the insect seems to break out from a center, gradually destroying the more remote trees, so that isolated trees remain comparatively free.

2. After applying a band (saturated with fish-oil, petroleum, &c.) to some trees which were about half denuded, found hundreds of the worms stopped both in ascending and descending the trees.

He also propounded the following query:

3. Do the beetles hibernate in the ground, so that they can be poisoned, or are they perpetuated only by the eggs on the trees:

Allow me to add the following subjects for investigation as necessary to the devising of proper remedies against this foreign invader:

4. How soon do the insects appear in the spring; how rapidly do they propagate; and what time is passed in each stage of development?

5. Are the larvæ and beetles eaten by insectivorous birds, or are they protected by offensive secretions, as is the case with *Doryphora 10-lineata*, *Orgyia leucostigma*, and several other noxious insects?

6. What proportion of the brood hibernates, and in what stage, pupa or perfect insect, and where?

If the materials for furnishing answers to these questions are not yet within your reach, will you kindly direct the attention of some of your trusty observers to the subject, so that persons interested in the preservation of the shade trees which are so justly esteemed may be properly instructed as to the measures to be adopted during the next summer.

Very truly, yours,

J. L. LE CONTE,
Philadelphia, Pa.

The above inquiries were received from our esteemed correspondent some time since, and we employ them as a ready means of giving our experience with the beetle.

For the benefit of the general reader it may be remarked that the natural history of this Elm Leaf-beetle is quite similar to that of the well-known Colorado Potato-beetle and of the Grape-vine Flea-beetle. The only deviation in the Elm Leaf-beetle is in the mode of pupation, which rarely takes place in the ground, unless this be very friable, but at the base of the tree or under any shelter that may present itself near the trees, such as old leaves, grass, &c.

(1) The phenomenon here described is doubtless due to the gradual increase in spring from one or more females.

(3 and 6) Like most, if not all, *Chrysomelidæ*, the Elm Leaf-beetle hibernates in the perfect state. As places suitable for hibernation abound, any attempt to successfully

* *American Entomologist*, December, 1880, p. 291.

fight this pest in winter time, with a view of preventing its ravages the subsequent season, will prove fruitless. A large proportion of the hibernating beetles doubtless perish, since the insect is comparatively scarce in the earlier part of the season.

(4 and 5) The beetles fly as soon as spring opens, and we have observed the first larvæ early in May,* in Washington, D. C., or some time after the elm leaves are fully developed. The ravages of the insect begin to be apparent with the second generation of larvæ, which appear in June.

In 1878 we made many notes and experiments on the species, and the development of the third and most injurious generation occupied about one month. The numerous pupæ, which in the latter part of August were to be found under the trees, were mostly destroyed that year, partly by continuous wet weather prevailing at the time, partly by the many enemies of the insect. Among these there are *Platynus punctiformis* and *Quedius molochinus*, which feed on the full-grown larvæ when these retire for pupation, and also on the pupæ. The larva of a *Chrysopa* (probably *C. rufilabris*) feeds upon the eggs of the *Galeruca*; *Reduvius novenarius* sucks both beetles and larvæ on the leaves, while *Mantis carolina* preys upon the beetle. Of the numerous other insects found among the pupæ under the trees, *e. g. Tachyporus jocosus*, sundry spiders, myriapods, &c., several are doubtless enemies of the *Galeruca*, though we have, as yet, no proof of the fact. Many birds were observed on the trees infested by the beetles, but the English sparrow, which was the most numerous, did not feed on the insect in any stage of growth.

The only method of warfare against this pest recommended by European writers is to jar the larvæ down onto sheets, and then in one way or another to destroy them. This may answer for young trees, but is then tedious and but partial. We found that the quickest and most satisfactory way of destroying the insect and protecting the trees was by the use of Paris green and water in the manner frequently recommended in these columns, and London purple will evidently prove just as effectual and cheaper. The syringing cannot be done from the ground except on very young trees, though a good fountain pump will throw a spray nearly 30 feet high. Larger trees will have to be ascended by means of a ladder and the liquid sprinkled or atomized through one of the portable atomizers, like Peck's, which is fastened to the body and contains 3 gallons of the liquid.

The mode of pupation of the insect under the tree, on the surface of the ground, beneath whatever shelter it can find, or in the crevices between the earth and the trunk, enables us to kill vast numbers of the pupæ and transforming larvæ by pouring hot water over them. We found that even Paris-green water poured over them also killed. If the trees stand on the sidewalk of the streets the larvæ will go for pupation in the cracks between the bricks or at the base of the tree, where they can also be killed in the same way. This mode of destruction is, take it all in all, the next most satisfactory one we know of, though it must be frequently repeated.

(2) We have largely experimented with a view of intercepting and destroying the larvæ in their descent from the tree. Troughs, such as are used for canker-worms, tarred paper, felt bands saturated with oil, are all good and the means of destroying large numbers. Care must be taken, however, that the oil does not come in contact with the trees, as it will soon kill them, and when felt bandages are used there should be a strip of tin or zinc beneath them. The trouble with all these intercepting devices, however, is that many larvæ let themselves drop down direct from the tree and thus escape destruction.

In conclusion we would remark that it is highly probable that Pyrethrum powder stirred up in water might be successfully substituted for arsenical poisons, but experiments in this direction have not yet been made. From experiments we have made with dry, unmixed powder, we found that it affects very quickly the larva, pupa, and the perfect insect, but in order to be applied on a large scale and on large trees the powder must of course be mixed in water. There is, however, no danger in the judicious use of the arsenical liquids upon shade trees.

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* Some years, in Washington, it is the end of May before any larvæ hatch, and the time varies, of course, with latitude and season.

MORE RECENT EXPERIENCE AT THE DEPARTMENT.

The more recent experience in the destruction of this Galeruca on the Department grounds may now be summed up, the experiments having been intrusted to Dr. Barnard.

Past History of the Elms in question.—According to Mr. William Saunders, of this Department, these trees have been annually attacked by the European Elm Leaf-beetle since they were planted ten years ago, and about one year in three the injury has been severe, resulting in their defoliation, while in other years, as in 1879 and 1880, there appeared comparatively none. In some seasons a second or autumnal set of leaves appeared after the trees had been stripped, and in certain of these instances the second crop of leaves became eaten; but in all cases he thinks the lives of the trees have not seemed to be endangered and they soon repaired the damage done. His belief is also that the pest did not become gradually worse and worse through the series of years during which it has been observed by him, still he regards the attack of 1882 as worse than any known to him before on these trees or others, and he has noticed the effects of this insect since 1850, first in its earliest ravages about Baltimore, and later elsewhere.

Condition and Characteristics of the Grove in 1882 *and* 1883.—However it may be for the past history or future desirability of certain trees in the grove, in 1882 many exhibited various grades of feebleness, and some had dying branches. Indeed, a few of them had a very unhealthy aspect the previous year also. Of course it can be claimed that their unhealthy condition is due to other causes than the insects; and it should be remembered that most are foreign species, each often represented in two or more of its varieties. Here all grow on level ground, whereas in a state of nature some belong to mountainous localities; others to the damp climate of England, &c. Therefore, many of them are growing under abnormal conditions. They exhibit much variety in the relative abundance, size, form, and texture of the leaves. There is also great diversity in the density and form of branching.

Extent of Injury in 1882 *and* 1883.—All the varieties and species of elms in this grove, without exception, were preyed upon by the pest in 1882 and 1883. The insect, however, showed decided preferences for certain individual trees, varieties, or species, stripping some completely before doing more than very slight harm to the leaves of others, the former becoming completely eaten in midsummer, the latter not until toward the close of the season, or remaining only slightly damaged until then. In 1882 the leaves were eaten faster than they could be developed, and the insect continued abundant enough to prevent a second crop of foliage until in November, when it became too cold for the leaves and active insects to exist.

On these grounds the southeast half of each tree has suffered more than the northwest half. This peculiarity has been very strongly pronounced this year, 1883, on all the trees affected, and upon some examples far more markedly than upon others. This one-sidedness is especially apparent in the trees which were the most severely eaten. Some trees show the southeast side completely devoured, but the northwest side only half consumed and comparatively green. Such are average cases.

The inferences have been, that the shade, dampness, and coolness of the tree on the northwest side during the morning is too unhealthy for the favorable development of the larvæ or of the eggs deposited there; but whether this be true or not, the insect probably prefers to deposit chiefly in the middle of the forenoon, and on that part of the tree which is then warmest. This would give a greater number of the eggs at the outset on the southeast side, as observation seems to confirm, and since the young larvæ do not migrate to any noteworthy extent, the one-sidedness described would result, whether the northwest side were unhealthy or not. The former explanation is most probably the correct one, as we have noticed that the insect is less injurious during very wet summers.

Preferences of the Elm-beetles for certain Varieties and Species of Elms.—The American Slippery Elm does not occur in this grove, but only one native species, the common American Elm, *Ulmus americana.* This is practically free from the ravages of the beetle, on which account it may be preferred to the European species. It is tall, and has gracefully arched branches, making it as ornamental as any European kind, yet as a shade tree it does not equal the *U. montana* of the Old World. The latter has a broader, denser crown, but the attack on it is considerable, enough to leave the choice in favor of the American species.

U. montana seems the best European species grown here for shade, since the other foreign elms here cultivated are not dense enough. This applies to *U. campestris*, *U. suberosa*, *U. effusa*, and *U. parvifolia* (*siberica*). The last named is not attacked as much as the American. The young larvæ cannot develop on it, but die quite soon, without growing, and they gnaw the leaves very little. The other foreign species mentioned are seriously eaten; the severest attack being upon the *U. campestris*, the favorite food of this insect.

As early as June 25, in 1883, this species was completely eaten and brown in our grove, at which date the *U. montana* examples retained more than half their verdure; in some individuals nearly all; and the common American elm was perfectly green. The *U. campestris* is one of the poorest elms for shade, and its total abolishment throughout the entire country would probably lessen the assault on *U. montana* to a comparatively unobjectionable extent. This measure should be instituted against the pest, and for the sake of the other species of elms.

Effects of arsenical Poisons on Insect and Plant.—Species of elms are somewhat differently affected by the poison. When treated alike there is always manifest some difference in the susceptibility of different elms to the corrosive effects of the poison. Even individuals of the same species or variety are differently impaired. As a rule, those which suit the insect best are injured most by the poison, and those which resist the insect most withstand the poison best. The latter have coarser foliage with a darker green color and more vigorous general growth; the former have more delicate foliage, lighter in color and weight, apparently less succulent.

Certain elms of the species *U. campestris* and other species which were overpoisoned, and shed most of their leaves in consequence, in the last of June, 1883, sent out a profuse new growth of leaves and twigs. The foliage fell gradually for three weeks, and this was somewhat promoted by the succeeding rains.

The larvæ move from place to place so seldom that if the leaves are imperfectly poisoned from the mixture being weakly diluted, or from its application only in large, scattered drops, which are much avoided by the larvæ, they are not killed off thoroughly for several days, and in all cases it requires considerable time to attain the full effect of the poison. This result appears on the plant and on the insect. After each rain the poison takes a new effect upon the plant and the pest, which indicates that the poison is absorbed more or is more active when wet, and that it acts by dehydrating thereafter. Where the tree is too strongly poisoned, each rain causes a new lot of leaves to become discolored by the poison or to fall. On some of the trees the discoloration appears in brown, dead blotches on the foliage, chiefly about the gnawed places and margins, while in other instances many of the leaves turn yellow, and others fall without change of color. The latter may not all drop from the effects of poison, but the coloration referred to is without doubt generally from the caustic action. The poison not only produces the local effects from contact action on the parts touched by it, but following this there appears a more general effect, manifest in that all the foliage appears to lose, to some extent, its freshness and vitality. This secondary influence is probably from poisoning of the sap in a moderate degree. When this is once observable, no leaf-eater thrives upon the foliage. Slight overpoisoning seems to have a tonic or invigorating effect on the tree.

Preventive Effects of the Poison.—In this grove the elms that were poisoned in 1882 were attacked in the spring of 1883 less severely than were those which were not poisoned the previous year. This would seem to imply that the insects deposit mostly on the trees nearest to where they develop, and are only partially migratory before ovipositing. The attack afterward became increased, probably by immigration and the new generation, so that later in the season the trees were mostly infested to the usual extent.

In the region of Washington *a preventive application of poison should be made* before the last of May or first of June, when the eggs are being deposited and before they hatch. This will prevent the worms from ever getting a start. By the preventive method the tree escapes two kinds of injury; first, that directly from the eating by the insect; second, that which follows indirectly from the deleterious effects of the poison on the plant, for its caustic effect is much greater where the leaves have been so gnawed that the poison comes in contact with the sap.

Treatment with London purple.—Already early in June the insect appears plentiful. On June 7, 1882, it was at work on all the trees, and its clusters of eggs were numerous beneath the leaves. Some of the trees had half of the leaves considerably gnawed and perforated by larvæ of all sizes, and by the adults. At this date fifteen trees, constituting the south part of the grove, were treated.

Preparation of the Poison.—London purple (one-half pound), flour (3 quarts), and water (barrel, 40 gallons) were mixed, as follows: A large galvanized iron funnel of thirteen quarts capacity, and having a cross-septum of fine wire gauze, such as is used for sieves, also having vertical sides, and a rim to keep it from rocking on the barrel, was used. About three quarts of cheap flour were placed in the funnel and washed through the wire gauze by water poured in. The flour in passing through is finely divided, and will diffuse in the water without appearing in lumps. The flour is a suitable medium to make the poison adhesive. The London purple is then placed upon the gauze and washed in by the remainder of the water until the barrel is filled. In other tests the flour was mixed dry with the poison powder, and both were afterward washed through together with good results. It is thought that by mixing in this way less flour will suffice. Three-eighths of a pound of London purple to one barrel of water may be taken as a suitable percentage. Three-eighths of an ounce may be used as an equivalent in one bucketful of water. The amount of this poison was reduced to one-fourth of a pound to the barrel with good effect, but this seems to be the minimum quantity, and to be of value it must be applied in favorable weather and with unusual thoroughness. With one-half or three-fourths of a pound to the barrel, about the maximum strength allowable is attained, and this should be applied only as an extremely fine mist, without drenching the foliage.

Effects of the Mixture.—The flour seems to keep the poison from taking effect on the leaf, preventing to some extent the corrosive injury which otherwise obtains when the poison is coarsely sprinkled or too strong. It also renders the poison more permanent. On the leaves, especially on the under surfaces, the London purple and flour can be seen for several weeks after it has been applied, and the insect is not only destroyed, but is prevented from reappearing, at least for a long period. By poisoning again, a few weeks later, the insect is deterred with greater certainty for the entire season. By being careful to administer the poison before the insect has worked, and, above all, to diffuse the spray finely but not in large drops, no harm worth mentioning will accrue to the plant from the proportion of poison recommended. The new growth, that developed after the first poisoning, was protected by one-fourth of a pound to the barrel in 1882. From midsummer until autumn the unpoisoned half of the grove remainded denuded of foliage, while the poisoned half retained its verdure. The little damage then appearing in the protected part was mostly done before the first treatment. Eggs were laid abundantly throughout the season. Many of these seemed unhealthy and failed to develop, probably because they were poisoned. Many hatched, but the young larvæ soon died. The eggs were seldom deposited on the young leaves that were appearing after the poison was applied, but were attached to the developed leaves, and here the larvæ generally got the poison to prevent their attack upon the aftergrowth. Still the young leaves became perforated to some extent. The adults, which fly from tree to tree, appeared plentifully without much interruption throughout the season, and often several could be seen feeding on each tree. Possibly many of these may have become poisoned before depositing the eggs.

The efficiency of London purple being established, it will generally be preferred to other arsenicals, because of its cheapness, better diffusibility, visibility on the foliage, &c. As the effects of the poisons commonly do not appear decidedly for two or three days after their administration, the importance of the preventive method of poisoning in advance cannot be too strongly urged. As the effect is slow in appearing, impatient parties will be apt to repoison on the second or third day, and thus put on enough to hurt the plant when the effect does come. Much depends on dryness or wetness of the weather; but good effects may be expected by the third or fourth day.

London purple seems to injure the plant less than Paris green.

Treatment with Paris green.—In 1883 the Paris green was first applied on the 29th of May, at which date the eggs were extremely abundant and hatching rapidly on the leaves. Paris green, flour, and water were mixed by the means previously employed with London purple and already described. The mixture was applied to the north part of the same grove of elms. Thus far experience shows that the Paris green is effective against the insect, but that this poison injures the plant more than does the London purple.

Three-fourths of a pound of Paris green to a barrel (36 or 40 gallons) of water, with 3 quarts of flour, may be regarded as a poison mixture of medium or average strength for treating elms against these beetles, and the indications thus far are that the amount of Paris green should not be increased above one pound or be diminished much below one-half a pound in this mixture. To a bucketful of water three-fourths of an ounce of Paris green may be used. The action of this poison is slow but severe, and varies much with the weather. Thus far the results of tests have been varied so much by the weather and different modes of preparation and application that they will be repeated. When used strong enough to cauterize the leaves the poisonous action upon the plant may be observed to continue for several weeks.

Mechanical Means of applying the Poison.—When many trees were to be sprayed a cart or wagon was employed to haul the poison in a large barrel provided with a stirrer, force-pump, skid, &c. The following brief account of the skid, mixer, barrel, and pump may be reproduced here from our Annual Report for 1882:

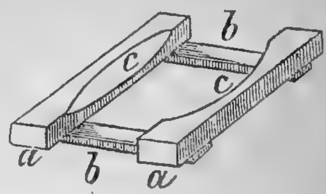

FIG. 2.—*Barrel rest or skid;* two coupling cleats, *b b*: two side rests, *a a*; chamfered concave, *c c*.

The skid is a simple frame to hold the horizontal barrel from rolling, and consists of two pieces (Fig. 2 *a a*) of wood, about the length of the barrel, and in section about 3 by 4 inches, joined parallel, apart from each other, by two cleats, *b b*. The inner upper angles may be cut to match the curve of the barrel, as at *c c*. The barrel being placed upon this frame is next to be filled.

A good device for mixing the poison thoroughly with the water and for filling the barrel is shown in section in Fig. 3. It consists of a large funnel that will hold a bucketful, and has cylindrical sides, *g g*, that rest conformant on the barrel. In this is a gauze or finely perforated diaphragm, or septum, *d*, and a funnel base, *t t*, with its spout, *p*, inserted through the bung.

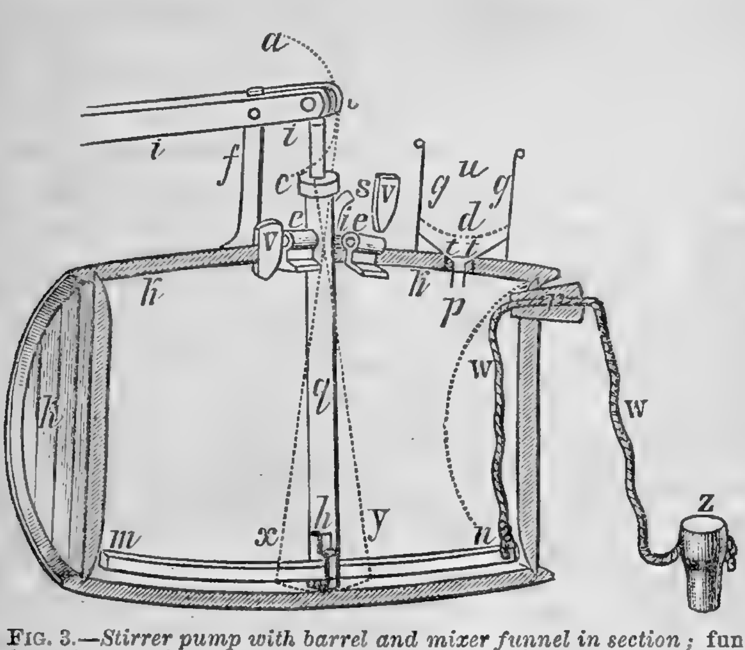

FIG. 3.—*Stirrer pump with barrel and mixer funnel in section;* funnel, *u*; its cylindrical sides, *g g*; funnel base, *t t*; spout, *p*; (in bung-hole, *k*), gauze septum, *d*; barrel, *k k*; trunnions, *i*; trunnion eyes, *e*; wedge, *v*; lever-fulcrum, *f*; pump lever, *i i*; swing of the lever head and piston top, *a b c*; cylinder packing cap, *c*; cylinder, *q*; its swing, *x y*; stirrer loop or eye, *h*; stirrer bar, *m n*; rope, *w w*; bung, *r z*.

By reference to Fig. 3, the barrel, *k*, will be seen in section, and some of its details, together with those of the pump and stirrer, may be noticed. The fulcrum, *f*, has a foot below, screwed to the barrel. Through its top is a pivot, *o*, on which tilts the pump-lever, *l*, which is similarly hinged at *b* to the top of the piston-rod, *t*. The pump-cylinder, *g*, is also hung upon trunnions, *i*, projecting into eyes. In this illustration the eyes, *e e*, have each a neck fitting in a slot cut through the stave, opposite from the side of the bung-hole, and beneath the stave is a foot on the eye-piece. Its neck is so short that the eye is held down firmly against the top of the stave, while the foot is as tight against its under surface. The length of its eye-piece is a little less than the diameter of the bung-hole, into which it may be inserted to be driver laterally into the slot. The slot is longer than the eye-piece, so the latter may be driven away from the bung-hole for a distance greater than the length of the trunnion pivot. Then the pump being inserted, until these pivots come opposite the eyes, the latter may be driven back as sockets over the pivots, which play in them when the pump is worked. To hold these eyes toward the pump and upon the trunnions a wedge, *r*, is driven in the slot beyond each eye-piece. Thus the pump is easily attached or removed, and its union with the barrel is strong and firm. Perchance it be desired that this pump-hole be bunged, the side slots may be wedged to make the barrel tight.

The parts of the pump being hung as described, the hinge, *b*, forms a toggle-joint, and in its action causes the pump to oscillate on its trunnions, its basal end swinging wider than its top, as indicated by the dotted line from *x* to *y*. Upon the extremity of this swinging end is a loop, *h*, through which is passed the stirrer-bar, *m n*, made to sweep back and forth in the lower side of the barrel, thus to agitate and mix the substances considerably during the operation of the pump, every stroke of the handle causing one or two strokes of the stirrer.

The method of inserting and extricating the stirrer-bar is as follows: It is raised with the pump until the end, *m*, comes opposite the bung-hole, *x*, through which the bar may be pulled out by the cord, *w*, which is attached to the end, *n*, and also preferably to the bungs *r* and *z*, as shown. Through the same hole the bar may be inserted. This stirring device is the simplest in construction and operation of any yet contrived. While working as it does with reference to the concavity of the barrel it is perfectly effective.

The pump is double-acting and very powerful, giving strong pressure to disperse the liquid far and finely, for, with the eddy-chamber nozzle used, the greater the pressure the finer is the liquid atomized. A block or other catch may be fixed on the side of the barrel to fit against the skid and prevent the barrel from rocking therein, as might otherwise happen when it is nearly empty if much power is applied. About one pailful of poisoned water was sprayed upon each tree. When only two or three trees were to be treated an Aquapult or other bucket-pump was used to force the poison from a bucket carried by hand. The Paris-green mixture needs to be almost constantly stirred, as this poison precipitates quickly; but with London purple the agitation is only occasionally necessary.

Connected with either pump is a long, flexible pipe, with its distal part stiff, and serving as a long handle whereby to hold its terminal nozzle beneath the branches or very high up at a comfortable distance from the person managing it. Parts of one form of this extension pipe are shown in Figs. 4 and 5.

To the pump spout is attached the long, 2-ply, flexile hose, *h h*, of ¼-inch caliber. Its considerable length, 12 feet or more, allows the nozzle to be carried about the tree without moving the pump. Beyond its flexile part the hose, *h*, passes through a bamboo pole, *b*, from which the septa have been burned out by a hot iron rod. At the distal end of the pole the hose terminates in a nozzle, *n* or *m*. When the nozzle is in its natural position, *m*, the spray, *z*, is thrown straight ahead, and this suits well for spraying very high branches, but for spraying the under surfaces of the lower parts of the tree it is necessary that the nozzle discharge laterally from the pipe, and this is accomplished with a nozzle having a direct discharge by bending it to one side. The nozzle, *n*, and spray, *s*, are directed laterally, and the nozzle, *n*, is maintained in this position by a metallic hook or eye, *v*, having a crooked stem inserted at the side of the hose in the end of the pole. Where the side spray is permanently desired, the metallic stem is inserted inside the hose and connected with the base of the nozzle, or the tubular stem of the nozzle is given the desired crook. For small trees the simpler extension pipe shown in Fig. 5 is satisfactory The metallic tube, *t*, several feet in length, is used as the stiff part, *t*, connected with the hose, *h*. One longer metallic pipe, having telescopic sections made tight by outside segments of rubber tubing, has also been employed, and is a very desirable extension pipe. Where only low end-spraying is to be done, as upon small trees, &c., the eddy-chamber nozzle (Fig. 6) is set upon such a pipe, or upon its own stem, so as to discharge at right angles therefrom ; but a diagonal position of the chamber, *n*, on its stem, *i*, throws the spray, *s*, at an intermediate angle between the right angle and a direct line, by which, without any readjustment, the spray, *s*, can be directed higher or lower. beneath the foliage or above. For general use, this kind of nozzle is the best. It consists of a shallow, circular, metal-chamber (Fig. 6, *c*), soldered to a short piece of metal tubing, *a*, as an inlet. The inlet passage, *x*, penetrates the wall of the chamber tangentially, admitting the fluid eccentrically, and causing it to rotate rapidly in the chamber. The outlet consists of a small hole, *s*, drilled in the exact center of the face, *e*, of the chamber, and through this outlet the fluid is driven perpendicularly to the plane of rotation in the chamber, and converted into a very fine spray. For a full description of this nozzle the reader is referred to our report as Entomologist to the Department of Agriculture for the years 1881–'82, p. 162. With ordinary force-pump pressure the discharge-hole of the nozzle is about one sixteenth of an inch in diameter for misty sprays with particles invisibly small. Rather than use the larger, coarser sprays, which were usually employed in these tests, it is better to use the finest spray. The spray falling upon the extension pipe soon accumulates enough to flow down the pole and wet the hands. To prevent this a wrapping washer of leather or other flange

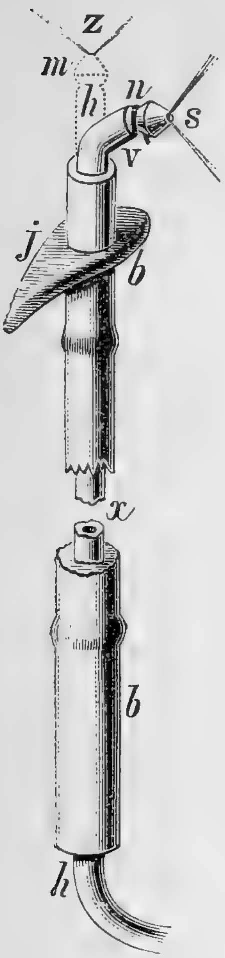

FIG. 4.—*Parts of hose-pole device for spraying trees* ; bamboo pole, *b b* ; drip washer, *j* ; hose, *h x* ; side hook, *v* ; eddy chamber nozzle, *n m* ; spray, *z s*.

FIG. 5.—*Metallic hand pipe with diagonal nozzle*: hose, *h* ; metallic pipe, *t* ; diagonal eddy chamber nozzle, *n* ; its removable face, *i* ; spray, *s*.

may surround the pole proximally from the spray, and the drip will drop off from its margin. Such an arrangement is indicated at *j* in Fig. 4.

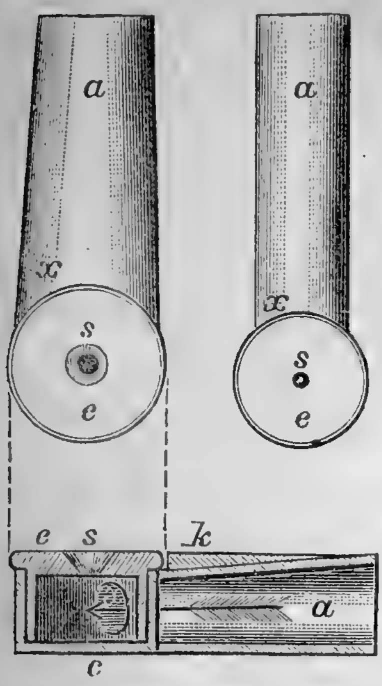

FIG. 6.—*Eddy-chamber nozzle*, natural size; face view and section.

While one person operates the pump, another, standing in the vehicle or upon the ground, directs the spray by the stiff part of the pipe. Thus the operator can not only spray higher and lower with convenience, but he can, to a great extent, move the spray from place to place without leaving his own position and without moving the vessel of poison with the pump.

The hose and bamboo combination was conceived of, and used as the lightest, long, stiff tube practicable for these purposes, and it has answered admirably. A similar pole, with a metallic tube in its interior, with a nozzle not producing the very fine mist desired, and lacking the side discharge, &c., was afterward learned of as being used in California. (See Agricultural Department Report, 1881-'82, p. 208.)

By the apparatus used, when everything is prepared, a tree can be sprayed quickly, and a large grove is treated in a short time. It is equally adapted for forestry use in general, and likewise available for poisoning on fruit trees, when not in fruit, while the shorter style of extension-pipe is convenient for underspraying all kinds of low plants.

THE BAG-WORM.

(*Thyridopteryx ephemeræformis* Haw.)

Although this species was not particularly destructive to our shade-trees in 1886, and in numbers greatly inferior to the Fall Web-worm and the Tussock-moth, yet in 1879 it was much more formidable, and at irregular intervals becomes a great pest where not properly dealt with, especially in more southern States. For the past two or three years it has been on the increase in special localities in Washington, and should be carefully looked after.

HABITS AND NATURAL HISTORY.

The Eggs.—During winter time the dependent sacs or bags of this species may be seen hanging on the twigs of almost every kind of tree. If they happen to be on coniferous trees, and they are usually more abundant on these than on deciduous trees, they are not infrequently mistaken for the cones. In reality they are the coverings spun by our worm, and they serve not only as a protection to it, but also to the eggs. Upon cutting open the larger of these bags in winter time they will be found to contain the shell of a chrysalis (technically called the puparium), which is filled with numerous small yellow eggs (Fig. 7 *e*). Each of these is a little over 1 millimeter in length, obovate in form, and surrounded by a delicate, fawn-colored, silky down. In this condition the eggs remain from fall throughout the winter and early spring.

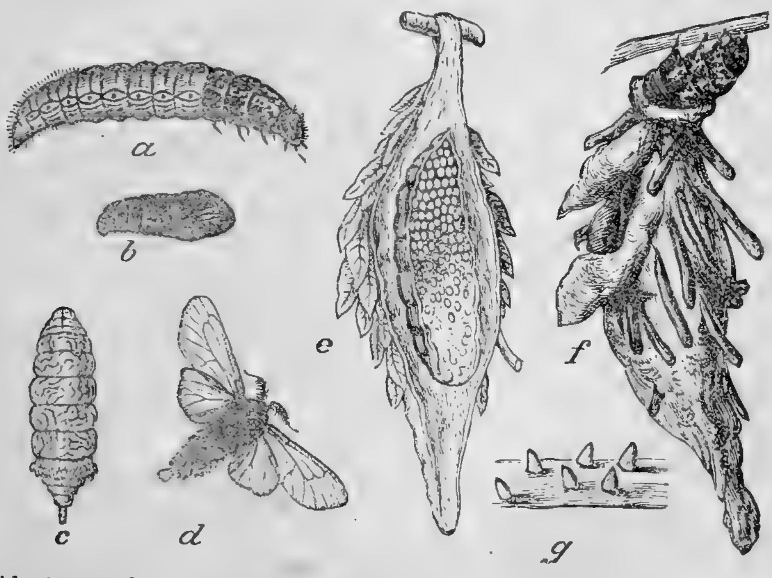

FIG. 7.—*Thyridopteryx ephemeræformis*: *a*, larva; *b*, male chrysalis; *c*, female moth; *d*, male moth; *e*, follicle and puparium cut open to show eggs; *f*, full grown larva with bag; *g*, young larvæ with their conical upright coverings; all natural size.

The Larva and its Bag.—About the middle of May in this latitude the eggs hatch into small but active larvæ, which at once commence to construct a portable case or bag in which to live. The way in which this bag is prepared is curious (Fig. 8). The young larva crawls on a leaf, and

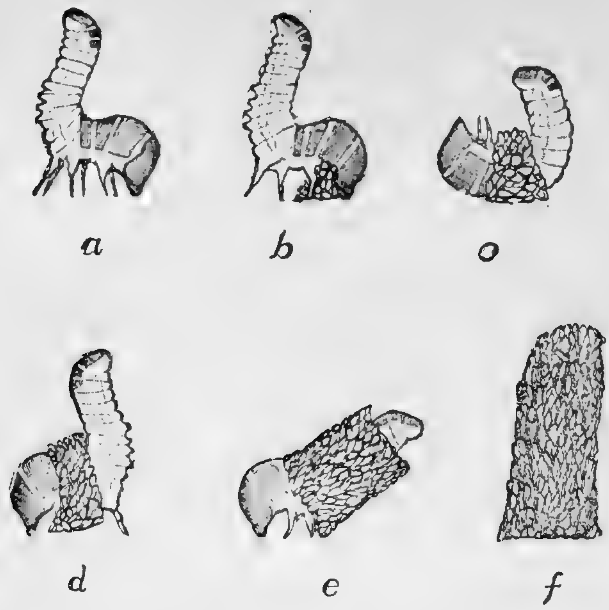

FIG. 8.—*Thyridopteryx ephemeræformis.* How the young larva prepares its bag.

gnawing little bits from the surface, fastens these together with fine silk, produces a narrow, elongate band, which is then fastened at both ends onto the surface of the leaf by silky threads. Having secured itself from falling down by some threads, it now straddles this band and, bending its head downward (Fig. 8 *b*), makes a dive under it, turns a complete somersault and lies on its back, held down by the band (Fig. 8 *c*). By a quick turning movement the larva regains its feet, the band now extending across its neck (Fig. 8 *d*). It then adds to the band at each end until the two ends meet, and they are then fastened together so as to form a kind of narrow collar which encircles the neck of the worm. Far from resting, it now busies itself by adding row after row to the anterior or lower end of the collar, which thus rapidly grows in girth and is pushed further and further over the maker (Fig. 8 *e*). The inside of this bag is now carefully lined with an additional layer of silk, and the larva now marches off, carrying the bag in an upright position (Fig. 7 *g* and Fig. 8 *f*). When in motion or when feeding, the head and thoracic segments protrude from the lower end of the bag, the rest of the body being bent upward and held in this position by the bag. As the worms grow they continue to increase the bags from the lower end and they gradually begin to use larger pieces of leaves, or bits of twigs or any other small objects for ornamenting the outside. Thus the bags will differ according to the different kind of tree or shrub upon which the larva happens to feed; those found on coniferous trees being ornamented with the filiform pine leaves, usually arranged lengthwise on the bag, while those on the various deciduous trees are more or less densely and irregularly covered with bits of leaves interspersed with pieces of twigs. When kept in captivity the worms are very fond of using bits of cork, straw, or paper, if such are offered to them. When the bags, with the growth of the larva, get large and heavy, they are no longer carried, but allowed to hang down (Fig. 7 *f*). The worms undergo four molts, and at each of these periods they close up the mouth of their bags to remain within until they have cast their skin and recovered from this effort. The old skin, as well as the excrement, is pushed out through a passage which is kept open by the worms at the extremity of the bag.

The young larva is of a nearly uniform brown color, but when more full-grown that portion of the body which is covered by the bag is soft, of light-brown color and reddish on the sides, while the head and thoracic joints are horny and mottled with dark-brown and white (Fig. 7 *a*). The numerous hooks with which the small, fleshy prolegs on the middle and posterior part of the body are furnished, enable the worm to firmly cling to the silken lining of the bag, so that it can with difficulty be pulled out.

The bag of the full-grown worm (Fig. 7 *f*) is elongate-oval in shape, its outlines being more or less irregular on account of the irregularities in the ornamentation above described. The silk itself is extremely tough and with difficulty pulled asunder.

The larvæ are poor travelers during growth, and though, when in great numbers, they must often wander from one branch to another, they rarely leave the tree upon which they were born unless compelled to do so by hunger through the defoliation of the tree. When full-grown, however, they develop a greater activity, especially when very numerous, and, letting themselves down by a fine silken thread, travel fast enough across sidewalks or streets and often for a considerable distance until they reach another tree, which they ascend. This migratory desire is instinctive; for should the worms remain on the same tree they would become so numerous as to necessarily perish for want of food.

Pupation.—The bags of the worms which are to produce male moths attain rather more than an inch in length, while those which produce females attain nearly double this size. When ready to transform, the larva firmly secures the anterior end of the bags to a twig or branch, and instinct leads it to reject for this purpose any deciduous leaf or leaf-stem with which it would be blown down by the winds. The inside of the bag is then strengthened with an additional lining of silk, and the change to chrysalis is made with their heads always downward. The chrysalis is of a dark-brown color, that of the male (Fig. 7 *b*) being only half the size of that of the female (Fig. 7 *e* and Fig. 9 *a*).

The Imago or perfect Insect.—After a lapse of about three weeks from pupation a still greater difference between the two sexes becomes apparent. The male chrysalis works its way to the lower end of the bag and half way out of the opening at the extremity. Then its skin bursts and the imago appears as a winged moth with a black, hairy body and glassy wings (Fig. 7 *d*). It is swift of flight, and, owing to its small size and transparent wings, is rarely observed in nature. The life-duration of this sex is also very short. The female imago is naked (save a ring of pubescence near the end of the body of yellowish-white color), and entirely destitute of legs and wings (Fig. 7 *c*, and Fig. 9 *b*). She pushes her way partly out of the chrysalis, her head reaching to the lower end of the bag, where, without leaving the same, she awaits the approach of the male. The manner in which the chrysalis shell is elongated and reaches to the end of the bag is shown in Fig. 9 *a*, and an enlarged side view of the female, showing the details of structure, is shown at *b*, in the same figure. The extensility of the male genitalia, which permits him to reach the female within her bag, is set forth in the accompanying Fig. 10, where the parts are shown at rest, *c* and *d*, and in action, *b*. Fertilization being accomplished, the female works her way back within the chrysalis skin and fills it with eggs, receding as she does so toward the lower end of the bag, where, having completed the work of oviposition, she forces, with a last effort, her shrunken body out of the opening, drops exhausted to the ground, and perishes. When the female has withdrawn the slit at the head of the puparium and the elastic opening of the bag close again, and the eggs thus remain securely protected till they are ready to hatch the ensuing spring.

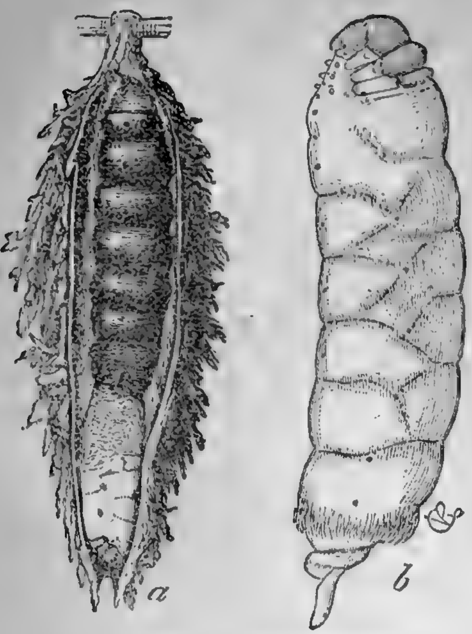

FIG. 9.—*Thyridopteryx ephemeræformis*: *a*, Follicle cut open to show the manner in which the female works from her puparium and reaches the end of the bag, natural size; *b*, female extracted from her case, enlarged.

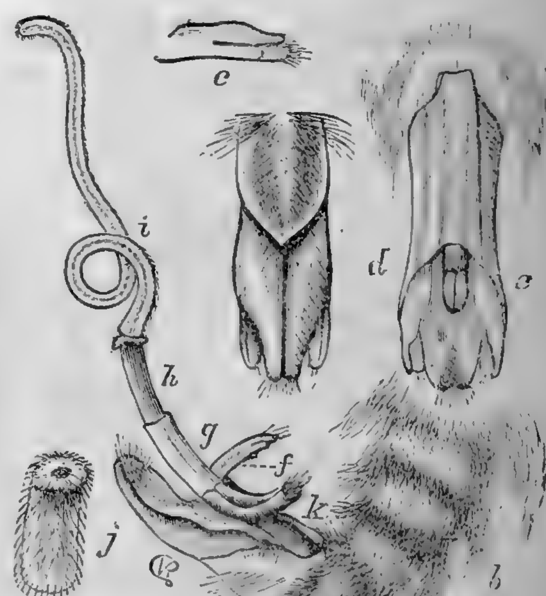

FIG. 10.—*Thyridopteryx ephemeræformis*: *b*, The end of male abdomen from the side, showing genitalia extended; *c*, genitalia in repose ventral view; *d*, do , dorsal view enlarged.

GEOGRAPHICAL DISTRIBUTION.

The Bag-worm occurs most frequently in the more southern portion of the Middle States and in the Southern States, but seems to be absent from the Peninsula of Florida. Within these limits it extends from the Atlantic to Texas, and reaches the less-timbered region west of the Mississippi. Northward, it is occasionally found in New York, and even Massachusetts, but so rarely and locally restricted that neither Dr. Harris nor Dr. Fitch mention it in their publications on economic entomology. Wherever it occurs it prefers the gardens and parks within or near the cities, being much less abundant in the woods remote from cities, and this dependence upon the vicinity of human civilization is more marked in this species than in any of the others here treated of.

FOOD PLANTS.

The Bag-worm is known to feed on a large number of trees and shrubs, but has a predilection for certain kinds of coniferous trees, notably the Red Cedar and Arbor Vitæ, and as these evergreens are much less able to stand the loss of their foliage than the deciduous trees, the worms are much more dangerous to the former than to the latter. The Hard Maples are, as a rule, avoided by the worms, and it is also quite noticeable that they are not particularly fond of oak leaves and those of the Paulonias. The Ailanthus trees are also generally exempt from their attacks, either on account of the unpleasant taste of the leaves, or perhaps on account of the compound nature of the leaves, the worms fastening their bags to the leaf stems which fall to the ground in Fall. With these exceptions,* the worms, when sufficiently numerous, do great damage to most other kinds of trees used in our cities as shade and park trees.

ENEMIES.

The Bag-worm is so well protected in all its stages that no insectivorous bird nor predaceous insect is known to attack it. In spite of

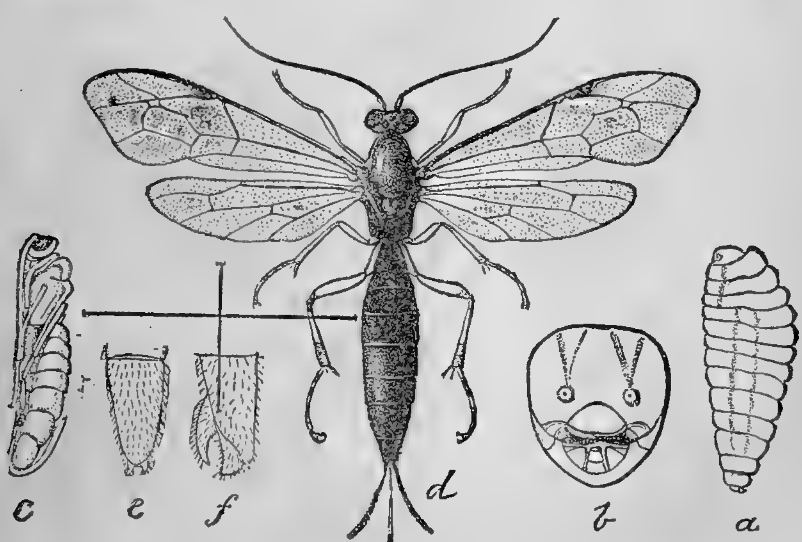

FIG. 11.—*Pimpla conquisitor: a*, larva; *b*, head of do. from front; *c*, pupa; *d*, adult female (hair line indicating natural size); *e*, end of male abdomen from above; *f*, same from the side—all enlarged.

the absence of predaceous enemies, the Bag-worm suffers from the attacks of at least six true parasites, while two others, which may be

* The China trees of our Southern cities are entirely exempt from the worms.

primary but are probably secondary. are reared from the bags. Three of these are Ichneumonids, viz: (1) *Pimpla conquisitor* Say (Fig. 11); (2) *Pimpla inquisitor* Say, and (3) *Hemiteles thyridopterigis* Riley (Fig. 12).

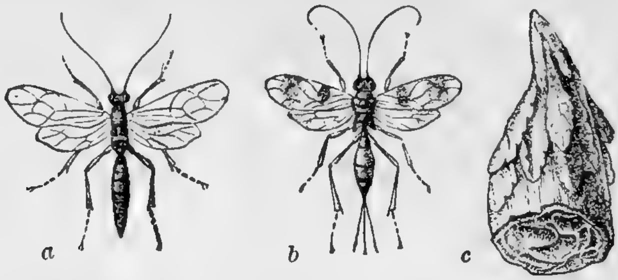

FIG. 12.—*Hemiteles thyridopterigis: a*, male; *b*, female; *c*, sack of bag-worm cut open, showing cocoons of parasite, natural size.

Of these, the last-named is most abundantly bred, and we have always considered it as the most important parasite of the Bag-worm. The past season, however, we have ascertained that three species of the genus *Hemiteles*, viz: *H. utilis*, and two undescribed species, are unquestionably secondary parasites, and this renders it quite likely that *H. thyridopterigis* may also be secondary, or, in other words, a parasite of one of the true parasites of the Bag-worm. It is a question, however, which only the most careful study, with abundant material, can decide, as the law of unity of habit in the same genus finds many exceptions in insect life. The other parasites are as follows: (4) *Chalcis ovata* Say. This parasite is a very general feeder on Lepidopterous larvæ, and we have bred it from seven widely different species. (5) *Spilochalcis mariæ* (Riley). This species, while parasitic on Thyridopteryx, is more partial to the large silk-spinning caterpillars, as we have reared it from the cocoons of all of our large native Silk-worms. (6) *Pteromalus* sp. This undescribed Chalcid is found very abundantly in the Bags, but may be a secondary parasite. (7) *Dinocarsis thyridopterygis* Ashmead. This parasite was bred from the Bags in Florida by Mr. William H. Ashmead, who believes it to be parasitic on the eggs. (8) *Tachina* sp. We have bred a large bluish Tachinid from the Bags. Its eggs are commonly attached to the Bags externally, near the neck, and the young larvæ, on hatching, work their way into the case. They frequently fail, however, to reach the Bag-worm.

THE WHITE-MARKED TUSSOCK-MOTH.

(*Orgyia leucostigma* Smith & Abbot.)

HABITS AND NATURAL HISTORY.

The Eggs.—During the month of June, and more especially late in fall and throughout the winter, glistening white objects may be seen on the trunks and the larger branches of trees, or in the corners of the fences near by, or on bunches of dead leaves hanging on the tree (see Fig. 13 *a*). Upon examination these masses will be found to be glued onto a cocoon of dirty gray color, and to consist of numerous perfectly round, cream-white eggs, which are partly covered by a glistening white froth

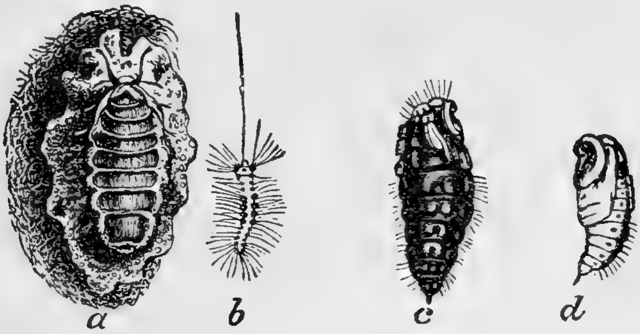

Fig. 13.—*Orgyia leucostigma*: *a*, female on cocoon; *b*, larva; *c*, female pupa; *d*, male pupa.

or spittle-like matter. In one of these egg-masses which we received from Kansas we have counted as many as 786 eggs, while from another mass we obtained upward of 400 young caterpillars.

Development and Characters of the Larva.—In the latitude of Saint Louis, Mo., and Washington the eggs begin to hatch about the middle of May, and the newly-born caterpillar, not quite 3 millimeters in length, is of dull whitish-gray color, with the under side paler, the upper side being covered with rather long hairs and tufts of a dark-brown color. In two days from hatching small orange spots begin to appear along

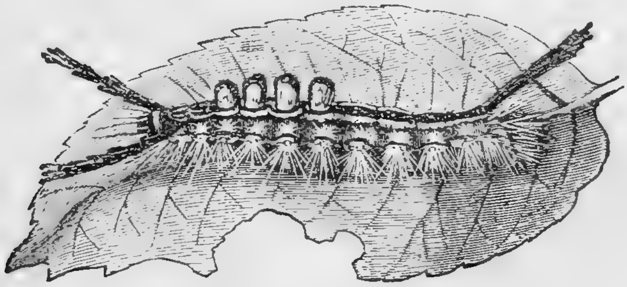

Fig. 14.—*Orgyia leucostigma*: female caterpillar.

the back, and on the seventh day the first molt takes place, to be followed at intervals of six days each by the second and third molts. The changes that take place during this time in the appearance of the caterpillar are remarkable, and after the third molt it is a beautiful object and of striking appearance (Fig. 14). The head and two little elevated spots situated on joints 9 and 10, are bright vermilion-red; the back is velvety black with two bright yellow subdorsal lines, and another yellow line each side along the lower sides. The whole body is thinly clothed with long pale yellow hairs, originating from small wart-like elevations. Four cream-colored or white dense brushes of hair are in a row on the middle of the fourth, fifth, sixth, and seventh dorsal joints, while from each side of the head arises a long plume-like tuft of black hair projecting forward and outward. A similar plume projects upwards from the last dorsal joint. The hairs composing these plumes are coarse, barbed, knobbed, and arranged in sets of unequal length, thus giving the plumes a turbinate appearance.

Habits of the Larva.—The young caterpillars scatter all over the tree soon after hatching. When disturbed they make free use of a fine silken thread which they spin, and by which they let themselves down. The full-grown larvæ are often seen to change quarters and travel from one branch to another, or from one tree to another. Their rather quiet way of moving contrasts strongly with the nervous movements of the Fall Web-worm.

A new Form of Orgyia Attack.—In the first edition we omitted to make mention of a most interesting account of a new form of Orgyia attack which had just been published at that time by Mr. Lintner in his second report as State entomologist of New York. We can not now do better than to insert his account of this peculiar injury in his own words. It is an interesting instance of a new habit having been locally acquired, and, so far as we have been able to ascertain, it has been observed nowhere else—

"In the summer of 1883, contemporaneously with the first appearance of the Orgyia attack upon the foliage, between the 10th and the 15th of June, the sidewalks, streets, and public parks in Albany, wherever the white elm (*Ulmus Americanus*) was growing, were observed to be sprinkled with newly-fallen leaves. They continued to drop in increasing number until toward the close of the month, when, in many places where they had been permitted to lie undisturbed, they completely covered the walks or ground.

"Upon taking some of them up for examination, they were found to be attached to the tips of the twigs and to comprise nearly all of the new growth of the season. The pieces were from 2 to 3 inches in length, each bearing from four to ten fresh uninjured leaves. It was evident that they were not being broken off by unusually high winds, for even in the absence of winds each day continued to add to their number and to increase the abundance of the fall.

"Making critical observation for the discovery, if possible, of the cause of so unusual a phenomenon, it was noticed that from above the point at which the tip had been broken the bark was entirely removed for an extent averaging one-tenth of an inch. The manner of its removal showed it to have been eaten by an insect. The suggestion was made to me that it was the work of some small insect of similar habits to those of the twig girdler, *Oncideres cingulatus* (Say), but the closest examination failed to show either scar or egg within the tip.

"From the character of the injury, together with the abundant presence of the caterpillar upon the trees at the time, and of no other observed depredator, I believed that it was the work of the Orgyia. If so, it was of especial interest, as showing a new habit developed, for this form of attack had never been recorded of the insect. To verify the belief, after ascending some trees and examining branches within reach from windows, I went upon a house-top, where the limbs of a large elm projecting over the roof gave an excellent opportunity for examination. The larvæ were abundant upon the tree; the flat roof was strewn over and heaped in corners with the broken-off tips; very many girdled tips still held their place on the tree, and after careful search Orgyia larvæ were discovered in the act of eating the bark at the girdled points. From later observations it appeared that the girdling had at this time nearly ceased.

"The following explanation of the cause of the falling of the girdled tips seems a rational one. Upon the eating away of the bark by the Orgyia caterpillar, the wood rapidly dried from its exposure to the air and arrest of circulation, and soon became so brittle that from a moderate swaying of the branches the weight of a half dozen or more of large succulent leaves would occasion the breaking off of the slender twig—often not exceeding in its dried state the diameter of an ordinary pin.

"For the occurrence at this time of this novel form of Orgyia attack, I can only offer the following as a plausible explanation: The spring had been remarkably cold, and as a consequence the development of the foliage had been delayed to quite beyond the ordinary time. The sudden advent of warm weather caused a corresponding sudden start in vegetation, followed by a vigorous growth, and the young tips of the elm would, as the result, be unusually tender. The particular feeding ground of many of the lepidopterous larvæ is known to be selected only after repeated tastings and rejections of such portions of their food-plant as they traverse and a final acceptance of that most agreeable to them. By a process like this the Orgyia may have made the discovery that just at the commencement of the new growth, as the result of the seasonal conditions above mentioned, there was concentrated in the tender bark nutriment far more acceptable to it than that offered in the leaves, upon which alone it had hitherto been accustomed to feed. As the bark hardened with the advancing season it would cease to be desirable for food. * * *

"On my return to Albany for a few days, on the 21st of July, most of the tips then falling and many of those upon the ground presented a new feature. The breaking, instead of being at the base of the girdling, just above the commencement of the new growth, was, in these, at the preceding node, covering the growth of the former year. As a rule, the twigs showed a greater diameter at their decorticated portion, compared with those of the earlier fall, and the leaves attached to them had been all more or less eaten by the Orgyia. Their greater strength had permitted them to remain longer upon the tree, and until the death of the preceding internode, which soon followed the arrest of the circulation—its starvation ensuing—it being unprovided with leaves through which a circulation could still be maintained. When dead, a slight movement of the branch by the wind, or even the weight of the terminal leaves, would be sufficient to disconnect it at its lower and weaker node. In a few instances, where the girdling had been at a little distance above the node marking the commencement of the present year's growth, the separation had been at this point, while others separated in this manner, instead of the narrow girdling band, had had the bark irregularly removed for the extent of an inch or more. All these later falling twigs showed the interval that had elapsed between the injury and the fall, in that the roughened edges of the bark left by the gnawing had healed over with the peculiar roughened and rounded enlargement following the deposit of the reparative material under such conditions. Some of the twigs gathered gave excellent illustration of the ascent of the sap through the outer wood, and its return, after assimilation in the leaves, through the inner bark. In one instance, where the leaves were unusually large, the descending sap, arrested at the girdled point, had built up structure in the tip until its diameter was more than double that of the starved internode below, while the immediate point of the arrest was quite enlarged from the material there deposited.

"This peculiar attack did not extend to the other principal food-plants of the Orgyia, as the horse-chestnut, maple, apple and plum, nor would it be expected to occur in connection with growth and structure so different from that of the elm."

Pupation.—Six days after the third molt a portion of the larvæ spin up; all these produce male moths. The female caterpillars, which up to this time have been undistinguishable from the male caterpillars, undergo a fourth (and, as it appears from more recent experience, in some instances even a fifth) molt and acquire twice the size of the male caterpillar. This last, when full grown, measures about 20 millimeters in length. The cocoon spun by the male caterpillar is of whitish or yellowish color and sufficiently thin to show the insect within. It consists of two layers, the hairs of the tufts and brushes of the caterpillar being interwoven with the outer layer. The female cocoon is correspondingly larger, of gray color, and much more solid and denser than the male cocoon. The male chrysalis (Fig. 13 *d*), which is soon formed within the cocoon, is of brownish color, sometimes whitish on the ventral side, and covered on the back and sides with fine white hairs. The female chrysalis (Fig. 13 *c*) is much larger than the male, and otherwise differs, especially in lacking the wing-sheaths and in having on the three first segments after the head transverse, flattened protuberances composed of scales, which are much less visible in the male. The duration of the pupa state is less than a fortnight.

The Imago.—The male (Fig. 15) is a winged moth with feathery antennæ and very hairy fore legs. The general color is ashy-gray, the front wings being crossed by undulated bands of darker shade, with two black markings on the outer edge near the tip and a white spot on the inner edge also near the tip. He may frequently be seen sitting on the trunks of trees or on the shady side of houses, etc., as he rests during the day, and flies only after dusk, often being attracted by light. The female (Fig. 13 *a*) is totally different from the male in appearance and resembles a hairy worm rather than a moth, since she possesses the merest rudiments of wings. She is of a pale gray color, the antennæ being short and not feathered, the legs

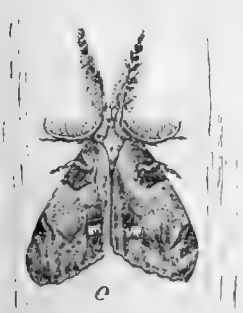

FIG. 15.—*Orgyia leucostigma*: male.

rather slender and not covered with long hairs. She has consequently no power of flight, and is barely able to walk. After working her way out of the chrysalis and cocoon she takes her place on the outside of the latter and patiently awaits the approach of the male. Here she also deposits and protects her eggs in the manner already mentioned, after which she drops exhausted to the ground and perishes. The white mass covering the eggs is at first viscous, but soon dries, becoming brittle, and is impervious to water.

Hibernation.—The species hibernates normally in the egg state, but occasionally a living chrysalis may be found in winter time. On January 30, 1874, we received from Mr. Hunter Nicholson, from Knoxville, Tenn., a newly-hatched female, and this had, no doubt, prematurely issued from a hibernating chrysalis. This is, however, quite exceptional, and the different climatic conditions to which the species is subjected in its wide distribution do not seem to alter the normal mode of hibernation.

Number of Annual Generations.—In the latitude of Washington the species is two-brooded, the imagos of the first generation appearing in the first part of June, those of the second generation in September and October. On several occasions we have found, however, that a portion of the caterpillars from one and the same batch of eggs would be feeding while the rest had already transformed to imagos. The result of this retardation and irregularity in development is that caterpillars may be found continuously throughout the season from June till October, and that there is, consequently, no distinct dividing line between the two generations. In the more northern States the species is single-brooded, the caterpillars appearing in the months of July and August.

FOOD-PLANTS.

This caterpillar has most often been referred to by writers on economic entomology as injurious to fruit trees, such as Plum, Pear, and more particularly the Apple; but it also attacks a great many shade trees, and has been for many years particularly injurious to the elms and the soft or silver maples in some of our larger New England cities. It has also a predilection for old or large trees.

NATURAL ENEMIES AND PARASITES.

The fact that the caterpillar makes no effort to conceal itself shows that it enjoys immunity from enemies, and notably from birds. In fact, the American Yellow-billed Cuckoo, the Baltimore Oriole, and the Robin are the only birds which have been observed to feed upon the larvæ. Predaceous insects are also not particularly fond of this hairy caterpillar, the well known Wheel-bug (*Prionidus cristatus*, see Fig. 16) and a few other Soldier-bugs being the only species which occasionally suck its juices. Nocturnal birds, and especially bats, will, no doubt, devour many of the male moths flying about after dusk, but the destruction of a portion of the males has no appreciable influence on the decrease of

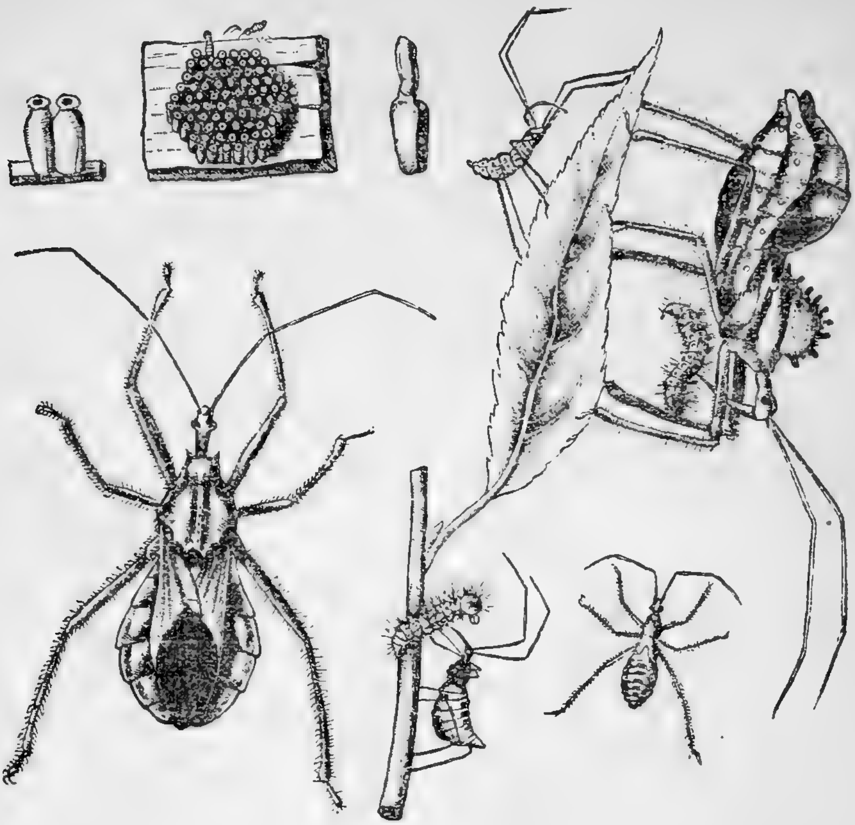

Fig. 16.—*Prionidus cristatus:* eggs, larvæ, and full-grown specimens.

the worms of the next generation. The egg-masses appear to be effectually protected by the froth-like covering, as neither bird nor predaceous insect has been observed to destroy them.

While the list of enemies that devour the species is thus small, that of the parasites is fortunately quite large, and it is due to their influence that the caterpillars are not permanently injurious. There are several true parasites of this insect. Fitch described one species which he bred in considerable numbers from the larva, as *Trichogramma? orgyiæ*, but a perusal of his account indicates plainly that this parasite is an *Eulophus*. He also described a closely-related insect as *Trichogramma? fraterna* and gave it as a very probable parasite of *Orgyia*. There is, however, not the slightest evidence of such parasitism, and this insect must in future be excluded from the list of parasites of the Orgyia larvæ. We have reared from this insect *Pimpla inquisitor*, and an undetermined Tachinid fly, and have had from the larva the cocoons of a Microgaster which has not been reared to the imago. We have also bred a true egg-parasite of the genus *Telenomus*, two distinct species of the genus *Pteromalus* from the larvæ, and Mr. Lintner has sent us a specimen of a species of *Tetrastichus* which is probably parasitic upon one of the *Pteromali*. Further characterization of these species we defer to another occasion.

GEOGRAPHICAL DISTRIBUTION.

This species is widely distributed in North America east of the more timberless regions of the West, extending northward as far as Canada and southward well into the Southern States. It is most abundant in the Middle and New England States, but it is a noticeable fact that wherever it occurs it is more frequent within our cities, or in gardens and orchards near by, than in the woods remote from human habitation.

THE FALL WEB-WORM.

(*Hyphantria cunea*, Drury.)

"This insect has from time to time attracted general attention by its great injury to both fruit and shade trees. Many authors have written about it, and consequently it has received quite a number of different names. The popular name 'Fall Web-worm,' first given to it by Harris, in his 'Insects injurious to Vegetation,' is sufficiently appropriate as indicating the season when the webs are most numerous. The term is, however, most expressive for the New England and other Northern States, where the insect is single-brooded, appearing there during August and September, while in more southern regions it is double-brooded. In our Third Missouri Report we have first called attention to its double-broodedness at Saint Louis, and we find that it is invariably two-brooded at Baltimore and Washington. Except in seasons of extreme increase, however, the first brood does no wide-spread damage, while the fall brood nearly always attracts attention.

"We have decided to call attention to this insect somewhat in detail in this report, because of its exceptional prevalence and injury in the Atlantic States during the year 1886, and because it became a public nuisance in the city of Washington, and the District Commissioners have formally requested information from us on the subject."

NATURAL HISTORY.

Limitation of Broods.—"At Washington we may say in general that the first brood appears soon after the leaves have fully developed, and numerous webs can be found about the first of June, while the second brood appears from the middle of July on through August and September. In Massachusects and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The species invariably hibernates in the chrysalis state within its cocoon, and the issuing of the first brood of moths is, as a consequence, tolerably regular as to time, *i. e.*, they will be found issuing and flying slowly about during the evening, and more particularly at night, during the whole month of May, the bulk of them early or late in the month, according as the season may be early or late. They couple and oviposit very soon after issuing, and in ordinary seasons we may safely count on the bulk of the eggs being laid by the end of May. During the month of June the moths become scarcer and the bulk of them have perished by the middle of that month, while the webs of the caterpillars become more and more conspicuous. The second brood of moths begins to appear in July, and its occurrence extends over a longer period than is the case with the first or spring brood. The second brood of caterpillars may be found from the end of July to the end of September, hatching most extensively, however, about the first of August.

"In Massachusetts and other Northern States the first moths issue in June and July; the caterpillars hatch from the last of June until the middle of August, reach full growth and wander about seeking places for transformation from the end of August to the end of September.

"The following general remarks upon the different stages refer to Washington and localities where the same conditions hold:

The Eggs (Fig. 17, *b*).—"The female moth deposits her eggs in a cluster on a leaf, sometimes upon the upper and sometimes on the lower side, usually near the end of a branch. Each cluster consists of a great many eggs, which are deposited close together and in regular rows, if the surface of the leaf permits it. In three instances those deposited by a single female were counted. The result was 394, 427, and 502, or on an average 441 eggs. But in addition to such large clusters, each female will deposit eggs in smaller and less regular patches, so that at least 500 eggs may be considered as the real number produced by a single individual. The egg, measuring 0.4 millimeters, is of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give it under a magnifying lens the appearance of a beautiful golden thimble. As the eggs approach the time of hatching this color disappears and gives place to a dull leaden hue.

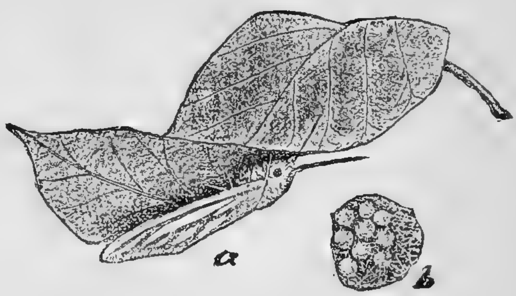

FIG. 17.—*Hyphantria cunea: a*, moth in position on leaf laying eggs, side view; *b*, eggs enlarged.

"The interval between the time of depositing and hatching of the eggs for the first brood varies considerably, and the latter may be greatly retarded by inclement weather. Usually, however, not more than ten days are consumed in maturing the embryo within. The eggs of the summer brood seldom require more than one week to hatch.

"Without check the offspring of one female moth might in a single season (assuming one-half of her progeny to be female and barring all checks) number 125,000 caterpillars in early fall—enough to ruin the shade-trees of many a fine street.

The Larva (Fig. 18, *a*, *b*, and *c*).—"The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head, and with quite sparse hairs. When full grown they generally appear pale yellowish or greenish, with a broad dusky stripe along the back and a yellow stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is,

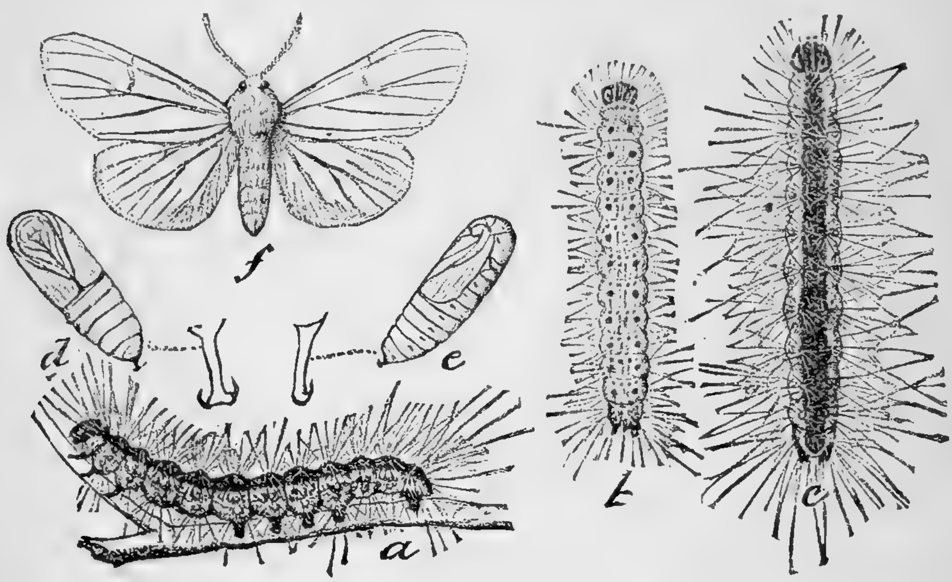

FIG. 18.—*Hyphantria cunea*: *a*, dark larva, seen from side; *b*, light larva from above; *c*, dark larva from above; *d*, pupa from below; *e*, pupa from side; *f*, moth.

however, very variable both as to depth of coloring and as to markings. Close observations have failed to show that different food produces changes in the coloration; in fact, nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker with browner hairs than the spring generation.

"As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes quite bulky, and, as it is filled with brown and skeletonized leaves and other discolored matter, as well as with their old skins, it becomes quite an unpleasant feature in our public thoroughfares and parks. The caterpillars always feed underneath these webs; but as soon as they approach maturity, which requires about one month, they commence to scatter about, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food-supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time.

"When the young caterpillars are forced to leave their webs they do not drop suddenly to the ground, but suspend themselves by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both old and young ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger.

Pupa and Cocoon.—"Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground; in some cases even the empty cocoons of other moths.* The angles of tree-boxes, the rubbish collected around the base of trees and other like shelter are employed for this purpose, while the second brood prefer to bury themselves just under the surface of the ground, provided that the earth be soft enough for that purpose. The cocoon itself is thin and almost transparent, and is composed of a slight web of silk intermixed with a few hairs, or mixed with sand if made in the soil.

"The pupa (Fig. 18, *d* and *e*) is of a very dark-brown color, smooth and polished, and faintly punctate; it is characterized by a swelling or bulging about the middle. It is 0.60 inch long and 0.23 inch broad in the middle of its body, or where it bulges a little all round.

The Moth (Fig. 18, *b*).—"The moths vary greatly, both in size and coloration. They have, in consequence of such variation, received

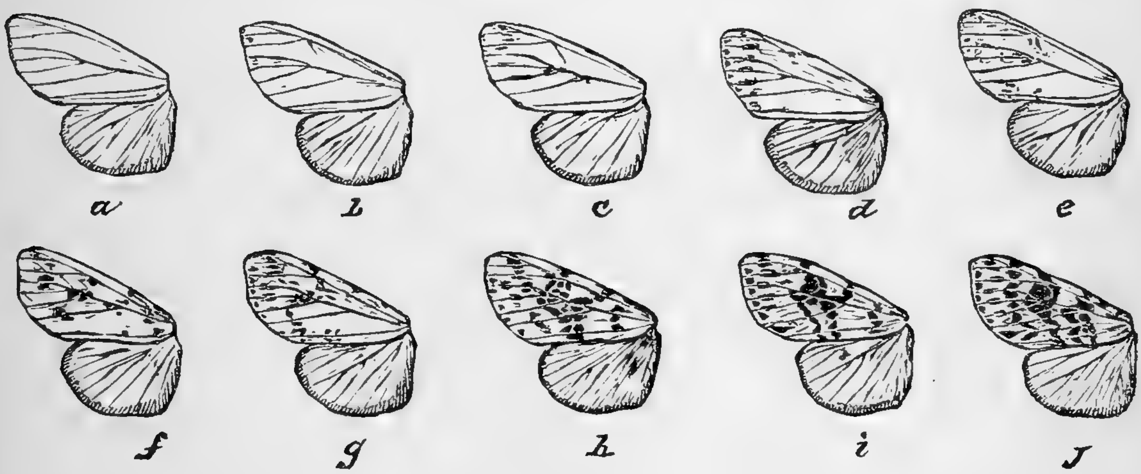

FIG. 19.—*Hyphantria cunea: a–j*, wings of a series of moths, showing the variations from the pure white form to one profusely dotted with black and brown.

many names, such as *cunea* Drury, *textor* Harr., *punctata* Fitch, *punctatissima* Smith (Fig. 19). But there is no doubt, as proven from frequent breeding of specimens, that all these names apply to the very same insect, or at most to slight varieties, and that Drury's name *cunea*, having priority, must be used for the species.

"The most frequent form observed in the vicinity of Washington is white, with a very slight fulvous shade; it has immaculate wings,

* We have known the substantial cocoon of *Cerura* to be used for this purpose.

tawny-yellow front thighs, and blackish feet; in some specimens the tawny thighs have a large black spot, while the shanks on the upper surface are rufous. In many all the thighs are tawny yellow, while in others they have scarcely any color. Some specimens (often reared from the same lot of larvæ) have two tolerably distinct spots on each front wing—one at base of fork on the costal nerve and one just within the second furcation of the median nerve. Other specimens, again, have their wings spotted all over, and approach the form *punctatissima*, described as the "Many-spotted Ermine-moth" of the Southern States. The wings of the moths expand from $1\frac{1}{4}$ inches to $1\frac{3}{8}$ inches. The male moth, which is usually a little smaller, has its antennæ doubly feathered beneath, and those of the female possess instead two rows of minute teeth.

"The pupa state lasts from six to eight days for the summer brood, while the hibernating brood, however, requires as many months, according to the latitude in which they occur.

INJURY DONE IN 1886.

"During the past year the city of Washington, as well as its vicinity, was entirely overrun by the caterpillars. With the exception of trees and plants the foliage of which was not agreeable to the taste of this insect, all vegetation suffered greatly. The appended list of trees, shrubs, and other plants shows that comparatively few kinds escaped entirely. The fine rows of shade trees which grace all the streets and avenues appeared leafless, and covered with throngs of the hairy worms. Excepting on the very tall trees, in which the highest branches showed a few leaves too high for the caterpillars to reach, not a vestige of foliage could be seen. The trees were not alone bare, but were still more disfigured by old and new webs made by the caterpillars, in which bits of leaves and leaf-stems, as well as the dried frass, had collected, producing a very unpleasant sight. The pavements were also constantly covered with this unsightly frass, and the empty skins of the various molts the caterpillars had to undergo were drifted about with every wind, and collected in masses in corners and tree-boxes. The parks fared a little better. Because of the great variety of trees planted there some escaped entirely, while others showed the effect of the united efforts of so many hungry caterpillars only in a more or less severe degree. The grassy spots surrounding the different groups of trees had also a protective influence, since the caterpillars do not like to travel over grass, except when prompted by a too ravenous hunger. The rapid increase of this insect is materially assisted by the peculiar method of selecting shade trees for the city. Each street has, in many cases, but one kind of shade tree; rows of them extend for miles, and the trees are planted so close together that their branches almost interlace. Thus there is no obstacle at all to the rapid increase and distribution of the caterpillars. If different kinds of trees had been planted, so as to alternate, less trouble might be experienced. Plate I shows a view of Fourteenth street, taken late in September, which illustrates this point; the poplars on the west side being completely defoliated as far as the eye can reach, while the maples on the east are almost untouched.

"As long as the caterpillars were young, and still small, the different communities remained under cover of their webs, and only offended the eye. But as soon as they reached maturity, and commenced to scatter—prompted by the desire to find suitable places to spin their cocoons and transform to pupæ—matters became more unpleasant, and complaints were heard from all those who had to pass such infested trees. In many localities no one could walk without stepping upon caterpillars; they dropped upon every one and everything; they entered flower and vegetable gardens, porches and verandas, and the house itself, and became, in fact, a general nuisance.

"The chief damage done to vegetation was confined to the city itself, although the caterpillars extended some distance into the surrounding country. There, however, they were more local, and almost entirely confined to certain trees, and mainly so to the White Poplar and the Cottonwood. Along the Baltimore and Potomac Railroad tracks these trees were defoliated as far as five miles from the Capitol. In Georgetown the caterpillars were equally noxious, but in the adjoining forests but very few webs could be seen.

"The proportionate injury to any given species of tree is to some extent a matter of chance, and in some respects a year of great injury, as 1886, is not a good year to study the preferences of a species, because when hard pressed for food the caterpillars will feed upon almost any plant, though it is questionable whether they can mature and transform on those which they take to only under the influence of such absolute necessity. Again, the preference shown for particular trees is more the result of the preference of the parent moth than of its progeny in a case of so general a feeder as the Fall Web-worm. We had a very good illustration of this in Atlantic City last autumn. The caterpillars were exceedingly abundant during autumn along this portion of the Atlantic coast, especially on the trees above named. We studied particularly their ways upon one tree that was totally defoliated by September 11. The bulk of the caterpillars were then just through their last molt, though others were of all ages illustrating different hatchings. There was an instinctive migration of these larvæ of all sizes, and the strength of their food habits once acquired from birth upon a particular tree was well illustrated. At first the worms passed over various adjacent plants, like honeysuckles, roses, etc., the leaves of which they freely devour if

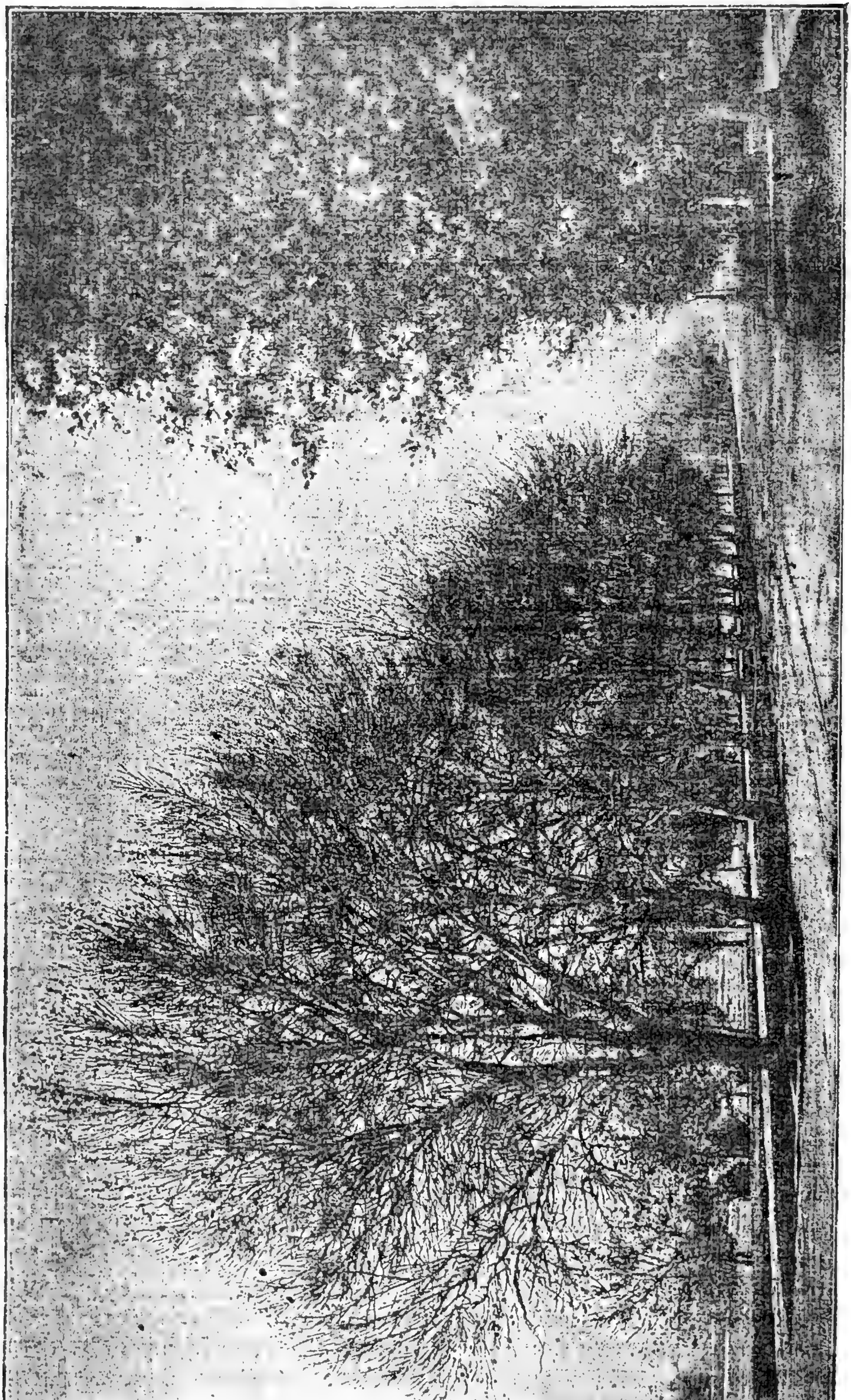

PLATE I.—TREES DEFOLIATED BY THE WEB-WORM.

hatched upon them, but as the migrating swarm became pressed with hunger they finally fell upon these, and even upon plants like the Peach, and Ailanthus, which ordinarily are passed over. They would pounce upon any food, and a rotten apple placed in their way was soon literally swarming with them and sucked dry.

"In a general way it may be stated that conifers, grapes, and most herbaceous plants are free from their attacks, and it is very doubtful whether the species can mature upon them.

"The list of plants which follows is arranged according to the relative damage to the foliage in the city of Washington. The three first named are most subject to attack, and, in fact, are almost always defoliated.

PROPORTIONATE INJURY TO DIFFERENT PLANTS AND SHADE TREES.

"The damage done in the city of Washington was exceptional, but so was also the general damage throughout the New England States, if not throughout the country. In New England the greater predilection which the species showed for Poplar, Cottonwood, and the ranker growing Willows was everywhere manifest, and so much was this the case that the destruction of the first brood on these trees would have substantially lessened the damage to other trees."

Plants marked 1 have lost from 75 to 100 per cent. of their foliage.
Plants marked 2 have lost from 50 to 75 per cent. of their foliage.
Plants marked 3 have lost from 25 to 50 per cent. of their foliage.
Plants marked 4 have lost from 0 to 25 per cent. of their foliage.
Plants marked with two figures have shown the relative immunity or injury indicated by both, the variation being in individual trees.

1. *Negundo aceroides* Mœnch. (Box Elder.)
1. *Populus alba* L. (European White Poplar.)
1. *Populus monilifera* Aiton. (Cottonwood.)
1–2. *Populus balsamifera* L. (Balsam Poplar.)
1–2. *Populus tremuloides* Mich'x. (Amercan Aspen.)
1–2. *Fraxinus americana* L. (White Ash.)
1–2. *Fraxinus excelsior* L. (European Ash.)
1–2. *Sambucus canadensis* L. (Elder.)
1–2. *Pyrus* species. (Cultivated Pear and Apple.)
1–2. *Prunus avium* and *cerasus* L. (Cherries.)
1–4. *Syringa vulgaris* L. (Lilac.)
1–4. *Ilex* spec. (Holly.)
2. *Platanus occidentalis* L. (Sycamore.)
2. *Salix* species. (Willow.)
2. *Tilia americana* L. (American Linden.)
2. *Tilia europœa* L. (European Linden.)
2. *Populus dilatata* Ait. (Lombardy Poplar.)
2. *Ulmus americana* L. (American White Elm.)
2–3. *Ulmus fulva* Mich. (Slippery Elm.)
2–3. *Prunus armeniaca* L. (Apricot.)
2–3. *Alnus maritima* Muhl. (Alder.)
2–3. *Betula alba*, L. (White Birch.)
2–3. *Viburnum* species. (Haw or Sloe.)
2–3. *Lonicera* species. (Honeysuckles.)
2–3. *Prunus americana* Marsh. (Wild Red Plum.)
2–3. *Celtis occidentalis* L. (Hackberry.)
2–3. *Rosa* species. (Rose.)
2–3. *Gossypium album* Ham. (Cotton.)
2–3. *Cephalanthus occidentalis* L. (Button Bush.)
2–4. *Convolvulus* spec. (Morning Glory.)

2-4. *Acer saccharinum* Wang. (Sugar Maple.)
2-4. *Geranium* species. (Geranium.)
3. *Betula nigra* L. (Red Birch.)
3. *Tecoma radicans* Juss. (Trumpet Creeper.)
3. *Symphoricarpus racemosus.* Mich'x. (Snowberry.)
3. *Larix europæa,* Del. (European Larch.)
2. *Corylus americana,* Walt. (Hazel-nut.)
3. *Quercus alba* L. (White Oak.)
3. *Diospyros virginiana* L. (Persimmon.)
3. *Carya* species. (Hickory.)
3. *Juglans* species. (Walnut.)
3. *Wistaria sinensis* Del. (Chinese Wisteria.)
3. *Wistaria frutescens* DC. (Native Wisteria.)
3. *Amelanchier canadensis* T. & G. (Shad-bush.)
3. *Cratægus* species. (Haw.)
3. *Rubus* species. (Blackberry.)
3. *Spiræa* species. (Spiræa.)
3. *Ribes* species. (Currant and Gooseberry.)
3. *Staphylea trifolia* L. (Bladder Nut.)
3-4. *Cydonia vulgaris* Pers. (Quince.)
3-4. *Asimina triloba* Dun. (Papaw.)
3-4. *Berberis canadensis* Pursh. (Barberry.)
3-4. *Catalpa bignonioides* Walt. (Indian bean.)
3-4. *Catalpa speciosa* Ward. (Bignonia.)
3-4. *Euonymus atropurpureus* Jaeg. (Burning Bush.)
3-4. *Cupressus thyoides* L. (White Cedar.)
3-4. *Juniperus virginiana* L. (Red Cedar.)
3-3. *Cornus florida* L. (Flowering Dogwood.)
3-4. *Cornus alternifolia* L. (Alternate-leaved Dogwood.)
3-4. *Carpinus americana* Mich'x. (Hornbeam.)
3-4. *Castanea americana* Mich'x. (American Chestnut.)
3-4. *Castanea pumila* Mich'x. (Chinquapin.)
3-4. *Ostrya virginica* Willd. (Hop Hornbeam.)
3-4. *Quercus coccinea* Wang. (Scarlet Oak.)
3-4. *Quercus phellos* L. (Willow Oak.)
3-4. *Quercus prinus* L. (Chestnut Oak.)
3-4. *Quercus rubra* L. (Red Oak.)
3.4. *Diospyros kaki* L. (Japan Persimmon.)
3-4. *Buxus sempervirens* L. (Common Box.)
3-4. *Hamamelis virginica* L. (Witch Hazel.)
3-4. *Sassafras officinale* Ness. (Sassafras.)
3-4. *Cercis canadensis* L. (Red Bud.)
3-4. *Hibiscus syriacus* L. (Tree Hibiscus.)
3-4. *Rhamnus alnifolius* L'Her. (Alder-leaved Buckthorn.)
3-4. *Prunus virginiana* L. (Choke Cherry.)
3-4. *Persica vulgaris* Mill. (Peach.)
3-4. *Æsculus hippocastanum* L. (Horse Chestnut.)
3-4. *Paulownia imperialis* Seeb. (Cigar Tree.)
3-4. *Ailanthus glandulosus* Daf. (Tree of Heaven.)
3-4. *Maclura aurantiaca* Nutt. (Osage Orange.)
3-4. *Ampelopsis quinquefolia.* Virginia Creeper.)
3-4. *Clematis* species. (Clematis.)
3-4. *Trifolium* spec. (Clover.)
3-4. *Helianthus* spec. (Sunflower.)
3-4. *Jasminum* spec. (Jesamine.)
3-4. *Ficus carica* L. (Fig.)
4. *Rhus cotinus* L. (Smoke Tree.)
4. *Pinus* spec. (Pine.)
4. *Taxus* spec. (Yew.)
4. *Nyssa multiflora* Wangerh. (Sour Gum.)
4. *Fagus ferruginea* Ait. (Beech.)
4. *Kalmia* spec. (Laurel.)
4. *Rhododendron* spec. (Rhododendron.)
4. *Ricinus communis* L. (Castor-oil Plant.)
4. *Liquidambar styraciflua* L. (Sweet Gum.)
4. *Gleditschia triacanthos* L. (Honey Locust.)
4. *Gymnocladus canadensis,* Lamb. (Kentucky Coffee Tree.)
4. *Robinia pseudacacia* L. (Locust.)
4. *Liriodendron tulipifera* L. (Tulip Tree.)
4. *Magnolia* spec. (Magnolia.)
4. *Chionanthus virginicus* L. (Fringe Tree.)
4. *Ligustrum vulgare* L. (Privet.)

4. *Zanthoxylum americanum* M. (Prickly Ash.)
4. *Acer dasycarpum* Ehrh. (White or Silver Maple.)
4. *Acer rubrum* Wangert. (Red Maple.)
4. *Æsculus flava*, Ait. (Sweet Buckeye.)
4. *Æsculus glabra* Willd. (Ohio Buckeye.)
4. *Morus rubra* L. (Red Mulberry.)

"Trees in the vicinity of the White Poplar and Cottonwood suffered most. Even trees usually not injured, as, for instance, the Sugar Maple, are often badly defoliated when in such contiguity.

"This list contains a number of plants not usually injured by these caterpillars. In some cases the injury was due to the fact that twigs containing the web, with its occupants, had been pruned from the tree and thrown near plants, instead of being at once burned or otherwise destroyed.

"In other cases the injury is due to the peculiar position of the plant injured, *i. e.*, under a tree infested by the caterpillars. These when fully grown commence to scatter, and dropping upon the plants underneath the tree so defoliate it without actually making their home upon it. The great number thus dropping from a large tree will soon defoliate any smaller plant, even if each caterpillar takes but a mouthful by way of trial. Thus Holly, a plant not usually eaten by these insects, soon becomes denuded. Other plants unpalatable or even obnoxious to the caterpillars are sometimes destroyed by the multitudes in their search for more suitable food.

"Hungry caterpillars leaving a denuded tree in search of food wander in a straight line to the next tree, sometimes a distance of 25 feet, showing that they possess some keen sense to guide them. If such a tree offers unsuitable food, they still explore it for a long time before deserting it. In this manner two columns of wandering caterpillars are formed, which frequently move in opposite directions.

PECULIAR EFFECT OF DEFOLIATION UPON SOME PLANTS.

"During the early part of October many trees, mainly apple and pear, which had been entirely denuded of their foliage by the caterpillars, showed renewed activity of growth. Some had a few scattered flowers upon them, others had one or two branches clothed with flowers, while in some few cases the whole tree appeared white. It looked as if the trees were covered with snow, since they lacked the green foliage usually seen with the blossoms in spring. Some few flowers were also observed upon badly defoliated cherry-trees. Even as late as the middle of November, owing perhaps also to the pleasantly warm weather, some few flowers could be observed upon some imported plants belonging to the genus *Spiræa* and upon the Chinese Red-apple. All these plants usually blossom early in spring. The caterpillars having entirely defoliated the trees produced thus an artificial period of rest, or winter, which was followed by unseasonable budding and flowering. Such a result often follows summer denudation by any insect, and we have referred to some remarkable cases in our previous writings.*

ENEMIES OF THE WEB-WORM OTHER THAN INSECTS.

"The caterpillars have comparatively few enemies belonging to the vertebrate animals. This is not owing to any offensive odor or to any other means of defense, but is entirely due to their hairiness. Chickens, and even the omnivorous ducks, do not eat them; if offered to the former they pick at these morsels, but do not swallow them.

"The English sparrow has, in this case at least, not proven of any assistance whatever. Indeed, as before stated, its introduction and multiplication has greatly favored the increase of the worms.

"The 'pellets' of a Screech-owl (*Scops asio*) found in the vicinity of Baltimore, Md., and examined by Mr. Lugger, consisted apparently almost entirely of the hairs of these caterpillars, proving that this useful bird has done good service.

"Perhaps the statement may be of interest, that this little owl is getting much more common in the vicinity of such cities, in which the English sparrow has become numerous, and that the imported birds will find in this owl as bold an enemy as the Sparrow-hawk is to them in Europe, and even more dangerous, since its attacks are made towards dusk, at a time when the sparrow has retired for the night and is not as wide awake for ways and means to escape.

"If our two cuckoos, the black-billed as well as the yellow-billed species, could be induced to build their nests within the city limits or in our parks, we should gain in them two very useful friends, since they feed upon hairy caterpillars.

"The common toad (*Bufo americana*) has eaten great numbers of these caterpillars, as shown by dissections made by Mr. Lugger, and it should be carefully protected instead of being tormented or killed by boys or even grown people. The toad is always a useful animal and ought to be introduced in all gardens and parks.

"The following species of spiders were observed to eat the caterpillars, viz, *Marpessa undata* Koch and *Attus* (*Phydippus*) *tripunctatus*. Neither species builds a web, but obtains its prey by boldly leaping upon it; they are, in consequence of such habits, frequently called Tiger-spiders. The former was exceedingly common last year, more so than for many previous years, thus plainly indicating that the species did not suffer for lack of food. This species is usually found upon the trunks of trees, and is there well protected by its color, which is like that of the bark. It hides in depressions and cracks of the bark, and, jumping upon the passing game, or, cat-like, approaching it from behind, it thrusts its poisonous fangs into the victim, which soon dies and is sucked dry. The *Attus* has similar habits, but is still more cautious; it usually hides

* See Eighth Report on the Insects of Missouri, p. 121.

under loose bark. Both spiders are wonderfully active, and kill large numbers of caterpillars. Their large flat egg-masses can be found during the winter under dead bark and in cracks. Both species hibernate in silken nests in similar localities."

PREDACEOUS INSECT ENEMIES.

The caterpillars of this moth have quite a number of external enemies, which slay large numbers of them. The well-known Rear-horse (*Mantis carolina*, see Fig. 20) seems to be very fond of the caterpillars.

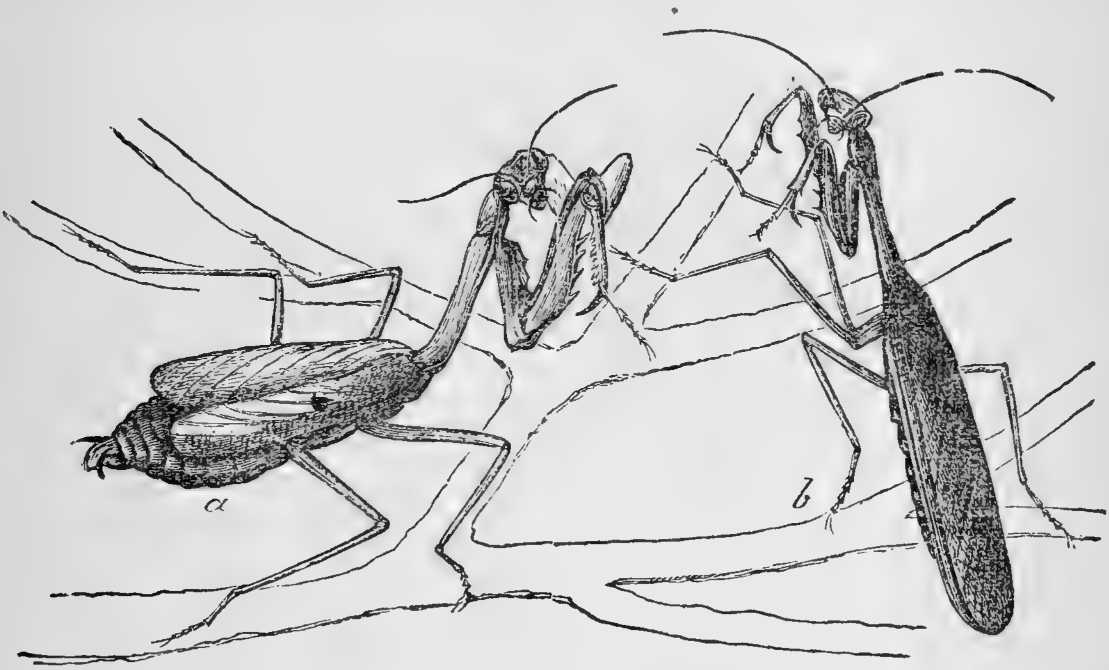

FIG. 20.—*Mantis carolina*: *a*, female; *b*, male.

The so-called Wheel-bug (*Prionidus cristatus*, see Fig. 16) has proved to be one of our best friends in reducing the numbers of the caterpillars. This insect was formerly by no means very common in cities, but of late years it has greatly increased in numbers, and is now a well-known feature in all our public parks and such streets as possess shade-trees. Outside of the city it is rarely met with; nor does it extend much farther north than Washington. It is, like the Mantis, in all its stages a voracious feeder upon insects, slaying alike beneficial and noxious ones. The bright red larvæ and pupæ, also carnivorous, are seen in numbers during the summer; they usually remain together until hunger forces them to scatter. They assist each other in killing larger game, and are to this extent social. The Wheel-bug could be observed almost anywhere last summer, usually motionless, stationed upon the trunk of trees, waiting for the approach of an insect. If one comes near, it quite leisurely inserts its very poisonous beak, and sucks the life-blood of its victim. When this becomes empty it is hoisted up in the air, as if to facilitate the flow of blood, until eventually it is thrown away as a mere shriveled skin. The appetite of the Wheel-bug is remarkable, whenever chances offer to appease it to the fullest extent. Frequently, however, times go hard with it, and notwithstanding it is very loth to change a position once taken, it is sometimes forced to seek better hunting grounds, and takes to its wings. The Wheel-bug has been observed to remain for days in the same ill-chosen position, for instance upon the walls of a building, waiting patiently for something to turn up. It is slow in all its motions, but withal very observant of everything occurring in its neighborhood, proving without doubt great acuteness of senses. It does not seem to possess any enemies itself, and a glance at its armor will indicate the reason for this unusual exemption.* During warm weather this bug possesses a good deal of very searching curiosity, and a thrust with its beak, filled with poison, is very painful indeed. Boys call it the Blood-sucker, a misnomer, since it does not suck human blood. The eggs are laid during the autumn in various places, but chiefly upon smooth surfaces of the bark of tree-trunks, and frequently in such a position as to be somewhat protected against rain by a projecting branch. The female bug always selects places the color of which is like that of the eggs, so they are not easy to see, notwithstanding their large size.

"*Euschistus servus* Say, is another hemipterous insect that preys upon the caterpillar of *H. cunea*, and in a similar manner to the Wheel-bug. It is a much smaller, but also a very useful insect.

"*Podisus spinosus* Dall. (Fig. 21), in all its stages was quite numerous during the caterpillar plague. Its brightly-colored larvæ and pupæ (Fig. 22) were usually found in small numbers together; but as they grew older they become more solitary in their habits. All stages of this insect frequent the trunk and branches of trees, and are here actively engaged in feeding upon various insects. As soon as one of the more mature larvæ or a pupa has impaled its prey, the smaller ones crowd about to obtain their share. But the lucky captor is by no means willing to divide with the others, and he will frequently project his beak forward, thus elevating the caterpillar into the air away from the others. The habit of carrying their food in such a difficult position has perhaps been acquired simply to prevent others from sharing it. A wonderful strength is necessary to perform such a feat, since the caterpillar is sometimes many times as heavy as the bug itself. The greediness of this bug was well illustrated in the following observations: A pupa of *P. spinosus* had impaled a caterpillar, and was actively engaged in sucking it dry; meanwhile a Wheel-bug utilized a favorable opportunity and impaled the pupa, without forcing the same to let go the

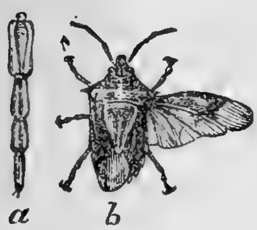

FIG. 21.—*Podisus spinosus*: *a*, enlarged beak; *b*, bug, with right wings expanded.

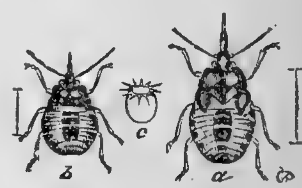

FIG. 22.—*Podisus spinosus*: *a*, pupa; *b*, larva; *c*, egg.

* The eggs of the Wheel-bug are pierced, however, by a little egg-parasite—*Eupelmus reduvii* Howard.

caterpillar. The elasticity of the beak (Fig. 21*a*) of these bugs must be very great; they can bend it in any direction, and yet keep it in sucking operation. The poison contained in the beak must act very rapidly, since caterpillars impaled by it squirm but for a very short time, and then become quiet."

FUNGUS DISEASES OF THE WEB-WORM.

"The first brood of these caterpillars showed in some quite well-defined localities the indications of a fungus disease.* This did not become, however, as general as later in the season, when it prevailed everywhere; yet it could be observed that the contagion had started from certain points. In such localities almost all the caterpillars were diseased and large numbers of the dead were huddled together as in life. But when investigated their bodies were hard and dry, and would readily crumble to pieces when pressed, producing an odor like that of some mushrooms. Only full-grown, or rather caterpillars in their last larval stage, were thus affected. The dry remains had retained the original shape, and, if killed but recently by the fungus, their color as well. Before dying the caterpillars had fastened themselves very securely to trunks, twigs, and leaves of various trees, somewhat like the common house-fly, that dies by a similar disease in large numbers during September in our houses, and produces around itself such a characteristic halo of white spores. Caterpillars infested by the incipient stages of this disease wander about aimlessly and at an irregular speed; often they halt for some time, then squirm about frantically to start again, and frequently in an opposite direction to the one they were going before. If such a diseased caterpillar is confined to a glass jar and observed it is soon seen that a white mealy substance gradually grows out of all the soft spaces between their segments, which eventually covers the whole insect, leaving generally only the black head and tips of hairs visible. Before long many spores are scattered about, forming a circle of white dust around the caterpillar, and, if not arrested by an obstruction in its expulsion, the halo thus formed is quite regular and about 2 inches in diameter. Outdoors this white dust is but seldom observed, because even the slightest draft of air will carry it away and drift it about. Even the white mealy substance adhering to the caterpillar itself is usually swept away, and the victims look very much like healthy caterpillars; but they darken with time and eventually drop to the ground. The magnifying glass, however, still reveals some spores adhering to the hairs, upon the underside, and upon the bark or leaf of the tree in their immediate neighborhood.

"This fungus kills caterpillars even after they have made their cocoons. Nor does the pupa escape. In the latter case the spores form a white crest over every suture of the thoracic segments; the abdominal segments, however, remain free from it. Evidently the caterpillars were nearly full-grown when attacked by the disease, and possessed

* This fungus has been determined by Mr. Roland Thaxter as *Empusa grylli*.

vigor enough to transform into pupæ; later the fungus grew, and, pressing the chitinous portion of the pupa apart, forced its way to the air to fructify.

"Plants not usually eaten by the caterpillars, as well as others not eaten at all, have upon them the largest numbers of caterpillars killed by the fungus, provided that they grow in the vicinity of suitable food-plants. Perhaps unsuitable food, predisposing the caterpillars for any disease, is one of the causes of the innumerable host killed by this fungus.

"The white cocoons of a parasite (*Apanteles hyphantriæ* Riley) of this caterpillar were in some cases observed to be covered with similar spores of a fungus. Opening such cocoons it was seen that the spores were not simply blown upon the silk and there retained, but that they came from the victim within, and had forced their way through the very dense silken covering."

Experiments to obtain percentage of diseased caterpillars.

Experiment I:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) at random in one of our public parks. They were imprisoned in large glass jars and daily supplied with suitable food.

Result, October 18, 1886:

11 apparently healthy pupæ.
3 deformed pupæ.
18 yellow cocoons of *Meteorus hyphantriæ*.
9 dead pupæ, killed by fungus or otherwise.
84 dead caterpillars, killed by fungus or otherwise.
—
125

In the earth of the jar were found 17 pupæ of Tachina flies, leaving 67 caterpillars and 9 pupæ killed by the fungus, or 61 per cent.

Experiment II:

One hundred and twenty-five nearly grown caterpillars were gathered (October 7, 1886) from a trunk of a Soft Maple tree (unsuitable food) and treated as above.

Result, October 18, 1886:

8 apparently healthy pupæ.
1 deformed pupa.
7 yellow cocoons of *Meteorus hyphantriæ*.
3 dead pupæ, killed by fungus or otherwise.
104 dead caterpillars, killed by fungus or otherwise.
2 cocoons containing Tachina larvæ.
—
125

In the earth of the jar were found 28 pupæ of Tachina flies, leaving 76 caterpillars and 3 pupæ killed by fungus, or 63 per cent.

In both experiments it has been assumed that each Tachina fly had killed one caterpillar.

On November 15, 1886, the jars were again investigated, and it was found that a number of the pupæ had been killed by the fungus since October 18, 1886, and that in fact all the remaining ones did not look healthy. The percentage of death by the fungus in the two experiments was thus increased to 63 per cent. in Experiment I and to 67 per cent. in Experiment II.

TRUE PARASITES OF THE WEB-WORM.

Up to the present time no parasites of this insect have ever been recorded. On August 18, 1883, we bred a number of egg-parasites from a batch of eggs found upon a willow leaf at Washington, but unfortunately no description was made of them at the time, and, as they belonged to the soft-bodied genus *Trichogramma*, the specimens have now become so much shriveled and altered that they are unfit for descriptive purposes. We noticed after our return from Europe in September of this year that, at a number of points in New England, the worms were quite commonly attacked by parasites, and careful investigation at Washington by Mr. Lugger showed the presence of no less than five distinct species of primary parasites in addition to the *Trichogramma* just mentioned. These will be considered in some detail. The first was a new egg-parasite which we have named *Telenomus bifidus;* the others were all parasitic on the larvæ, and consisted of a Braconid (*Meteorus hyphantriæ* n. sp.); a Microgaster (*Apanteles hyphantriæ*, n. sp.); an Ophionid (*Limneria pallipes* Prov.), and a Tachinid, which, though probably new, we shall not attempt to describe. These last four have been mentioned in about the order of their relative abundance and consequent importance. An astonishing number of Web-worms were killed by the four parasites, and so many died from this cause and from the fungus disease previously mentioned as to fully warrant the prediction of almost complete immunity for the summer of 1887.

In addition to these parasites found last fall, the note-books of the Division show a prior breeding of another primary parasite, which will not be treated in detail here on account of insufficient material. It is an external feeder on the larva and belongs to the genus *Euplectrus*. It is closely related to *E. platyhypenæ*, described by Mr. Howard in Bulletin 5 of this Division.

Telenomus bifidus Riley.—A single egg of the moth of *H. cunea* is a very small affair, yet it is large enough to be a world for a little parasite, which undergoes all its transformations within it, and finds there all the food and lodgement required for the short period of its life.

In several instances batches of eggs of this moth were parasitized, and instead of producing young caterpillars they brought forth the tiny insects of this species. The batches of parasitized eggs were found July 27 upon the leaves of Sunflower, and August 18 upon leaves of Willow; judging from these dates it was the second brood of moths that had deposited them. There can be no doubt, however, that eggs

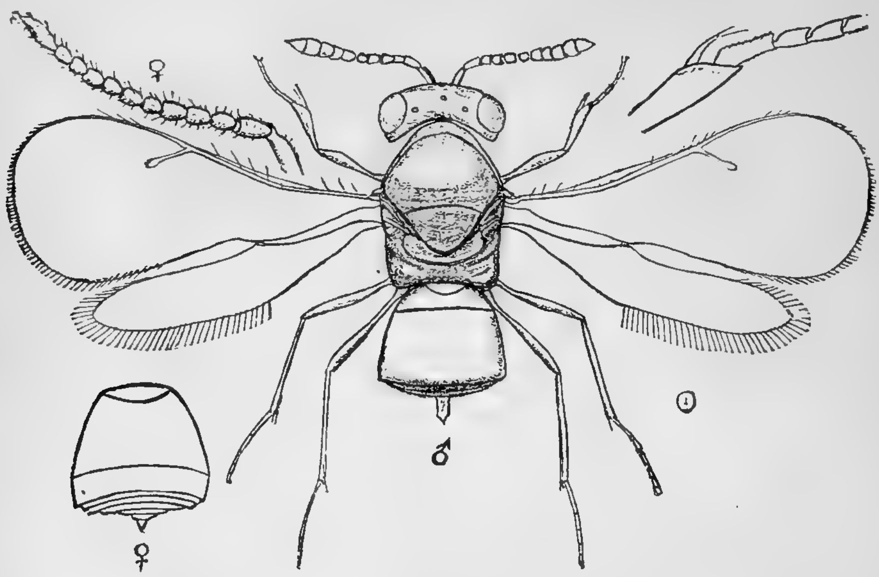

FIG. 23.—*Telenomus bifidus* (greatly enlarged).

produced by moths emerging from their cocoons in early spring had been parasitized as well. The female *Telenomus* was also observed, August 2, busily engaged in forcing its ovipositor into the eggs, and depositing therein. The female insect is so very intent upon its work that it is not easily disturbed, and one can pluck a leaf and apply a lens without scaring it away. The eggs soon hatch inside the large egg of the moth, and the larvæ produced soon consume the contents. This egg-parasite is a very useful friend, nipping the evil in the bud, so to speak.

Meteorus hyphantriæ Riley.—"This parasite (Fig. 24) has performed very good services during the caterpillar plague and has done much to check any further increase of the Web-worm. During the earlier part of the summer this insect was not very numerous, but sufficient proofs in the form of empty cocoons were observed to indicate at least one earlier brood. Towards the end of September, and as late as the 15th of October, very numerous cocoons of a second brood were formed; they could be found in all situations to which the caterpillar itself had access. But the great majority of them were suspended from the trunks and branches of trees, and chiefly from near the base of the trunk. Each cocoon represents the death of one nearly full-grown caterpillar, since the latter harbors but one larva of the parasite.* A careful watch was kept to see how such a suspended cocoon was formed,

* In only one instance the cocoon of this parasite was found inside that of its host.

but in vain. Once a larva had just started to make a cocoon, but it was prevented from finishing it by a secondary parasite, and it died. Another larva had already spun the rough outside cocoon, but became detached and dropped out of the lower orifice, and commenced a new one. The larva, suspended by the mandibles, evidently spins at first loose, irregular, horizontal loops around its body, until a loose cradle is formed. The silk secreted for this purpose hardens very rapidly when exposed to the air. When secure inside this cradle it lets go its hold with the mandibles, and finishes the soft inside cocoon in the usual manner. If the larva has dropped to the ground it still makes an outer loose cocoon, but the silken threads are thicker and much more irregular. In cocoons made during a high wind the threads that suspend them are much longer, reaching sometimes the length of 4 inches; the more normal length varies from 1½ to 2 inches.

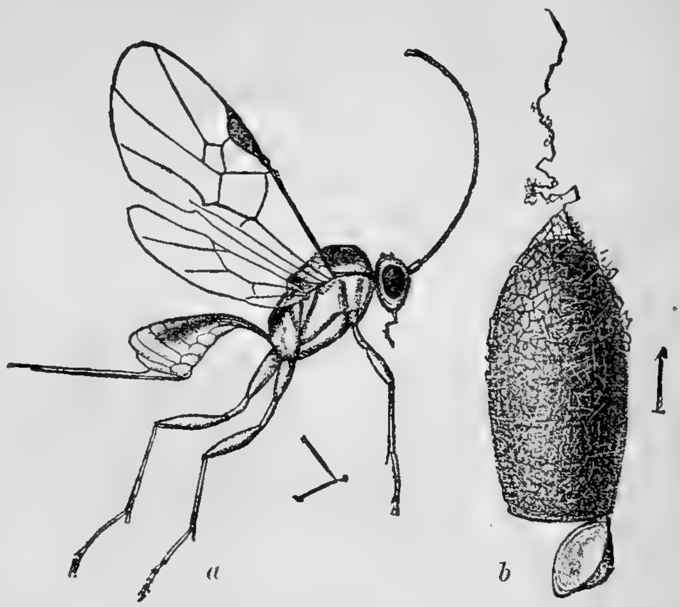

FIG. 24.—*Meteorus hyphantriæ*: *a*, female; *b*, cocoon (enlarged).

"To find out the length of time which this insect occupies in maturing inside the cocoon, 44 freshly made cocoons were put in a glass jar. With a remarkable regularity but ten days were consumed by the insect in changing from the larval to the winged form. The winged *Meteorus* issues through a perfectly round hole at the lower end of the cocoon by gnawing off and detaching a snugly-fitting cap. There are several secondary parasites of the *Meteorus* which we may mention later, and they always leave the cocoon of their host by smaller holes cut through the sides. Most of the adults had issued by the first of November, but it is possible that some may remain in their cocoons until spring.

"In order to obtain the proportion between the *Meteorus* raised from cocoons and its parasites, *i. e.*, secondary parasites of *Hyphantria*, 450 cocoons were confined in a glass jar the latter part of September. Up to the first week in November only 70 specimens of *Meteorus* were bred from these cocoons, the rest giving out secondary parasites, which continued to issue up to date of writing (December 20, 1886). Thus, only 16 per cent. of the cocoons produced the primary, while 84 per cent. produced secondary parasites."

Apanteles hyphantriæ Riley (Fig. 25 represents a closely allied species).—"This insect was about as numerous as the *Perilitus communis*, and did equally good service in preventing a further increase of the caterpillars. It appeared somewhat earlier in the season, and killed only half-grown caterpillars. From the numerous old and empty cocoons in early summer it was plainly seen that a first brood had been quite numerous, and that from these cocoons mainly *Apanteles* had been bred, and not, as during the autumn, mostly secondary parasites. The white silky cocoon is formed almost under the middle of a half-grown caterpillar, and is fastened securely to the object its host happened to rest upon, and but slightly to the host itself, which is readily carried to the ground by wind and rain, and can therefore only be found in position in the more sheltered places, such as cracks and fissures of the bark of trees. But one *Apanteles* is found in a caterpillar, so that each

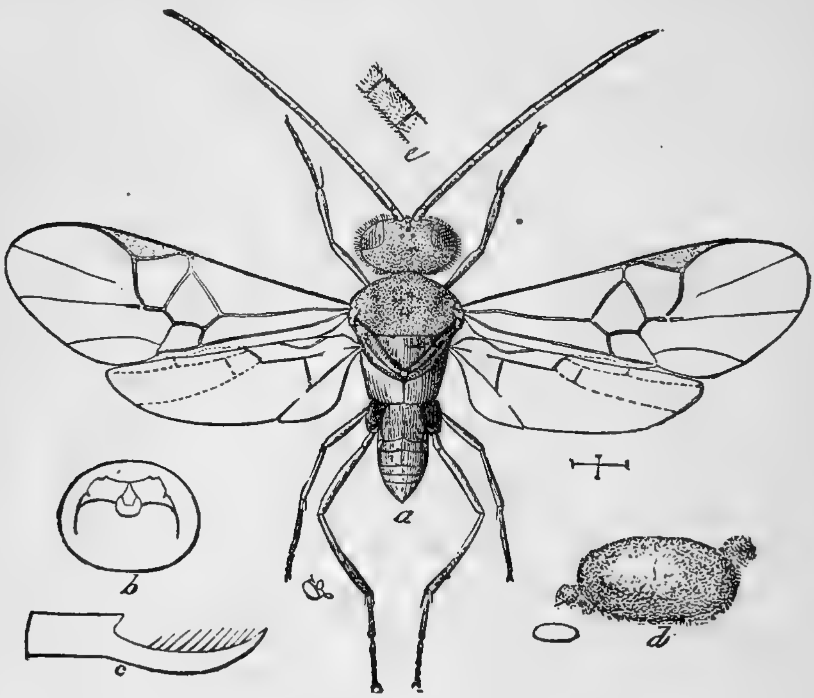

FIG. 25.—An *Apanteles*: *a*, female fly; *b*, outline of head of larva in position to show the chitinized parts of the mouth, the mandibles not visible, being withdrawn; *c*, one of its mandibles as seen within the head of a mounted specimen; *d*, cocoon; *e*, joint of antenna—all enlarged; natural size of *a* and *d* in hair-line.

white cocoon indicates, like a tombstone, the death of a victim. In some places, and notably upon the trunks of poplars, these cocoons were so numerous as to attract attention; it seemed as if the trunk had been sprinkled with whitewash. But notwithstanding such vast numbers, but two specimens of the architects of these neat cocoons were raised; all the rest had been parasitized by secondary parasites. It is barely possible, however, that some specimens may hibernate in their cocoons, since numbers of them have as yet (December 20, 1886) not revealed any insects. The winged *Apanteles* leaves the cocoon by a perfectly round orifice in the front, by cutting off a little lid, which falls to the ground. Its parasites, however, leave by small holes cut through the sides. These secondary parasites were very common late in September and early in October, and busily engaged in inserting their ovipositors through the tough cocoon into their victim within. It seems as if the cocoons formed early in the season were on an average a little smaller than those formed later.

"The cocoons of this *Apanteles* are of a uniform white color, but exceptionally a distinctly yellowish cocoon is found. From these yellow cocoons nothing has so far been bred; but since, as we have elsewhere shown,* the color of the cocoon may vary in the same species, it is probable that the variation here referred to is not specific.

"Not quite one-half of 1 per cent. produced parasites of various kinds.

"*Limneria pallipes* Provancher.—In addition to the two Hymenopterous parasites treated of, a third one has been very numerous, and has done much good in reducing the numbers of caterpillars. This, an Ichneumonid and a much larger insect, does not form an exposed cocoon like that of the other parasites described. Yet a little attention will soon reveal large numbers of them. Upon the trunks of various trees, but chiefly upon those of the poplars and sugar maples, small colonies of caterpillars, varying in numbers from four to twelve, could be observed, which did not show any sign of life. When removed from the tree they appeared contracted, all of the same size, and pale or almost white. A closer inspection would reveal the fact that the posterior portion of the caterpillar had shrunken away to almost nothing, whilst the rest was somewhat inflated and covered with an unchanged but bleached skin, retaining all the hairs in their normal position. Opening one of these inflated skins, a long, cylindrical, brown cocoon would be exposed; this is the cocoon of the *Limneria* under consideration. As numbers of such inflated skins would always occur together, it was clearly seen that the same parent *Limneria* had oviposited in all of them. Most of the cocoons were found in depressions of the rough bark or other protected places. Single ones were but rarely met with. The Hyphantria larva in dying had very securely fastened all its legs into the crevices of the bark, so that neither wind or rain could easily dislodge them. Only half-grown caterpillars had thus been killed. Many of these inflated skins showed in the early part of October a large hole of exit in their posterior and dorsal ends, from which the ichneumons had escaped. Trying to obtain winged specimens of this parasite one hundred and forty of these cocoons—and only such as were not perforated in any way—were collected and put in a glass jar. Only a single female was produced from all up to time of writing, whilst very large numbers of secondary parasites issued from October 11 till the 20th of November, and doubtless others will appear during the spring of 1887, because some of these inflated skins show as yet no holes of exit.

"*Tachina* sp. (Fig. 26).—The parasites of *H. cunea* described so far all belong to the order Hymenoptera, which furnishes the greatest num-

*Notes on North American Microgasters, p. 7 (author's edition).

ber of them. But the fly now to be described is fully as useful as any of the others.

"Tachina-flies are very easily overlooked, because they resemble large house-flies, both in appearance and in flight, and their presence out of doors is not usually noticed on that account. Yet they play a very important rôle, living as they do in their larval state entirely in insects. During the caterpillar plague such flies were often seen to dart repeatedly at an intended victim, buzz about it, and quickly disappear. If the caterpillar thus attacked was investigated, from one to four yellowish-white, ovoid, polished, and tough eggs would be found, usually fastened upon its neck, or some spot where they could not readily be reached. These eggs are glued so tightly to the skin of the caterpillar that they can not easily be removed. Sometimes as many as seven eggs could be counted upon a single caterpillar, showing a faulty instinct of the fly or flies, because the victim is not large enough to furnish food for so many voracious maggots. If the victim happens to be near a molt, it casts its skin with the eggs and escapes a slow but sure death. But usually the eggs hatch so soon that the small maggots have time to enter the body of the caterpillar, where they soon reach their full growth, after which they force their way through the skin and drop to the ground, into which they enter to shrink into a brown, tun-like object (known technically as the coarctate pupa), which contains the true pupa. The caterpillar, tormented by enemies feeding within it, stops feeding and wanders about for a long time until it dies. As a rule not more than two maggots of this fly mature in their host, and generally but one. The caterpillar attacked by a Tachina-fly is always either fully grown or nearly so.

"Tachina-flies abounded during the whole term of the prevalence of the caterpillars. But it is impossible to state positively whether they were all bred from them or not, since the many species of this genus of flies resemble each other so closely that a very scrutinizing investigation would have been necessary to settle such a question. But there is no doubt that they were very numerous during the summer. Some maggots obtained from caterpillars kept for this purpose in breeding jars changed to the fly in six days; others appeared in twenty-three days, and still others, obtained at about the same time, are still under ground, where they will hibernate. The maggots of these flies do not, however, always enter the ground, as some were found inside cocoons made by caterpillars among rubbish above ground."

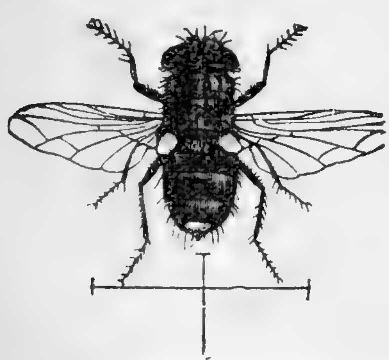

FIG. 26.—A Tachina-fly.

We have found, moreover, that three of these primary parasites of the Web-worm, viz, the *Apanteles*, the *Limneria*, and the *Meteorus*, were killed off at a serious rate late in the season by secondary parasites, most of which belong to the family *Chalcididæ*, with the exception of three species of the Ichneumonid genus *Hemiteles*. So extensive has been this killing off of the primary parasites by the secondary, that were not the fates of the three classes, viz, the plant-feeder, the primary and the secondary parasites so interwoven, the destruction of these beneficial insects might be considered a serious matter in dealing with the plant-feeder.

We have not taken time to determine these secondary parasites specifically, but give a little table showing the number of species concerned, mentioning them only by their genera:

SECONDARY PARASITES.

On *Apanteles*:

1. *Hemiteles* sp.
2. *Elasmus* sp.
3. *Eupelmus* sp.
4. *Panstenon* sp.
5. *Cirrospilus* sp.
6. *Pteromalus* sp.
7. *Pteromalus* sp.

On *Meteorus hyphantriæ*.

1. *Hemiteles* sp. (= 1 on *Apanteles*).
2. *Spilochalcis* sp.
3. *Hemiteles utilis* Nort.
4. *Eupelmus* sp. (= 3 on *Apanteles*)
5. *Hemiteles* sp.
6. *Pteromalus* sp. (= 6 on *Apanteles*).
7. *Pteromalus* sp. (= 7 on *Apanteles*).

On *Limneria pallipes* Prov.:

1. *Eupelmus* sp. (= 3 on *Apanteles*).
2. *Tetrastichus* sp.
3. *Pteromalus* sp. (= 6 on *Apanteles*).
4. *Pteromalus* sp. (= 7 on *Apanteles*).
5. *Elasmus* sp. (= 2 on *Apanteles*).

The observations just recorded were made in the main during the summer of 1886, a season of exceptional abundance of the worms. We may add that, in accordance with our predictions in the first edition of this Bulletin, there was an immense decrease in the number of the worms with the opening of the spring of 1887. So many had been taken off by the fungus disease and by parasites that the result was that except in a few streets the worms did not become abundant. Moreover, the parking commission sent out carts and men as soon as the webs had begun to be easily seen, and so thoroughly were the nests destroyed that the second generation of worms attracted no attention whatsoever.

Moreover, whole rows of old Silver-leaved Poplars (*Populus alba*), more than 1,500 in all, were cut down during the winter of 1887–'88, and their places filled by young Red Oaks, Sugar Maples, and Silver Maples. Many of the Box Elders were also taken down, although these were in the main young trees. A number of old tree boxes were removed, and where the tree was large enough to stand up by itself and simply needed protection from horses, a coarse wire screen was substituted for the box with good effect.

SUMMARY OF THE HABITS OF THE FOUR SPECIES.

It follows from the above that we have to deal with four very different insects, each of them requiring modification in treatment, especially so far as winter work is concerned. Here, as in every other case in dealing with injurious insects, correct knowledge of the habits of the species to be dealt with must necessarily precede intelligent action, else we shall be apt to err, as did the authorities of our neighboring city, Baltimore, many years ago, by incurring a great deal of unnecessary expense without producing any beneficial result. Their blunder is historical. Observing that the elm trees around Cambridge, Mass., suffered from defoliation and were effectually protected by troughs of oil around the trunk, they ordered similar troughs of oil to be placed around their trees in Baltimore, which were also being defoliated. In Cambridge, however, the insect involved was the Spring Canker Worm (*Paleacrita vernata*), which has a wingless female that issues from the ground early in spring, and is effectually prevented by the oil troughs from ascending the trees; whereas the trees in Baltimore were suffering from the Galeruca, which we have just described, and which has ample wings in both sexes.

1. The imported Elm Leaf-beetle is a small yellowish beetle, about a quarter of an inch long, and marked with two longitudinal dark stripes on the back. It passes the winter in the beetle state in holes and crevices in the bark of trees, in fences and tree-boxes, in barns and out-houses, etc., and the eggs are laid on the young leaves of elms in April and May. The eggs are yellowish, elongate, and pointed, and are laid on end upon the leaves in groups of from five to twenty or more. The resulting worm feeds on the leaves, gradually skeletonizing and gnawing holes through them. The larvæ molt four times and transform to pupæ at the surface of the ground under grass and stones. There are several broods, and and the worms are pretty constantly at work through the months of June, July, and August.

This is an imported insect, is confined to the Elm (genus *Ulmus*), has a predilection for the European Elm and for trees in cities, and the female flies long distances.

2. The Bag-worm is one of our commonest native American insects, and its bags hang from the smaller limbs of our shade trees so as to be easily seen, especially in winter, when the leaves have fallen. These bags are made by the larva or worm which lives within them. The female moth is wingless, and only leaves the bag in which she passed her larval and pupal life after she has deposited her eggs in her empty

chrysalis skin or puparium. She then falls to the ground and perishes. The eggs remain in the bag all winter and hatch in spring into young worms, which scatter and at once make new bags, which increase with their growth and protect them from the attacks of birds.

The male moth is a small, black, hairy-bodied creature, with ample transparent wings, and escapes from the chrysalis after it is partially worked out of the hind end of the bag. This worm is a very general feeder, but is, on the whole, more injurious to evergreens than to deciduous trees.

This species has several insect parasites.

3. The White-marked Tussock moth has a very beautiful hairy larva or caterpillar marked with black and yellow and red. The female cocoons are to be found during the winter on the trees and upon neighboring fences and tree-boxes, and each cocoon is plastered with a number of eggs, protected by a white, frothy, glutinous covering. The eggs hatch in spring and the young worms feed upon the fresh leaves. The males spin their cocoons after three molts and the females after four. The moths issue in July, pair and lay eggs for a second brood of worms, which in turn transform and bring forth moths in October, the eggs from which hibernate. The male moth is active, with ample wings, which are brown, with a conspicuous white spot, while the female is pale and wingless, and only crawls out of her cocoon to lay her eggs thereon and die. This species is never found on evergreens, and is chiefly injurious to elms and maples, and prefers large and old trees to young ones, because of the greater shelter which they offer for its cocoons. In Washington it is yet chiefly confined to our parks, and it has not begun to be as injurious as in cities like Philadelphia and Baltimore, where the trees are older and larger. Two probable egg-parasites and seven parasites of larva and pupa are known to me.

4. The Fall Web-worm passes the winter in the pupa state. The cocoons are found during the winter principally at the surface of the ground, mixed with dirt and rubbish, or in cracks and crevices of tree-boxes, in fences, and under door-steps and basement walls. The first moths issue from these cocoons in May, and lay their eggs in flat batches on the under side of the leaves. The young worms feed preferably in company, webbing first one and then several leaves together, and gradually extending their sphere of action until a large part of the tree becomes involved. The worms become full grown in July and spin cocoons, from which a second generation of moths issue early in August and lay eggs, from which the worms hatch; so they are once more in force by the latter part of August. This is the species which did the damage last year. The parent moth is white, with a varying number of spots; is winged in both sexes; and the female prefers to oviposit on Box Elder (*Negundo aceroides*), the Poplars, Cottonwoods, Ashes, and Willows. The worm feeds, however, on many other trees, but not upon Conifers. It has numerous enemies and parasites.

REMEDIES AND PREVENTIVE MEASURES.

WINTER WORK.

The preventive measures that can be taken during winter time vary according to the species to be dealt with. For No. 1, or the Galeruca, which is confined to the Elms, no treatment of the trees themselves or of the boxes; in fact, no treatment that can well be given in the winter season will avail much in destroying the insect in its hibernating retreats, because the parent beetle finds shelter in all sorts of out-of-the-way places. It flies long distances, especially upon awakening from its winter torpor, so that it may be attracted to the trees from regions into which it is practically impossible to effectually pursue and detect it.

With No. 2, the Thyridopteryx, on the contrary, effective work can be done during the winter time or when the trees are bare. The bags which contain the hibernating eggs, and which are very easily detected, then may be gathered or pruned and burned. This work may be so easily done that there is no excuse for the increase of this species. Where intelligent action is possible the bags were better collected and heaped together in some open inclosure away from trees, rather than burned. By this means most of the parasites will in time escape, while the young Bag-worms, which will in time hatch and which have feeble traveling power, must needs perish from inability to reach proper food.

Much can also be done with No. 3, the Orgyia, because it also hibernates in the egg state upon the female cocoons upon the trunks and in all sorts of recesses.

In regard to No. 4, the Hyphantria, which is the species we are more particularly dealing with, something also may be done in the winter time by systematic clearing away of the cocoons from the sheltered places in which they may be found. These hibernating retreats are, however, so numerous about our houses and our grounds, that complete destruction of all cocoons becomes an impossibility.

ONE SIMPLE PREVENTIVE REMEDY FOR ALL.

It so happens, fortunately, that there is one thoroughly simple, cheap and efficacious remedy applicable to all four of these tree depredators. From the natural history facts already given it is clear that they all begin their work very much at the same season or as soon as the leaves are fairly developed, and arsenical mixtures properly sprayed on the trees about the middle of May and repeated once or twice at intervals of a fortnight later in the season, will prove an effectual protection to trees of all kinds. This can be done at small expense, and will prove the salvation of the trees. An apparatus can be readily constructed, such as has been used on the grounds of the Department of Agriculture, on a sufficiently large scale to economize time and labor. It should consist of a water tank mounted on a cart and furnished with a strong force pump operated by one man and furnished with two sets of rubber tubing of a sufficient length (a hose reel can be constructed on top of the cart), each hose supported by a bamboo extension pole with a cyclone nozzle at tip. With such an apparatus as this three men could drive along the streets and thoroughly spray two trees simultaneously; while if it were found advisable, four independent tubes and four men to work them could be employed with a sufficiently powerful pump, and thus expedite the work. The details of the more important devices connected with this tank-cart are given in considering the Galeruca. The bamboo "extension pole" is used simply to stiffen the rubber hose and to enable the operator to elevate the spraying nozzle into the center of the tree and spray to a so much greater height. The same result can be accomplished by means of a brass rod, in sections, and this has the advantage of superior strength, and will consequently carry a heavier nozzle or a bunch of nozzles at the end.

The "Cyclone" or "Eddy-chamber" nozzle (see Fig. 6) is better suited for work of this kind on small trees than any yet in use. It is small, simple, cheap, will not clog, and gives an admirable spray. A combination nozzle may be made of several of these which will be readily supported by the section rod and will throw a more profuse spray.

The arsenical compound known as London purple is, as already shown, perhaps preferable to white arsenic or Paris green in that it is not so liable to burn the leaves while its color enables one to readily distinguish poisoned from non-poisoned trees. Moreover it is very cheap. From one-quarter to three-quarters of a pound of this substance should be used to a barrel of water, and with this quantity of water it is best to mix three quarts of cheap or damaged flour which will serve both to render the mixture adhesive to the leaves and also to lessen the tendency of the poison to burn the leaves. Three-quarters of a pound to the barrel may prove too strong a mixture for delicate and susceptible young trees, and it will be best for general application to make the amount from three-eighths to one-half pound to the barrel. Paris green will require a somewhat heavier dose—say from one-half to 1 pound per barrel of water.

A number of other means have been tried and are more or less effectual in destroying these defoliators. Such are the application of various other insecticides, particularly an emulsion of milk and kerosene, the burning of the webs (in case of the web-worm) by thrusting a lighted torch, made of various patterns, into the webs; but after full trial, nothing has been found more satisfactory than the arsenical mixtures.

here recommended. They have the advantage over all other means that they kill directly the worms begin feeding, and at the same time have a preventive influence. Properly sprayed on the under side of the leaves so as to adhere, they are not easily washed off, and they not only kill, without injury to the tree, all the worms at the time upon such tree, but all those which may hatch upon such tree for a number of days and even weeks subsequently.

We are satisfied that with two or three special tanks, such as we have built at the Department of Agriculture, and a gang of three men to each, the trees of the city could be easily protected at a nominal cost beyond labor, and that two sprayings, one about the middle of May and one the first week in June, will effectually prevent the repetition of any such nuisance as that we suffered from last summer. Each gang of three men could properly protect in the neighborhood of from three hundred to five hundred medium-sized trees per day, and in ordinary seasons and in dealing with the web-worm it would only be necessary to poison such trees as are preferred by the insect.

We may here with propriety describe, as supplementary to the general consideration of machinery on pp. 19–22, two recently-invented machines which could be used to advantage in this work.

The first is the invention of Mr. A. H. Nixon, of Dayton, Ohio, and will answer very well for the spraying of arsenical solutions. The cyclone nozzle, with all its advantages on small or medium-sized trees, is not so well adapted for spraying very high trees, and Mr. Nixon's nozzle and several others which might be mentioned have an advantage in that they throw a spray to a greater height or distance, in a more powerful and narrower stream, which nevertheless breaks up into a floating spray.

We have personally tested Mr. Nixon's nozzle and find it is a very satistactory one. Mr. W. B. Alwood, the agent of the Division at Columbus, Ohio, in a report upon it, writes:

"The necessity of a good apparatus for spraying tobacco in a packing-house led Mr. Nixon to experiment with many different kinds of apparatus, until almost by accident he discovered that a jet of water projected against a wire gauze of proper sized mesh held at a certain distance would produce a perfect spray. He was several years in working up a scheme to utilize this newly discovered fact, and then succeeded very imperfectly, but produced an apparatus which found quite common use in his and other tobacco warehouses in the Miami Valley.

"However, some three years ago he conceived the notion of perfecting his nozzle and bringing it into shape for practical utility on a force-pump. In this I think he has succeeded most admirably. Several styles of apparatus have been made by him for using his nozzle in practical work both in doors and out. Those designed for outdoor work have especial reference to the destruction of insects. How useful these may prove I would not venture an opinion, not having had a chance to use them in actual work, but of the fact that his nozzle will produce spray as fine or as coarse as can possibly be desired there is not the possibility of a doubt, and this, too, without any waste of liquid.

"The pump used on his machines is a single cylinder double action force-pump of extremely simple mechanism and of great power and durability.

"The nozzle (in which lies all the mechanism which he can really call his own invention) is very simple. It consists of a brass nipple three-quarters to 1 inch in length, pierced by a small hole varying in diameter according to the amount of spray desired. This nipple screws on to the discharge pipe and on its outer end is screwed a chamber three-quarters to 1 inch in diameter and 3 inches long. These dimensions have been determined by experiment. The nipple and chamber are made of brass. On the outer end of the chamber is soldered a wire gauze varying in size of mesh to suit size of orifice in nipple.

"The nipples tested by me were as follows:

No. 1. One sixty-fourth inch orifice projected spray 10 feet in straight line; discharged pint of liquid in 20 seconds; pressure could not be measured, but I think was 75 to 100 pounds in all the tests. Spray floated like mist.

No. 2. One thirty-second inch orifice projected spray little farther and little coarser; discharged 1 pint in 15 seconds.

No. 3. Five sixty-fourths inch orifice projected spray 18 feet; discharged 1 pint in 8 seconds; spray coarser than previous, but floated well in the air.

No. 4. One-eighth inch orifice projected spray 25 feet; discharged 1 pint in 5 seconds; still coarser, but fell in perfect mist, completely wetting soil.

"The apparatus tested by me was really yet in the experimental stage but gave very satisfactory results.

"The special features which commend this nozzle are that it is very simple, discharges spray farther in a straight line than any apparatus ever tested by me, and the capacity is practically unlimited.

"The complete machines which Mr. Nixon had made and were tested by me were as follows:

"No. 1. Sulky cart, drawn by horse, which also furnished motive power to pump by gearing from wheel. This machine as timed by me was capable of going over 21 acres of ground in eight consecutive hours, and completely spraying any low crop. Tank holds 70 gallons; pump arranged inside and so rigged with safety valve that pressure could be made to suit requirements of the nozzle used. This machine could also be used as a hand-pump by throwing out of gear and putting on a lever.

"No. 2. Is a hand machine on trucks with a small rest wheel in front. Tank holds 40 gallons and can be used for all ordinary purposes of spraying beds and lawns; also mounted in a wagon would be very serviceable for spraying orchards.

"No. 3. Is a small machine, 15-gallon tank, intended for use indoors."

The second machine is the invention of Mr. John Bowles, of Washington, D. C., and is used for the purpose of vaporizing naphtha of grade 77. Experiments made by Mr. Bowles and witnessed by Mr. Howard with this machine upon the Web-worm were successful in killing the worms, leaving the foliage uninjured. Fig. 27 shows the machine in section. Mr. Bowles' description is as follows:

"The mechanism employed for the purpose of applying the oil in the form of spray consists, essentially, of an oil-compresser, combined with an air-compresser, so that both may be actuated by the same effort, the leverage being adjusted so that the greater pressure may be applied to the oil-compresser, and the communicating together of the streams of oil and air at a nozzle for their discharge.

The form of machine shown meets these requirements. S is an oil-tank, that, for convenience, may be mounted on wheels. P is a bellows, attached to the tank, and actuated by the board *h*, by means of the handle, V, being pivoted to the top of the tank at U. An oil-pump is shown, within the chamber of the bellows, having a suction pipe, *s*, extending into the oil, and a discharge-pipe, *w*, connecting with the oil-pipe E, while the air discharged from the bellows passes through the air-pipe D, the oil-pipe being within the air-pipe, and both pipes meeting at the point of discharge, at the nozzle. The plunger or piston of the oil-pump is actuated by a rod

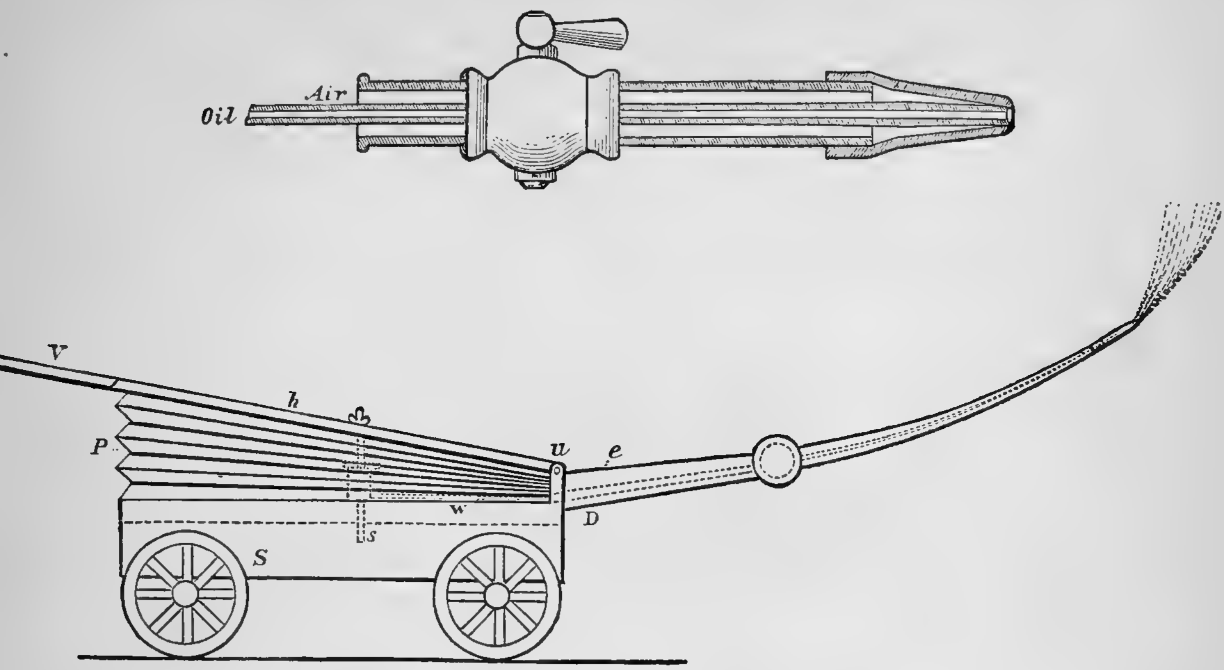

Fig. 27.—Atomizing machine invented by John Bowles, Washington, D. C.

pivoted to the board *h*, at a point that will give the oil-compresser such increased leverage as may be demanded for its proper discharge.

PRUNING AND BURNING.

The old and well-tried remedies of pruning or burning, or pruning and burning, will answer every purpose against the Web-worm in ordinary seasons, where it is thoroughly done and over a whole neighborhood. It must, however, be done upon the first appearance of the webs on the trees, and not, as was done by the Parking Commission of this city last season, after the first brood of worms had attained their full growth and many had already transformed to pupæ. The nests at that time had assumed large proportions, and their removal entire injured the appearance of many young trees. Then, too, they were piled upon an open wagon, which was dragged for many hours around the streets, permitting a large proportion of the worms to escape.

On the first appearance of the webs, which should be looked for with care, they should be cut off or burned off, and if cut off they should be burned at once. The "tree pruners," manufactured for the trade and well known to all gardeners, answer the purpose admirably.

The customary method of burning the nests is by means of rags saturated with kerosene or coal-tar and fastened to the tip of a long pole. An old sponge has been substituted to advantage for the rags, but probably the best substitute for this purpose is a piece of porous brick. In a pointed communication published in the *Evening Star*, of August 21, Major Key, agent of the Humane Society, thus describes the making of a brick torch: "Take a piece of soft brick, commonly termed salmon brick, trim it to an egg shape; then take two soft wires, cross them over this brick, wrapping them together around the opposite side so as to firmly secure it; now tie this end to a long stick, such as the boys get at the planing mills, by wrapping around it; then soak the brick in coal-oil, light it with a match, and you are armed with the best and cheapest weapon known to science. Holding this brick torch under the nests of caterpillars will precipitate to the sidewalk all the worms on one or two trees at least from one soaking of the brick, and it can be repeated as often as necessary. Then use a broom to roll them under it and the work will be done, the controversy ended, and the tree saved."

Asbestos may also be used to advantage, and a little thorough work with some simple torch *at the right time* will in nearly every case obviate the necessity of the more expensive remedies later in the season, when the worms of the first brood have grown larger or when the second brood has appeared.

MULCHING.

After a bad caterpillar year, a little judicious raking together of leaves and rubbish around the trunks of trees which have been infested, at the time when the worms of the second brood are about full-grown and before they commence to wander, will result in the confinement of a large proportion of the pupæ to these limited spaces, where, with a little hot water or a match, they can readily be destroyed during the winter. Many of the caterpillars, of course, reach the ground by dropping purposely or falling accidentally from the branches, but the great majority descend by the trunk, and, finding the covenient shelter for pupation ready at the foot of the tree, go no farther. This has been tested on the Department grounds the past season, and is mentioned as a method of riddance supplementary only to others.

INFLUENCE OF TREE-BOXES.

However necessary it may be in cities to protect trees, by means of tree-boxes, against bodily injury, chiefly committed by mischievous boys and loafers, such protection should only be afforded for a limited time, or long enough for the growing tree to attain a sufficient thickness to prevent its being broken by any ordinary accident. After such a thickness has been reached the boxes ought to be discarded. They are unnatural, and both injurious to the tree and unpleasant to the eye. A great number of trees are forever injured by such boxes, and the great increase of some kinds of insects is solely due to them. For instance, the Maple Bark-borer (*Trochilium acerni*) is almost solely confined to the injured bark of maple trees protected by boxes, and is scarcely ever found in normally growing trees. Such tree-boxes furnish good shelters for the formation of cocoons, and afford winter quarters for many noxious insects. The Web-worm under consideration makes excellent use of them. A small Box Elder, with a trunk of about 4 inches in diameter—a tree strong enough to thrive without protection—had been inclosed by the usual form of a wooden tree-box. This was removed, and the inside of the box and the collected rubbish in it was carefully investigated by one of our assistants, Mr. Otto Lugger. This is the result: 74 cocoons of *H. cunea*; 43 egg-masses of *Orgyia leucostigma*; 4 cocoons of *Acronycta americana*, and 1 pupa of *Anisota rubicunda*, besides innumerable old and empty pupal skins of these and other insects. It is to be added in this connection that this tree grew in a park in Baltimore, and was not as badly infested as trees in Washington.

A young tree in a tree-box ought to be firmly fastened at the top to all sides of the box, and this by means of flexible bands, to be renewed from time to time. In this manner a high wind would be prevented from producing any friction of the trunk or branches against the edges of the box. After the tree attains a size of 2 inches in diameter the tree-box ought to be removed, and the members of the city police should be instructed to pay especial attention to their further necessary protection. The shelter afforded by the wooden tree-boxes is, in my judgment, the prime reason why the Web-worm has become such a great nuisance in Washington. They should either be discarded entirely after the trees have attained a trunk diameter of 4 inches, and heavy penalties enacted for hitching horses or for in any way cutting or defacing the trunk; or, what would perhaps be safer, and certainly very much less objectionable, they should be replaced as soon as possible by round iron ones like those now in use on Fifteenth street, between New York avenue and K street. These will afford less shelter for cocoons, and are in every way less objectionable.*

WHITEWASHING OF TRUNKS.

Whitewash covers a multitude of sins; but sins should not be covered up, they should be eradicated, which a simple whitewashing will not do. A whitewashed tree is an eyesore, and whole rows of them, or even groves in parks treated in such a way, produce a sight to be deplored by all people admiring the beauty of nature. One is forcibly reminded of a grave-yard when walking through some of the Washington streets after sunset; the white trunks glisten like the broken shafts in an old cemetery. If the trunks of trees must be covered with lime at all, why not choose at least a color more in harmony with nature, the color of the bark for instance? There is no necessity, however, in Washington to whitewash the trunks of our shade trees. As a protection against flat and round-headed borers (species of *Chrysobothris* and *Saperda*) it is of value when a certain proportion of arsenic is mixed with it; but the principle "what is sauce for the goose is sauce for the gander" does not apply in this instance, and as a remedy for the Web-worm it is practically useless. Only one of the insects mentioned can be in any way be lessened by this practice, and that is the species that Washingtonians are just now least concerned with, viz, the Orgyia.

* Since this was written a very simple and excellent mode of protection has been adopted by the Parking Commission of the District, viz., encircling the trunks with woven galvanized wire.

It is very questionable whether the whitewash will destroy its eggs, but there is every reason to believe that the friction of the brush and the disengaging of many of the cocoons will cause the destruction of a certain number. On our larger trees the greater number of these cocoons are never reached by such whitewashing, because they are upon the higher limbs. The Web-worm cannot be affected by the practice, as the hibernating chrysalids and cocoons are not found upon the trunks. As against these negative results of whitewashing, however, we must put the injurious results that follow indirectly; because a great many of the enemies of the defoliators are destroyed by whitewashing. This is particularly the case with the egg-masses of spiders and many of the softer and more delicate cocoons of parasites.

BIRDS: THE ENGLISH SPARROW.

All four of these insects have a certain immunity from the attacks of birds: No. 1 by virtue of an offensive odor; No. 2 by the protection of its bag; Nos. 3 and 4 by the protection afforded by the hairs of the caterpillars, which are also mixed into their cocoons. A few native birds we have seen occasionally feed upon Nos. 3 and 4, but the English sparrow, to which, being emphatically a city bird, we should look for help, has never been known to attack any of them. In fact, we noticed and announced many years ago that in some of the northern cities (as Boston and Philadelphia) the increase of the Orgyia was indirectly a result of the increase of the English sparrow, which feeds in the breeding season upon smooth worms less harmful to our trees, and thus gives better opportunity for the rejected Orgyia to increase, a result still further promoted by the habit of driving away the native birds which the English sparrow is known to have. The same reasoning will hold true in respect of the Web-worm; and, putting all sentiment aside, we may safely aver that this bird is an impediment rather than an aid in preserving our trees from their worst insect defoliators. There is every reason to believe that the Bag-worm is carried, when young, from tree to tree upon the claws and legs of the bird, and its dissemination is thus aided and its destruction rendered more difficult; while the yellow suspended cocoons of the *Meteorus hyphantriæ* (the most important of the parasites of the Web-worm) are sought by the sparrow, probably being mistaken for grains of wheat.

While our feathered friends, owing to the sparrow's pugnacity, are now things of the past, and can only be seen in the spring when they pass through the cities in their migrations to more peaceable nesting places, yet something might be done to encourage their stay. Nesting places might be provided for them not alone by bird boxes, which, good in themselves, are at once occupied by the English sparrow; they must be afforded safer and natural quarters. This has been successfully achieved in portions of Europe and by the following very simple methods: First, a number of low but dense trees and bushes, forming in themselves fine-looking groups, are surrounded by dense and thorny hedges, to prevent cats and other enemies of birds from entering the inclosed space. Second, in the crotches of taller trees, and chiefly in the first crotch, bundles of thorny branches are fastened in such a way as to prevent cats from climbing above them. Such bundles would not look well during the winter, but they could then be removed to be replaced by fresh ones in the early spring. A broad strip of tin would, perhaps, answer the same purpose, but would not, at first, be as attractive to the birds themselves. A strict law against the use of slings, stones, and other weapons in the hands of the boys must, of course, be strictly enforced. In a very short time birds of various kinds will discover the safety of such places, and utilize them. Even if these birds should not alone avail against the ravages of insects, they would do good service, and their presence would pay for the little trouble of an invitation to them.

THE FUTURE OF OUR TREES—PRUNING.

Before closing this article it may be well to call attention to another danger from which our shade trees are threatened in the future. We refer to the reckless and almost cruel pruning which has in the past been indulged in, and which, if we are rightly informed by Mr. Saunders, the Parking Commission find it very difficult to prevent. No one looking to the future of our shade trees can have witnessed without indignation the gangs of careless men who periodically go through our streets cutting, hacking, and lopping indiscriminately and without intelligence the limbs of the trees until they have become on many of the older streets deformed and unsightly objects. The result of senseless pruning is easily seen on some of these older streets as compared with the trees in our parks which have been more often left alone and more intelligently pruned. Street shade trees should be pruned from below and not lopped off from the top, so that in the future there will result a tall straight trunk, not intercepting the view of the buildings from the street and yet furnishing the desired shade and beauty. The trees of such cities as Cambridge, New Haven, Saratoga, &c., may be cited by comparison with what ours are fast becoming. But there is another side to this question which justifies us in calling attention to it in this connection. To use the language of our Seventh Report on the Insects of Missouri, published in 1874, in treating of the Flat-headed Borer (*Chrysobothris femorata*), one of the most destructive borers of our trees: "Many a fine orchard tree, and many more city shade trees, receive their death shock from the reckless sawing off of limbs without effort being made to heal the wounds by coating with grafting wax, clay, or other protecting substances. Around such an unprotected sawed limb, as around the frustrum of a felled tree, the rain and other atmospheric in-fluences soon begin their work of causing decay between the bark and the solid wood; and this is but the forerunner of greater injury by insects which are attracted to the spot, and which, though hidden meanwhile from view, soon carry the destruction from the injured to the non-injured parts."

There is, in fact, more danger that our trees in future (especially the Soft Maple) will begin to fall and perish from the ravages of Borers, as a result of reckless pruning, than that they will ever be seriously or permanently injured by leaf-eaters. These last, as we have seen, may be overcome, but the Borers are not only more deadly but more difficult to manage.

TREES WHICH ARE UNINJURED.

I have already indicated a few of the trees which are most subject to injury from this Web-worm. There is also quite a list of trees which are either very little affected or are never attacked, and in this connection it may be well to mention a few of these which are, not only on this account but in every other way, desirable for shade trees and should be strongly urged upon the Parking Commissioners as substitutes for those, like the Box Elders, which are so seriously affected. In this list of desirable trees which have immunity I would mention:

Tulip tree (*Liriodendron tulipifera* L.).
Sweet Gum (*Liquidambar styraciflua* L.).
Sweet Buckeye (*Æsculus flava*, Ait).
Ohio Buckeye (*Æsculus glabra*, Willd.).
The Maples (*Acer rubrum*, *A. saccharinum*, *A. pseudoplatanus*, and *A. dasycarpum*).
Honey Locust (*Gleditschia triacanthus* L.).
Kentucky Coffee Tree (*Gymnocladus canadensis*, Lamb).
Sour Gum (*Nyssa multiflora*, Wangerh.).
Beech (*Fagus ferruginea*, Ait).
Yews (*Taxus* spec.).

GOOD AND BAD EFFECTS OF OUR TREES.

The beauty of Washington is very greatly enhanced by its shade trees, and the Parking Commission deserve very great credit for the gigantic work they have carried out in the last fifteen years. But while these trees are and ought to be in the future an unending source of pleasure and healthfulness, yet here, as is so often the case, the good has some corresponding evil. This last, however, may be easily avoided. We hear much of malarial troubles in Washington, and the Potomac flats come in for nearly the entire blame. During the month of October our streets are constantly covered with fallen leaves from our shade trees, eddying and whirling about and carried by every heavy rain into the sewer traps. Now, however vigilant the authorities may be during the heat of summer in cleaning out these traps, at the approach of cold weather the necessity for their frequent cleaning is supposed to be removed. As a consequence of this, vast masses of black, decomposing, and reeking leaves are left to fester during the late fall and early winter, and even through the whole winter, sending forth their injurious and insidious emanations from every street corner. From personal experience we are convinced that this is a source of much sickness hitherto almost entirely overlooked, and it behooves the authorities to have the traps on all the tree-planted streets thoroughly cleaned out immediately after the trees have become essentially bare.

PROSPECTS THE COMING SEASON.—CONCLUSION.

From the habits of the Orgyia as compared with the Web-worm there is good reason to believe that the former will become in the future more and more numerous and more and more of a nuisance, just as it has become the most grievous pest in Boston and Philadelphia and other cities where the trees are older. As to the prospects of a repetition of the Web-worm nuisance the coming season, the probabilities are that it will be very much less troublesome than it was in 1886. It is almost a universal rule in insect life that abnormal increase of a plant-feeding species is followed by a sudden check. This is due to two causes: *First*, the great multiplication of the parasites and natural enemies of the species which such undue increase permits; *secondly*, to the greater feebleness and tendency to disease resulting from insufficient food, which is a very general accompaniment of such undue increase. From the diseased condition in which the bulk of the last generation of the Web-worm was found, and from the great increase in its parasites that we know to have taken place from actual observation, we may safely expect exceptional immunity the present year.

SOURCE OF ILLUSTRATIONS.

Plate I is from a photograph. Figures 1, 2, 3, 4, 5, 6, and 11 are republished from former Government reports by the author. Figures 7, 12, 13, 14, 15, 20, 21, 22, and 26 are from the author's Reports on the Insects of Missouri. Figures 9, 10, and 25 are from other miscellaneous papers by the author. Figure 8 is from Hubbard, and figure 16 is from Glover; while figures 17, 18, 19, 23, 24, and 27 were drawn for this Bulletin and for our Annual Report as Entomologist to the Department of Agriculture for 1886.

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 11.

REPORTS OF EXPERIMENTS

WITH

VARIOUS INSECTICIDE SUBSTANCES,

CHIEFLY UPON

INSECTS AFFECTING GARDEN CROPS,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 14, 1886.

SIR: I have the honor to submit for publication Bulletin No. 11 of this Division, which contains in condensed form the results of a series of experiments with insecticides, carried on by certain agents of the Division during the past summer.

Respectfully,

C. V. RILEY,
Entomologist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

EXPERIMENTS WITH INSECTICIDES.

INTRODUCTION.

There are a number of remedies against insects, which have been pro posed from time to time, and which have been published without any definite record of experiment, their reputation resting upon hearsay evidence. The list of such remedies is growing longer every day, and with a view of testing some of those which are most frequently recommended, in order to enable us to speak with definiteness concerning their value, we prepared a list early in the summer and sent dupli cates to two of our agents, Prof. H. Osborn, at Ames, Iowa, and Mr F. M. Webster, at La Fayette, Ind. At the same time, being desirous of testing the infusions and decoctions of certain plants popularly supposed to have insecticide properties, we engaged Mr. Thomas Bennett, of Trenton, N. J., a practical gardener of many years' experience, to experiment in this direction. The reports of these three gentlemen are subjoined, and their results, though in the main negative, are nevertheless of considerable interest and value.

KEROSENE WITH MOLASSES.

It will be noticed that the kerosene emulsion used by Messrs. Webster and Osborn was made of equal parts of kerosene, molasses, and water. This method of making an emulsion was first suggested to us by Mr. E. S. Goff, of the New York agricultural experiment station at Geneva, N. Y., early last August. Mr. Goff had made what he thought a tolerably perfect emulsion with these substances by using a crude sorghum molasses, and his experience at once interested us on account of the fact that the mixture was made without heat, and because of the probability that the molasses would render the dilute emulsion more or less adhesive. After a long series of experiments, however, Mr. Goff came to the conclusion that he had overestimated the value of the preparation. We quote from his last letter on the subject:

"I write to say that after abundant experimenting with the molasses-kerosene emulsion, of which I wrote to you in August last, I fail to find it equal to the soap emulsion. By boiling the molasses and water and adding the kerosene to the hot solution, a very fair emulsion may be made, but on standing, a fermentation seems to take place which causes it to separate, and after that it will not remain mixed. The unexpected success of my first attempt with the very thick sorghum molasses led me to premature and unwarrantable conclusions."

Following out the first suggestion, Professor Osborn found it impossible to make a stable emulsion from the cold mixture of equal parts of molasses, kerosene, and water, using ordinary low-grade New Orleans molasses, no matter how violent and prolonged the agitation. In from fifteen to twenty minutes, at the most, the oil would almost entirely separate from the mixture, rendering necessary its immediate use after preparation.

COLD WATER AND CABBAGE WORMS.

In addition to the results of the experiments with cold water as a remedy for cabbage-worms, as given by both Professor Osborn and Mr. Webster, we have received several communications since our publication early in the summer, in the columns of the *Rural New Yorker*, of the suggestion* which originally came to us from Mr. C. H. Erwin, of Painted Post, N. Y. All of these communications are condemnatory of the remedy. We extract from one (written by Mr. E. S. Goff) an experiment which is worthy of publication in this connection:

> In experimenting with ice-water for the cabbage caterpillars I tried to intensify the conditions as much as possible. I immersed leaves having the caterpillars upon them in ice-water, leaving them there a quarter of a minute. I then removed the leaves to a bench on the west side of the house, about 3 o'clock p. m., on a very hot day. The temperature must have been at least 100 degrees. Half an hour later I examined them and found the leaves very much withered and becoming brown from the heat, but the worms had crawled to the rear side and were exhibiting no inconvenience.

In our article just mentioned we left the question as to the efficacy of the remedy open to experimenters, but the positiveness of Mr. Erwin's assurances, and the thorough, careful tone of his letter, inclined

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* The text of this suggestion was as follows:

"Mr. Charles H. Erwin, of Painted Post, N. Y., has accidentally hit upon a simple and yet, according to his experience, so perfect a remedy for the imported cabbage worm that I wish to give his experience as much publicity as possible, that it may be widely tested, and, if possible, verified the coming season. It is (to sum up an extended experience which he narrated) simply ice-cold water, or water but a few degrees warmer than ice-water, sprinkled upon the worms during the heat of the day. Mr. Erwin found that such an application in the hot sun caused them to quickly let go their hold upon the leaves, curl up, roll to the ground and die, while the cabbage suffered nothing, but looked all the fresher for the application. Should this method prove as successful with others as it has with him, it is evident that we have here a remedy of very general application, and one which in cheapness and simplicity far transcends the pyrethrum, which, since I first discovered its value for the purpose in 1880, has been, on the whole, our safest and most satisfactory remedy against *Pieris rapae*. Where ice is readily obtainable, as in the more northern States, or where cold springs are found, Mr. Erwin's discovery will prove of very great value to cabbage-growers, and will prove as useful against some other cabbage worms."

us to believe that there might be something in the remedy. When these adverse reports came in we wrote to Mr. Erwin to inquire whether he had made further experiments and for further evidence. He replied as follows, August 23, 1885:

I received last Thursday evening your assistant's (L. O. Howard) report of your unsuccessful trial of the "cold-water remedy" for cabbage worms. I have since called upon two old gardeners in the vicinity, who had used it. Mr. Thomas Homer was the only one whom I found at home, and he was ill. When I told him the result of your experiments he interrupted me by saying: "They have not used very cold water, or have used a rose-sprinkler when they should have thrown away the rose and used the spout. I have used ice-water, and it would make them turn white and would not hurt the plants. Deacon Farwell used to make me use ice-water and drench the plants at noon or in the hottest part of the day. I have used nothing else for many years, and have lost scarcely a head of cabbage since I used it." I have in answer quoted this honest old Scotch gardener for the reason that for the last three or four years I have not worked in or done any gardening for myself. I used to drench my plants every few days, always in the warmest part of the day, or about the time the pests were the most active and destructive—when they were on the upper side of the leaf—and have been told by others that they have succeeded after the worms had filled every crevice with their droppings and rejected chippings, which they had by drenching cleaned out; and here you discover is another benefit and argument for a copious shower of water.

Possibly those who have experimented have, through fear of injuring the plants, hesitated to use water cold enough or have used it too sparingly and in the cooler part of the day. In making the discovery I was too late to avail myself of caution about the safety of the plant, and was compelled to solace myself with the idea that if the cold had injured and killed them I was not in a worse predicament than before using the cold water, for if I had killed the plants I had only anticipated a few days the certain result of the pests.

Perhaps the vermin are of a tougher habit in a warmer climate, and I would not hesitate to reduce the temperature of the water another degree or two and be sure of the top degree of the day to apply it.

Several persons have told me that they used it last season with success, and one person that he had not been troubled this season, not yet having discovered any worms; but until recently but few persons in our vicinity grew more than a hundred plants. This season I have noticed not a few acres planted with cabbages.

Please have your tests made properly and in the right time, and I think you will succeed. It may seem too simple to be of much benefit, and scarcely worth the trial, and single efforts may fail for want of a little care. Let them act as if there should be no such thing as failure, and they will succeed. Drench more frequently.

In view of such positive statements on both sides we cannot consider the question as decisively settled yet, but a pretty strong case is made against the remedy in the reports which now follow.

C. V. RILEY.

REPORT OF EXPERIMENTS AT LA FAYETTE, INDIANA.

By F. M. Webster.

I.—Imported Cabbage Worm. (*Pieris rapæ* Sch.)

Experiment 1.—ICE WATER.

(August 4, 1885.)

Temperature of atmosphere about plants, 99° F. Temperature of water, 40° F. Drenched two cabbage plants, now well headed and seriously infested.

Result.—None perceptible.

Experiment 2.—ICE WATER.

Temperature of atmosphere, 104° F. Temperature of water, 38° F. Drenched two plants.

Result.—None are injured, and only seem to have been displaced.

Experiment 3.—ICE WATER.

August 4, 1885.—Temperature of atmosphere, 98° F. Temperature of water, 36° F. Drenched plants as before.

Result.—A number were washed off, but none died from the effects of their cold bath.

Experiment 4.—ICE WATER.

Temperature of atmosphere, 98° F. Temperature of water, 34° F. Plant seriously infested, larvæ from $\frac{3}{8}$ inch long to full grown. Drenched at 1.45 p. m., September 11, 1885, by pouring one quart water on head of plant, thoroughly wetting all larvæ visible.

Result.—At 5 p. m. all worms have returned to the leaves and are actively feeding.

Experiment 5.—ICE WATER.

Temperature of atmosphere, 96° F. Temperature of water, 34° F. September 19, 12.45 p. m., poured water from pitcher on two plants.

Result.—On one plant, worms, even the smallest, $\frac{1}{2}$ inch long, were uninjured; on the other two small worms were found dead soon after.

These were discolored when found, and I cannot say whether they died from the effects of water or from an epidemic disease that is destroying these larvæ in great numbers; some on this same plant being affected and afterwards died, and I think the latter more probably the cause.

EXPERIMENT 6.—SALT WATER.

August 5.—Dissolved salt in water to fullest capacity. Drenched a number of plants badly infested with larvæ.

Result.—On examination, 24 hours after application, I find no dead larvæ, but the living are feeding in abundance.

EXPERIMENT 7.—SALTPETER AND WATER.

Dissolved in water to fullest capacity. Drenched plants thoroughly.

Result.—Examined 24 hours after application, but find none dead, nor any diminution in the numbers of the living, which are feeding as usual.

EXPERIMENT 8.—CARBOLIC ACID AND WATER.

Solution of 1 part acid to 100 parts water. Drenched two plants.

Result.—This injured both plants, one quite seriously, by killing the younger, tender leaves, while such of the larvæ as were protected by these leaves did not seem to have suffered.

EXPERIMENT 9.—PYRETHRUM POWDER.

A mixture of one part of powder to three parts flour was thoroughly dusted on plants with Woodason's powder bellows, care being taken to get the mixture thoroughly introduced among the leaves and cavities eaten out by the larvæ.

This experiment was made in order to establish a basis from which to judge of the efficiency of other insecticides. I will further state that the pyrethrum powder used was sent me from the Department last season (1884), and had been kept in a glass jar closely corked.

Result.—Fully three-fourths of the larvæ were killed.

EXPERIMENT 10.—WOLF'S SOAP.*

Solution of 1 ounce soap dissolved in ½ gallon of water, applied at a temperature of 90° F., by drenching plants thoroughly, first wetting them with water, and drenching them with same a short time after application of solution.

Result.—At least one-half of the worms were killed and the plants not injured.

EXPERIMENT 11.—WOLF'S SOAP.

Solution as in 10. Sprayed lightly on several full-grown larvæ and confined them under glass.

Result.—None died.

* Manufactured by the Milwaukee Soap Manufacturing Company, Milwaukee, Wis.

EXPERIMENT 12.—WOLF'S SOAP.

Solution, 3 ounces soap to 1 gallon water; temperature 90°. Sprayed on plants with the Woodason atomizer.

Result.—Seems to have been rather more effective than in experiment 10.

EXPERIMENT 13.—WOLF'S SOAP.

Solution as in Experiment 12. Drenched plants thoroughly.

Result.—Does not seem to have been any more effective, although a much larger amount of the solution was used. The spraying method seems the more satisfactory.

EXPERIMENT 14.—WOLF'S SOAP.

Solution, 4 ounces soap dissolved in 1 gallon water. Sprayed on wet surface of leaves and head.

Result.—Killed a large number of the larvæ, but by no means all of them.

EXPERIMENT 15.—BUCKWHEAT FLOUR.

Dusted the article usually put up for family use on a number of infested plants.

Result.—The larvæ did not seem to suffer any inconvenience.

EXPERIMENT 16.—BUCKWHEAT FLOUR.

Placed 11 larvæ in some of this same flour, and covered with glass.

Result.—Forty-eight hours after, none had died, while some had climbed to top of glass and pupated.

EXPERIMENT 17.—AMMONIA AND WATER.

Solution of 3 tablespoonfuls of ammonia to 1 gallon of water. Applied with syringe.

Result.—None were injured by the application.

EXPERIMENT 18.—POWDERED ALUM.

Applied to dew-wet leaves at 8.10 a. m., abundantly.

Result.—Cannot see that any are destroyed.

EXPERIMENT 19.—COPPERAS AND WATER.

Dissolved one-half ounce copperas in 1 pint water; drenched several plants.

Result.—This only seemed to cause the worms to seek less exposed positions. Watched for a number of days, but found none dead.

EXPERIMENT 20.—BLACK PEPPER.

Applied the ground article of commerce copiously to two heads of cabbage.

Result.—I could not see that it affected those which came in contact with it, and all continued to feed as though no application had been made.

EXPERIMENT 21.—CARBOLIZED LIME MIXTURE.

Mixture of carbolized lime 1 part, quick lime $\frac{3}{4}$ part, gypsum 20 parts. Dusted mixture on two plants.

Result.—Twenty-four hours after, the worms were crawling about on the leaves, feeding, and although some of the powder adhered to their bodies, I saw no fatal results.

EXPERIMENT 22.—TAR WATER.

Sprayed on plants.

Result.—None apparent.

EXPERIMENT 23.—TOMATO WATER.

Steeped leaves of tomato vines, and applied strong decoction.

Result.—As in preceding.

EXPERIMENT 24.—ARKANSAS INSECTICIDE.*

Placed 24 larvæ on leaf of cabbage, and dusted both leaf and worms thickly with the insecticide, at 10.25 a. m., August 25. The leaf and worms were confined under a glass.

Result.—At 10.25 next day, they seemed to be feeding from some parts of the leaf not covered with insecticide. August 27, they did not seem to relish the leaf with the insecticide thereon, but found enough not at all or thinly covered to keep them alive. This is not of practical utility for large plants, but might do on those very young.

EXPERIMENT 25.—ARKANSAS INSECTICIDE.

Tested this thoroughly on plants, with results like those on leaf under cover. In this experiment the larvæ were watched closely for a period of four days.

EXPERIMENT 26.—SOLUBLE PINOLEUM.†

Solution of 1 part pinoleum to 40 parts water, sprayed copiously on plants in garden, August 25.

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*Manufactured by Hoag & Beecher, Judsonia, Ark.

†Manufactured by Hansen & Smith, Wilmington, N. C.

A sample of this "soluble pinoleum" was also sent to our agent at Cadet, Missouri, Mr. J. G. Barlow, who reported in brief, as follows: "Have experimented a little with the soluble pinoleum sent to me by your desire from North Carolina. I found that a solution of one part to 10 of water was not too strong for larvæ of

Result.—On 27th, not over 25 per cent. of worms were destroyed. Living worms abundant, showing no effects whatever.

EXPERIMENT 27.—SOLUBLE PINOLEUM.

Solution the same as in experiment 26. Placed larvæ on a leaf, thoroughly spraying the same.

Result.—The larvæ, with the exception of two small ones, survived, and devoured the leaf.

EXPERIMENT 28.—SOLUBLE PINOLEUM.

Solution, 5 parts insecticide to 100 parts water. Sprayed on plants in garden, September 2.

Result.—On 4th, a large number of larvæ of various sizes were alive and active, about 40 per cent. apparently having been destroyed.

Before further experiments could be made the larvæ began to die from effects of disease, and it was impossible to carry on the experiment and get definite results.

EXPERIMENT 29.—KEROSENE EMULSION.

An emulsion consisting of equal parts of kerosene, molasses, and water, was diluted with three times its volume of water. Syringed plants on September 7. Rain during night. Sprayed with same mixture again, September 10.

Result.—September 8, 80 per cent. of all worms exposed were destroyed. The result of second application could not be definitely determined, as many were dying from disease.

I do not think younger plants would withstand emulsion of this strength, but it would probably not be required for younger larvæ.

EXPERIMENT 30.—CARBOLATE OF LIME.

Dusted plants thoroughly with carbolate of lime, using the Woodason bellows.

Result.—Two days after, both large and small were still on the plants, with no dead to be found.

EXPERIMENT 31.—HAMMOND'S SLUG SHOT.*

Dusted insecticide thickly over the plants with powder bellows, September 11. Rain fell on 13th. Dusted again on 14th.

Result.—September 12, quite a number were found dead.

Noctuids and Pieris. The solution in these proportions will kill these larvæ in from one to two minutes. Plant-lice it will kill instantly. Tried several specimens of the larvæ of *Sphinx quinquemaculata*, and found to my surprise that not even the solution in full strength would kill them. I think the pinoleum will be useful as an insecticide, but not if mixed with so much water as the proprietors direct."—C. V. R.

*Manufactured by B. Hammond, Fishkill-on-Hudson, N. Y.

Of the first result I can only say that all larvæ died from disease shortly after, and at this date (October 19) the fact is clearly noticeable in the leaves, those appearing previous to about the 15th are badly eaten, while those that were put forth after that date are almost intact.

On October 1, the difference between the plants treated with slug shot and those not treated was very apparent in the much more thrifty look of the former, and the larger number of perfect leaves, and this difference is still very perceptible.

Just what per cent. of leaves was killed by insecticide, it is of course impossible to determine, but the plants have a better look.

II.—Native Cabbage Worm. (*Pieris protodice* Boisd.)

Experiment 1.—HAMMOND'S SLUG SHOT.

Upwards of 50 larvæ, taken from leaves of turnip, were placed in a cage, and leaves, slightly dusted with the insecticide, placed therein.

Result.—Two days after, many were dead and others were dying. On the third day nearly all were dead. Eventually but 5 pupated. The single meal of dusted leaves proved sufficient, although ample food not dusted was afterwards supplied them.

III.—Fall Web-Worm. (*Hyphantria textor* Harris.)

Experiment 1.—WOLF'S SOAP.

Solution of 1 oz. soap to half gallon water; temperature, 90° F. sprayed with atomizer on foliage adjacent to web; also in web, wetting same quite thoroughly, nearly all of the caterpillars being within.

Result.—Two days after application, about 60 per cent. were found to have been destroyed. The foliage which had been sprayed did not appear to suffer for about three days, when the caterpillars again returned to it and ate the leaves as though they had not been treated.

Experiment 2.—POTASSIUM SULPHIDE.

Solution, 1 part sulphide to 500 parts water; applied to web and foliage with garden syringe.

Result.—On following day, a small per cent. appeared to have been destroyed, but a week later the effects of the experiment could not be noticed. Does not seem to render the foliage distasteful.

Experiment 3.—COPPERAS WATER.

Dissolved 1 oz. copperas in one pint of water; drenched web, and thoroughly wetted foliage.

Result.—One day after, many caterpillars were dead and others scattered about in the web, seemingly very sick. Five days after, the foliage remains untouched and all are dead.

Experiment 4.—COPPERAS WATER.

Dissolved 1 oz. in 1 quart of water. Used as in previous experiment.
Result.—It does not seem to have affected the larvæ.

Experiment 5.—TAR WATER.

This water had been standing for several days in a cask partly filled with tar. Water applied with syringe, wetting larvæ and foliage.
Result.—On first day after, none appeared to have been injured, and many were feeding. Five days after, the results were as on the first.

Experiment 6.—AMMONIA WATER.

Solution of 1 tablespoonful to 1 pint water. Drenched as in experiment 5.
Result.—First day after application, none injured. Five days after, the situation is unchanged.

Experiment 7.—CARBOLIZED WATER.

Solution, 1 part carbolic acid to 123 parts water. Drenched web thoroughly.
Result.—First day after application, none injured. Five days after, situation unchanged.

Experiment 8.—TOMATO INFUSION.

Drenched web with strong infusion.
Result.—First day after application, none injured. Five days later, no change.

Experiment 9.—CARBOLATE OF LIME.

Dusted young larvæ and the leaves on which they were feeding, thoroughly.
Result.—First day after application, a few seem to be dead. Second day, not over 10 per cent. were injured.

Experiment 10.—SOLUBLE PINOLEUM.

Solution of 1 part pinoleum to 32 parts water. Sprayed several colonies and also adjoining foliage.
Result.—After four days all seem to be active, except a small per cent. that were drenched more thoroughly than the rest.

Experiment 11.—POTASSIUM SULPHIDE.

Solution of 1 part sulphide to 500 parts water. Sprayed on young caterpillars less than one-half inch long.
Result.—None were destroyed.

IV.—Colorado Potato-Beetle. (*Doryphora 10-lineata* Say.)

Experiment 1.—WOLF'S SOAP.

Solution, 1 ounce to 1 gallon of water. Temperature normal. Sprayed on a number of adults.

Result.—Twenty-four hours after, none were injured.

Experiment 2.—WOLF'S SOAP.

Solution and temperature same as in Experiment 1. Sprayed larvæ of various sizes about as I would apply Paris green and water.

Result.—Only a small number of the youngest were destroyed.

Experiment 3.—WOLF'S SOAP.

Solution of 3 ounces to 1 gallon of water, applied to nearly full-grown larvæ on potato vines.

Result.—Nearly all were alive next day.

Experiment 4.—WOLF'S SOAP.

Solution of 3 ounces to 1 gallon of water. Sprayed on tomato vines being eaten by nearly full-grown larvæ and adults.

Result.—Two hours after, both larvæ and adults had left the vines, but I found no dead. Three days after, adults were again feeding on the same vines, but no larvæ were observed to return.

Experiment 5.—AMMONIA AND WATER.

Solution of 3 tablespoonfuls of ammonia to 1 gallon water. Sprayed on plants infested by larvæ of various sizes.

Result.—One day after, only a very few of the youngest larvæ had been destroyed.

Experiment 6.—AMMONIA AND WATER.

Solution as in Experiment 5. Placed enough of this mixture in glass to cover bottom; put in glass nearly full grown larvæ and beetles, shook thoroughly, turned off fluid and insects and inverted the glass over them.

Result.—Not a single larva or adult was injured.

Experiment 7.—AMMONIA AND WATER.

Solution, 1 tablespoonful to 1 quart of water; applied as in Experiment 6.

Result.—The same as in previous experiment.

Experiment 8.—CARBOLATE OF LIME.

Sprinkled thickly on tomato vines that were being eaten by adults and larvæ.

Result.—Twenty-four hours after application the insects had apparently deserted the vines, but I found none dead.

EXPERIMENT 9.—CARBOLATE OF LIME.

Sprinkled larvæ and adults with carbolate of lime, and placed under glass.

Result.—None died.

V.—STRIPED CUCUMBER BEETLE. (*Diabrotica vittata* Say.)

EXPERIMENT 1.—WOLF'S SOAP.

Solution, 3 ounces to 1 gallon water, applied at normal temperature, to adults.

Result.—After 6 hours none appeared injured.

EXPERIMENT 2.—CARBOLATE OF LIME.

Dusted on male blossoms of squash in which six adults were feeding on the pollen.

Result.—Two days after, they were dead in the blossom.

VI.—MARGINED BLISTER BEETLE. (*Epicauta cinerea* Forst.)

EXPERIMENT 1.—TAR WATER.

Applied to a row of mangel wurzels, seven rods in length, which was being seriously defoliated by this insect.

Result.—Five hours after, only an occasional plant was being eaten.

EXPERIMENT 2.—WOLF'S SOAP.

Applied solution of 3 ounces of soap to 1 gallon of water to a row of mangel wurzels beside that used in Experiment 1.

Result.—Five hours after, only three beetles were found on the leaves, but none were found dead or injured.

EXPERIMENT 3.—COPPERAS WATER.

Solution, 1 ounce to 1 pint water sprayed on row next to Experiment 2.

Result.—Five hours after, the number of beetles feeding on leaves does not seem to have diminished.

NOTE.—Three days after, the beetles had returned to all three rows in about equal numbers.

VII.—ANTS.

EXPERIMENT 1.—CARBOLIC ACID.

Large numbers of ants had excavated burrows between the crevices of a brick walk in my yard, and kept the entire walk in an unsightly condition by reason of the numberless little circular heaps of excavated earth. To these burrows I applied about a tablespoonful of a solution of 1 part carbolic acid to 64 parts water.

Result.—No ants appeared in the burrows, and no attempt was made to re-establish these burrows again.

About two weeks later, a few burrows were excavated in the crevices, and these were treated in the same manner. The results were as favorable as before, and up to date (October 20), no ants have attempted to work in crevices of the walk.

EXPERIMENT 2.—CARBOLIC ACID.

Solution of 1 part acid to 128 parts water was applied to burrows, about two-thirds of a tablespoonful to each burrow.

Result.—In some cases, 24 hours after application, the ants had returned to work in the old burrows, but in most cases the burrows showed no signs of life.

EXPERIMENT 3.—CARBOLIC ACID.

Solution of 1 part acid to 96 parts water, applied as in Experiments 2 and 3.

Result.—Only in a single instance was any attempt shown to dig out the old burrows, and about this were a large number of dead ants that had been removed in re-excavations.

A few attempts to excavate burrows in the vicinity of the old ones were observed a few days after first application, but these burrows were drenched as before, and no attempt was afterwards made to excavate between the crevices in that vicinity.

EXPERIMENT 4.—COPPERAS WATER.

Solution of 1 ounce to 1 pint water was poured into the burrows.

Result.—Next day the ants were busily engaged in clearing out the old burrows.

EXPERIMENT 5.—AMMONIA WATER.

Solution of three tablespoonfuls to one gallon water was used, as in previous experiments.

Result.—Same as in Experiment 4.

EXPERIMENT 6.—TAR WATER.

Drenched as in previous experiments.

Result.—The ants did not attempt to clear out the old burrows, but excavated others close behind them.

VIII.—LETTUCE APHIS. (*Siphonophora lactucæ* Linn. ?)

EXPERIMENT 1.—SALT WATER.

Dissolved salt in water to its full capacity. Sprayed solution on lettuce plants infested, the aphids being on upright stalks and hence easily reached.

Result.—About 50 per cent. were killed. A second application on the following day was fatal to nearly all of the remainder, and to the plant also.

EXPERIMENT 2.—WOLF'S SOAP.

Solution of 3 ounces soap to 1 gallon of water. Sprayed on aphids on plants.

Result.—Thoroughly effective.

IX.—WOOLY APHIDS. (*Species various.*)

EXPERIMENT 1.—WOLF'S SOAP.

(Species on Tree-Ferns in green-house.)

Solution of 4 ounces soap to 1 gallon of water. (Temperature normal.) Sprayed on foliage previously wetted; drenched with water soon after application of solution.

Result.—This made no impression on the insects.

A second application after 24 hours had elapsed from first.

Result.—Only a small per cent. were destroyed.

A third application, the foliage not being sprinkled with water after application of solution, proved fatal to the aphids and killed the entire foliage of the plant.

EXPERIMENT 2.—TAR WATER.

WOOLY APHIS OF APPLE. (*Schizoneura lanigera* Hausm.)

Tar water sprayed on infested branches, August 31.

Result.—September 2, does not seem to have had the least effect.

EXPERIMENT 3.—SOLUBLE PINOLEUM.

Species as in Experiment 2. Solution of 5 parts pinoleum to 100 parts water. Sprayed on branches with atomizer.

Result.—On following day, many active lice were observed. Three days after, they were abundant, and five days after, were as abundant as at first.

EXPERIMENT 4.—SOLUBLE PINOLEUM.

Species as in Experiments 2 and 3. Solution of 15 parts pinoleum to 82 parts water. Sprayed on branches, September 15.

Result.—Three days after application, none were to be found, and up to October 20, none have appeared on these branches.

EXPERIMENT 5.—KEROSENE EMULSION.

(*Glyphina eragrostidis* Middleton.)

An emulsion, composed of equal parts kerosene, molasses, and water, was diluted with three times its volume of water. This was sprayed on aphids, September 12.

Result.—September 13, found hardly a trace of aphids. September 16, a very few have appeared. September 25, they have spread over the grass, and are as abundant as ever.

EXPERIMENT 6.—SOLUBLE PINOLEUM.

Solution of 5 parts pinoleum to 100 parts water, sprayed on same species, September 3.

Result.—September 4, none appear affected and none are destroyed.

X.—APPLE APHIS. (*Aphis mali* Fabr.)

EXPERIMENT 1.—SOLUBLE PINOLEUM.

Solution of 15 parts pinoleum to 85 parts water. Sprayed on twigs and leaves.

Result.—The aphids were completely destroyed.

XI.—APPLE LEAF SKELETONIZER. (*Pempelia hammondi* Riley.)

EXPERIMENT 1.—SOLUBLE PINOLEUM.

Solution of 15 parts of pinoleum to 85 parts of water. Sprayed over leaves, September 15.

Result.—Probably 75 per cent. of the larvæ were destroyed, but full-grown larvæ were observed on leaves, October 1st.

EXPERIMENT 2.—HAMMOND'S SLUG SHOT.

Dusted leaves seriously affected by larvæ, September 15, when no dew was on them.

Result.—September 16, 50 per cent. are dead. Dusted again, on 17th, on dew-wet leaves. October 1, not one living larva could be found on the leaves that had been dusted, while numbers were on leaves not treated. September 26, nine days after, a larva established itself on one of the dusted leaves, ate a very small spot on the leaf, and died.

XII.—YELLOW-NECKED CATERPILLAR. (*Datana ministra* Dru.)

EXPERIMENT 1.—POTASSIUM SULPHIDE.

Solution of 1 part potassium to 500 parts water. Sprayed on larvæ feeding on walnut.

Result.—The larvæ were uninjured.

EXPERIMENT 2.—POTASSIUM SULPHIDE.

Solution as in 1. Applied to larvæ clustered on trunk of tree, preparatory to molting.

Result.—The larvæ molted, and ascended the tree. I could not see that the application had the slightest effect.

EXPERIMENT 3.—WOLF'S SOAP.

Solution, 4 ounces to 1 gallon of water. Sprayed on larvæ feeding on walnuts.

Result.—The larvæ only changed their location for a branch higher up.

EXPERIMENT 4.—COPPERAS WATER.

Solution of 1 ounce to 1 pint of water. Sprayed two colonies of nearly full-grown worms.

Result.—This seemed to destroy a very few larvæ, and the remainder changed their location on the tree.

EXPERIMENT 5.—COPPERAS WATER.

Solution as in Experiment 4. Sprayed cluster on trunk of tree.

Result.—They molted, and ascended the trunk and began feeding.,

EXPERIMENT 6.—SOLUBLE PINOLEUM.

Solution of 1 part pinoleum to 32 parts water. Sprayed one cluster on leaves and another on trunk.

Result.—There appears to be some reduction in the numbers of those feeding, and those on trunk were destroyed.

EXPERIMENT 7.—SOLUBLE PINOLEUM.

Solution of 5 parts of pinoleum to 100 parts water. Sprayed half grown larvæ on branch high up in tree, so that I could only give them a slight wetting.

Result.—None were injured, and, two days after, they were feeding as though nothing had happened.

EXPERIMENT 8.—SOLUBLE PINOLEUM.

Solution of 15 parts to 85 parts water. Sprayed copiously on cluster on trunk of walnut tree.

Result.—About 50 per cent. were killed, some dying after the second day. The cluster became detached from the tree and fell to the ground, but a few larvæ detached themselves from it, and again ascended the tree, and molted.

EXPERIMENT 9.—AMMONIA WATER.

Solution of 1 tablespoonful to 1 pint of water. Sprayed cluster on trunk of tree.

Result.—They molted and ascended the tree.

EXPERIMENT 10.—KEROSENE EMULSION.

An emulsion, of equal parts kerosene, molasses, and water, was diluted with three times its volume of water. Sprayed on cluster on trunk of tree.

Result.—Not over 20 per cent. molted, and many of these died before ascending the tree.

EXPERIMENT 11.—KEROSENE EMULSION.

Emulsion the same as in 10. Sprayed on caterpillars on leaves and twigs in walnut tree.

Result.—All disappeared within forty-eight hours after application.

EXPERIMENT 12.—HAMMOND'S SLUG SHOT.

Dusted leaves on which nearly full-grown larvæ were feeding.

Result.—The worms changed their position soon after to a distant branch, but their route was clearly indicated by occasional dead larvæ hanging to the branch along which they had crawled, and soon after all disappeared.

REPORT OF EXPERIMENTS AT AMES, IOWA.

By Prof. Herbert Osborn.

Sir: I send you with this a summary of my tests of various remedies for cabbage insects, &c. My work has been almost entirely confined to cabbage pests, as some of the insects mentioned in your instructions had already passed the active stages, while some mentioned have not appeared in this locality. There are no gardens worthy the name in the vicinity, so that some of the most common vegetables, with the insects infesting them, have not been within my reach. Even cabbages were rather scarce this year. One patch of about eighty plants, on the college farm, was quite well stocked with insects—*Pieris rapæ*, *Plusia brassicæ*, *Plutella cruciferarum*, *Aphis brassicæ*, *Haltica striolata*, &c. Another patch on the college farm, containing a greater number of plants, contained scarcely one with a solid head, and they were so poor that the insects seemed to consider them beneath notice. Scarcely a cabbage worm could be found there during the entire fall.

A small patch of about eighty plants, on a farm owned by Professor Mount, was quite free from worms till the 1st of October, after which they were more plentiful, and served for experiments with several substances. The small number of plants necessitated experimenting on a few for any one substance, and going over the same plants with other remedies after the lapse of a few days, sufficient to note results.

The appearance of the epidemic disease among the cabbage worms, mentioned in connection with the cold-water experiments, made it necessary to be very careful in judging of results. It commenced about the middle of September, and continued till all the worms disappeared, great numbers dying from it, though all the plants in a patch would not be found to contain diseased worms at the same time (at one time a great many dead or diseased worms could be found at one end of the patch and none at the other). The characteristic appearance of the worms dying of this disease makes it easy to distinguish them for a time after death, but later they turn dark and shrivel, and do not differ much from worms that have been killed by parasites or predaceous insects or by application of remedies. Parasites have been quite abundant, both in Aphides and worms. Coccinella larvæ and adults, Syrphus larvæ, and Ichneumons were on hand, and I noticed one cabbage worm impaled on the beak of a soldier-bug, and others which appeared to have had their life extracted by the same foe. Altogether the worms and Aphides have had a hard time. Only a small proportion of *Pieris rapæ* could have pupated in a healthy condition.

Concerning the cold-water remedy, to which you desired me to give particular attention, my tests, while not crucial, for the reasons stated, satisfy me that it has no direct effect on the worms. I applied the water ice-cold (at one time with temperature of air above 80° F.), so as to thoroughly soak many of the worms which I could see, and in one instance I placed lumps of ice on a couple of cabbages so as to come in contact with worms, and so that the water running from these lumps would give them a cold bath for some time, but could not discover any worms dead from its effect. However, the worms on the plants treated with the ice water died off very rapidly with the micrococcus disease, and I think it possible that the treatment made them fall an easier prey to this epidemic.

Respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

TESTS OF REMEDIES.

Kerosene and Molasses Emulsion.—Made by shaking together violently equal parts of kerosene, molasses, and water. Emulsion thus formed would remain for some minutes, but gradually separate. This emulsion, applied September 10, 1885, killed cabbage worms of all kinds, Aphides, and other insects, provided it came in contact with them; but owing to their secreting themselves so fully within the leaves, many escaped. Even when applied so thoroughly as to kill the leaves of the plant, numbers of the worms would escape, and were seen afterwards as healthy as ever upon the plants treated with the emulsion. Not more than half the insects were killed by this treatment.

Cost of this application, one-fifth of a cent per cabbage, not counting time of making or applying.

Cold-water Application.—September 19, applied cold water from a well* direct to cabbage worms, at about 11 a. m.; day warm (77° F., at noon). Examinations later in the day showed no result. On the 21st, on plants thus treated were a number of dead larvæ, also many alive and healthy. Those dead had the appearance of worms dying from the micrococcus disease introduced from Illinois two years ago, and microscopic examination of the body contents showed them to be swarming with micrococci apparently the same as those in the disease of two years ago. Later many of these dead larvæ were found on plants not treated, so it

*Temperature of water in well here is about 40° F.

is uncertain whether the applications of water produced any effect. On September 21, at about 11.30 a. m. (temperature at noon, 81° F.), applied ice water to cabbage worms. Worms were decidedly disturbed when it came in contact with them, but I could get no positive evidence of any of them dying from its effects. On the plants thus treated the worms soon after began dying, as in the case of the first application of water; but as they also died on plants not treated, it is unsafe to conclude that this application induced the disease. On these plants worms died off till scarcely a living worm could be found. October 6, on farm of C. F. Mount, applied cold water to cabbage worms (day cool; at noon, 51° F.)—water cold enough to make the worms curl up and drop when it came in contact with them. Examined October 7, and could find none killed or dying from effect of this application.

Carbolic Acid in Water.—September 21, applied carbolic acid in water, very dilute (1 dram carbolic acid to 1 gallon water). An hour or two later no effect could be noted, nor on subsequent days. September 26, applied carbolic acid and water to plant-lice on squash and on cabbage, and to worms on cabbage and parsnips. Up to October 1 no effect was to be noted from this application. On October 6, on farm of C. F. Mount, applied carbolic acid and water (one-half ounce to gallon of water), sprinkling eighteen plants. On October 7, on plants thus treated a number of dead worms were found, but a considerable number had escaped. Professor Mount applied carbolic acid, about one-half ounce to one gallon of water, for the first brood of worms, and his cabbages were not injured till late in fall. He does not know that any were killed, but thinks it prevented injury.

Bran.—October 6, applied bran to cabbage plants on which worms were quite plenty. October 7, found the worms as numerous and apparently as healthy as before. Perhaps they avoid places where bran is thick.

Salt Solution.—September 21, this solution was applied to cabbages, on which were numerous worms and Aphides. Worms neither killed nor driven away. Aphides unaffected, except where they were washed off. The plants were watched until the 25th, and no result noted. The solution was also applied to Aphides on weeds, with no effect. Was also applied as a warm solution to Aphides on weeds, and some branches thickly covered with the insects were dipped into the solution, without effect on the Aphides that held to the plant. Some were washed off or crushed, but the colonies a few hours later and on following days were as thickly populated and as healthy as ever.

Saltpeter Solution.—September 21, applied saltpeter in solution to cabbages on which worms and Aphides were abundant. Neither seemed affected by the application. Up to September 25 there were no signs of injury. October 6, applied solution of saltpeter to eighteen cabbages on which worms were tolerably plenty. October 7, no effect to be seen; worms plenty and healthy.

Alum.—September 26, dusted pulverized alum on cabbages where worms and Aphides were abundant. Up to October 1 no effect was noted on either. September 26, it was applied in solution to them, but no signs of injury to either worms or Aphides were observed. October 6, applied to cabbages on which worms were plenty. October 7, worms as healthy and numerous as ever.

Kerosene in Ashes.—On October 4, applied this mixture to cabbage plants on which worms and Aphides were plenty, and watched for some time to see the effect. Could not find any worms killed by the application, though many were seen with the oily particles in contact with them on the leaves or adhering to their hairs. On subsequent days no decrease in numbers could be noted as a result of this application. Aphides were killed in some instances, but their position under leaves made it very difficult to dust them. The worms (*P. rapæ*) seem to be protected by their hairy covering, which prevents the particles from coming in direct contact with the skin, and renders the spreading of the oil less effective. The worms with smooth skin might be killed more readily, but they were not plenty enough on the plants treated to enable me to arrive at any positive conclusion.

Kerosene in Gypsum.—Applied on October 4, the gypsum containing as much kerosene as possible while allowing it to be dusted on the plants. The results were the same as followed the use of ashes, but I found it more difficult to mix and apply. There was a constant tendency to form lumps too large to be dusted on the plants, and unless quite fine the particles will simply roll off the leaves.

Kerosene in Sawdust.—Sawdust thoroughly saturated with kerosene was applied, October 17, to a number of plants on which cabbage worms were but moderately plenty. They were watched for nearly two hours, without any marked result. Unfortunately, I was prevented from making any further observations for several days, and in the meantime some severe frosts, the ravages of disease, and the maturing of the worms, left scarcely a living worm to be found even on plants not treated.

Tomato-vine Infusion.—Applied, October 7, to 18 cabbage plants infested with cabbage worms. The plants were thoroughly drenched with the infusion, and many of the worms were well soaked in it without apparent inconvenience to them. On the following day the plants thus treated were as badly infested as before and the worms were all vigorously feeding.

REPORT OF EXPERIMENTS AT TRENTON, NEW JERSEY.

By Thomas Bennett.

Trenton, N. J., *June* 15, 1885.

Sir: Under your direction I have tested the insecticide value, to a limited extent, of five of the six vegetable substances you gave me to experiment with. These were as follows: Jamestown weed (*Datura stramonium*); tomato leaves (*Lycopersicum esculentum*); Elder (*Sambucus*); Ailanthus; mandrake root (*Podophyllum peltatum*); and Tansy (*Tanacetum*).

At this date I have not been able to procure tomato leaves in sufficient quantity to experiment with; the others I have. The first insect that I found requiring attention was the green Aphis, or plant louse (*Myzus persicæ*), of the Peach, which was collected in great numbers on six young peach trees in my garden. They were only on the ends of the branches of the present summer's growth. I marked one tree, and prepared a decoction and also an infusion of tansy in the following manner:

Tansy.—June 5: weighed a handful of tansy, weight ½ pound; put it in three quarts of water; set on to boil; let it simmer an hour, then set away to cool. At the same time, made an infusion of ½ pound tansy by pouring on three quarts of boiling water, and set away to cool. This extract I found much the stronger of the two.

The leaves of the peach trees were so curled that I could not apply the liquid by other means than by dipping; besides, I wished to save my liquid. I dipped one side of the tree in the decoction, the other side in the infusion or extract. I found the liquid in both cases would wet the leaf but not the insects. They seemed covered with an oily substance which prevented the preparation in both cases from adhering to them; and it would roll off as water rolls from an oiled flag or piece of polished marble. Then I thought, as lye has an affinity for oils and grease, I would try lime-water and also urine, in the proportion of first one-quarter, then one-half; but although each proportion and each sort did some good, they were not satisfactory. However, the insects did not increase any, and I dipped them every day, for four days, and at this writing (June 15) there are few to be seen.

Elder Leaves.—June 7: made an infusion of elder leaves and tops, weight ½ pound; poured on two quarts of boiling water; set on back of range to draw; time, two hours. I had expected a good result from elder, as it has long been used by gardeners and farmers, combined with burdock and walnut leaves, &c., as an application against insects; but in this case it did not seem to work well. I marked another tree, and applied it by dipping the ends of the branches. The water rolled off as usual, and would not stick. I mixed a little alkaline lime-water, but it seemed not to injure them in the least. I noticed that the infusion was nauseous but not bitter. I cannot see how it acts as an insecticide unless by the smell. Some insects have a great dislike to pungent and strong smells. After the fourth dip, which was on the fourth day, I despaired of its doing any good in this case, and so tried my next remedy, which was mandrake root.

Mandrake Root.—June 8: made a decoction of mandrake root, 1 pound; put in two quarts of water; let it come to a boil, and then simmer or stew slowly for one hour. When cool it tasted very bitter and was rather dark colored, and I had good hopes of it, in which I was not disappointed. I applied it to another young peach tree, and also to a young, six-year-old cherry tree, infested with black Aphides (*Myzus cerasi*). Three dips almost cleaned them entirely from the peach tree, and also from the cherry tree, so that the Ladybug and her larvæ made short work of the few sickly ones that remained. I cannot account for it, but this wash seemed to take a better hold of the insects, so that the Peach Aphis would turn brown after the second dip; and in my subsequent experience I found that whenever the insects turned brown it was a sure indication that their time was short. They would not increase afterwards, and the Ladybug larvæ soon destroy them. I also tried this remedy on rose bush Aphis, with about the same result.

Ailanthus.—June 9: made an infusion of 8 ounces of the leaves of Ailanthus in two quarts of water; let it draw two hours. The liquor was very dark, and the infusion similar to elder in its effects; the water rolled off and would not adhere to the insects. An infusion of the bark was clear, only slightly brown. I added some lime-water, for the purpose mentioned in my first experiment, and also applied a little fine dust through a small dredging box. This made the infusion adhere very closely, and the Aphides succumbed after the third dip. It will be remembered in all these cases that I made only one dip each day, and waited till next day to see its effects; then dipped again. No one need be surprised that these different bitter and obnoxious plants had no better effect on these insects when I say that I afterwards tried two of the strongest vegetable bitters we know—namely, quassia and coloquintida, or the colocynth gourd—with no better effect.

I may here remark that I bottled and labeled all those bitters for other experiments.

N. B.—I have since found that the ailanthus bark contains the bitter principle very largely, but takes a long time to draw.

Stramonium.—June 10: made an infusion of 6 ounces of the leaves and young tops of Stramonium in 3 pints of water. Let it draw two hours. When cool I applied it as I did the others, by dipping the ends of the branches. The liquid was not bitter, but I depended on the effects of the poisonous narcotic principle, which, like its near relative, tobacco, it very largely contains. In this I was not disappointed, for, although it would not adhere very closely, the Aphides seemed to diminish and die after the third application; and if any scattering ones remained they were soon eaten up or destroyed by their enemies. I should note that a few rose bushes, infested with Rose Aphis (*Siphonophora rosæ*), were treated in a similar manner to the peach and cherry leaves, but the lice seemed somewhat harder to kill.

Alder Bark.—June 11: I thought I would try an infusion of alder bark, because it contained the tanning principle, which is an astringent, and as all astringents, whether vegetable or mineral, are more or less insecticidal in their nature, I thought that perhaps it might be of some value. I found it had some effect as an insecticide, but as the infusion is very dark, almost as black as ink, and discolors the leaves a good deal, I left it off and do not recommend it.

Quassia.—June 11: made an infusion or extract of quassia chips or bark, ground fine. These are made more nicely prepared than formerly. Gardeners know well the power of this bitter, in greenhouses and graperies, in keeping down Green Fly, as they call it (*Siphonophora viticola*), also Thrips (*Erythroneura*), and Red Spider (*Tetranychus*). I poured two quarts of boiling water on four ounces of quassia. This made a strong infusion of a beautiful brown color, similar to the tea we use from the shops. I thought surely this would kill at the first dip, but it did not, though very bitter. It took three dips of this strong liquid to kill these Aphides on the Peach, the Cherry, and the Rose, and then there were some stragglers around, of which I could not be sure whether they escaped from the effects of the dipping, or came in from other parts of the tree or rose bush.

Coloquintida, or Colocynth Gourd.—June 11: this bitter principle I have formerly used to a limited extent, in greenhouses, and have a high opinion of its merits; but quassia being so much cheaper and generally effective, I have mostly used it. However, I procured an ounce of colocynth, ground it up, and put on nearly a pint of boiling water, and drew it as tea. It is very powerful as a bitter, but it took three dips to eradicate the Aphides from the rose bush, peach, and cherry trees.

Further Experiments.—Monday, June 15: went out a short distance in the country, about one mile east of Trenton, to the lands occupied by Mr. James McGrath, who is an extensive cabbage-grower, and got liberty to make some tests with a view to preventing the cut-worm from injuring the young cabbages. I had previously learned that he was going to plant on this day. Was allotted a piece to experiment on, that contained

60 plants to each row. I poured on the stems and lower ends of the leaves of

Row No. 1: Mandrake infusion;
Row No. 2: Elder infusion;
Row No. 3: Stramonium infusion;
Row No. 4: Ailanthus infusion;

and, Tansy being plentiful on the place, I made a strong infusion of it, and wetted over 1,000 plants which were to be planted on another part of the lot. I also made a solution of

Alum, 2 ounces to 1 pint of water;
Niter, 2 ounces to 1 pint of water;
Saleratus, 4 ounces to 1 pint of water;
Lime water, 4 ounces to one quart of water;

and applied these strong liquids to rows 5, 6, 7, and 8, which together made 9 tests or experiments.

I did not examine these for results till June 29. The Tansy seemed to show the best results, and I could only find 4 plants eaten off by cut-worms.

The saleratus had been strong, and killed several plants, and I could not pronounce any of the other experiments entirely successful.

Mr. McGrath had lost many plants in this lot of about four acres by cut-worms during the last two weeks.

June 17: tried the effect of infusion of Ailanthus, Tansy, Elder, and mandrake, sprayed on with a brush by drawing the hand lightly over the brush till all the leaves were wetted. These did not give very satisfactory results, though partially effective. Next day, I thought I would assist them with some cheap powders. I procured some gas lime, and sifted it; and also made a powder of gas-tar and lime, then sifted. This last was composed of ½ ounce of tar to 1 pound of lime. I also made a preparation of quicklime, well sifted. After spraying the vines, and making a number for each experiment, I proceeded thus—

No. 1. Elder leaves, followed by a dusting of gas-house lime.
No. 2. Stramonium, followed by a dusting of tar lime.
No. 3. Mandrake, followed by a pure lime dust.
No. 4. Tansy water, followed by pure lime dust.
No. 5. Ailanthus leaves tea, followed by gas-house lime.
No. 6. Ailanthus leaves tea, followed by tar lime.
No. 7. Ailanthus, followed by pure lime.
No. 8. Lime water alone, as a thin whitewash.
No. 9. Niter water alone, 2 ounces to 1 pint of water.
No. 10. Alum water alone, 2 ounces to 1 pint of water.
No. 11. Saleratus, 4 ounces to 1 pint of water.
No. 12. Gas lime and pure lime, mixed in equal quantities.
No. 13. Tar lime alone.
No. 14. Pure lime alone.

I had never seen potato vines more thickly covered with bugs than these were when I commenced with them, owing to the fact of the owner having removed to the other side of the city, and not having time to attend to them. On Saturday, June 20, there were no bugs there. I did not see them again till June 28, then I saw only 5 bugs on the lot. I have given them another sprinkling of tar lime since then, and there is not a bug to be found. I am sure they never got a particle of Paris green.* As many persons have an objection to putting Paris green on potatoes, I can recommend a dead shot made of one pint of gas tar to 1 peck of lime as an effectual remedy against potato bugs.

July 15, 1885.—As you directed, I have continued through this month to make experiments with the six vegetable substances you advised, namely, Ailanthus, Tansy, stramonium, Elder, mandrake, and tomato.

Before I proceed further, I wish to say that during the fore part of this month I succeeded in cleaning a few hop vines in my yard and those of some of my neighbors from two species of a destructive caterpillar, and also a species of Coreus or Stink Bug, which was doing much harm by sucking and killing the leaves of the vines. I herewith send specimens of the bug and the caterpillar.† I made a powder of gas tar and lime, which soon cleared the vines of every insect, and now there are none to be found on them. I find this powder is good also for every species of Plant-louse.

July 6.—Collected these leaves and plants, and made strong infusions. First tried them on the Cabbage Cut-worms, by burying a worm one-half inch deep and within 1 or 2 inches of each cabbage plant, wetting them thoroughly with each liquid, and labeling each one. At the same time I tried Hansen & Smith's Pinoleum, diluted with 25 parts of water. Next morning, when I went to examine my plants, I found the worms had all moved away but one; this one had been wetted with tansy, was curled up in the usual way, and apparently in good health. It was evident, however, they did not like their situation, for only one ventured to cut his plant, and that was the one wetted with elder; he was also gone.

I next tried the effect of these infusions on the Jumping Flea-beetle (*Haltica*), on Early Dutch cabbages. Most of them proved very good, but were most effectual when followed by a dusting of lime powder or plaster.

The liquid adheres better after the garden syringe than the watering pot. Infusions of ailanthus leaves and also of stramonium I have used in former years for this and green fly and cabbage lice with good effect, but they were mostly followed by a dusting of lime in fine powder. I would remark just here that tobacco dust, lime powder, plaster, ashes, or soot well mixed with five or six times its bulk of charcoal dust, or in fact any other dust, will effectually keep off the Jumping-bug, if the ground around the plants be kept stirred; and here is where many fail in applying these powders; they do not seem to be aware that it is necessary to stir the

*I should note that the saleratus was too strong, and killed part of the leaves of the potatoes as well as the bugs.

†These insects were *Agrotis malefida, Arctia virginica*, and *Coreus tristis*.—C. V. R.

ground often around the plants. If a field of turnips or a bed of cabbages, when just coming over the ground, be only lightly stirred, by drawing a garden rake over the plants, along close to the rows, there will be very little if any powder required, but this must be done often to keep down this bug; and in this the secret of saving the crop lies, of which few seem to be aware. These bugs seem to breed in and come from the ground around the plants, but, it seems, cannot generate if the ground be kept frequently stirred. This I have proved to my entire satisfaction; and when the ground cannot be stirred, all of the above powders will often fail.

I next tried the effect of these infusions on cabbage lice (*Aphis brassicæ*) on about 200 plants. Here, again, I found it was essential to follow with the lime powder, for although these washes killed some and stunned most of the others, yet it had not the powerful effect of the lime powder. This, as far as I have gone, has proved effectual, and I think if put on in time will keep down this pest altogether.

During this month I have also been trying to find out something to prevent the Cut-worm from injuring cabbages after being planted. I have tried soft soap and tobacco water separately and combined, as a dip, also Hansen & Smith's Pinoleum in 12 times its volume of water. They were all too strong and killed many of the plants at first. Nothing daunted, I tried again, at least the soap and tobacco. Infused two ounces of tobacco stems in one quart of water, as a dip for the stems and lower ends of the leaves. Also made a suds of one teaspoonful of soft soap to one pint of water. With each of these I wetted 25 cabbage plants, and placed a Cut-worm in the ground near the stem of each. This was done a week since, and I have had none of these cut yet, and they continue to be cut in a field of 14 acres near by. The owner has only saved this lot of cabbages by keeping boys constantly searching for and killing the grubs around the plants and occasionally transplanting. I also tried a plan of former days, by putting a little freshly slacked sifted lime around 115 plants, with this exception, that in order to make the test good I buried 12 Cut-worms, about one-half inch deep, and from one to two inches from the stems of each of a dozen plants. I have seen them every day for more than a week, and I have not found one plant cut yet. I have also tried the effect of these infusions on the Slug (*Selandria*), a small soft-bodied caterpillar I found on pear and cherry trees. Syringed the branches, and wetted them well. The stramonium water was the most powerful; seemed to kill at once, but next day I found many yet on the leaves. I then gave them a dusting of lime powder, and that completely banished them.

I formerly used a powder of ailanthus and also of stramonium leaves to eradicate this pest from fruit trees, but of late years I find lime powder, well sifted and dusted on, involves less labor, and is a most effectual remedy against this pest.

I find cabbage-growers in general make a great mistake by planting too deep. They put nearly all the stem into the ground; this gives easy access to the Cut-worm to destroy the heart of the cabbage; they would do much better not to plant so deep, especially the late-grown kinds, as the hard stem is less liable to be cut than the heart of the cabbage.

July 31, 1885.—In your favor of the 17th instant you requested me to continue my experiments as heretofore with infusions of Tansy, Ailanthus, stramonium, Mandrake root, Elder, and tomato leaves, in order to give a definite answer as to which may be of value as an insecticide and which are worthless. I beg leave to say I have gone to work very willingly to try to answer this important question, and made tests on various insects.

As most of the above plants are now easily procured, I made infusions in large quantities, but of about the same strength as heretofore. I find it is better to let these leaves dry two or three days before the infusions are made. These liquids seem also to gain strength by age. At a week or ten days old they are much stronger than when first made. One pound weight of the partially dried leaves to one gallon of water makes a good wash. I first tried the relative value of these infusions on some brown and yellow hairy caterpillars, the larvæ of a Bombycid moth (*Arctia virginica*), 1½ to 2 inches long, which had been very plenty in this locality, on the Sunflower. I marked a certain number of plants for each test, and sprayed and wetted both sides of each leaf thoroughly. They all continued to eat the leaves after this as before; but with those sprayed with ailanthus, stramonium, and mandrake not nearly so ravenously—they seemed rather dainty in their biting.

Next day I wetted again as before, with about the same result; but when I wetted the worms thoroughly with stramonium they fell off and crawled away, and seemed not to ascend the plant any more.

Then, in order to satisfy myself as to the merits of the different liquids, I collected a number of these caterpillars and placed them in six groups, on a short piece of board. I wetted them all over equally. They were all able to crawl out of their bath; but, when I pushed them back and wetted their heads, they did not get out again from either mandrake, ailanthus, or stramonium. The others crawled out of several wettings; but these remained on the board, and were dead next day.

About the middle of the month I sowed a patch of white turnips in drills, for the purpose of testing these liquids on the Turnip Fly (*Haltica*). They were up in about four days. I commenced wetting them; not all, but part of each of six rows. I found it was necessary to wet them every day for a week, and afterwards two or three times, before they got ahead, in order to keep down this pest; and where I did not wet them they were all eaten off in about seven or eight days, and I could not say positively which of these liquids was the best.

I tried these infusions also on the Grape-vine Thrips, on an outdoor arbor, and both sides of the leaves had to be wetted. In this case the stramonium and tansy seemed the best, but the leaves had to be well drenched twice, and in some cases three times, before the insects forsook them or were all killed.

I have also tried the effects of these washes on the Cabbage Louse (*Aphis brassicæ*). These seem easier killed now than about the beginning of this month. Each liquid seems to have a better hold of them than at first, and two applications killed them all on every head to which these washes were applied. I sprayed 12 heads, two to each liquid used.

I also tried the power of these infusions on some cucumber vines, to see what effect they would have on the Striped Cucumber Beetle (*Galeruca*), and find that unless these washes are very plentifully applied they will have but little effect on this bug.

On the 24th of this month I procured six Cabbage Cut-worms, and put one near the stem of each of six cabbage plants, and placed it about one inch under ground. I then placed a common tomato can over each plant and sunk it in the earth about one-half its depth. I had previously cut off both ends smoothly with a pair of scissors; then about one-half pint of liquid was poured into the can around each plant, and this wetted the ground, I should say, about three inches. The following night the plant wetted with elder was cut off by its worm, and the fourth night, the 28th instant, another, marked "Ailanthus," was cut; but since then no more have been cut.

My object in this experiment was to find out, if possible, the real value of each of these infusions as a preventive to the Cut-worm; for if some will not cut at all, after being starved, as it were, in prison, I think that wash may be depended on.

These infusions have been taken on their merits alone, and I do say they all have some good properties as insecticides. I do not think much in general of tomato leaves, nor Elder alone; nor do I think Mandrake will ever become popular, from the fact of the extra labor and difficulty of collecting and preparing it. Tansy, Ailanthus, and stramonium are the best, in my opinion, and of these three stramonium stands the highest in my estimation.

I have to thank Professor Riley very much for assistance rendered in determining the species of many insects in these and many other tests performed by me.

Most respectfully,

THOMAS BENNETT.

Professor C. V. Riley,
Entomologist, &c.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 12.

MISCELLANEOUS NOTES

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FOR THE

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., June 7, 1886.

SIR: I have the honor to submit for publication Bulletin No. 12 of this Division, which contains certain notes on the work of the Division made during the year 1885, and which were excluded for lack of space from my report of that year. I have also added a paper on *Cicada septendecim*, sent at my request by the author, and containing many interesting original observations, if not always agreeing with those of others.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

CONTENTS.

PRODUCTION AND MANUFACTURE OF BUHACH.

BY D. W. COQUILLETT.

DEAR SIR: In accordance with your written request for me to prepare a report upon the growth, manufacture, &c., of the insect powder known as "Buhach", as practiced by the Buhach Producing and Manufacturing Company, of Stockton, Cal., I beg leave to submit the following: For much of the information contained herein I am indebted to Mr. G. N. Milco, one of the proprietors of the above firm, and also to the pages of the *Pacific Rural Press.* I obtained much information concerning this new industry while staying at the company's plantation last summer when investigating the locust plague for the Department.

The Buhach Producing and Manufacturing Company's plantation is situated about one mile east of Atwater Station, in Merced County, and contains 800 acres, 300 of which are planted to *Pyrethrum cinerariæfolium*, from the dried flowers of which the above company manufacture the insect powder to which they have given the proprietary name of Buhach.* The soil of this plantation is a sandy loam, so sandy in fact that when the growing upon it of the *Pyrethrum* plants was first attempted many of the plants were buried beneath the loose, drifting sand which was blown about by the winds. To overcome this evil, lines of Lombardy and Carolina poplar trees were planted along the banks of the irrigating ditches to serve as wind-breaks.

The great Merced Irrigating Canal passes through the middle of the Buhach plantation, and the latter is supplied with water from it by a system of irrigating ditches which, if extended in any one direction, would reach to a distance of about thirty miles.

The seeds of the *Pyrethrum* are sown in the spring or fall of the year, and are buried in the soil to the depth of about half an inch by lightly disturbing the soil with a rake. The seed-beds, which are not unlike those used for starting cabbage and tomato plants, are occasionally sprinkled with water. During the rainy winter season the plants are transplanted to the fields, where they are set out in rows four feet apart, and two feet apart in the rows. During the dry summer season the plants are irrigated about once every month.

* The word *Buhach* is derived from the Sclavonic word *Buha*, which signifies a flea; but there is no such word as *Buhach* in the Sclavonic language.

In preparing the ground for irrigation a deep furrow is made between each two rows of the plants by means of a plow drawn by one horse; this plow is so constructed as to throw the dirt to each side of the furrow. After one of the fields has been thus furrowed out, a cross-furrow is made at the ends of these furrows on the highest ground, and the water is turned into this cross-furrow from one of the irrigating ditches. From this furrow the water is in turn let into one of the other furrows, one or two at a time, according to the amount of water supplied by the cross-furrow.

Dams are placed in the irrigating furrows at a distance of about one rod apart, and as soon as the furrow is filled with water to the first dam the latter is removed, and the water flows on to the second dam, and at the proper time this one is also removed; and this process is repeated until all the furrows have been supplied with water.

The next day or so a one-horse cultivator is run once or twice through each of these furrows, for the purpose of filling them up, and also to loosen up the soil to prevent its drying out too rapidly. If the field is weedy the men follow with hoes, and cut out the weeds.

In this manner the plants are treated until the time for gathering the flowers arrives, with the exception that the irrigating is dispensed with during the rainy winter season.

A few of the plants will produce flowers the first year after having been transplanted to the fields, but they produce the most profusely about the third year. The majority of the plants now growing upon the Buhach plantation are six years old, and still bear well. A certain proportion of the plants die every year, and their places are supplied with young plants during the winter season.

The flowers are gathered during the months of May or June. The operator seizes all of the flower-stems growing upon one plant in one of his hands, and with the other cuts them off 3 or 4 inches above the ground by means of a sharp, hooked knife resembling an old-fashioned hand-sickle. They are then conveyed to a wooden stand to which is affixed an iron comb, the teeth of which are wide enough apart to permit the flower-stems to pass between them, but are sufficiently close together to catch the flower-heads. The operator takes a handful of the flower-stems, catching them below all of the flowers, and passes the stems between the teeth of the iron comb, the latter being between his hand and the lowest flower; then giving his hand a jerk the flowers are pulled off of the stems and fall into a wooden box, while the stems are thrown to one side out of the way, to be burned as soon as dry enough.

The flowers are spread out to dry, and at night are covered up to prevent the dew from falling upon them, which would naturally injure their insecticidal qualities. As soon as they have been thoroughly dried they are put into sacks and sent in car-load lots to the mill at Stockton.

Arriving at the mill the flowers are fed to a set of burr mill-stones, just as wheat is handled in making flour by the old process. The grist is carried by an elevator to a separator which, by proper sieves, separates the coarser particles of the grist, allowing only the finest, dust-like powder to pass through. This powder is carried by an elevator to an adjoining building, where it is put up in tin cans for the market, while the coarser particles thrown off by the separator are returned to the millstones again.

The flowers become considerably heated while being reduced to a powder, but the latter, in passing through a large series of elevators, loses its heat to a great degree before it is put into the cans for the market.

This powder is put up in tin cans of five different sizes, holding respectively 2 ounces, 5 ounces, 10 ounces, 1 pound and 6 pounds. The 2 ounce and 5-ounce cans are packed into boxes containing a dozen cans, and also into cans of 12 dozen cans each; the 10-ounce and 1-pound cans are packed into boxes containing a dozen cans each, and the 6 pound can into boxes holding 6 cans.

Each can of powder bears the company's trade-mark, which is a guarantee of the purity of the powder contained therein. The design of this trade-mark consists of an enlarged figure of a flea above, and a figure of a grasshopper below, while between them are the words: "Buhach: G. N. Milco's California Universal Insect Exterminator," and in the upper corners are the words "Trade-mark." The essential element of this trade-mark is the word Buhach.

Mr. Milco informs me that two years ago a certain firm doing business in this State undertook to put a fictitious article upon the market under the name of Buhach; the Buhach Producing and Manufacturing Company brought a suit against them, but as the said suit has not been decided up to the present writing it is impossible to say what the outcome will be.

Mr. Milco made the first experiment to introduce the growth of the *Pyrethrum cinerariæfolium* into this State in the year 1870. In 1873 he sold a few pounds of the powder, at the rate of $16 per pound. In 1878 he raised about 900 pounds of the powder, which at first he sold at the rate of $4.50 per pound, but finally reduced the price to $1.25 per pound.

In the year 1879 Mr. J. D. Peters united with Mr. Milco in the cultivation of the *Pyrethrum cinerariæfolium* and the manufacture of Buhach, under the firm name of the "Buhach Producing and Manufacturing Company," and for several years they sold the Buhach at the rate of 75 cents per pound, wholesale.

The present price of the Buhach is as follows:

The 6-pound cans are sold to the largest wholesale dealers at from 45 to 50 cents per pound; the wholesale dealers sell them to retail dealers at the rate of 56½ cents per pound, when a case of six cans is purchased at one time, but when less than a case is taken the price is 60 cents per pound. The retail dealers sell these cans to consumers at the rate of 75 cents per pound when the whole can is purchased at one time, but when only a fractional part of the can is wanted the price is $1 per pound.

The 1-pound cans are sold to wholesale dealers at the rate of $115.20 per gross, less 15 per cent. discount; these are sold to the retail dealers at the rate of $9.60 per dozen, and these dealers sell them to consumers at the rate of $1.25 per can.

The 10-ounce cans are sold to wholesale dealers at the rate of $63 per gross, less 15 per cent. discount; the wholesale dealers sell them to retail dealers at $5.25 per dozen, and the latter charge the consumers 75 cents per can.

The 2-ounce cans are sold to wholesale dealers at the rate of $18 per gross, less 15 per cent discount.; the retail dealers pay $1.50 per dozen for these cans and sell them to consumers at the rate of 25 cents per can.

The company also puts up a small sample box of the Buhach, which is mailed to all applicants free of charge.

The company has two different kinds of instruments for distributing the dry Buhach powder. One of these is called an "insufflator," and somewhat resembles a tin oil-can, such as is commonly used for oiling sewing-machines, but the distributing tube is placed low down on one side, while on the upper side is a tube, open at both ends and projecting into the can; this tube contains a piston which, when pushed downward, throws the Buhach out of the distributing tube in a fine shower, while a spring again pushes the piston upward in its proper place as soon as the pressure from above has been removed. This instrument is held in one hand and the piston is operated by the thumb of the same hand. It is intended for distributing the Buhach in places where only a small quantity of it is required.

It was formerly constructed with an opening in the piston leading into the interior of the insufflator, through which the latter was filled with the Buhach, the opening being afterwards closed with a tight-fitting cork; but an improvement has lately been made by having nearly the whole bottom in the form of a screw-cap, like that on glass fruit-jars, which can be removed by being unscrewed; by this arrangement the insufflator can be filled much easier and quicker than by the old way.

The present price of this insufflator is 25 cents each.

The second instrument, referred to above, is intended for distributing the dry Buhach in large quantities. It consists of a tin can somewhat resembling a common lard-can holding 5 pounds of lard. In the lower part of the can, upon one side, is an opening, into which the nozzle of a small hand-bellows is inserted, while on the opposite side, also near the bottom of the can, is a smaller opening, leading into a spoon-shaped nozzle on the outside. This nozzle is furnished with a slide, so arranged as to regulate the quantity of the buhach that is forced through it by the bellows. The top of the can has an opening 4 inches in diameter, and is closed by a tightly-fitting screw-cap, similar to that of a glass fruit-jar.

The price of this instrument is $2.50.

For applying the Buhach and water the company has a small pump, which is attached to a galvanized iron vessel holding about 8 gallons. To this pump is attached 10 feet of rubber hose, to the end of which is affixed a small iron tube 5 feet in length, and so constructed that several of them can be fastened together, end to end. To the tip of this is attached a cyclone nozzle, which is screwed on to the end of the iron tube. This nozzle was introduced by the Department of Agriculture a few years ago, and is far superior to any other nozzle that I have ever seen.

The pump consists of a strong brass tube about 2 feet in length, into which is fitted a piston or plunger, which is operated by one hand, while with the other the tube containing the nozzle is moved about at the will of the operator.

The present price of this pump, complete, is $15.

The cost of setting out an acre of *Pyrethrum* plants varies considerably, but should not exceed $90. If the plants are set out in rows 4 feet apart, and 2 feet apart in the rows, it will require about 5,445 plants to the acre. The plants should not cost more than 1 cent apiece, if grown by the person intending to plant them out, and the Buhach Company offers to send a package of the seeds of *Pyrethrum cinerariæfolium* sufficient to plant an acre for the sum of $5.

There will be little or no income from the plants the first year that they are transplanted to the fields. After the second year the plants will yield from 300 to 600 pounds of dried flowers to the acre, but when the winter is dry and cold the plants will not yield more than 150 to 200 pounds of dried flowers per acre the following season.

The kind of *Pyrethrum* now grown upon the Buhach Company's plantation is the *cinerariæfolium*. There are a few plants of the *P. roseum* growing in their nursery, but this species is not considered by them to be so desirable as the former species, although it is hardier and easier to start from the seeds. When a flower of the *cinerariæfolium* is crushed it gives forth a very strong odor peculiar to itself, and doubtless existing in the insect-destroying property of these flowers. The flowers of *P. roseum* give forth no odor when crushed, and the powder made from them is far inferior to that made from the flowers of *cinerariæfolium*, as far as its insecticidal qualities are concerned.

The flowers of all of the *cinerariæfolium* plants appear at the same season of the year, or within a short time of each other, thus permitting the whole field to be harvested at one time, whereas the *roseum* is much more irregular in its flowering, continuing to produce flowers during the greater part of the summer season, sometimes producing a second crop of flowers the same season, but it does not blossom as profusely as the *cinerariæfolium*.

The insect-destroying property of Buhach consists of a volatile oil which, in evaporating, exhales a gas that causes death by asphyxia to those insects which breathe it, producing a similar effect upon insects that chloroform and ether have upon human beings. But, what is very singular, while being so destructive to insect life, Buhach has no injurious effect upon human beings. That such is really the case can easily be proved by a visit to the company's mill at Stockton when in full operation. At such times the air in the room where the flowers are ground into powder is filled with the fine, dust-like particles of the powder; many of the workmen are obliged to remain in this room continuously for several hours at a time, and take no more precautions against breathing the powder than a miller takes against inhaling the fine particles of flour in his mill; and yet they never suffer from the effects of thus inhaling the fine particles of the Buhach powder.

Neither is the Buhach poisonous to either man or animals who eat some of it by chance or otherwise. Mr. Milco writes me that a teaspoonful of the alcoholic extract of Buhach was administered to a certain person afflicted with tape-worm; the dose was repeated every hour for ten consecutive hours, with the effect of removing the tape-worm without in the least degree injuring the patient.

Neither is Buhach poisonous to insects. I have seen locusts feed upon cabbage leaves that had been so thoroughly sprayed with a solution of Buhach and water that the leaves were thickly covered with Buhach after the water had evaporated; still the locusts were not at all injured by thus feeding upon it.

At the stables of the Buhach plantation several tons of the dried stems of the *Pyrethrum cinerariæfolium* were fed to the horses; the latter appeared to relish it very much, and I could not discover that they were injured in the least by thus feeding upon these stems.

It is this perfect immunity from poisonous or other injurious qualities to those using it that has given to Buhach a prominent position among our insecticides, and makes it a perfectly safe remedy to use about the house.

While in one form or another it is so destructive to insect life, still it appears to have little or no effect upon the eggs; it also is not so fatal in its effects upon the pupæ or chrysalids of those insects which pass through a quiet pupa state as it is to the larvæ and to the adult insects. It appears to have the greatest effect upon the higher forms of insect life, while the lower or more or less degraded forms are not so easily affected by it.

Buhach is sometimes applied in a dry state, but for out-door purposes this occasions a great loss, since the finer particles of the powder will float in the air, and be carried away by the wind. A much more satisfactory way of applying it is to mix it in water and spray the insects with the solution.

As the Buhach at first merely paralyzes the insect, it is necessary that this influence upon the latter should continue until death results. To accomplish this some viscid substance should be combined with the solution of Buhach and water, in order to cause the solution to adhere to the insects for a sufficient length of time to deprive the latter of their lives. One of the best known substances of this kind is glucose, a semi-liquid refuse of sugar refineries. This substance combines readily with the Buhach solution, and does not appear to have an injurious effect upon the plants that have been sprayed with it. A low grade of brown sugar would doubtless answer the same purpose, although not in an equal degree, not being so viscid when mixed with water.

Besides using the Buhach in a dry form, and mixing it with water, it is sometimes also mixed with alcohol, in the proportion of 1 pound of Buhach to a quart of alcohol; this should stand in a closed vessel for an hour or so, when it may be diluted with water to any extent required. In regard to this solution Prof. E. W. Hilgard, of the University of California, writes as follows to the *Pacific Rural Press* of May 5, 1883 (p. 413):

"I find that the effect of the Buhach is materially increased in duration when instead of the tea the diluted tincture is used, as was suggested by Professor Riley two years ago. The reason is that the alcohol extracts with the essential oil also a green resin, which prevents the too rapid evaporation of the volatile oil, and makes it stick to the insect.

"A quart of alcohol to a pound of powder is the best proportion, but less alcohol may be used. The alcohol may simply be left on the powder for an hour, and the whole then put into 45 or 50 gallons of water, if to be used through a 'San José nozzle.' But it is far better to let the alcohol percolate through the powder, and thus get a clear tincture, of which aliquot parts may at any time be used through any nozzle whatsoever, after proper dilution with water. Thus it becomes a great convenience, since the insecticide solution is ready at any moment without need of boiling or dissolving, and thus the work may be done just when wanted without any preparation. I find a solution made as above quite strong enough for any ordinary insect, including the hairy caterpillar, which at first seems not to mind it much, but after a while tumbles down and succumbs after vain efforts to crawl away. I have not had an opportunity of trying it upon the Diabrotica or 'spotted lady-bug,' but am told that it also succumbs despite its ability to eat almost anything from tobacco to belladonna and henbane. All the aphids yield to it at once, as does the Red Spider when hatched; but it will not kill eggs."

In using the Buhach out of doors the best effect will be obtained when the weather is still and rather cool. In very hot weather the insecticidal properties of the Buhach evaporate too rapidly, thus rendering its time of action so brief as to permit the insect in many cases to recover. In windy weather the evaporation is also rapid, and the deadly properties of the Buhach are lost, being blown away from the insect, instead of being kept where the latter is compelled to breathe it.

The following experiments with Buhach were made the past season either by myself or where I was permitted to witness them in person:

Tomato worms—the larvæ of *Macrosila carolina*, Linn.—sprayed with a solution composed of one pound of Buhach stirred in ten gallons of water were killed in a few minutes by it. When first sprayed they manifested their dislike by jerking their heads and the forepart of the body from side to side, at the same time emitting from their mouths a dark greenish, semi-liquid substance, as almost every locust or grasshopper will do when taken in the hand. The jerking gradually increased in violence, until finally the worms let go their hold of the plants and fell to the ground, where they wriggled around for a short time, and finally expired. I am not aware that a single tomato worm treated with the above solution recovered from its effects.

The above solution appeared to have no effects upon a Bordered Squash-bug (*Largus succinctus*).

At about 4 o'clock in the afternoon a Twelve-spotted Diabrotica (*Diabrotica duodecim-punctata* Fabr.) was immersed in a solution composed of one and one-half pounds of Buhach stirred into five gallons of water; it was still alive at 9 o'clock, but was dead when examined the next morning.

A horned beetle (*Notoxus cavicornis* LeC.) was immersed in the same solution and at the same time as the above; it was still alive at 3 o'clock in the afternoon of the next day, but was dead when examined the following morning. It became unable to walk about five minutes after it had been immersed, and it remained in that condition, occasionally moving a leg or foot, until it died. Another specimen was sprinkled with the dry powder, but was not killed thereby; this would seem to indicate that Buhach wetted so as to adhere to the insect is far more effective than in a dry state, even though it is diluted to a considerable extent with water.

A black cricket (*Gryllus* sp.?) sprayed with the above solution in the evening was dead the next morning.

An *Eleodes quadricollis* LeC. that had been rolled in the pure Buhach was still alive eight days later, although it did not appear to be as sprightly as it was before being treated with the powder.

A single application of Buhach, either in a dry state or when mixed with water or with alcohol, will not kill locusts or grasshoppers that have been dusted or sprayed with it. When treated to the powder or to either of the solutions they show signs of its effects in from ten minutes to half an hour. At first the hind legs are affected, and the insects raise them over their backs and kick around for a short time, and finally lose all control of them, crawling about by means of their four anterior legs, and dragging their hind legs aftert hem. After a while the locusts fall down, roll once upon their sides or backs, jerk their legs occasionally, and gradually become quiet. They remain in this condition for a longer or shorter time, and gradually recover, but sometimes a whole day or a day and a half passes after the application has been made before the locusts have wholly recovered from the effects of it.*

Although the locusts are not killed by a single application of the Buhach in either of the forms mentioned above, still they do not enjoy the same immunity when treated with an alcoholic extract of Buhach; a few drops of this extract was dropped upon an adult locust at 1 o'clock in the afternoon, and early the next morning the locust thus treated was dead. This extract is much stronger than the solution of Buhach and alcohol described above, and costs about $3 a pint. It failed to have a fatal effect upon the locusts when diluted with water to any considerable degree.

For the destruction of locusts and other insects that the Buhach will not kill outright, it may still be used with advantage by spreading blankets upon the ground beneath the tree or shrub infested with these insects, and then dusting the latter with the Buhach, or spraying with one of the solutions; this will have the effect of causing the insects to fall upon the blankets in a perfectly helpless condition, when they can easily be gathered up and be destroyed by burning or otherwise.

In order to give some idea of what success other persons have met with in using Buhach for the purpose of destroying various kinds of injurious insects, I will give a few extracts from communications made by the parties using this insecticide.

The following is extracted from a communication which appeared in the *Pacific Rural Press* of January 6, 1883 (p. 12):

"The Buhach powder was mixed with cold water in the proportion of 1 pound of powder to 50 gallons of water. On the 14th instant I sprayed 10 apple trees, the branches of which were literally covered with the Cucumber-beetle (*Diabrotica vittata*), and the result was that these pests immediately fell to the ground in myriads. The spraying was done with a Merigot pump, and the trees were covered a short time only with a fine mist. Although several gallons were mixed, probably not over one gallon was used. I placed in a small box a number of the beetles that had been touched by the spray, and up to the present time all efforts to resuscitate them have failed. A small number of the insects which were not touched by the spray were placed in a phial, and are still living. The Cucumber-beetle plays havoc with pear blossoms and is otherwise destructive, and judging from the very signal success of my late

*Locusts appear to be endowed with more life than the generality of insects. On one occasion I saw a hind leg of a Differential Locust (*Caloptenus differentialis* Thom.) move after it had been separated from the body for several hours. The femur would draw the tibia toward it, then move it back again; and the last movement of this kind that I saw it make occurred *eight hours* after the leg had been separated from the body.

experiment, I feel confident that I will have very little trouble in stopping its ravages during the fruit season.—JOS. HALES."

The following appeared in the same journnal for October 13, 1883 (p. 306):

"This year, with increased yards and more extensive plans, I had scarcely commenced my work when, to my great annoyance, vermin, and especially those mites which infest the nests of sitting hens, came in forces quite appalling. Old remedies were now again employed, but, as before, found insufficient to match the foe. Half discouraged, I was relating my trials to a neighboring druggist; he advised flea powder, and I purchased of him a bottle of Persian insect powder and at once tested its merits. I found it a partial, but only a partial, relief to the few nests where used. Thinking, however, that in this, though imperfect, remedy I had perhaps a hint, a good suggestion, I at once sent to the producers and manufacturers of Buhach at Stockton, Cal., for a small can of their powder, to test still further that kind of 'death to vermin.' A package (one-fourth of a pound) of Buhach powder was promptly mailed to me, and used as soon as received. To my gratification, it seemed to be just the thing I had long been looking for, yet half despaired of ever finding. The first quarter-pound of this powder 'did the business,' where used in sufficient quantity; but it was not enough to go around. So I secured more—two pounds—and I have tested it thoroughly. It is the thing for poultry. It is a success, especially when used freely and frequently. I have tested its merits in nests, upon chicks and hens, on roosts, in cracks and crevices of coops, &c., and with complete success everywhere, I believe. This Buhach powder is the cleanliest, simplest, most easily applied, and safest remedy for vermin which I have yet found good enough."—*Poultry Grower.*

For further experiments with Buhach, I would refer the reader to the back numbers of the American Naturalist, and also to the several Reports of Prof. C. V. Riley, as entomologist to the Department of Agriculture, contained in the Annual Reports of that Department.

D. W. COQUILLETT.

Prof. C. V. RILEY,
Entomologist.

ADDITIONS TO THE THIRD REPORT ON THE CAUSES OF THE DESTRUCTION OF THE EVERGREEN AND OTHER FOREST TREES IN NORTHERN NEW ENGLAND.

By A. S. PACKARD.

INTRODUCTORY NOTE.

In Dr. Packard's third report, prepared for the Report of the Entomologist, Annual Report of the Department of Agriculture for 1885, was contained certain matter, mainly descriptive, which, though valuable, was considered hardly appropriate for a report which it is desired to make severely plain and practical. This matter was, therefore, pruned from the Annual Report and is published here in the more limited edition of the Bulletin.—(C. V. R.)

THE BLACK-HEADED SPRUCE BUD WORM.

(*Teras variana*, n. sp., Fernald.)

This caterpillar is so commonly met with on the spruce and fir that we have given it the above English name, though there are other species which have green bodies and black heads. We first met with it on the terminal shoots of the Black Spruce on Peaks Island, in Portland Harbor, June 22, 1881, and also at Brunswick and Harpswell on the day following, when it was associated with the caterpillars of the Spruce Bud-worm (*Tortrix fumiferana*). Unlike that species it does not, so far as we have observed, cause any decided alteration in the appearance of the shoots of the tree, not being social or abundant enough to strip the leaves from a single shoot, as in the case of the Spruce Bud-worm, or the Reddish-yellow Spruce Bud-worm (*Steganoptycha ratzeburgiana*) found on the White Spruce last season.

The egg-laying habits are not yet known, as none of the moths on issuing from the chrysalis mated or proceeded to deposit eggs.

The caterpillars usually live near the ends of the shoots, feeding on the new leaves, which begin to grow out early in June; cutting off the tender leaves, they make a passage-way between them and the shoot, which they line with white silk. When disturbed they rapidly crawl out of their silken retreat and let themselves down to the ground by a silken thread. They are very active in their habits and in confinement in tin boxes will squeeze through the narrow space between the box and the cover, so that only an unusually tightly closed box will confine them. Sometimes, at least in two instances, the caterpillars construct a case of the leaves which they had cut off at the end of a fresh bud.

The caterpillars were very abundant this year in spruce and firs on the shores and islands of Casco Bay, from June 10 until July 20. As full-grown larvæ are abundant during the early part of June, it seems that it hibernates among the shoots of the tree during the winter, and that as in the case of the Spruce Bud-worm (*Tortrix fumiferana*) it hatches in August, or at least late in the summer, and becomes nearly fully grown before cold weather sets in.

The caterpillar when fully grown is of the usual shape of a leaf-roller, deep green, with a dark reddish head and cervical shield; before the last molt the head and prothoracic or cervical shield are black.

From the 14th to the 16th of June the caterpillars change to chrysalides within the slight white cocoon they spin among the bases of the leaves next to the shoot. The moths begin to issue early in August, and continue to appear until the middle of the month. In one case the insect pupated from July 6th to the 10th, the moth issuing on the 19th; hence the pupal period lasts about two weeks. Others which pupated July 14 to 16 appeared three weeks later. None of the insects lingered in the pupa state beyond the 14th of August. The moths are subject to great variation, the details of which are given in the description. In their color they are assimilated to the moss-covered bark of the larger branches of the trees they rest on.

The caterpillars are sometimes preyed upon by ichneumons, two small Ichneumonidæ having been bred from pupæ in confinement. No Chalcid parasites have yet been observed to prey upon this species.

Should the worms attack shade or ornamental firs and spruces, they can be subdued by spraying and striking the branches and shoots so as to dislodge the worms.

DESCRIPTIVE.

Larva before the last molt.—Body pale green, nearly of the color of the fresh leaves, with the head and cervical or prothoracic shield black. Length, 10–11^{mm}.

Full-grown larva.—Body pale pea-green, moderately thick, gradually tapering from the middle to the end of the body. Head of the usual shape, somewhat bilobed, not so wide as the body; dull reddish amber, or greenish-yellow amber-colored in front; partly brownish-black behind and on the sides, the black forming two patches on the vertex. Prothoracic or cervical shield black on a greenish ground; varying to greenish-amber edged behind with blackish; sutures and lateral ridge slightly tinged with yellowish. On the body-segments the piliferous warts green, not distinct; arranged as usual in a trapezoid. Thoracic legs greenish amber-colored, first pair larger and darker than the others; abdominal legs pale green, concolorous with the body. Length, 12–14^{mm}.

Pupa.—Body rather slender, the double rows of dorsal spines as usual, but the spines are smaller and not so sharp as usual. End of the abdomen broad, square, and much flattened vertically, with a small down-curved spine on each side; on the square edge of the tip are from four to six slender, small, curved, stiff bristles. There are two similar bristles on the under side within the edge of the square tip. Length, 8–9^{mm}.

Moth.—Head white or subochreous; palpi dull gray, with white scales. Thorax either white and black or reddish ochreous with white scales. Fore wings with the basal third either black, gray or snow white; usually dark gray; on the outer edge of the dark portion are two groups of sharply raised scales. Beyond is an irregular white band, the white sometimes obscured by gray scales; this band is very irregular in width, being narrow on the costa, widening towards the middle of the wing; it is indented on the inner side at the second tuft of raised scales; where the band is widest, viz., on the outer edge behind the middle of the wing, is a deep sinus, very distinct in those specimens where the band is white; on each side of the mouth of the sinus is a sharp tuft of raised black scales, and within (one near the costa) are the smaller tufts. In those specimens in which the rest of the wing is whitish there is a large triangular dark spot, with the base resting on the costa; usually, however, the outer third of the wing is dusky or clear gray, with dark specks and clouds, and the triangular patch is obscured. Sometimes when the wing is clear gray the veins on the outer third are hardly clouded with a darker shade of gray. Hind wings and abdomen slate gray. Expanse of wings, 12–15^{mm}.

This is a very variable moth, but the four or five raised tufts are nearly always present. Some striking varieties are here noted:

(*a*) Fore wings gray, with a broad whitish-gray band just before the middle of the wing; the large dark triangular spot not present.

(*b*) The outer third of the wing concolorous with the band, thus leaving a large distinct triangular spot.

(*c*) Fore wings snow white at base, with a snow-white band near the base, in the outer edge of which the sinus is very distinct; the outer third of the wing is either white or blackish.

(*d*) The base of the fore wings clear, deep ochreous, and ochreous streaks on the thorax.

(*e*) The most aberrant form, and which would readily be referred to a distinct species if it had not been reared from the same kind of caterpillar. It has a dark, grayish-white head, and two black bands on the thorax. The fore wings are dark gray, finely lined and mottled with black, but interrupted by a broad, very conspicuous, clear ochreous band extending from the base of the wing to the apex, inclosing the median vein and submedian fold. There is only a single high black tuft on the lower edge of the basal third of the wing. One appeared July 30, and another August 20. Hind wings dark slate gray, with an obscure ochreous slash at the apex.

The following description was prepared by Professor Fernald from five specimens sent him:

Head and palpi ashy gray, the latter a little darker on the outside.

The thorax is dark ashy gray, with a few blackish cross-streaks on the forward part of it, and there is a stout thoracic tuft tipped with reddish brown on the posterior part.

The fore wings are ashy gray, variegated with black and white, with a few yellowish scales intermingled. The basal patch is black, more or less broken with whitish, and has three black tufts of scales on the outer edge—one on the fold, another on the cell, and the third between this last and the costa. An oblique band, white on the costa, but suffused below, starts from the basal third of the costa and crosses the wing outside of the basal patch. The inner margin of this band is slightly angulated, the most prominent angle being on the fold. The outer side of the band gives off a prominent angle on the cell, which ends at a large tuft of black scales near the end of the cell, and there are several other tufts along the outer margin of this band. The surface of the outer part of the wing is of a somewhat leaden blue color, especially when worn, and mottled with black, white, and yellow scales, but the black is mostly in coarse streaks containing several small tufts. The costa beyond the middle is blackish, with three small white spots at nearly equal distances apart. The fringes of the fore wings, the upper side of the hind wings and abdomen are darker gray with a silky lustre. The under side of the hind wings is lighter, with darker cross-streaks or reticulations, which are much brighter towards the apex. The under side of the fore wings is dark gray, except along the costal border, where the markings of the upper side are dimly reproduced. The legs are brown on the outside, but pale yellowish within and on the end of the joints. This seems to be a very variable species, and at first sight one might think that there were more than one species.

One variety has the top of the head yellowish, and the oblique band and outer part of the wing dull whitish and slightly touched with yellowish. Another variety is quite dark, and has a broad bright ochre yellow band through the middle of the fore wing, from the base to the apex.

A third variety, in very poor condition and bred on white spruce in Ashland, Me., has the head white and the basal part of the fore wings white with only slight traces of the black tufts and markings. Expanse of wings, 14^{mm} (Fernald).

THE FIR TORTRIX.

(*Tortrix packardiana*, n. sp., Fernald.)

This moth was bred from the fir on Peaks Island, Casco Bay, Maine, and sent to Professor Fernald, who regarded it as new and sent us the following description:

Head whitish; palpi and thorax ashy gray; fore wings with a whitish ground color, and marked with black, which is more or less overlaid with pale bluish or whitish scales. The black basal patch has an obtuse angle pointing out on the middle of the wings. An oblique black band broken in the cell crosses the middle of the wing. A black patch rests on the costa before the apex, marked with one or two white costal spots; a similarly colored patch within and above the anal angle, and still another on the outer border inclosing the apex, sends in a square projection towards the end of the cell. All the black markings are overlaid more or less with white scales, and the white portions of the wings are somewhat stained with gray. The fringes are dark smoky brown.

The hind wings and abdomen above are ashy gray. Fringes lighter. Under side of the fore wings ashy gray, with the white costal marks reproduced. Under side of the hind wings whitish, irrorate with gray. Expanse of wings, 16–18^{mm}.

Bred from Fir by Dr. A. S. Packard, for whom I name this species in recognition of his extensive and valuable work on North American insects.

THE RED SPRUCE BUD-WORM.

(*Gelechia obliquistrigella* Chambers.)

[Plate I, Fig. 2.]

Associated with the preceding bud-worm occurred in abundance, both on the terminal shoots of the spruce and fir, a little reddish cylindrical caterpillar, about two-thirds as large as the larva of *Teras variana*, and very active in its habits. It occurred as early as the 10th of June, but it disappeared earlier than the caterpillar of *Teras variana*, and the moths, which were common, flying in spruce at and soon after the middle of July, were not seen after the first week in August.

The caterpillars were beaten from the trees from June 10 to July 17; after that it was impossible to find any of them. The moths began to appear July 16–19, and continued to emerge in the breeding boxes until August 1. The duration of the pupa state is about one week

It is evident that the species is single-brooded and that the caterpillar is hatched in August, and becomes nearly full grown in the early autumn, hibernating when nearly full-fed, since the fully grown caterpillars are abundant by the first week of June. The species has been identified for me by Professor Fernald. It was described from Kentucky by Mr. Chambers, but the larva and food-plant have been hitherto unknown.

When about to pupate it spins a small, thin, delicate cocoon, being a tubular case of silk covered with bits of the scales of the spruce or fir buds. It is placed next to the shoot in the débris made by the larva at the base of the leaves. Length, 6^{mm}; diameter, 2^{mm}.

DESCRIPTIVE.

Larva.—Body cylindrical, of the usual form, reddish brown in color, and about $6–7^{mm}$ in length.

Pupa.—Body rather thick, of the usual pale mahogany brown color, the antennæ and tips of the wings on the under side reaching to the middle of the fifth abdominal segment. End of the abdomen full and rounded, with about ten unequal, irregularly situated slender bristles, which are slightly curved at the end; besides these there are several fine bristles along the side of the body near the tip. Length, 5^{mm}.

Moth.—Head cream white; antennæ with the basal (second) joint white, beyond ringed with white and black. Palpi white, first and second joint speckled with black, second (longest) joint ochreous at the end; third (last) joint with two black rings of unequal size, the outer the longer; the tip white. Fore wings moderately wide, oblong ovate. Ground color ochreous whitish gray; costal region blackish, base black. A broad oblique band proceeds from the costal edge to the middle of the submedian space, ending in two white spots; there are some whitish scales on the outer edge of the band. Just before the middle of the wing is a broad irregular black band, and beyond it in the submedian space a black spot. A third broad black band crosses the wing, ending on the hind margin and breaking up into three black spots on the hind margin; the band incloses near them two twinned white dots. Near the outer fourth of the wing is a conspicuous white line, sharply bent outwards just behind the middle of the wing; beyond the apex of the angle of the line are several white scales. At the base of the fringe is an oblique line of black scales. The fringe, like the adjoining part of the wing, is of mixed gray ochreous, with black scales. Hind wings rather broad, pointed, pearly slate gray. Legs, including tarsi, banded with black. Expanse of wings, 13^{mm}.

When rubbed the green color of the fore wings becomes paler, and the three oblique black bands are more distinct.

THE EVERGREEN SPAN-WORM.

(*Thera contractata* Packard.)

A very common caterpillar on various evergreen trees, such as the Spruce, White Pine, Hackmatack, and the bush or common Juniper, is a little green one, striped with white, which is so assimilated in color to the glaucous green leaves with their whitish under side as to enable the caterpillar to escape ordinary observation.

During the past summer I have found this caterpillar most frequently on the common Bush Juniper in Maine, but in former years have beaten the chrysalids out of the trees already mentioned.

The caterpillar is found in July, but becomes fully grown from the 1st to the 15th of August. Before transforming, it spins the leaves together with a few coarse silk threads and remains in the tree. Those reared on the Juniper became chrysalids by the 19th or 20th of August, and the moths appeared by the 9th of September, so that the pupa state lasts about three weeks. The moths continue to appear until the middle or last of September. Those found on the Spruce appeared September 15, and a pupa found on the White Pine disclosed the moth September 13. Probably by the middle of September all the moths have appeared. Whether they hibernate and lay their eggs in spring, or whether their eggs are laid in the autumn on the terminal twigs, and the species is alone represented by the eggs, remains to be ascertained.

The moth is easily recognized by the sharp fore wings with the narrow, dark, mesial band, which is black and very narrow on the inner edge, and by the pale zigzag line reappearing beneath, also by the black streak near the apex and a smaller apical black dot. It is closely related to the European *T. juniperata*, which feeds on the common Juniper.

DESCRIPTIVE.

Larva.—Body smooth, cylindrical; head smooth, slightly bilobed, not quite so wide as the body. Head and body green, the color of the upper side of the juniper leaves on which it feeds. A broad pale glaucous white dorsal band, on each side of which is a yellowish-white line, which extends along the sides of the supra-anal plate, but not meeting its fellow at the apex. Anal legs broad and large, green, with two tubercles which are large and rounded conical. Thoracic legs pink. Length, 16^{mm}.

Pupa.—Of the usual family shape; green, with a white lateral stripe from the head to the tip of the abdomen, and another lower down along the abdomen, as well as two parallel dorsal whitish stripes. Abdominal spine larger and longer than usual, flattened vertically, acute, surface corrugated; two stout terminal bristles excurved at the ends, a much smaller pair at base of these and along the sides of the spines two additional pairs. Length, 6^{mm}.

Moth.—Pale ash, base of fore wings with two bent parallel black lines, the outer heavier, and marked with longitudinal stripe on the veinlets. Beyond is a broad pale band slightly bent on the median vein. Still beyond is a median band margined with black, narrowing more than usual on the inner margin of the wing, where the two black margins meet, forming two contiguous black patches; in front the band incloses obscure ashen ringlets. A black discal dot; beyond, an obscure pale patch. A white zigzag marginal line, the sharp scallops inclosing dark dots. Hind wings uniformly pale ash color, crossed by two dusky lines. Expanse of wings, 25^{mm} (one inch).

THE PINE PHEOCYMA.*

(*Pheocyma lunifera* Hübn.)

DESCRIPTIVE.

Larva.—Body long and slender, tapering considerably behind the fourth pair of abdominal legs. Head not so wide as the body, rather deeply bilobed, with a lateral V-shaped white spot. A pair of small prominent tubercles on top of the eighth ab-

* This descriptive matter is additional to the note published on p. 327 of the Annual Report for 1885.

dominal segment, and in place of them on the segments is a pair of more widely divergent short black dashes; on the segment next to the last is a transverse ridge. Anal legs long and slender. General color of the body wood or horn brown, of the shade of old twigs, sometimes reddish or greenish. Head marbled with a set of transverse wavy whitish lines on each side of the median line. Body with a lateral row of black dots; beneath, much paler, glaucous green. Length, 35^{mm}.

The larvæ are very variable; in some the body is reddish with longitudinal bands much more distinct than usual; in some the body is pale pea-green, a little paler than the pine leaves; there is a firm, quite wide medio-dorsal line, and on the sides a wider white line next to the broader very conspicuous pale red spiracular line, which is similar in color to the reddish sheath of the pine leaf. Head reddish, with the characteristic oval white spots on each side. In others (as pitch pine) the body is beautifully marbled with gray and whitish. A V-shaped white spot on the side of the head. On the segment next to the last abdominal are two small inconspicuous warts. A faint, broad, grayish-white dorsal band, broadly interrupted at the sutures of the segments by an irregular transverse umber-brown stripe. A faint lateral broad band, containing on the side of each segment a clear, white point. Length, 42^{mm}.

Pupa.—Of the usual rather slender Catocala shape, covered with a slight whitish bloom. The abdominal tip rather blunt, the surface corrugated with irregular longitudinal furrows above and on the sides; spine small, bearing at the end two very large, long stout bristles curved outwards at the ends, which are blunt; at their base are two pairs of slender bristles. Length, 17^{mm}.

Moth.—Body and wings dark ash-gray and reddish brown; thorax crested, dark reddish brown, with two blackish transverse lines. Patagia with a white stripe behind the middle and white scales at the tip; hinder part of the thorax dusted with white. Fore wings black and reddish brown at base, with interrupted and broken black and white lines. Within the middle of the wing is a broad, slightly sinuous whitish-gray band. A large black mark forming a hollow square, the hollow grayish, at the end of the discal space. Beyond this spot are two nearly parallel black lines, the inner bent inwards at a right angle upon the costa, and sending an angle into the extra-discal space; the line is bent outwards on the 1st median vein, then curving inwards and ending on the hind margin of the wing. The outer line curves outwards on the costa towards the apex, is bent on the 1st median vein, and behind is nearly parallel with the inner line. A fine black scalloped hair-line at the base of the fringe, which is darker on the points of the scallops. Hind wings with a double black curved band beyond the middle, the space within the lines filled in with black towards the hinder edge of the wing. An indistinct broad diffuse shade passes across the wing just within the middle. On the under side of both pairs of wings the discal dots are present, and there is a diffuse dark line common to both wings. Expanse of wings, 36^{mm}.

THE PERIODICAL CICADA IN SOUTHEASTERN INDIANA.

By AMOS W. BUTLER, *Brookville, Ind.*

In presenting what I have to say concerning the Periodical Cicada, I have tried not to follow in the footsteps of others. I have gathered much information that is new to me, and, coupled with this, the fact that these observations were made in a locality where this insect had not been previousiy studied shall, I trust, assure me your consideration.

From our older inhabitants I learn the Cicada has heretofore appeared in Franklin County in the years 1834, 1851, and 1868. This year I have received reports of its occurrence in the counties of Dearborn, Decatur, Rush, Union, Ripley, Franklin, Fayette, Wayne, and Delaware. The latter, however, is not one of the counties in the southeastern part of the State. In Delaware County my informant reports it as "not abundant"; in Union County it was very common; and, I should think, was as numerous in Dearborn and Ripley Counties. In this county and in Fayette it was at no place as common as was expected. We are entirely without the range of the thirteen-year race.

The regularity of its appearance in certain localities is very interesting. Dr. George Sutton, of Aurora, writes me: "In 1851 the first I saw fully developed was on the 24th of May. In 1868 I first saw them on the 28th of May. This year I discovered them on the 29th of May, although there was evidence that a few had made their appearance a day or so before." Its appearance in Franklin County this year was very irregular. The first representatives appeared in a few localities on May 28, and in such localities Cicadas were rather common two days later. In other places, less than half a mile from those just mentioned, no Cicadas appeared until June 4, and in other neighborhoods they were even alter in coming forth.

Many pupæ were turned up by the plow in April and May. When these insects emerge from the ground it is with a rush, and a lively scramble ensues for each elevation near the point of their emergence. Trees, bushes, weeds, poles, stumps, fences—in short, everything upon which they can get above the level of their recent homes is ascended. A friend tells me that his hogs thought so much of the Cicadas as an article of food that they would not return to their accustomed feeding place. They preferred to remain within the woodland at night, and one morning he found attached to the hair of the animals a number of pupa cases. The Cicadas had clambered upon the backs of the hogs, and there left their outer garments. I have learned of several instances in which hogs discovered the Cicadas before they emerged from the ground, and in some localities they rooted over a considerable amount of ground, to some depth, searching for this new-found food.. Farmers gathered the immature insects upon their appearance and fed them to poultry.

In most localities where they had been abundant seventeen years before they appeared this year, but in many instances but few insects represented the vast numbers of their previous maturity. In many places where they were abundant at their last preceding appearance no representatives appeared this year. Many were there which did not emerge from the pupal covering, but from the heat of the morning sun, the attacks of birds and of insects, perished.

May 31 they began making their peculiar noise, and by June 7 the woods resounded with their rattling notes. June 5 they began mating. Five days later most of them appeared to be mated. Ten days after beginning mating they commenced depositing eggs. In this work I have always seen the female with the head higher than any other part of the body. Owing to this fact the eggs appear on some trees to have been deposited from a certain direction, while on others the opposite appears to be the direction whence they came. Upon the oak and apple, trees whose limbs generally grow quite erect, the ovipositor has been inserted from above, or from towards the end of the limb; while upon beech, elm, and other trees, which have a drooping habit, the eggs were deposited from the opposite direction, that toward the base of the limb. The female effects an opening into the wood by means of two small saw-like organs. An excavation is made, consisting of two apartments separated by a thin partition of wood. Into these cavities the ovipositor is inserted; apparently an egg is deposited in each of these chambers at the same time, and each one is lying at the same angle with the partition wall. The eggs are packed very regularly, and under a glass of low power look very much like grains of rice. The openings of these egg-cavities are from five-sixteenths to one-half of an inch in length, and were found three-eighths, and occasionally a few one-half, of an inch apart. Sometimes but two or three punctures were to be seen on a limb, and again the punctured limb would be upwards of a foot in length. A limb of Black Gum (*Nyssa multiflora*, Wang.), showing a line of incisions 18 inches long, proved by actual count to have 48 egg chambers upon it, all in a straight line, and doubtless the work of a single insect. The largest limb found punctured was not over one-half an inch in diameter. Egg-laying was not confined to trees of any particular species, yet there were some kinds of trees apparently more desirable than others.

Beech (*Fagus ferruginea*, Ait.), Maple (*Acer saccharinum*, Wang.), Oak (*Quercus*, several species), Honey Locust (*Gleditschia triacanthos*, L.), Black Gum (*Nyssa multiflora*, Wang.), Thorn (*Cratægus*, several species), Wild Crab-apple (*Pyrus coronaria*, L.), Elm (*Ulmus fulva*, Michx. and *U. americana*, L.), Osage Orange (*Maclura aurantiaca*, Nutt.), Sycamore (*Platanus occidentalis*, L.), and among orchard trees, Apple, Quince, and Peach, were trees upon which the females deposited their eggs in greatest numbers, but, from the fact that all of these trees are not present in equal numbers, they could only be occupied in proportion to their abundance. Cicadas were also found laying upon the Tulip Tree (*Liriodendron tulipifera*, L.), Black Locust (*Robinia pseudacacia*, L.), Sweet-brier (*Rosa rubiginosa*, L.), Red Bud (*Cercis canadensis*, L.), Grape (*Vitus cordifolia*, Michx.), Poison Ivy (*Rhus toxicodendron*, L.), Catalpa (*Catalpa bignonioides*, Walt.), and upon the domesticated species of Plum, Pear, Gooseberry, and Currant. I have found them very rarely ovipositing on Hickory (*Carya*, several species), Ash (*Fraxinus americana*, L.), Linden (*Tilia americana*, L.), Walnut (*Juglans nigra*, L.), and Butternut (*J. cinerea*, L.). No eggs were found upon the Wild Cherry (*Prunus serotina*, Ehr.), or upon the cultivated Cherry.

Twenty-three days after the appearance of the Cicadas a perceptible decrease in numbers was observed. Up to this time the males had greatly outnumbered the females, but the decrease in numbers appears to come from the disappearance of the former, which, being the first to appear, are also the first to leave us. Nine days later but few examples could be found, and these were mostly females. Thirty-nine days after appearing but an occasional Cicada could be found, and their season may be said to be ended. These observations were made in localities where they first appeared, but observations in other places sustain the chronology I have given. At a point 5 miles east of Brookville, on July 15, nine days after they had disappeared from the river valleys, I found Cicadas abundant and very active, indicating that they had not yet reached the wane of their maturity.

The typical species, *Cicada septendecim*, L., and the smaller form, *cassinii*, Fisher, were both found here, but the latter was much the more common. Each form frequents a different locality.

I have never seen a place where the territory of the two kinds could be said to overlap. True it is that an occasional representative of one form may be found within the range of the other, but such cases are rare, and when they do occur are easily distinguished.

There are three different sounds produced by the Cicada. The note of surprise is one which never fails to startle the intruder; it is a shrill screech of varying length. When several insects utter this noise at the same time it is almost deafening to one who is close at hand. Another sound is the peculiar rattling noise made by the insect when flying. This utterance is very monotonous, without inflection, and prolonged to various lengths according to the distance of flight. The sounds just mentioned were uttered by both forms of the insect found here, and were so nearly alike that that uttered by either species could not be distinguished from similar sounds of its relative. I was somewhat surprised at this. The difference in the size of the insects and therewith in the size of the sound organs and of the controlling muscles should, I thought, indicate a difference in the sound produced. In the third distinct sound, that in which the males display their musical charms to the other sex, I found a difference which, in all the investigations I made, proved constant. The note of the varietal form is uttered without much change of tone and, individually, is quite low compared with that of the other form, but collectively the noise, when the observer is near, sounds like the rushing of a strong wind through trees of dense foliage. I have distinguished this sound at a distance of a quarter of a mile from the place of its origin, and at that distance it sounded like the noise made by a swarm of bees passing through the air close at hand. The sound made by the specific form is so peculiar as to at once attract attention. It is uttered in an uncertain quivering way, gradually rising, then falling and passing away as though ended by the exhaustion of the insect. This sound is well represented thus: Fe-e-e-ro-o-o. My friend, M. J. F. McKee, whose valued assistance I have had in preparing my notes on the Cicada, watched the action of this insect in giving utterance to this sound. He says: "The male Cicada (*C. septendecim*) assumes a position on the upper side of a limb or on the body of a tree, always with the head upward, then it elevates the posterior end of its body, at the same time appearing to inflate the abdomen. With the beginning of the sound the elevated portion of the body descends, the abdomen appears to contract until, when the parts reach their natural position, the notes cease. The insect then remains quiet for a period about equal to the length of the musical effort, when the performance is repeated. A noise may be produced from a freshly-killed male by taking hold of each end of the body with one's fingers, and alternately expanding and contracting the abdomen, similar to the manner in which an accordion is played. The sounds thus produced are not similar to those produced by the insect itself, but in many particulars there is a decided resemblance, and this, I think, demonstrates the manner in which the sounds are produced." Evidently this is done by inflating the hollow abdomen with air, and then forcing the air against the corrugated surface of the insect's drum-like membranes, when, by the vibration of these membranes as permitted by the powerful muscles attached thereto, the noise is produced. I have not been enabled to make as satisfactory an examination of variety *cassinii* when uttering its sounds. They are evidently produced in a similar manner, but the motions occurring are different, a trembling of the posterior parts being all that I have discovered.

Toward the latter part of their lives the Cicadas appear to be affected by a peculiar fungus growth. This is most common to the males, but females are also affected by it. Dr. E. G. Grahn, a friend whose assistance I value highly, has, at my request, examined the Cicada with a microscope. The result of his examination I give in his own words:

"An examination of many of the Cicadæ reveals the fact that they have lost several of the posterior segments of the abdomen, and that this part of the insect is filled with a mealy-looking substance of a somewhat yellowish color. I subjected this substance to microscopical examination and found it to consist of numberless spherical bodies having the general appearance of spores, and it probably is the *Massospora cicadina* (Peck.), but as I had no description of this fungus I could not be certain of this.

"In Bulletin No. 8 of the United States Department of Agriculture, Division of Entomology, Prof. Charles Riley mentions this fungus, and quotes Mr. R. H. Warder, of Cleves, Ohio, who states that 'It seemed to be a drying up of the contents and membranes of the abdomen,' and that he found it in the males who may have lost the posterior segments of the abdomen during copulation, and alludes to it as a 'dry rot,' which 'might be the result of the broken membranes.'

"He further states that he 'never found a perfect male thus affected,' but finally concludes that 'this is not positive proof.' Whether or not Mr. Warder examined this substance microscopically is not stated, but true it is that in the Cicadæ of this year the microscope and the various straining agents reveal countless spherical organized bodies which could not be formed simply by decomposition or transformed of the 'contents and membranes of the abdomen,' and must therefore be regarded as a growth or multiplication of similar organized bodies having the properties and functions of seeds or spores, which have, in some manner, gained access to the bodies of the Cicadæ. It is true, also, that this fungus is found not only in male Cicadas who have lost the posterior segments of the abdomen, but in perfect males as well, as also in females who are yet in possession of many eggs, and in these specimens the eggs and fungus completely fill up the abdomen. In view of these facts—which are well attested—it seems somewhat strange to find Professor Riley quoting without comment the statements of Mr. Warder. The spherical bodies referred to have a diameter of about $\frac{1}{800}$th of an inch, and have the appearance of being covered on their exterior with small granules, spherical in outline, and about $\frac{1}{8000}$th of an inch in diameter. In their fresh state they were subjected to the action of the iodine solution recommended in Huxley and Martin's 'Practical Biology.' A dark border revealed itself, indicating that the cell wall had taken the stain. Acetic acid rendered them more transparent. Aniline green stained both the cell wall and its contents of a nearly uniform color. Being in doubt whether or not the spherical bodies were single spores, I subjected some rather dry ones to pressure, and the cells thus ruptured emitted large numbers of small spherical bodies, having a diameter of from $\frac{1}{10000}$th to $\frac{1}{8000}$th inch, each large cell having the appearance of a ruptured sporangium of the ordinary *Penicillium glauca* or *Mucor mucedo;* hence I concluded that the cells were really sporangia, filled with spores. So far I have discovered no traces of mycelium, upon which these sporangia grow, and am thus led to conclude that they multiply by fission—probably external gemmation—and that after a sporangium is thus produced its contents are again divided by a process of fission into numerous spores. As this process was not really seen to take place, the foregoing remarks respecting it may be taken as being theoretical; yet, while making my observations, and particularly upon the slide treated with aniline green, I noticed a number of transparent nucleated bodies, of various sizes, approaching that of the large spherical cells, some of them exhibiting a slight, others a considerable, bulging out of the cell wall together with the contents of the cell. In some of these, this bulging out had proceeded to a length equal to one-half the diameter of the cell itself, and left one to infer that a new cell was to be produced, and that, too, by a process of fission. Hence, my conclusions as before mentioned. This, together with quite a number of the fully formed spherical bodies, was seen in material taken from a complete, perfect male. It is only proper to state that in this case the contents of the abdomen did not completely fill this cavity, and the material was in rather a semi-liquid state and exhibited also immense numbers of minute spherical and rather long rod-shaped moving bodies which were doubtless bacteria. These latter were also found in other specimens in which the posterior segments were missing and the contents of the abdomen, although of the mealy character, were yet somewhat moist, thus affording conditions for the growth and multiplication of bacteria. Being curious to know what could be discovered in the abdomen of a perfect and active male Cicada, I subjected some of the material to examination with a one-quarter inch objective and a 2-inch ocular and later with a 1-inch ocular. In the field of the microscope were seen numerous flat bands, scattered about over and around each other irregularly. In great numbers were seen also very fine hair-like filaments which could be traced distinctly and were found to belong to the flat bands. These latter were made up of a large number of hair-like filaments arranged alongside of each other, which filaments emanated from each other as fibers from a large thread; each fiber preserving its identity, and not being given off as a branch whose identity is lost in its union with the main trunk. What these hair-like filaments really were, I was unable to make out."

I am satisfied that the greater number of Cicadas which escape a forcible death die from the effects of the fungus previously mentioned.

As much time as possible was devoted to studying the enemies of the Cicada. Not only those species which kill them, but also those species which feed upon the dead insects were noted. Among birds the English sparrow, *Passer domesticus*, Leach, is perhaps its greatest enemy. Within one week from the date of the appearance of the Cicada in

Brookville not one could be found, and I doubt if a single specimen was permitted to deposit its eggs, owing to the persistent warfare waged by this garrulous sparrow. Of native birds the Robin, *Merula migratoria*, Sw. & Rich.; Blackbird, *Quiscalus purpureus æneus*, Ridg.; Cat-bird, *Galeoscoptes carolinensis*, Cab.; Red-headed Woodpecker, *Melanerpes erythrocephalus*, Sw.; Golden-winged Woodpecker, *Colaptes auratus*, Sw.; Towhee Bunting, *Pipilo erythrophthalmus*, Vieill.; and Orchard Oriole, *Icterus spurius*, Bp., were their greatest enemies. Food of every other sort appeared to be neglected in order that they might feast for a limited period upon the easily captured Cicada. Of other birds examined the following contained Cicada remains: Brown Thrasher, *Harporhynchus rufus*, Cab.; Baltimore Oriole, *Icterus galbula*, Coues; Scarlet Tanager, *Pyranga rubra*, Vieill.; Blue-gray Gnatcatcher, *Polioptila cœrulea*, Scl.; Worm-eating Warbler, *Helminthotherus vermivorus*, S. & G.; Purple Martin, *Progne subis*, Baird; Wood Pewee, *Contopus virens*, Cab.; Wood Thrush, *Hylocichla mustelina*, Baird; Yellow-throated Vireo, *Lanivireo flavifrons*, Baird; Cardinal Grosbeak, *Cardinalis virginianus*, Bp.; Tufted Titmouse, *Lophophanes bicolor*, Bp.; Carolina Chickadee, *Parus carolinensis*, Aud.; Chipping Sparrow, *Spizella domestica*, Coues; Downy Woodpecker, *Picus villosus*, L.; Great-crested Flycatcher, *Myiarchus crinitus*, Cab.; Indigo bird, *Passerina cyanea*, Gray; Cow bird, *Molothrus ater*, Gray; White-bellied Nuthatch, *Sitta carolinensis*, Gmel.; Yellow-billed Cuckoo, *Coccyzus americanus*, Bp.; Black-billed Cuckoo, *C. erythrophthalmus*, Baird; Gold Finch, *Astragalinus tristis*, Cab.; Crow, *Corvus frugivorus* Bartr., and Cedar bird, *Ampelis cedrorum*, Baird. But two species of all the birds examined showed no evidence of Cicada-eating. These were the Blue Warbler, *Dendroeca cærulea*, Baird, and the Warbling Vireo, *Vireosylva gilva*, Cass. Most birds only eat the softer parts, but some species—the Robin, Brown Thrasher, Towhee Bunting, and a few others—eat also the wings and legs, and even occasionally the head. I found Fox Squirrels, *Sciurus niger ludovicianus*, Allen, eating them, the young showing greater fondness for this food than did their parents. The Ground Squirrel, "Chipmunk," *Tamias striatus*, Baird, was very fond of them. I have seen this mammal climb to the highest limbs of an apple tree seeking Cicadas. When Cicadas fell into our streams many of them became the prey of various species of fish. Our fishermen complained of their inability to get fish to take the hook while they were feeding upon this new food. The remains of these insects were found in Black Bass, *Micropterus salmoides*, Henshall; Blue Cat Fish, *Ichthaelurus punctatus*, Jordan; and White Sucker, *Catostomus teres*, LeS. Rev. D. R. Moore, a valued fellow-worker, found two species of snails, *Mesodon exoleta*, Binn., and *M. elevata*, Say, feeding upon dead Cicadas. This fact was a great surprise to me. But few instances were recorded of Digger Wasps killing these insects. *Stizus grandis*, Say, was the only species observed. Aside from the enemies mentioned above, there were many others to which I could not direct my attention.

In general it may be said beetles, spiders, and other insect enemies prey upon them incessantly, while parasitic flies, scavenger beetles, and ants destroy great numbers of their dead bodies.

Young trees upon the lands of nurserymen attract the Cicada in great numbers. I do not know that any specific remedy was tried; if so, no doubt it failed, as those interested secured laborers who collected all the insects they could and killed them. Here and in our orchards is where the greatest damage was done.

Many peculiar ideas are associated with anything that is mysterious. To the uneducated mind the regular appearance of the Cicada, with which it is incapable of associating any thought of growth or of development through other forms, is a great mystery. Such a person also never thinks of an insect save as a destroyer of that which is necessary for his welfare. It was not infrequent to hear agriculturists of fossilized minds discussing the amount of damage the Cicadas would probably do to growing crops. The expressions of another class of persons showed another train of thought. "Why," say they, "these are the same kind of locusts which troubled Pharaoh in Egypt. The Lord has marked them. Don't you hear them say Pha-a-a-r-o-oh ?"

From the best information I can gather, I think with each septendecimal visit these insects are becoming less numerous. The sites of towns, the immense tracts of cultivated lands, together with artificial ponds and other changes which man is causing, are each year lessening the amount of ground suitable for their adult life. Besides what man is doing to make the country unsuited for their habitation, the insects are preyed upon by many enemies which man has brought within the region of their habitation. Natural enemies, by the removal of certain barriers, are enabled to increase. Others, by reason of changes of environment, are found in greater numbers within certain restricted areas; others, again, by changes of habits, are made more aggressive. All in all, he who can carefully look back over the past half or three-quarters of a century, and intelligently study the great changes which have taken place in both fauna and flora, must conclude that, with but a few more returns, this periodical insect will be represented by few or perhaps no descendants of its now vast numbers.

NOTES OF THE YEAR.

THE COLORADO POTATO BEETLE IN GEORGIA.—In the spring of the present year we received the Colorado Potato Beetle (*Doryphora 10-lineata*) for the first time from the State of Georgia. Under date of May 18 we received from Mr. Woodward Barnwell, of Savannah, a letter accompanied by specimens of the larvæ of this insect. There could be no question as to their identity. Both Mr. Barnwell and Dr. A. Oemler, the president of the Chatham County Agricultural Society and author of "Truck Farming at the South," wrote that they had never before heard of this insect within the limits of the State.

The evidence shows that the *Doryphora* did not reach Savannah by gradual spread, as we have heard of it from no nearer point of late years than eastern Tennessee,* and the chances are that it has been directly imported from the North. Such an importation is a very easy matter, as many of the truck farmers in the vicinity of Savannah buy seed potatoes at the North from time to time. Mr. Barnwell himself got last winter 110 barrels seed potatoes from Aroostook County, Maine. Under these circumstances the beetle has probably often been taken to Savannah before, and the very fact that it has never heretofore developed there in sufficient numbers to be noticed affords the best indication that it is not much to be feared in so warm a climate. Still we advised Mr. Barnwell to be on the safe side, and to destroy it as thoroughly as possible by the use of Paris green.

THE SUGAR-CANE BEETLE INJURING CORN (Plate I, fig. 1).—Six years ago *Ligyrus rugiceps* Lec., injured the sugar-cane crop quite severely in certain portions of Saint Mary's Parish, Louisiana. A note upon this habit was given in the Annual Report of the Department for 1879 (pp. 246–247), and the report for 1880 contained quite an extended article on pages 236–240, the result of observations made by Mr. Howard in the spring of 1881 upon the infested plantations. The same article was embodied in Special Report No. 35 of the Department, published April 28, 1881.

The beetle seems to have done little damage to sugar-cane outside of Saint Mary's Parish along the Bayou Teche, and since the great floods in the spring of 1882, which were especially disastrous in that particular region, we have heard no further complaint of sugar-cane pests.

* Specimens of the beetle and larva were received May 31, 1885, from Mrs. Mary Frist, of Chattanooga, Tenn., who wrote that they were destroying the crop of Irish potatoes in her garden.

The present season, however, we were somewhat surprised to receive the same insect—*Ligyrus rugiceps*—from Mr. H. M. Houston, of Monroe, Union County, North Carolina, accompanied by a letter written June 2, 1885, in which he stated that the insect was new to himself and his neighbors, and that it worked just under the surface of the ground, cutting into young corn with five or six leaves, working in as far as the heart and killing the center blades without injuring the outside ones or without cutting the plant down. Fig. 1, Plate I, was drawn from specimens working in sugar-cane, but indicates precisely the method of work in young corn.

Mr. Houston gave no particulars as to the amount of damage being done, and although he was written to for further information we did not hear from him again, and the inference is that the beetles disappeared without doing much damage. It was so well shown in Louisiana that this species is capable of exceptional increase and corresponding injury under favorable circumstances that it is not at all improbable that we have here the beginning of a serious damage to corn in North Carolina.

The life-history of this beetle is not known. The most careful search in the Louisiana sugar fields in 1881 failed to show a trace of the larvæ or pupæ, and it was judged probable that they bred in the surrounding swamps. Until something definite is learned concerning the life-history and larval habits, we can only recommend as a remedy the use of fires and trap-lanterns in the field, as the evidence of 1881 shows that the beetle is strongly attracted to light.

THE CORN-ROOT WEB-WORM AN OLD PEST IN INDIANA.—Professor Forbes' recent discovery of *Crambus zeellus* in Illinois, and his interesting article upon the species in the Fourteenth Report of the State Entomologist of Illinois (1884), in which he treats it as an entirely new pest (and such it is for all that has been published concerning it), renders the following letter from Mr. B. F. Ferris, of Sunman, Ind., received through our Indiana agent, Mr. Webster, of considerable interest:

"In the *Indiana Farmer*, of this date, I notice a communication from yourself in regard to a 'new corn pest,' and asking for information in regard to them. They are not a new pest to me by any means. My first experience with them was about thirty years ago. I had broken up a field of 17 acres of sod, and planted it on the 1st of May in as fine condition as I ever had a sod. Almost every hill came up, and I would not have paid a very high premium to have been insured 50 bushels of corn to the acre. But the corn was not more than well up before I noticed that the cut-worms, as I thought, were cutting it off. Upon examination, however, I discovered that they were not our common cut-worms, but a small dark-colored worm that enveloped itself in a slight web, just as you have described them, and for want of a name I called them 'web-worms,' and they are known by that name in this neighborhood at this time. As a result, they entirely destroyed my field of corn, with the exception of about an acre or so at each end of the field, where the ground was a little broken by small hollows. They were very numerous in this vicinity that season, and occasionally there have been a few of them since, but not doing much damage until the present season. In one field of mine, which had been pastural two years before breaking, they have almost entirely taken up 4 or 5 acres, so that I have planted a part of it with white beans, and contemplate sowing the balance with buckwheat.

"I think they are produced by a small, whitish miller, with dirty, brownish stripes upon it, as I have seen a great many of them about the fields. They made their appearance about the time the worms commenced their depredations. I also saw a great many about on the first visitation of the 'web-worms,' and supposed at the time that they were the authors of the mischief." * * * [B. F. FERRIS, *Sunman, Ind.*, *July* 4, 1885.

MONEPHORA BICINCTA DAMAGING BERMUDA GRASS. [Plate I, fig. 6.]—This rather striking-looking bug, belonging to the family Cercopidæ, and easily recognizable from its marked coloration, is widely distributed and by no means rare over the more southern portion of the country, but has never been reported as injuring cultivated plants. This season, however, a large number of specimens were received from Hon. A. P. Butler, Commissioner of Agriculture of the State of South Carolina, dated Columbia, October 20, in which he stated that they appeared in 1884 on the farm of Mr. Speigner, on the Congaree River, near Columbia, and destroyed a small patch of Bermuda grass. This year it again appeared in large numbers on the same farm, and completely ruined a 10-acre field of the same grass. Major Butler examined the field in person, and states that it looked as if a fire had passed over it, while thousands of the bugs were found. This exceptional increase of the insect is of considerable interest. The best remedy will be found in burning over the field in the fall.

A NEW ENEMY TO THE PERSIMMON.—Mr. C. W. Johnson, of Saint Augustine, Fla., wrote us, June 23, concerning the work of an insect which punctured twigs of Persimmon and layed its eggs, from which the larvæ hatched and bored into the heart wood. The specimens were recognized as *Oberea bimaculata*, a beetle which customarily lays its eggs in Raspberry or Blackberry, but which we have also observed to oviposit in Cottonwood. It has never before been recorded as injuring Persimmon. *Oberea schaumii*, a closely related species, we have also observed on Cottonwood, and Mr. Schwarz has found it ovipositing in Sassafras.

THE BLACK SCALE OF CALIFORNIA (*Lecanium oleæ* Bernard).—This destructive scale was treated of in the Annual Report of the Department for 1880, pp. 336–337, but little beyond structural details was given We have received the past season a few notes concerning it from Mr.

Alfred W. Hinde, of Anaheim, Los Angeles County, California, which we think of sufficient interest to publish:

"This is the most common species of scale insect found in southern California, being especially partial to the orange and olive, on which it thrives and increases very rapidly. It appears to do very little harm to the tree itself, even when allowed to multiply undisturbed to its full capacity. But, owing to the sweet secretion which the scale is constantly exuding, and which drops on the leaves and branches, it is always accompanied by a species of black fungus, which thrives on the sweet secretion combined with moisture. It is this fungus which does the real harm, for it grows on the fruit as well as on the leaves and branches. In the case of olives it renders the fruit unfit for making a fine quality of oil; and with oranges it renders the fruit so unsightly that it does not bring near the price that clean fruit does, unless each orange is thoroughly rubbed with a moist cloth, which is a very tedious process. When the scale is killed the fungus disappears, hence the fight against the scale. It is one of the easiest species to kill; a good kerosene emulsion, if thoroughly applied, is sure death to them, provided it is given at the right time, viz., just after the young have left the shelter of the parent scale. To make a thorough job of it the trees should have two sprayings, at intervals of several weeks, as all the young do not hatch out at the same time. A year ago last September we gave our old seedling orange trees a good spraying with a kerosene emulsion, but owing to our lack of experience in mixing the oil and soap, it was not a thorough emulsion, and hence only killed about 50 per cent. of the scale. The season of 1884 was extremely wet, and I find that the black scale increases much more rapidly in a wet than in a dry season. This wetness, combined with the ineffectual spraying, caused the fungus to greatly increase, and the oranges were extremely dirty, more so than in any previous season that I can remember. The present season (1885) has been the exact reverse of last season, being so dry that we have had less than one inch of rainfall since the first of January last to the present date (November 1). Besides being dry the summer has been very hot; at two periods a few weeks apart in August and September the mercury rose to 107° in the shade. At the first hot spell the heat continued for nearly a week. A few days after this hot week we noticed that all the old scale appeared to be dead on the orange trees. I could hardly believe that the hot weather could do this, so I made further examinations, and then I would have another doubting fit and start out and examine them again, but always with the same result, viz., I would not find more than two or three live oil-scale on the trees. The young ones I did not think to look for, as they were probably not yet hatched, except in a few instances. Then we had the last very hot day, September 23, when a thermometer placed in the sun, four feet from the ground, registered 148°, with a hot, burning wind all day. This capped the climax for the scale and I have no doubt saved this part of the State many thousands of dollars in the improved condition of the fruit without the expense of spraying. I have just now (November 1) made a thorough examination of our orange and olive trees, and find the following results: On large olive trees, no old scale alive, and 50 per cent. of the young dead; on old seedling orange trees, old scale all dead, and only 10 per cent. of the young alive; on young and medium-sized budded orange trees (4 to 7 feet high) I have been unable to find a single live scale, young or old. Under many of the old, dried-up scale insects I find what appear to be masses of dried eggs, but as my lens is not of sufficient power for me to be certain, I will mail you a sample so you can be sure if this is the case. I should be glad to hear from you on this point. The fruit of both olives and oranges is the cleanest I have ever seen here, being entirely free from old, black fungus. We have not sprayed the trees this year, as it was not necessary."

An examination of the specimens sent showed that all the eggs were empty, and that about one-half of the scales had been parasitized by the common California parasite of the Black Scale, *Tomocera californica* Howard, as was evidenced by the circular holes of exit, too large for any other species.

THE BLACK SCALE OF CALIFORNIA FOUND IN SOUTH CAROLINA.—This insect (*Lecanium oleæ* Bernard) is found in California infesting a great variety of trees and is one of the most serious enemies to Orange, Lemon, and other fruit trees in that State. In Europe it is confined to the Olive, and is but occasionally found on other plants. The species has not been definitely recorded in this country from any other locality than California, though Professor Comstock, in his Report as Entomologist to this Department for 1880 (p. 336), mentions a scale received from Fort George, Fla., on Live Oak, Holly, Oleander, and Orange as apparently the same.

Under date of May 29, 1885, Dr. J. H. Mellichamp, of Bluffton, S. C., sent a bark louse from White-flowering Oleander, which he had noticed for the past two or three years, which proved identical with California specimens of this insect. It is impossible to say at present what the probabilities are of the spread of this insect in the Southeastern States. If the insect mentioned by Professor Comstock five years ago was indeed *Lecanium oleæ*, it would then seem as though the chances were against its becoming a serious pest in the East.

BIBIO ALBIPENNIS AS AN INJURIOUS INSECT.—The general opinion among entomologists has always been that the White-winged Bibio could not be called an injurious insect, as it normally feeds in the larva state on damp, dead leaves on the ground or upon galls attached to such leaves; in other words, upon decaying vegetation. Our correspondence this year with Mr. C. F. Walters, of Northumberland, Pa., however, shows that where introduced with manure or compost they may injure certain crops. We quote a portion of his letter:

* * * "I am a trucker, and I find these maggots are becoming more numerous every year. The first that I ever saw was four years ago, when they got into my cold frames and destroyed some of my plants. Since then they have been on a rapid increase; at the same time I never was very much alarmed on account of them until last fall, when I plowed my ground (which I always do in the fall, preparatory for spring) I found them to be very numerous. They inhabit the earth not singly, but in masses. * * * I tried to count a batch of them and found that the number would not end in hundreds, but lead to thousands. When I find them in my cold frames the only remedy I have is to lift all the ground, together with the plants, and cast them out. The area which they occupy is from 10 to 24 inches. They are found very close to the surface, just so that they have a very slight protection. When I plowed my ground in the fall I found them under old cabbage leaves and under anything that would shield them from the light. * * * The only soil that I have as yet found them in is such as has been heavily manured for several years in succession. In fact it seems to me that they breed in the manure; at least I have found them in old manure that I had purchased from parties who had kept it over a year, and consequently it was very fine and seemed to suit them. Cold and freezing seem to have no effect upon them. Just as soon as there is the least thaw, if there are any plants suitable to their taste, they will attack them." * * * [C. F. WALTERS, *Northumberland, Pa., March 23, 1885.*

We advised as a remedy the plentiful sprinkling of the infested earth with a kerosene emulsion, well diluted where plants are liable to be damaged, but strong where used on earth in the spring before plants have been set out.

AN ENEMY TO SILK-WORMS.—The common Spined Soldier-bug (*Podisus spinosus* Dall.) is a well-known predaceous insect, and is often mentioned in treatises on injurious insects as one of the beneficial enemies of the destructive species. It has turned up the present season, however, in the role of a noxious insect itself. Mr. E. J. McAuley, of Oakdale, Ill., who fed his silk-worms on leaves of the Osage Orange, found that certain specimens of the bug, brought in by accident upon the leaves, played havoc among his worms, sucking their juices and destroying them. This naturally suggests that the leaves of both Osage and Mulberry should be carefully examined for predaceous insects before giving them to the worms.

GREAT DAMAGE TO BEANS BY BLISTER BEETLES.—Nuttall's Blister Beetle (*Cantharis nuttalli*, Say), one of the largest and most beautiful species of its family, has often been reported as damaging field crops. In the Annual Report of the Department for 1879 it was recorded as doing damage to beans at Fargo, Dak., and the present season it has appeared in great numbers and inflicted severe injury on the great seed farm of Northrup, Braslan & Co., of Minneapolis, Minn., at La Moure, Dak. This firm has nine hundred acres in beans alone at La Moure, and the loss which they sustained was quite serious. We advised the use of the old remedy of driving the beetles into wind-rows of straw which are then burned.

ANTHOMYIA ANGUSTIFRONS A LIGNIVOROUS INSECT.—Late in the summer we received from Mr. John G. Jack, of Chateaugay Basin, Province of Quebec, Canada, specimens of a fly which he described as feeding in the larva state upon planted beans. Somewhat to our surprise the flies proved to belong to *Anthomyia angustifrons*, Meig., a species which we had described both in our Ninth Report on the Insects of Missouri and in the First Report of the United States Entomological Commission, as preying upon the egg pods of the Rocky Mountain Locust. This discrepancy in habit is so marked that we wrote to Mr. Jack for full particulars and quote from his reply:

"In answer to your inquiries about the bean-feeding habit of *Anthomyia calopteni*, I gladly give what notes I possess. I first noticed the larvæ on June 25. We had planted a bushel of Golden Wax beans and a few of some other varieties on or about June 15. They had not come through the soil by the 25th, and on scratching away a little of the earth above the rows, I was surprised to find that, although the beans were well sprouted and some of them were near the surface, yet they had an unhealthy appearance, and on examining the cotyledons and stems, I found them infested with maggots. They were in numbers of from one or two to twenty-five or more in a plant, and the interior of the bean and stalk was so eaten away in many instances that only a very thin wall remained. I collected a large number of the larvæ and kept them until they had produced the flies. The larvæ were collected on June 25, and on the 28th a good number had entered the ground to pupate, and on July 2 all of my specimens had pupated and I could not find a maggot in the field. On July 9 and 10 most of the imagines appeared. One-half of the field in which these larvæ were so abundant had been sown in buckwheat the year before, and the other half had a black currant plantation from which the old bushes had been removed. It was in that part of the field where the currant bushes had been that the Anthomyia larvæ were most destructive. Certainly more than nine-tenths (90 per cent.) of the beans were completely destroyed and never grew sufficiently to reach the ground. On the other half of the field, where the buckwheat had been grown, very few of the beans were affected. They were all covered with a plow, with about three inches of soil. The soil is a sandy loam, and the rows ran north and south through both pieces of land, so that the difference caused by the attack of Anthomyia was very marked. In another field, on July 17, I found occasional beans that had not come through the ground, and in them I found several maggots which I think were of the same species, but I did not keep them. I think that I have noticed similar larvæ in young growing beans during the past year or two, but they were rare and I gave no attention to them. Occasionally the infested beans grew through the surface and the first leaves expanded, but they soon turned yellow and withered and died."

THE TILE-HORNED PRIONUS IN PRAIRIE LAND.—In our Second Missouri Report we gave several instances of the finding of the larvæ of *Prionus imbricornis* in prairie land some distance from large trees, showing that in all probability they fed on the roots of herbaceous and even annual plants. The past summer another instance of the same thing has come to our notice, and Mr. Samuel W. Glenn, of Huron, Dak., states in a letter dated June 3, accompanying a specimen of this larva, that they were found "in large numbers by Mr. J. B. Coomer, a farmer residing six and a half miles southwest of Huron, in ground which was broken in June, 1883, and not since plowed till to-day. Their average distance from the surface was about seven inches. There are no trees within a radius of twenty miles."

THE CLOVER-SEED MIDGE IN WISCONSIN.—Up to the present season the Clover-seed Midge (*Cecidomyia leguminicola* Lintner) has been found only in New York, Vermont, District of Columbia, Virginia, and one locality in Pennsylvania (Lewisburg, Union County). During the past year, however, we have received specimens of infested heads of red clover from eastern Wisconsin, where it seems to have just been noticed for the first time. The chances are against the theory of recent introduction, however, and that the probabilities are that it has been present in the State for some years, becoming abundant enough to attract attention only this season. Mr. Claus Oesan, of New Holstein, Calumet County, wrote under date of June 26, 1885, that hardly a single blossom was to be seen in any of the Red Clover fields in his vicinity, while Alsike and White Clover blossomed as usual. He noticed this same paucity of bloom in the second crop of the previous year, but the first crop of 1884 was full of fine blossoms.

This insect was treated in the reports of the Entomologist, United States Department of Agriculture, for 1878 and 1879, and the remedy recommended in the latter report is to cut the first crop of the season three weeks earlier than usual, giving the larvæ of the midge no time to mature. This remedy necessitates that the farmer should be familiar with the insect in all stages, and should make careful examinations at short intervals until the proper time for cutting arrives. All volunteer clover should also be mowed, and all of the farmers of a neighborhood should cut at about the same time, as otherwise the remedy will be only partly successful.

Dr. Lintner, in his First Report as State Entomologist of New York (p. 54), says:

In the many instances in which our economic entomologists have recommended plowing under the infested crop, I would venture to supplement this direction: fol low with a liberal application of fresh gas-lime, if it can be conveniently obtained of perhaps a hundred bushels to the acre. I believe that this would prove the best possible method of arresting severe attacks of the two great clover pests, the clover-seed midge (*Cecidomyia leguminicola*) and the clover-root borer (*Hylastes trifolii*), whenever they occur within easy reach of the gas-works of our cities, &c.

This recommendation followed Dr. Lintner's previous statement* to the effect that the best remedy he was prepared to offer was "turning deeply under the infested fields while the larvæ are most abundant" or (adopting our suggestion made in the report of the Entomologist, U. S. Dept. Agr. for 1878, p. 251) "cessation from clover culture for a period of time." These radical plans for extermination need not, however, be adopted unless the total destruction of the seed crop has been brought about, or unless the work of the midge is combined with that of the Root-borer (*Hylesinus trifolii*), and both hay and seed crops are destroyed. Where damage by the midge alone is concerned it will be well to give the remedy first mentioned—early cutting—a fair trial.

COLASPIS FLAVIDA INJURING THE LECONTE PEAR.—The LeConte pear is a very popular fruit in parts of the South, and a great deal of capital is invested in its culture, particularly in parts of Georgia, from which State enormous quantities are shipped every year to northern markets. Although, strictly speaking, it is a second-class fruit, its extreme prolificacy and hardiness render it valuable. It has been claimed that it is blight-proof and that insects will not injure it, but both of these assertions are unwarranted, as young trees, up to four or five years of age, frequently blight, and as the present season has developed an insect enemy of some importance.

This insect is the well-known *Colaspis flavida*, commonly known as the "Grape-vine Colaspis." Specimens were forwarded to us, July 23, 1885, by Mr. L. C. Bryan, of Savannah, together with a newspaper account of the method of work and the damage done in Liberty County, Georgia. The injury complained of was simply the work of the adult beetle, and consisted in riddling the young growth and the tender young leaves as they unfolded in May with small holes, as close together "as the holes in a pepper box." We treated this species in our Third Missouri Report, showing that in the larva state it feeds on the roots of strawberries, and, after issuing as an adult beetle, it feeds at first on strawberry leaves and afterwards flies to the vineyard, where it riddles the leaves of grape. It is also found feeding on clover leaves in July and August near Washington, and may be found throughout the woods on the wild grapevines. The species seems to be single-brooded in Missouri, and is probably so also in Georgia. No other larval food-plant than strawberry has been found, though doubtless such exist.

No satisfactory remedy has been proposed against the insect in the larva or pupa state, but where the adults occur on pear trees in any

* The Insects of the Clover Plant, Fortieth Ann. Rept. N. Y. State Agr. Soc. for 1880, Author's Edition, pp. 11–15.

number the trees should be sprayed, if the fruit is very young, with the Paris-green or London-purple solution. If they occur in injurious numbers later in the year they can be jarred down upon sheets saturated with kerosene.

GREAT DAMAGE BY THE COTTONWOOD BORER.—In our last annual report we devoted a few pages to the Cottonwood Leaf Beetle (*Plagiodera scripta*), which was surprisingly abundant during last season, and incidentally mentioned the Cottonwood Borer (*Saperda calcarata*), with the statement that its injuries had not of late been at all comparable with those of the former insect. During the season of 1885, however, not a single complaint of the Leaf Beetle has been received, while the work of the Borer in parts of Dakota has been very noticeable. Dr. J. V. Lauderdale, post surgeon at Fort Sully, sent us specimens of the larvæ on July 25, with the statement that they were committing "fearful ravages" among the cottonwoods at the post. "Trees of ten and twelve years' growth are dying from the top limbs to the ground."

This borer is a very difficult insect to fight, piercing the trunk of the tree, as it often does, midway up amongst the branches. There is really no remedy save cutting out the pupæ in April or May, or the larvæ earlier. The beetles make their appearance in June. Where a tree is so badly damaged that it has become unsightly, it should be cut down and burned before the beetles issue.

LEPTOCORIS TRIVITTATA INJURING APPLES (Plate I, fig. 5.).—This bug is quite a common species and has been found in a great variety of situations. It is characteristically a plant-feeder, but has never been known to occur in such numbers as to do much damage to any cultivated crop. It has been found in large flowers like magnolia, covered with pollen, and occurs in summer on the stems and leaves of annual plants, which it probably punctures. In August of the present year, however, specimens were sent to us by Mr. A. L. Siler, of Ranch, Kane County, Utah, as injuring fruit at Kanab, the county seat of the same county. Mr. Siler's attention was called to them by the postmaster, Mr. B. L. Young, who stated that these insects were destroying their fruit crop, eating the fruit as fast as it ripened. On one tree which Mr. Siler examined, and which bore apples of a medium size, they were present in enormous numbers, and every apple that he could see was covered with the bugs. They were stated to have bred on the Box Elder shade trees (*Negundo aceroides*).

We wrote Mr. Siler, advising him to have the trees sprayed with a dilute kerosene emulsion by means of a force-pump with a spray-nozzle. The breeding of the bugs on Box Elder, and their desertion of this tree for the ripening fruit, makes the case precisely similar to that of the Red Bug or Cotton Stainer (*Dysdercus suturellus*, to which it is moreover quite closely related) in Florida, as where cotton and oranges are grown near together the bugs desert the cotton, on which they breed, for the more attractive fruit. There the bugs are attracted to piles of cotton-seed or decaying oranges, on which they cluster in the cool of the morning, and are then readily killed in bulk by drenching them with hot water or pure kerosene.

This offers a suggestion as to the probable efficacy of a similar remedy for the Leptocoris, although as yet no experiments have been tried and no extended observations made as to its habits.

PROCONIA UNDATA IN INJURIOUS NUMBERS. (Plate I, fig. 4.)—August 14, 1885, Dr. A. Oemler, of Wilmington Island, Georgia, wrote us of an insect which was becoming very abundant and injurious to a number of different plants in his vicinity. August 29, in reply to a request, he sent a number of specimens of *Proconia undata*, and among them one specimen of *Analcises mollipes*, included probably on account of its superficial resemblance to the former species. He wrote that he observed them to be more common than usual in 1884, particularly on the young growth of a Black Hamburg grape-vine, and that this year they were plentiful, doing considerable damage to Okra by sucking the sap from its stems, and occurring also upon "mile maize." Writing again, September 6, he stated that one patch of Okra was nearly killed out, and that there were "eight or ten specimens at a time to each plant."

OCCURRENCES OF THE ARMY WORM DURING THE SEASON.—1885 has been a decidedly off year for *Leucania unipuncta*. In no case was the normal second brood injurious to any extent, so far as we can learn. The third brood appeared, however, in injurious numbers at Deer Park, Garrett County, Maryland, damaging the oat crop to a considerable extent on the farm of the ex-United States Senator, H. G. Davis, during the first week in August. Either the same brood retarded, or a fourth generation appeared about September 18 in Sussex County, Delaware. One of our correspondents, Dr. R. G. Ellegood, of Concord, writing under date of September 21, says:

"They made their appearance three days ago in a piece of low cornfield in this county. In one of my professional rides yesterday I came in contact with them. Though but three days in operation they have utterly destroyed 8 or 10 acres of corn. The ground is covered with them and with their excrementitious droppings."

On September 2, Mr. John B. Smith, visiting Goshen, Orange County, New York, for the purpose of studying the Onion Cut-worm (*Agrotis messoria*), found that the Army Worm was quite abundant in the oat fields near that place, so much so as to attract general notice. Returning to the same locality on October 5, he found no traces of larvæ, eggs, or imagines, and only a few pupa shells in the oat fields, but the larvæ could probably have been found in the neighboring grass-lands.

One of our correspondents, Mr. M. S. Crane, of Caldwell, N. J., wrote us October 13, that while sugaring for moths August 26 he counted over forty Army Worm moths on his first seven baits. He has captured the moths every year, but this season they were unusually abundant. No damage from the worms, however, was reported from his vicinity.

CALIFORNIA REMEDIES FOR THE WOOLLY APHIS.—Mr. W. G. Klee writes in Bulletin No. 55 of the Agricultural Experiment Station of the University of California about the widespread disease of the apple tree produced by the Woolly Aphis (*Schizoneura lanigera*) and its repression. He describes the insect and the astonishing rapidity of its increase in the dry climate of California. After trying the various remedies suggested for its extermination upon the twigs, such as rubbing kerosene on the infested spots, or washing them with lye (three-quarter pounds to the gallon), or with a solution of whale-oil soap, or sulpho-carbonate of potassium, he found them only of use in arresting the disease. If, however, the roots are once thoroughly infested, all the remedies usually recommended proved insufficient or impracticable. Gas lime was found very efficacious, as well as inexpensive. It has to be used with care, and the dose must be regulated according to the character of the soil and subsoil and the age of the trees. In a porous and deep soil there is less danger than in a clayey one, where the water charged with the antidote permeates the soil very slowly, and has time to corrode the bark. It is always safe to use only a small dose first—from one shovelful on a small tree to four on a very large one, spread over the surface, according to the spread of the roots; the rain will wash it into the soil. Fresh ashes should be piled close about the trunk to prevent the aphis from descending to the roots. He found that lady-bugs would consume most of the Aphids adhering to the twigs, and to protect these beneficial insects it is wise to have conifers growing in the vicinity of the orchards to provide hibernating quarters for them. Two to three sprayings of the trees are also recommended; the first application with hot water of 140° F., the second with tobacco water and whale-oil soap in the following proportions: In a decoction of tobacco (1 gallon water to one-half pound tobacco) put half a pound of whale-oil soap. This mixture ought to be applied at about 130° F., and should be followed in about a week by another application.

Seedlings of the Golden Russet and Rawle's Janet are exempt, possessing tough and wiry roots.

THE HESSIAN FLY IN CALIFORNIA.—A number of notices have occurred in the California newspapers during the season, relative to the appearance of the Hessian Fly on the Pacific Coast. Anxious to learn the truth of these reports, we wrote for confirmation to Mr. Matthew Cooke, of Sacramento, who answered under date of May 29 that he had traveled extensively through the infested section of the State and had seen unmistakable proofs of the presence of the fly. He defines the region as follows:

"Take a map of California; find Vallejo, in Solano County (opposite Mare Island Navy-yard), and draw a line to Benicia (8 miles). From Benicia continue the line to Suisun, and then in a north or northwest direction draw a line that will fall north of Napa City, in Napa County; thence back to Vallejo. This will be a line of nearly 60 miles, and the grain lands in this section are infested by the Hessian Fly. A section of country in Sonoma County, located between Petaluma and Santa Rosa, is also infested. I have not examined other sections reported. About six years ago it appeared in a field of grain (wheat) near Vallejo, and has spread since that time. Mr. Brownlee, of Creston, about 10 miles from where it first started, lost 380 acres of wheat in 1883."

Specimens which Mr. Cooke sent with his letter proved the correctness of his determination. If the insect has really, as he states, been a denizen of California for six years, it seems strange that the fact should never before have been authoritatively placed on record. We have been on the lookout for such a fact ever since the publication of Dr. Packard's first map of the distribution of the species,* and when Mr. Cooke in his work on injurious insects, in 1883†, stated that he had no knowledge of its existence in California, we accepted his evidence as practically conclusive.

We shall now watch its further spread in the State with interest, more particularly to see whether the energetic Californians will fight this pest any more successfully than the Eastern farmers have done.

It is worthy of note also that the False Chinch Bug (*Nysius destructor*) has done great damage in vineyards in California during the summer, and that it was also reported as injuring rye and wheat.

"WHEEL BUGS" DESTROYING HIVE BEES.—In October we received from Mr. C. M. Gibbens, of Winchester, Va., a live specimen of the Wheel Bug (*Prionotus cristatus*), with the information that it was found in abundance upon his grounds and preyed upon his honey bees, lurking about their hives. Although the Wheel Bug is, so far as we know, exclusively a predaceous insect, this particular habit has not, we think, before been observed.

AGONODERUS PALLIPES INJURIOUS TO CORN (Plate I, fig. 2).—This common ground beetle was, until quite recently, supposed to be strictly carnivorous. In 1882, Professor Forbes, in the Twelfth Report of the State Entomologist of Illinois, page 27, recorded that he found this species (referring to it as *A. comma*) under the clods and in the ground about the roots of corn in a field, which was injured by the Corn-root Worm (*Diabrotica longicornis*), and on examination of the stomach contents they were found to have partaken both of animal and vegetable food. In the same report (p. 43) he states that he found them in a field of corn infested by the Chinch Bug, and examination showed that they had fed in part on Chinch Bugs and other insects, but also on vegetation, which appeared to have been roots of corn. On page 111 (*loc. cit.*) he states that a dissection of the stomachs of fifteen specimens of this

* Report upon the Rocky Mountain locust and other insects, &c. Ninth Ann. Rept. U. S. Geol. and Geogr. Surv. Terr., Washington, 1877.

† "Injurious insects of the orchard, vineyard," &c. By Matthew Cooke, Sacramento, 1883.

species showed the presence of 50 per cent. of vegetable material, all fragments of the higher plants except 2 per cent. of common fungi.

During the last summer specimens of this beetle were received from Illinois (H. H. Harris, Lynnville, Morgan County) and Iowa (J. M. Evans, Salem, Henry County, through Dr. J. M. Shaffer, of Keokuk), with the information that it was damaging young corn by gnawing into the seed grain and by eating the sprouting roots. The exact amount of damage done was not stated, but it was said to be quite extensive. Specimens were sent to the Department showing the beetle actually engaged in eating a large cavity into the seed, as shown in the figure, so that there can be no doubt as to the accuracy of the observation.

If this damage should become extensive, a satisfactory remedy will be found in soaking all seed-corn for a short time before planting in some arsenical solution, such as Paris green or London purple, in water. Such a course will not injure the germinative quality of the seed, and will probably result in the death of all beetles which attempt to gnaw the seed.

EXPLANATION TO PLATE.

FIG. 1.—*Ligyrus rugiceps*—natural size (after Comstock).
FIG. 2.—*Agonoderus pallipes*—enlarged (original).
FIG. 3.—*Gelechia obliquistrigella*—enlarged (original).
FIG. 4.—*Proconia undata*—enlarged (original).
FIG. 5.—*Leptocoris trivittata*—enlarged (original).
FIG. 6.—*Monephora bicincta*—enlarged (original).

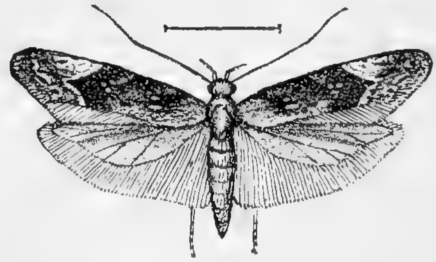

Fig. 3.

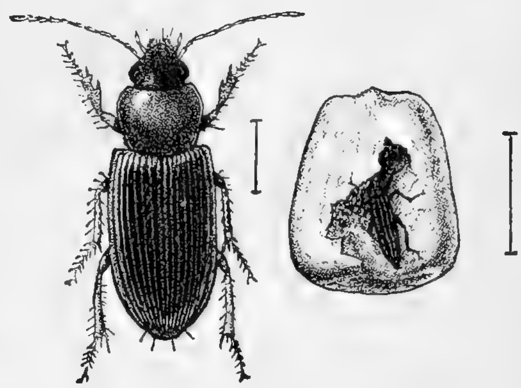

Fig. 2.

Fig. 1.

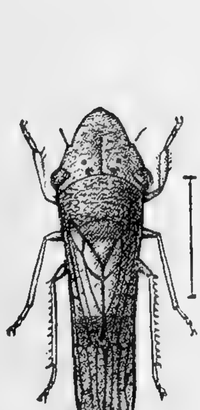

Fig. 4.

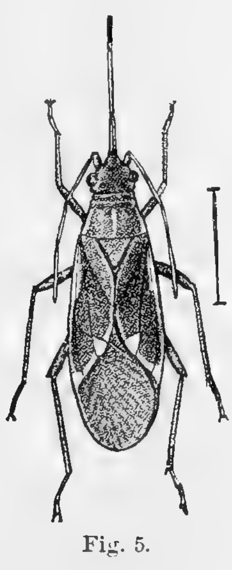

Fig. 5.

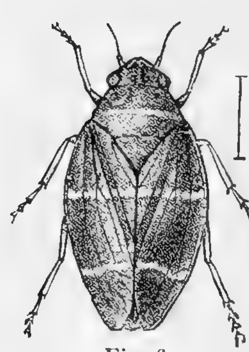

Fig. 6.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 13.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

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17528—No. 13

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 15, 1887.

SIR: I have the honor to submit for publication Bulletin No. 13 of this Division. This Bulletin comprises such of the reports of the agents of the Division for the season of 1886 as were necessarily excluded from the Annual Report for lack of space.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

CONTENTS.

INTRODUCTION.

This bulletin contains all of the reports from the Agents of the Division for the season of 1886 with the exception of those from Mr. Coquillett and Mr. Koebele on remedies for the Cottony Cushion-scale of California (*Icerya purchasi* Maskell), that of Mr. Webster on insects affecting grains, which will be published in the Annual Report of the Department, and that of Mr. Ashmead on insects injurious to garden crops in Florida, which is reserved for the next bulletin.

Mr. Bruner's report on locusts in Texas during the spring of 1886 is interesting in its local bearing and from the similarity of this outbreak of non-migratory or partially migratory species in the far Southwest to that in the extreme Northeast described in our Annual Report for 1883.

Miss Murtfeldt's notes from Missouri, Mr. Alwood's report on some injurious insects from Ohio, and Mr. Bruner's report on Nebraska insects are simply short accounts of the prominent injurious insects of this particular season in their respective localities. Dr. Packard's fourth report on insects injurious to forest and shade trees contains an account of a new and important enemy of spruce cones, and considerable matter which is new and of interest both from the entomological and from the forestry standpoints.

Mr. Webster's experiments upon the effect of the puncture of certain plant-bugs were undertaken with a view of settling the disputed question as to whether these punctures are poisonous. The experiments in the main prove such a poisonous effect, and I may here state, without going into a general discussion of the subject, that while in Columbus, Ohio, in May, 1886, I found the immature forms of *Poecilocapsus 4-vittatus* blighting the young shoots of both Gooseberry and Currant, and that in this case the poisonous nature of the puncture was unmistakable. The punctured shoots were without exception blasted and distorted.

Mr. Alwood's tests with insecticides upon garden insects were undertaken as a continuation of those recorded in Bulletin No. 11 of the division, and will be of interest both on account of the new locality and on account of several new substances experimented with.

The apicultural notes from Mr. McLain form a portion only of his report for the season of 1886, and were excluded from the annual report for want of space. The portion on bees *vs.* fruit is in the main an account of a repetition of the experiments detailed in the Annual Report for 1885. The results are corroboratory, but not absolutely conclusive of the inability of bees to injure fruit, in that the conditions were not varied sufficiently and that the fruits were substantially the same kinds as used last year.

C. V. R.

REPORT ON LOCUSTS IN TEXAS DURING THE SPRING OF 1886.*

By LAWRENCE BRUNER, *Special Agent.*

LETTER OF TRANSMITTAL.

SIR: Herewith is submitted a brief report of a trip to Washington County, Texas, and surrounding regions, made under your instructions for the purpose of investigating the locust plague of that section and reporting upon the same.

You will see from my notes and the specimens which accompany the report that the chief species causing the damage is, as you supposed, not *Melanoplus spretus* but *M. differentialis* or a closely allied form; and that it can be much more easily handled than can the migratory locust of the Northwest.

Immediately upon the receipt of your letter (April 16) containing the instructions, I arranged to leave by the first train (April 17). Arriving in Houston on the 20th and making all necessary preliminary arrangements, Dr. Flewellen and myself proceeded the next morning to the seat of trouble, which was reached late in the afternoon of that day.

Upon examination myriads of the young locusts were found on the plantation of the doctor's brother, Maj. J. P. Flewellen. These were chiefly confined to the edges of the fields and along the ravines where they had congregated upon the weeds.

After spending a few days in experimenting with poisons and other agencies for killing them, I returned to Houston for mail containing any possible further instructions. From here I went to Galveston, where I wrote a short communication for the *News*, giving remedies and urging co-operation in the efforts in destroying the plague. A copy of this article accompanies the report.

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* Our attention was called to the locust visitation in Washington County, Texas, in March of the present year by a letter received from Dr. R. T. Flewellen, of Houston, which reads as follows:

WASHINGTON COUNTY, TEXAS,
March 22, 1886.

DEAR SIR: This and many other localities of Texas had the crop of corn and cotton destroyed by grasshoppers, and I herein send you a small paper box of eggs taken from the ground to-day for your examination. This locality, 4 miles south of the old town of Washington on the Brazos River, lost not less than 20,000 bushels of corn and about 2,000 bales of cotton by the ravages of the pest, and judging from the vast quantities of eggs seen to hatch, the destruction of last will be repeated this year unless timely aid comes to the relief of the unfortunate planter. Hence this appeal to you. It is hoped that you will send some expert of your department to this immediate locality to learn the habits, species, and correct classification of the insect, and inaugurate some means for their destruction, for if not arrested this locality is doomed.

* * * * * * *

Very truly,

R. T. FLEWELLEN.

Prof. C. V. RILEY,
Washington, D. C.

We accordingly had Mr. Bruner visit the region in question with instructions to learn what he could concerning the extent of injury, the species concerned and their habits, and to experiment with such remedies as would aid the planters in saving the crops.

After leaving Galveston I visited various localities surrounding the immediate region infested to ascertain the exact area over which the locusts had hatched in injurious numbers, thereby anticipating your orders of April 29, which reached me at Austin on the 5th of May. From Austin I returned to the plantation of Mr. Flewellen in order to ascertain how the warfare was progressing in that neighborhood, and what the prospects were for the production of a crop this year. Upon my arrival I found a decided reduction in the number of hoppers, and a correspondingly brighter and more hopeful feeling among the planters of the stricken area. I also learned of another locust that appeared to be increasing very rapidly among the forests of post oak lying between the towns of Washington and Brenham. This very likely will prove to be an undescribed species, belonging somewhere between the genera *Melanoplus* and *Acridium*.

After spending several days in this locality, I returned to my home at West Point, where I arrived on the 14th of the month.

Very respectfully,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist, Washington, D. C.

I visited the region indicated in Dr. Flewellen's letter of March 22, arriving there on the evening of April 21, to find that the young had already hatched and were then nearly or quite three weeks old. Upon examination but few of these were found scattered over the cultivated fields, while the majority of them were still confined to the weed patches at the outer edges in ravines, along "turn rows" and in fence corners. That evening, after a short consultation with the neighboring planters, it was decided that immediate warfare begin, as no time should be lost if advantage was to be taken of the position which the enemy occupied. Accordingly, early the following morning, a team was dispatched to town for poisons and other munitions of war. While some present favored poisoning, others opposed this mode of warfare as dangerous and impracticable; but, as they could suggest no substitute, it was finally agreed that poisoning should be tried. This was agreed upon chiefly because all were supplied with the apparatus necessary for its application, and were accustomed to its use in fighting the Cotton Worm (*Aletia xylina*). I also proposed the use of coal tar and kerosene pans, and ordered the material for the construction of a trial machine. The following morning we started out over the plantation of Major Flewellen on a tour of inspection, only to find the majority of the eggs already hatched and the young locusts in their second and third stages. After digging for several hours and finding but a couple of unhatched eggs and no egg parasites, it was decided to devote the future to the destruction of the larvæ before they began spreading over the crops, notwithstanding the fact that you wished me especially to devote much of my time in digging for egg parasites.

By careful inquiry from old citizens I learned that ever since the war-times grasshoppers have occasionally appeared in unusual numbers at isolated localities throughout portions of Central Texas, and especially in the immediate neighborhood at present overrun. When this was the case, crops invariably suffered to a lesser or greater extent from their depredations. These visitations were so limited in extent and inconspicuous in their nature that but little attention was paid them at the time. There were other insect enemies that were attracting notice and required the attention of the planters, whose chief crop had been cotton. The Cotton Worm (*Aletia xylina*) had so increased in numbers as almost to render the growing of cotton an impossibility; but, owing to the perseverance of those interested, that insect has at last been reduced to such an extent as to be under control. Until within the past three years these grasshopper or locust depredations escaped popular notice (save during the visitation in the Fall of 1876 of the migratory species). Since this time, however, their increasing numbers and frequent damage to crops have been too great to be overlooked even by the most unobserving. They have appeared at widely separated localities, and although not committing general injury are known to have eaten away several of the outside rows of cotton and corn in fields bordering waste lands and ravines grown up with weeds and other rank vegetation. Not until last year, however, did the plague reach such a magnitude as to cause alarm; and this only after the total destruction of crops upon plantations situated in different localities and in adjoining counties.

Referring to notes taken while in the field, I find the following remarks: "There appear to be several species of the locusts which are causing the trouble here, and all seem to have had similar egg-laying habits. In looking about I find the larvæ of *Melanoplus differentialis* or *M. robustus*, *M. angustipennis*, *M. atlanis*, and *Acridium frontalis*. The last three species are in about equal numbers, while those of the first are by far the most numerous, and this is the only one which is charged with last year's depredations. I am not quite positive whether the large species is *M. differentialis* or *M. robustus*, as these two species are very nearly related, and I have never seen authentic larvæ of the latter. To-day (April 23) I found an old specimen of a male *robustus*, and was assured that it was one of the genuine offenders, while yesterday the femora of *differentialis* were pointed out to me as having belonged to 'the very kind'."

During my sojourn in the infested region I observed *M. atlanis*, fully fledged, quite frequently, while walking about the fields, while others, with those of *M. angustipennis*, were still in the pupal stage. These latter, with those of *Acridium frontalis*, were exceedingly common, and together nearly or quite equaled in number those of the larger species. These three, while not always mingled with the former, were generally to be found with them; especially was this the case upon rather damp ground at the edges of ravines and grass patches, and also in fields of small grain.

While the Rocky Mountain or Migratory Locust prefers rather solid soil upon somewhat elevated open fields and closely grazed pastures for depositing its eggs, all of these species now infesting Central Texas appear to find more suitable conditions among rank herbage for the deposition of their eggs and subsequent development of the young larvæ. The large species especially finds the protected roots of grasses and corn best adapted to the sheltering of its eggs, and almost invariably selects the varieties which grow in clumps for this purpose. In digging I have found as many as 8 or 10 egg-pods inserted among the root-stalks of a single clump of grass. Possibly the sheltered nature of these eggs protects them from the numerous parasites which attack those of the Migratory and other species which deposit in the unprotected ground. It is asserted by different persons in this region that the present species lays an average of 150 eggs to the pod, which, judging from the fragments of egg-shells found by digging, is nearly correct; at any rate the estimate is not too high. Egg-depositing with this species commences rather later than with some of the other representatives of the genus, but just at what date I did not learn. There is but a single pod formed by an insect, the entire complement of eggs being deposited at once.

The larvæ commence hatching during the latter part of March and continue to appear up to the middle of April, according to the forwardness or backwardness of the season. Wet warm weather favors the hatching, while dry weather rather retards the process. The young molt five times, at intervals of from 12 to 20 days, according to the condition of the weather. Dry weather with hot days retards, while damp or wet weather favors this process among insects by keeping the exuviæ pliable during molting, as well as in furnishing the necessary moisture required in growth. The winged or mature insects appear about the middle of July or a little earlier and begin to couple soon afterward, thus completing the cycle.

Their mode of attack does not differ greatly from that of *M. spretus*, save in that the latter begin upon the crops immediately after hatching, while these species do not. They wait until they are from three to four weeks old before venturing far from the places of hatching. Like that species they have the habit of huddling together upon plants and among grasses and débris during cool nights and on cloudy days. This appears to be a trait common to all insects when present in large numbers, and must be the result of some special instinct. When about half-grown the larvæ become pretty well scattered over the fields and do not hop back to the weed patches on the outskirts in the evening, as they do while younger and when first beginning their attacks upon the crops. The molting is the same as with other locusts, and need not here be redescribed. The grown hoppers do not migrate by flight, but do sometimes move in concert in certain directions by jumping. This can hardly be termed migration, since the change of location is merely performed for the purpose of obtaining food, while the act of migrating is towards obtaining more decided results. When feeding they can be driven like other locusts, and this trait in their nature has been taken advantage of at different times and by many of the planters as a means of partial protection to the crops.

It is sometimes quite a difficult matter to account for the rapid increase of certain insects during a series of seasons that for years before have scarcely appeared in numbers sufficient to be noticed. However true this assertion may be, I think the rapid increase in the present instance can be readily accounted for, and has its direct causes partly in the negligence of the planters over the area now suffering and partly through other and indirect but favoring circumstances. It has already been ascertained that all of the species which are combining in the present injury are partial to rank vegetation, and find the most favorable conditions for their egg-laying and subsequent development in the waste land at the borders of cultivated fields, in ravines which run through cultivated ground, and in neglected grounds which were at one time under the plow. Everywhere in this locust area do we find great neglect in this respect. There are not only large fields lying idle which were once cultivated in cotton, but also wide borders adjacent to ravines and gullies which have been permitted to grow up in bunch grasses and weeds. Each of these features is of too common recurrence, thus giving this and other insects of like nature ample harbor and room for multiplication year after year. This is the prime cause, but from inquiry it cannot be disputed that there are several other agencies which have aided in bringing about the present state of affairs. These are, primarily, the comparative scarcity of insectivorous birds, and secondarily the comparatively dry summers for the past three years. While the bird question cannot easily be remedied at once, or the seasons changed so as not to favor the increasing hoppers, there can be a great deal accomplished by clearing up these waste places and putting them once more under the plow. The dry seasons have aided the increase of the locusts by diminishing their natural enemies. These are chiefly soft-bodied insects, very delicate in structure, that are dependent to a much greater extent than the locust is on moisture for their development and subsequent career. It stands to reason, therefore, that dry seasons, while not materially affecting the more hardy nature of the locusts, are very injurious, if not altogether fatal, to insects whose organs are so delicate as are most of these parasitic forms.

Up to the present season but little or nothing has been done by the planters to protect their crops from the ravages of these locusts or towards diminishing their numbers. True, some of them tried to save their crops by driving the locusts off after they were fully matured and could fly. While this remedy will sometimes save a portion of a crop, it is only transient in its result, and must be repeated each day several times. It is also a remedy that works better with the migratory species than with the non-migratory forms that seldom fly more than a few yards at a time. To save crops from locust ravages the main object to be kept in view is, or rather should be, the destruction of the pest, and not merely a transient removal of it. If the insects are merely kept agitated while in the fields this does not prevent them from proceeding to the outskirts and depositing their eggs in the waste places heretofore mentioned, and thereby rendering the production of crops the ensuing year equally uncertain, and even, with favoring conditions, tenfold more so.

When I first visited the region infested, I learned of some efforts at poisoning the larvæ with arsenic and Paris green. These had been tried merely as experiments, and thus far had proved but partially successful. The poisons in every instance had been applied in too large quantities for the mixtures used, and resulted in the killing of the vegetation over which they had been distributed. Where this was the case, the hoppers escaped with little injury. These mineral poisons only take effect when taken internally with the food, and when the vegetation has been killed the young locusts will not eat it, but hop away to seek that which is fresh. Finding this to be the case, a series of experiments was instituted in order to ascertain just what proportions of the poisons were necessary in order to obtain the best results and not to kill the vegetation. By inquiry it was learned that of the arsenic the following solution had been used: to one barrrel (47.9 gallons) of water in which two quarts of molasses had been stirred, 12 ounces of the poison were added. The latter had first been boiled in a little water, with a pound or more of carbonate of soda, for about an hour in order to dissolve it. We therefore decided that the future experiments should be made with less poison to the barrel of water, and accordingly a half pound was substituted. This mixture also proved too strong for the vegetation. After continued experiments it was finally decided that from 4 to 5 ounces of the poison to the barrel of water gave by far the best results, and did not injure the vegetation unless put on too thickly or in too coarse a spray. Bright sunshine during spraying appeared to render the poison more injurious to the vegetation. A second spraying over the same grounds also had the same effect as the stronger mixtures. Light rains did not materially diminish the efficacy of the poisoning. The results of arsenious poisoning are not immediate upon the hoppers, but first show after about twenty-four hours, and prove fatal in about thirty-six to forty hours. When the first examination was made after the application (twenty-four hours afterwards) it was found that most of the larvæ had left the weeds and were found creeping and jumping about in a rather sluggish manner upon the ground underneath. No dead ones were to be found at this time. In examining the same locality a day later, a great many dead were found, also many others that were very sluggish, while but few really active ones were to be found. On the morning of the third day I counted upon 1 square foot of surface between fifty and sixty dead, and a few others were present that must certainly have followed before the expiration of another twenty-four hours.

This poison is best applied with a rather powerful force-pump, using a very fine spray, otherwise the vegetation will blister and much of the fluid be wasted by falling upon the ground. The finer the spray the more evenly the poison can be distributed, and hence a correspondingly better result will ensue. Where comparatively large areas are to be poisoned the best plan is to have two or more barrels, or, what is better still, a tank holding a hundred or more gallons of the poisoned water, mounted upon a wagon and drawn through the field with a team of horses or oxen. Always poison by going against the wind instead of with it, otherwise there is danger of poisoning both the team and the persons operating the pump. It should also be remembered that a muzzled beast is less liable to eat the poisoned vegetation than one without a muzzle. Again, poisoning should be done only upon such grounds as are never grazed, or over which stock is not permitted to run. Poisoning can only be done with safety in regions where fields are fenced, and upon such vegetation as will not afterwards be used as food for animals or man. While rains may wash off most of the poison from weeds, they never can do this from grasses and grains where the blades are fastened to the stem in such a manner as to catch all the rain which falls upon them and carry it to the body of the plant.

Paris green is used diluted with wheat flour or wood ashes, and applied by dusting it upon the vegetation by means of a fine meal-sieve. The proportions giving the best results as stated to me were 12 ounces of the green to about 20 pounds of flour. Some add one pound of very finely-powdered resin, which they claim acts as a sort of glue, causing the material to adhere to the vegetation. Great caution is also necessary in using this poison, both in its application and afterward in keeping stock away from the vegetation to which it has been applied. The best time for applying this remedy is in the morning while the dew is still on the vegetation and before the wind arises. While a few of the planters in the vicinity of Washington and Navasota seemed to think this remedy superior to the arsenic, I did not find it so upon Mr. Flewellen's plantation, where it was tested several times. Whereever used, it is true, the hoppers disappeared, but an examination revealed but few dead ones upon the ground. My opinion is that they only moved to other localities where the poison was not put. This I am pretty certain of, for frequently large numbers of the larvæ were observed adjacent to such localities one day where there had been none the day before. Vegetation also suffered from the effect of the poison.

In using poisons I would recommend the spray rather than the dry application. The sirup or molasses adds to the efficacy of this latter by enticing the hoppers to eat, since they are exceedingly fond of sweets. Poisoning is undoubtedly a good remedy against locusts and other injurious insects in countries where every field is fenced and where no stock is permitted to roam about. Where there are no fences, however, and stock roams at will over fields and along roadsides, its use is out of the question. There are also numerous instances in fenced districts where its use is impracticable and out of the question; as, for example, in pastures and grain-fields as well as in the garden. In these latter instances, therefore, it is necessary that other remedies be adopted. I therefore suggested the use of the coal-tar and kerosene pans and the various other machines and contrivances which have been used with success in other locust districts in times past. As a sample and illustration of their use I had one of these constructed, and had the satisfaction of seeing it adopted by almost every planter in the immediate neighborhood, as well as by others throughout the region afflicted. While this latter remedy or contrivance did not meet the approval of some of the larger planters, it was very popular with the colored population, who are exceedingly superstitious concerning the use of poisons of all kinds. It was also quickly adopted by persons of limited means, or where the locusts were confined to small patches and could be readily destroyed in a few days with a small machine dragged over the ground by hand.

In addition to the foregoing remedies one gentleman told me of a plan he had adopted for destroying the hoppers upon his place. It was about as follows: Having noticed that a certain piece of neglected ground had been largely used by the locusts last fall for depositing their eggs, he decided to plow it up this spring and, if possible, prevent them from hatching. When plowing began it was found that most of the eggs were thrust among the roots of large grass clumps. He therefore mustered all hands together and set them to gathering these clumps of grass and hauling them into piles which were afterwards set on fire and burned, thus destroying the locust eggs which they contained. No less than nine wagon loads of the grass clumps were thus gathered and burned, and this evidently did much good. Others who have recognized the insectivorous nature of fowls, and especially of the guinea-hen and turkey, have begun rearing these in large numbers. I also suggest to the planters in general that they protect the quails and quit shooting them for several years, since they, too, are of great aid as insect destroyers.

At this time locusts are present in damaging numbers in the following counties as nearly as I could ascertain by inquiry and travel: Washington, Burleson, Lee, Fayette, Austin, Grimes and Waller, and of these only Washington, Austin, Grimes and Waller have reported the loss of crops during last year from their ravages. This section lies just between the two "cross timbers" of east Central Texas and borders the prairie country. Judging from the timbered nature of this portion of the State, the climate as a rule must be rather more humid than it has been during the past few years, and consequently cannot always be overrun by locusts, if, as we understand it, aridity is favorable to the rapid increase of these insects. With the present warfare against them, if continued during the spring and summer into the fall, there certainly cannot be much danger of future depredations from locusts. Still I would suggest to the inhabitants of this and adjoining regions to keep on the alert, and wherever and whenever threatened to waste no time but to try and control them at once.

Although the loss of crops has been limited to comparatively small areas throughout these counties, nevertheless the damages sustained will aggregate more than might be imagined. As an example, we need only quote a few lines from Dr. Flewellen's letter where he writes: "This locality, 4 miles south of the old town of Washington on the Brazos River, lost not less than 20,000 bushels of corn and 2,000 bales of cotton by the ravages of the pest." When we add to this the losses sustained at other localities throughout these counties, and also those on other crops, we have before us quite formidable figures.

In closing my report, it might be thought proper for me to give my opinion as to the possible results of this summer's brood of hoppers. This can be done in very few words. Possibly in addition to a few outside rows, a few fields of cotton and corn will be taken in places where the weed patches were destroyed prematurely, thereby scattering the larvæ over the fields while the crops were still very small and tender. This I know to have occurred in several instances where it was thought that by destroying the weeds the little hoppers would also perish. Aside from this there need be but few complete failures on account of locust depredations.

THE POST OAK LOCUST OF WASHINGTON COUNTY, TEXAS.

In addition to the several species of locust that have been mentioned in the preceding pages, last summer for the first time another species of locust was noticed in vast numbers among the post oak timber lying between the towns of Washington and Brenham, in Washington county. These were so numerous in one locality that they completely defoliated the trees of the forest, even to the very topmost twigs. The region occupied by this insect, although not over a mile and a half in width by 7 or 8 miles in length, is sufficiently large for the propagation of swarms capable of devastating a much larger area during the present spring and summer, and by another year to spread over several of the adjoining counties.

Although there is at present no apparent injury to the trees thus defoliated last year, and now in progress again this year, there can be no question as to the final result if these attacks are continued for several years longer. The trees will eventually die. While up to the present time this locust has shown a decided arboreal habit, it may, and undoubtedly will be, obliged to seek food in the adjoining fields when compelled to do so through lack of its present diet, which is rapidly disappearing before the hungry myriads of young locusts.

Notwithstanding the great numbers of the foregoing described species which together have combined in injuring the cotton and corn crops throughout this and adjoining counties, it is my opinion that the present species is more to be feared in the future than they, on account of its arboreal nature and the difficulty of getting at it in order to destroy it. To kill these locusts either while feeding among the foliage or "roosting" upon the topmost boughs of the tall trees would be next to impossible. On the other hand, the other species are easily to be gotten at and destroyed, as just shown.

The habits of this locust, as nearly as I was able to learn through inquiry from others, and by personal observation, are briefly as follows:

The egg-pods are deposited in the ground about the bases of trees or indifferently scattered about the surface among the decaying leaves, &c., like those of all other ground-laying species. The young commence hatching about the middle of March and continue to appear until into April. After molting the first time and becoming a little hardened they immediately climb up the trunks of the trees and bushes of all kinds and commence feeding upon the new and tender foliage. They molt at least five or six times, if we may take the variation in size and difference in the development of the rudiments of wings as a criterion. The imago or mature stage is reached by the last of May or during the first part of June.

The species is very active and shy in all its stages of growth after leaving the egg. The larva and pupa run up the trunks and along the limbs of trees with considerable speed, and in this respect differ considerably from all other species of locusts with which I am acquainted. I am informed that the mature insects are also equally wild and fly like birds. They feed both by day and night; and I am told by those who have passed through the woods after night when all else was quiet, that the noise produced by the grinding of their jaws was not unlike the greedy feeding of swine.

Aside from its arboreal nature there is but a single instance mentioned of its preference to growing crops. This was a small field of either cotton or corn, or perhaps both. If the nature of the crop was told me at the time I have forgotten. At any rate the crop of one or the other of these two staples grew in a small clearing in the very midst of the most thickly visited area. The mature insects alone were the offenders in this instance. During the day-time they would leave the trees in swarms and alight upon the growing crop and feed until evening, when they would return to the trees. If, during the day, they were disturbed, they immediately took wing and left for the tops of the surrounding trees to return shortly afterward.

The exact classification of this locust has not yet been fully ascertained, since no mature specimens were to be obtained, or, to my knowledge, are contained in any of our American collections. The larvæ and pupæ collected, however, would indicate a relationship to both the genera *Melanoplus* and *Acridium*. It appears to be congeneric with an undescribed short-winged form, thus far only taken in Missouri, which lives among and feeds upon the oaks only of that region. The present species is also evidently undescribed, unless the mature insect should differ widely from the preparatory stages herewith presented. It is popularly known in that region as the "Red-legged hopper" of the post oaks.

The larvæ and pupæ are of rather bright color, giving them a gaudy appearance. The ground color of the body is dark wood brown deepening into black along the sides of the pronotum and the apex of the posterior femora. The head for the most part is of a bright lemon yellow, while the pronotum is of the same, varied by streaks and blotches of the brown. The antennæ and posterior femora are red internally, dimly banded with yellow and brown on the external face, through which the red color of the inner side can be plainly seen. The feet and tarsi are also dark. The pupæ average almost an inch in length and are rather robust in form, with short, broad heads and powerful jaws

FOURTH REPORT ON INSECTS INJURIOUS TO FOREST AND SHADE TREES.

By Dr. A. S. PACKARD, *Special Agent.*

LETTER OF TRANSMITTAL.

PROVIDENCE, *November* 1, 1886.

SIR: I herewith submit my report on insects injurious to forest trees, based on observations made during the past season in Rhode Island, Maine, and New Hampshire. This report contains observations on the Spruce Bud-worm, a new enemy to that tree, with notes on other forest insects. Other notes on incomplete larval histories do not necessarily appear until they have been completed.

Respectfully yours,

A. S. PACKARD.

Prof. C. V. RILEY,
U. S. Entomologist.

THE SPRUCE AND HACKMATACK WORMS IN 1886.

During the past season, as in 1885, no traces of the caterpillar or moth of *Tortrix fumiferana*, formerly so destructive to Firs and Spruces, were discovered. The moths must be now as rare as before 1878. Great progress has also been made by the younger growth of these coniferous trees in repairing the desolation caused by the attacks of this worm.

The Larch Saw-fly was, on the other hand, found to be still not uncommon. It was observed July 1 at Brunswick, Me., locally, the worm having freshly hatched upon a few trees, but it did not do any more harm than the previous year.

During the early part of September, however, it was observed in abundance along the Cherry Mountain road from Fabyan's to Jefferson, N. H., a few miles north of the White Mountain house. The Larches had been ravaged rather severely and many of the worms were still lingering on the branches, feeding upon the leaves; while many young trees had been stripped, wholly or in part, of their leaves. Some dead Larches were also to be seen.

We call attention below to a Phycid caterpillar which was observed in Maine preying upon the young cones of the Spruce, no lepidopterous insect with similar habits having before been observed.

We have also given more attention than formerly to the insects infesting the Willow and Alder, as these trees are the prolific source of many species which spread from them to other forest as well as to ornamental and shade trees. While the Willow has until recently been useful as a shade tree, when standing by the horse-trough or by the well, an occasional Weeping Willow being seen in towns, a new value is attached to the tree for the salicylic acid extracted from it, and in the Southern States there have already been established extensive plantations of willows, the twigs and branches being cut and gathered for the extraction and manufacture of this valuable remedy.

The number of species of insects affecting the Willow in Europe is said by Kaltenbach* to amount to three hundred and ninety-six; of these ninety-four are beetles and two hundred and fifteen moths and butterflies; while the European Alder supports one hundred and nineteen species of insects of different groups.

THE SPRUCE CONE-WORM.

(*Pinipestis reniculella* Grote.)

This is the first occurrence, so far as we know, of a caterpillar preying upon the terminal fresh young cones of the Spruce. We have previously † called attention to the Spruce Bud-louse (*Adelges abieticolens*) which deforms the terminal shoots of the Spruce, producing large swellings which would be readily mistaken for the cones of the same tree. Another species of Bud-louse (*Adelges abietis* Linn.), which appears to be the same as the European insect of that name, we observed several years since (August, 1881) in considerable numbers on the Norway Spruces on the grounds of the Peabody Academy of Sciences at Salem.

The species of caterpillar in question was observed, August 24, in considerable numbers on a young Spruce 10 to 20 feet in height at Merepoint on Casco Bay, Maine. The cones on the terminal shoot as well as the lateral upper branches, which when healthy and unaffected were purplish-green and about 1¼ inches long, were for the most part mined by a rather large Phycid caterpillar. The worm was of the usual shape and color, especially resembling a Phycid caterpillar not uncommon in certain seasons on the twigs of the Pitch Pine, on which it produces large unsightly masses of castings within which the worms hide.

The Spruce Cone-worm is usually confined to the young cones, into which it bores and mines in different directions, eating galleries passing partly around the interior, separating the scales from the axis of the cones (Fig. 1). After mining one cone the caterpillar passes into an adjoining one, spinning a rude silken passage connecting the two cones. Sometimes a bunch of three or four cones are tied together with silken strands; while the castings or excrement thrown out of the holes form a large, conspicuous light mass, sometimes half as large as one's fist, out of which the tips of the cones are

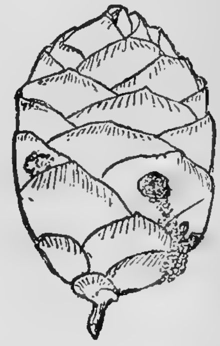

FIG. 1.—Single pierced cone (original).

* Die Pflanzenfeinde aus der Klasse der Insekten, 1874.

† Guide to the Study of Insects, p. 523, and Bulletin 7, U. S. Ent. Comm., p. 234.

seen to project (Fig. 2). Besides these unsightly masses of castings, the presence of the caterpillars causes an exudation of pitch, which clings in large drops or tears to the outside of the adjacent more or less healthy cones. Where much affected the young cones turn brown and sere.

Fig. 2.—Mass of infested cones (original).

The same worms had also attacked the terminal branches and twigs of the same tree, eating off the leaves and leaving a mass of excrement on one side of the twig, within which they had spun a silken gallery in which the worm lived.

On removing the bunches of diseased cones to Providence, one caterpillar transformed in a warm chamber into a moth, which appeared the end of October; its metamorphosis was probably accelerated by the unusually warm autumnal weather. All the others had by the 1st of November spun within the mass of castings a loose, thin, but firm, oval cocoon, about half an inch long and a quarter inch wide, but the larvæ had not yet begun to change to chrysalids. Whether in a state of nature they winter over in the larval state within their cocoons, or, as is more likely, change to pupæ in the autumn, appearing as moths by the end of spring, remains to be seen.

The chrysalis is of the usual Phycid appearance, rather slender, but with the abdominal tip blunt, with no well-marked cremaster or spine, though ending in the usual six curved stiff bristles, by means of which it hooks onto the walls of its cocoon, thus maintaining itself in its natural position.

I only found one tree next to the house thus affected by this worm. It is probable that in a dense spruce growth the trees would be less exposed to the attacks of what may prove a serious enemy of shade spruces. The obvious remedy is, to burn the affected cones and mass of castings late in summer.

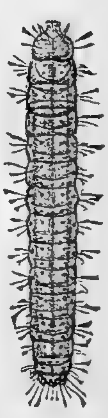

Fig. 3.—Spruce Cone-worm (enlarged. original).

Descriptive.—*Larva*. (Fig. 3.)—Of the usual Phycid form; the head and prothoracic shield deep amber-brown; the body reddish carneous or amber-brown, with a livid hue; a faint, dark, dorsal, and a broader, subdorsal line; piliferous warts distinct; each segment divided into a longer anterior and shorter, narrower, posterior section, bearing two dorsal piliferous warts, besides a lateral one. Length 16^{mm}.

Pupa.—Of the usual Phycid appearance; rather slender, the abdominal tip blunt, with six long slender up-curved bristles. Length 9^{mm}.

Moth. (Fig. 4.)—1 male. Fore-wings long and narrow, stone-gray, with no reddish or brownish tints. Head, palpi, and body dark gray with white scales intermixed. Fore-wings dark and light gray; a broad basal light pitch; before the middle of the wing a white zigzag line composed of a costal and median scallop. A square whitish distal patch, and half way between it and the outer margin is a narrow white zigzag line inclosed on each side by a dark border, the line being deeply angulated three times. Edge of the wing next to the base of the fringe deep black, interrupted by narrow pale gray spots. Fringe dusky, with fine white scales. Legs banded with black and gray. Hind wings pale gray. Expanse of wings 22^{mm}; length of body 10^{mm}. (Identified by Prof. C. H. Fernald.)

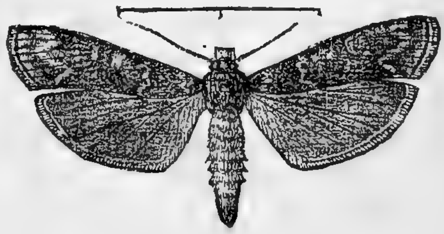

FIG. 4.—Moth of Spruce Cone-worm (enlarged, original).

THE GREEN-STRIPED PHYCID WORM.

(*Meroptera pravella* Gr.)

This a common insect on the Willow, occurring at Brunswick, Me., August 20, and through the month. It spins a web on the under side of the leaf, and pupates from the 15th to 20th of September, the moth in confinement appearing (in the breeding cage at Providence) the end of May (the 25th–31st). The caterpillar, which is longitudinally striped with light and dark green with black slashes on each side of the head, varies somewhat; in some there are only four slashes on the head, with no other markings. The moth differs from *Phycis rubrifasciella* on the Hickory in having no cross-band of raised scales, while the insect is much darker, and the palpi are twice as broad.

DESCRIPTIVE.—*Larva.*—Body of the usual form, tapering from near the head to the end. Head of the usual size, not quite so broad as the prothoracic segment; green, slashed vertically and mottled with large and small brown or jet-black spots. Prothoracic segment a little swollen; the shield not striped like the rest of the body. Body with narrow alternating light and dark green stripes; brown along the back, and inclosing a large round green spot on each segment; the brown portion with three interrupted green lines, one median and two lateral. Piliferous dots minute, not conspicuous. Length, 15^{mm}.

Pupa.—Of the usual Phycid shape; mahogany-brown; end of the terminal abdominal spine smooth, shining, convex, and ending in a stout curved lateral spine on each side. Length 10^{mm}.

Moth.—Body and fore wings dark gray, with brick-red scales and bands. Palpi very broad, especially the second joint; dark gray; vertex of head light gray, with dark scales; antennæ blackish. Prothoracic scales and shoulder tippets (patagia) dull brick-red; middle (disk) of thorax gray. Fore wings dark, dusky gray, with scattered pale gray scales; base of wings dull brick-red; a broad, diffuse band of the same color crosses the basal fourth of the wing; on the outer fourth of the wings is a similar broad, diffuse, dull brick-red band, sending a diffuse longitudinal stripe towards the basal band; an incomplete transverse pale gray line, curved outward in the middle of the wing, borders the inside of the outer reddish band. Costal edge dusky, the reddish bands not reaching it. Fringe of the same dull slate-color as the hind wings. Expanse of wings, 20^{mm}. (Identified by Prof. C. H. Fernald.)

THE ALDER FLEA-BEETLE.

(*Haltica alni* Harris.)

In the correspondence of the late Dr. Harris the following mention is made of this beetle: "In traveling from Centre Harbor, N. H., to Conway, on the 2d of August, 1854, and from Conway to Upper Bartlett, and subsequently to Jackson, we saw the Alders (*Alnus serrulata*) everywhere ravaged by insects which had destroyed their leaves in the manner of canker worms. Upon examination the spoilers were found not to be all dispersed and several were seen upon the leaves still continuing their work; at the same time were found in Conway numerous beetles, which proved to be a species of Haltica, eating the leaves off the same Alders. The larvæ which had ravaged the shrubs were doubtless those of the Haltica before named."

We have reared the beetles from the grubs during the past season. At Merepoint, near Brunswick, Me., during the middle of August, 1886, we noticed clumps of Alders standing in dry soil partly defoliated or with skeletonized, brown or blackish leaves, on which, as well as the still remaining green leaves, were black grubs, sometimes seven or eight on a leaf. All the alders in the region were not molested, the grubs occurring locally. August 15 we found a single beetle, on placing a number of leaves with the grubs in a tin box. We found a white pupa lying loosely on the bottom of the box August 20; soon more pupæ appeared, and the beetles began to appear in considerable numbers the last week of August. It is evident that in nature the larva falls to the ground to transform, the pupæ entering the earth.

Afterwards, September 10, we found whole clumps of Alders at the base of Iron Mountain, Jackson, N. H., stripped by the grubs, nearly all the riddled, brown, dead leaves having fallen off and thickly covering the ground under the bushes. Such a wholesale devastation of Alders we never witnessed. By this time the beetles had become very abundant, and were apparently feeding on the few leaves still attached to the tree. The Alder is the source of some of our destructive forest and fruit insects, and should this grub ever spread to other food trees it will be very annoying, though it can be subdued by proper spraying. There seems to be a periodicity in the appearance of this beetle in unusual numbers, Harris having seen the same grubs in great abundance in 1854 in the same region. We have never observed it so common and destructive before in Maine. It is most probable that the beetles hibernate under the leaves and, soon after the leaves expand in May, lay their eggs in masses on them, the grubs scarcely stirring from the leaf on which they are born, until ready to pupate. The grubs are probably distasteful to birds, otherwise they would fall an easy prey to them and be kept within due limits.

DESCRIPTIVE.—*Larva.*—Body somewhat flattened; head scarcely two-thirds as wide as the body in the middle; black, becoming brown in front near the jaws. Body livid brown above; the tubercles black; paler beneath; with three pairs of black jointed thoracic legs; no abdominal legs, but an anal prop-leg. The abdominal segments each with a traverse, oval-rounded, ventral, rough space forming a series of creeping tubercles; and in front on each segment is a transverse, oval, crescentic chitinous area bearing two piliferous tubercles; the back of each segment divided into two ridges, each bearing a row of six sharp tubercles, bearing short hairs; a single ventral row on each side of the ventral plate. Length, 7–10^{mm}.

Pupa.—Body rather thick, white. Antennæ passing around the bent knees (femero-tibial joints) of the first and second pair of legs, the end scarcely going beyond the middle of the body. Elytra with five or six rather deep longitudinal creases. The salient points of the body armed with piliferous warts. Abdominal tip square at the end, with a stout black spine projecting from each side. Length, 6^{mm}.

Beetle.—Uniformly deep prussian blue, with greenish reflections on the head. Antennal flagellum with fine whitish pubescence; tibiæ clothed with tawny hairs. Length, 5–6^{mm}.

THE ALDER LEAF-ROLLER.

(*Gelechia oronella* Walsingham.)

While the leaves of the Alder are variously folded and rolled, perhaps the most striking leaf-roller is the above species, which occurred in Maine late in the summer, in August and the early part of September.

The little worm is amber-colored, the body rather thick and cylindrical, but with no distinctive markings. One was observed which had sewed a portion of the edge of the leaf for half an inch in extent with four or five large white silk stitches. The moth, which appeared in the breeding cage May 4 of the following year, is described below.

In another example, probably of this species, the end of the leaf was rolled up one and a half turns, and sewed with three broad strong silk stitches. On unrolling it the end of the leaf was found to be more or less eaten, the roll being gradually drawn in and made more perfect as the caterpillar consumes the tip of the leaf. It pupated September 18.

DESCRIPTIVE.—*Larva.*—Body rather thick, cylindrical; body and head delicate amber-colored; end of the body with quite long hairs, longer than the body is wide. Length 6^{mm}.

Pupa.—Rather thick; mahogany-brown; length, 7^{mm}.

Moth.—Palpi with the second joint moderately broad, scarcely more than twice as wide as the third joint, which is moderately broad and two-thirds as long as the second joint. Head and palpi whitish-gray; second joint black externally; third joint white, with two black rings. Fore wings of the usual shape; white-gray; at the base a black streak parallel to the costa; on the basal fourth of the wing is a pair of converging black spots; beyond is a similar but thicker pair of black spots, and still beyond another pair, one of the spots being situated on the costa; four black costal spots towards the apex of the wing. Hind wings pale glistening gray. Expanse of wings, 18^{mm}. I am indebted to Professor Fernald for the identification of this species.

THE PINK-STRIPED WILLOW SPAN-WORM.

(*Deilinia variolaria* Guen.)

The caterpillar of this pretty moth is one of the commonest inch worms to be found on the Willow.

The genus to which this caterpillar belongs was founded by Huebner for a moth referred by Guenée to *Cabera.* The species of Deilinia are distinguished from those of *Corycia* by the pectinated antennæ, the two common lines, and the generally ocherous tint, though the females of *D. variolaria* are with difficulty separated from those of *Corycia*. From *Acidalia* the species differ in having pectinated antennæ, in the want of a decided band on the hind wing, and in the larger palpi. The species is figured on Pl. 10, fig. 26, of Packard's Monograph of Geometrid Moths.

The caterpillar occurred August 10 on the Willow at Brunswick, Me. It pupated August 14, and the moth emerged from May 20 till June 6. The moths are seen flying among willows in June and July. We have also found the larvæ July 24, and from that date till the first week in September.

DESCRIPTIVE.—*Larva.*—Body smooth, cylindrical. Head as wide as the body, flattened from above, especially in front; antennæ pinkish. Green with a pinkish tinge; on the side of the head a lateral distinct deep pink line, sutures and upper side of the segments pinkish. There are eight dorsal median spots along the abdominal segments, a central dark-brown dot, flanked on each side by a pale lilac patch. First pair of abdominal feet deep lilac; anal legs with a vertical anterior lilac line. Supra-anal plate large, triangular, with two minute tubercles. Length, 22^{mm}.

Pupa.—Thorax moderately stout, at first greenish, finally becoming like the abdomen, mahogany-brown; terminal spine (cremaster) rather stout and blunt, ending suddenly in two large curved bristles with three minute slender much curved ones on each side; the basal pair situated about half-way between the base and the middle of the spine. Length, 10^{mm}.

Moth.—Front of head deep reddish-ocherous; white on the front edge; palpi deep ocherous; antennæ white. Fore wings with the costal edge rather full. Both wings strigated more or less thickly with brown; sometimes the wings are pure white. In the male, the strigæ (or short lines) are arranged in two parallel lines on both wings. Beneath, pure white; sometimes a complete black discal dot on each wing. Fore and middle legs ocherous. Expanse of wings 26^{mm}. This species differs from *D. erythemaria* (Guen.), also common in the Atlantic States, by its white wings, which are often without lines, and by the deep reddish ocherous front of the head.

THE HERALD.

(*Scoliopteryx libatrix* Linn.)

This fine moth, common to the New and Old World, is in England called "the Herald." Here as well as in Europe it feeds as a general rule upon the Willow, but we are told by Mr. H. L. Clark that he has bred it from the Wild Cherry in Rhode Island.

Its habits so far as they have noticed are nearly the same as observed in Europe. Mr. Lintner, the State Entomologist of New York, says that the caterpillar feeds on and pupates among some of the leaves drawn together by silken threads to which the pupa is attached by an anal spine. The fall brood remains in the pupa state from fifteen to twenty days. He bred a moth which emerged August 3, hence he thinks that there are probably two annual broods of this species, since he has taken it in the early part of May. In Illinois Mr. Coquillett bred a larva which spun its cocoon August 23, while the moth appeared September 7.

Professor Riley's notes show that he found the larvæ at Kirkwood, Mo., in May, 1872; that they began to spin their cocoons May 29; and that the moths began to emerge June 11. On June 17 eggs were found.

We have found the larva on the Willow at Brunswick, Me., August 26, when it was nearly fully grown. It is easily recognized, since it is one of the few Noctuid caterpillars to be found on the Willow, and may be recognized by its pale green hue and the yellow lateral line as well as the yellowish sutures between the body segments. A chrysalis beaten out of a Willow tree during the last week in August disclosed the moth about the 12th of September. Another chrysalis was found at Jackson, N. H., during the second week in September, the moth appearing September 14. The larva had sewed together four or five willow leaves at the end of a terminal shoot, and the cavity thus formed was lined with a thin but dense whitish cocoon in which the pupa was situated with the head upwards, and firmly held in place by the hooks on the abdominal spine. The moth hibernates, appearing in May as soon as the leaves are unfolded, and we see no grounds for supposing that there is more than a single brood of caterpillars or of moths. The chrysalis is quite unlike that of most Noctuidæ which transform in the earth, and has a simple blunt spine. The cremaster or spine of the present species is much like that of those Geometrids which spin a cocoon.

We thus have an interesting departure from the usual structure and habits of a numerous family of moths, the end of the pupa being specially adapted for a residence in a cocoon to prevent its being shaken out of its exposed pupal abode. Like all tree-feeding Noctuidæ, the caterpillar is well protected from observation by its style of coloration; in the present case the pale green assimilating it to the leaves among which it feeds.

THE BROWN CRYPTOLECHIA.

(*Cryptolechia quercicella* Clemens.)

The leaves of the Oak and, as we have found the past season, the Aspen, are often bound together by a rather large flattened Tineid caterpillar, larger in size than most larvæ of the family to which it belongs. It is of about the size of the caterpillar of another less common species of the same genus (*C. schlagenella*) whose habits we have already described in Bulletin No. 3 of the Division of Entomology (U. S. Department Agriculture, p. 25.)

The larva of the present species (originally described by Clemens as *Psilocorsis quèrcicella*) was said by that author* to bind the leaves of oaks together in August and September (in Pennsylvania) and to pick out the parenchyma between the network of veins; to weave a slight cocoon between two leaves, appearing as a moth in March and April. Our observations confirm the accuracy of Clemens's observations. In

*Proc. Acad. Nat. Sciences, Phil., June, 1860. See also Clemens's Tineina of North America, edited by H. T. Stainton, p. 149.

1884 we reared it from the Oak in Providence, the moths in confinement appearing May 3 to 13 of the following spring.

During the season of 1886 we found the larvæ both on the Oak and on the Aspen at Brunswick, Me., during the last week in August (the 25th to 31st). It disfigures these trees by binding the leaves together, where it occupies a gallery in the mass of excrement filling the space. It weaves a slight, but quite consistent, oval, flat cocoon between the somewhat crumpled leaves; the moths appeared in the breeding cages from May 15 to 20; at first sight the moth resembles a Tortrix, the wings being wide and broad at the end, and the markings plain; it is very different in appearance from the moth of the other species we have mentioned, which is white, with longer, narrower wings. The abdominal spine of the chrysalis is also very peculiar in shape.

DESCRIPTIVE.—*Larva.*—Body flattened. Head wide, slightly narrower than the prothoracic segment; dark brown; prothoracic shield dark brown, slightly paler than the head. Body behind pale livid greenish flesh-colored; no dorsal setiferous warts, but on each side of each segment are two dark warts of unequal size giving rise to long hairs; below them are two smaller, paler, less conspicuous warts. Supra-anal plate large, broad, rounded, blackish, with five setiferous warts around the edges of the plate. All the legs concolorous with the body. Length, 12^{mm}.

Pupa.—Of the shape of the Tortricidæ, being unusually stout and of a mahogany brown color. Abdominal segments peculiar in having a single, finely crenulated ridge passing dorsally and laterally around the front edge of the segment; there are no teeth or spines, but a rough surface on the ridge with confluent granulations The tip is peculiar, the last segment being conical, with a stout spine (cremaster), which is rounded, a little flattened, and ending in two forks, from the sides and ends of which arise in all 6–8 long bristles, which stick into the silken lining of the rather slight cocoon in which it transforms. Length, 7^{mm}.

Moth.—Recognized by its large size, broad square wings, and long slender palpi, curving backwards high over the head. Head, thorax, and fore wings tawny gray, with a line of fine dark scales on the base of the antennae and on the upper and under side of the last joint of the palpi. Fore wings uniform tawny gray, mottled with fine blackish scales; no distinct markings except a dark diffuse discal dot. Fringe gray. Hind wings and abdomen as well as the legs shining pale tawny gray, much lighter than the fore wings; beneath of the same color, except that the fore wings are somewhat dusky except on the outer edge and outer half of the costal margin. Expanse of wings 20^{mm}.

THE BEECH SPAN-WORM.

(*Hyperetis nyssaria* Smith and Abbot.)

Although the Alder is one of the food trees of this not uncommon inch-worm, it is known to live on the Beech. The specimen reared from the Alder by us is described below.

I have reared this moth from a large span-worm found on the Alder September 6, at Brunswick Me., which exactly resembled a small twig of the same shrub. It pupated September 20, in a broad flattened oval cocoon spun between the leaves, and the moth appeared at Providence in the breeding cage May 15 of the following year.

Mr. W. Saunders has reared the moth from a caterpillar found on the Beech, and it will probably occur on other trees.

Larva.—Head rather small, much narrower than the body, somewhat flattened in front. First thoracic considerably narrower than the second thoracic segment; second and third thoracic segments with lateral slight swellings; the black spiracles are situated on dusky swellings; on the fifth abdominal segment is a dusky dorsal hump, edged in front with white, consisting of two rounded conical tubercles. Supra-anal plate rounded with two stiff terminal setae; anal legs rather broad, with a setiferous fleshy conical tubercle on the upper edge. General color of head and body lilac-brown; head slightly more reddish, and on the back of each segment is a pair of whitish spots, especially distinct on the second thoracic, but wanting on the first segment. Supra-anal plate and anal legs sea-green, mottled with dusky spots. Length 28^{mm}.

Pupa.—Body rather thick; mahogany-brown, ends of wings and legs reaching to the posterior edge of the third abdominal segment. Terminal spine of the abdomen (cremaster) large, flattened beneath, broad, triangular; the upper and under surface with fine irregular wavy longitudinal ridges. Four lateral curved bristles and a terminal pair about twice as thick and long as the others. On the under side at the base of the spine are two orbicular areas like flattened tubercles. Length 12^{mm}.

Moth.—Fore wings pale whitish, with fine cross specks as usual; the basal cross line is heavy on the costa and bent sharply outwards on the subcostal, with a smaller angle on the median vein and a larger angle on the submedian vein. The great but obtuse angle made by the outer line extends quite near the outer edge of the wing. Half way between the apex and the outer line two brown costal patches; two unequal black patches near the internal angle. Beneath, the lines and cross specks are reddish-brown. Expanse of wings 33^{mm}. The specimen does not agree with either of the four figures in my Monograph of Geometrid Moths, differing especially in the shape and direction of the outer line.

THE CLEFT-HEADED SPAN-WORM.

(*Amphydasis cognataria* Guen.)

This common inch or measuring worm is the largest species we have met with feeding on the Willow, and may be readily recognized by its deeply cleft head and reddish-brown or green body like a reddish or green willow twig, which it closely mimics. We have noticed it as frequently in Jackson, N. H., as in Maine. It becomes fully fed by the first week in September, my specimens transforming September 8, the chrysalis entering the earth. The moth appears in June in Maine, late in May in Southern New England and New York. I have raised this moth in Maine from the Larch (pupating September 15), also from the Missouri Currant, an ornamental shrub; also from the Apple, Elm, Cherry, and the Aspen in Rhode Island, though the Willow is probably its native food-plant, as it occurs in greatest abundance on that tree. Mr. Lintner states that the larva feeds on the Maple; that the caterpillar entered the ground for pupation August 11, the moth emerging the latter part of May. (Ent. Contr. III, 166.) My specimens emerged in Providence, May 13. The larva found on the Aspen is greenish and like a fresh aspen twig, with whitish granulations, which are black on the tubercles.

DESCRIPTIVE.—*Young larva.*—Head large, deeply notched, each tubercle distinctly conical; body cylindrical, slender, with no tubercles; a little smaller in the middle than at each end. Head and body uniformly of a dull, brick-red. Length 13 to 14^{mm}.

Larva before the last molt.—With the characters of the adult larva; salmon red. Length 35^{mm}.

Mature larva.—Twig-like, head very deeply notched, each side above conical; the face flat in front, the surface granulated. Prothoracic segment raised in front into a large granulated piliferous tubercle. On the fifth abdominal segment a pair of large lateral rough tubercles, a little paler than the body; on the 8th segment a pair of converging pale granulated tubercles. Anal legs very large and broad, with a pair of long dorsal sharp fleshy tubercles; supra-anal plate very large, conical and acute, with four setae near the apex. Body of even width throughout, reddish-brown, like a reddish willow twig, or sometimes greenish. The surface finely granulated with light and black, and with flat rough warts, paler in color than the rest of the body; our on the front edge of each segment, and two dorsal ones behind. It varies in color from reddish-brown to green, thus mimicing willow twigs of different colors. Length 55^{mm}.

Pupa.—Large, full, stout; dark brown. Cremaster large, stout, a projection on each side in the middle, beyond rounded, sharp, the point ending in a slender fork. Length 24^{mm}.

Moth.—A large stout-bodied moth, with heavily pectinated antennæ and rather small wings. Fore wings narrow, with the outer edge longer than usual; pepper and salt or ash sprinkled with black brown; an indistinct, diffuse, inner, curved line, with a second one nearer and diverging a little on the costa, being nearer together at the base. A third diffuse line encloses the discal spot. An outer distinct black hair-line always present. Hind wings with three dark lines. Abdomen with two rows of obscure black spots. Expanse of wings 60^{mm}.

ICHTHYURA STRIGOSA Grote.

The caterpillar of this interesting species was found July 30, at Brunswick, Me., feeding on the Aspen (*Populus tremuloides*). It moulted August 10, and about the 20th began to spin a silken cocoon between two leaves. The moth (a male) appeared in the breeding cage at Providence, May 20. Like *I. americana*, it sits with the wings folded sharply over the back, with the fore legs held straight out in front, with the tufted tail curved up.

DESCRIPTIVE.—*Larva before the last molt.*—Head broader than the body, flattened in front, dull black, with long white hairs. Body flattened, with yellow and reddish longitudinal stripes; three dorsal faint red stripes on a yellowish ground, and three deep lake-red lateral stripes, the lowermost the broadest and deepest in hue. Two bright yellow lateral stripes. Five pairs of flesh-colored abdominal legs, the legs pale amber, colored like the under side of the body. Length 9^{mm}.

Larva after the last molt.—Markings much as in the previous stage. Length 17 to 18^{mm}.

The rude cocoon is formed by tying a few leaves together, gathering them by a web at the edges, thus forming a roomy chamber, partly lined with silk, within which the chrysalis rests.

Pupa.—Smaller and not so full and rounded at the end as in *I. inclusa;* cremaster as in that species, ending in two stout, very short, recurved spines. Length 12^{mm}.

Moth.—One male. Smaller and duller brown than *I. indentata* Pack. Palpi whitish below, dark-brown above, as in *I. indentata* (which closely resembles Fitch's *I. vau*); front of head slightly broader and squarer; median thoracic brown band as in

I. indentata. Fore wings with the costal edge straighter and the apex less turned up than in *I. indentata*, the apex being slightly more rounded than in that species or in *I. inclusa.* Basal line distinct, making a sharp angle on the median vein, and more incurved in the submedian space than in *I. indentata;* second line much more suddenly incurved than *I. indentata*, the same line being straight in *I. inclusa;* the short third line as in *I. indentata*, but more sinuous. Fourth and outer line much as in *I. indentata*, but the species differs from all the others known by the large conspicuous irregular whitish ochreous patch which fills in the costal curve of this line and extends half way from the costal end of the line to the apex of the wing; no deep brick-red discoloration on each side of costal half of fourth line, so distinct in *I indentata*, but a long discal blackish stripe extends along the first median venule to the submarginal row of brown dots which are not so distinct as in *I. indentata* or *I. inclusa;* though the marginal row of dark brown lunules is as distinct as in *I. inclusa.* Fringe as in *I. inclusa*, but that on the hind wings much darker. Hind wings darker than in *I. indentata.* Wings beneath much as in *I. indentata*, but there is no reddish tint towards the apex, and the white oblique costal streak is much less distinct. There are traces of a common brown diffuse line. Abdomen a little shorter, the fan or tuft of scales perhaps shorter and expanding wider. Expanse of wings 25^{mm}.; length of body 12^{mm}.

THE LIVE OAK THECLA.

(*Thecla favonius* Smith and Abbot.)

The green, slug-like caterpillars of this beautiful butterfly were observed on the Live Oak at Enterprise, Fla., April 7 and 8, also a few days afterwards at Crescent City, and again on the Scrub Live Oaks on Anastasia Island, Saint Augustine. They pupated April 13, 14; the chrysalis in general appearance closely resembling that of *Thecla calanus*, found about Providence. They breed easily in confinement, my specimens having been placed in a small pocket tin box. After my return to Providence the butterflies emerged from April 30 to May 2. It is the most common species in the Southern States, and is said by Smith and Abbot to feed on *Quercus rubra* and other Oaks.

DESCRIPTIVE.—*Larva.*—Closely resembling in general appearance that of *Thecla calanus.* Body straw-yellowish green, with fine yellowish papillæ and dense short hairs. Head pale horn-color, small and narrow. Length 17^{mm}.

Pupa.—Of the same size and shape as that of *Thecla calanus*, the hirsutes the same, though not quite so coarse. In color rather pale horn, not so much mottled with black. It differs from *T. calanus* in the distinct lateral row of black dots. Length 10^{mm}.

Imago.—Wings of the usual form and color in the genus. Fore wings of male with a blackish sex-mark below the costa; a tawny patch in the first and a larger more distinct one in the second median cell. Hind wings with a large deep orange patch near the inner angle, with a minute one on each side; orange spots on the inner angle. "The points of the W formed by the inner line on the under side of the hind wings touching the outer line" (French). Expanse of wings, 23^{mm}.

THE LIVE OAK LEAF-ROLLER.

Tortrix quercifoliana Fitch.

While at Saint Augustine, Fla., early in April I noticed a pale green leaf-roller on the Live Oaks on Anastasia Island. April 14 it spun a slight cocoon, within which the worm changed to a pupa, April 16 or 17; the moth appeared April 30, after my return to Providence.

DESCRIPTIVE.—*Larva.*—Pale green; head green; otherwise of the usual appearance.

Pupa.—Body pale and slender, the cast skin thin and unusually so for a Tortrix. Cremaster or terminal abdominal spine peculiar in being long and narrow, as wide at the tip as at the base; the surface above and beneath with fine longitudinal ridges; a pair of short dorsal setæ near the end; edge of the extreme tip curvilinear, with four curved setæ of nearly equal length. Each abdominal segment with two rows of fine teeth. Length, 10^{mm}.

Moth.—Pale tawny yellow, with yellowish brown darker scales and dots and darker brown lines. Head pale, tawny brown on the vertex with a small spot in the middle of the front. Palpi dark, externally pale above and at tip of second joint. Fore wings pale whitish tawny yellow, densely speckled with darker scales; on the inner third of the wing an oblique, dark brown, narrow line beginning on the inner third of the costa and ending in the middle of the hind margin. An outer parallel line, which is forked on the costa and ends on the internal angle; from near the middle the line sends off a spur to the apex, but before reaching the apex a spur is sent to the costa, also a 3-forked line to the outer edge of the wing. Hind wings, abdomen, and legs almost white. Expanse of wings, 20^{mm}. (Identified by Prof. Fernald.)

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER, *Special Agent.*

This has been an unusually favorable year in Nebraska and adjoining States for the ravages of certain injurious insects. The spring was a little backward, rather drier than usual, and warm, suitable for the development of all kinds of our most destructive species. The summer was a hot and uncommonly dry one, killing off the parasites, while continuing favorable to most of the species causing injury to crops.

Among the species noticed to be injurious the following were chief: The Red-legged Locust (*Melanoplus femur-rubrum*), the Differential Locust (*M. differentialis*), Chinch Bug (*Micropus leucopterus*), the Striped Cottonwood Beetle (*Plagiodera scripta*), the Ash Saw-fly, the Colorado Potato Beetle (*Doryphora 10-lineata*), the Gray Blister Beetle (*Lytta cinereus*), the Corn Worm (*Heliothis armigera*), and the larvæ of the Ash Saw-fly, and early in the season the Box-elder Plant Louse.

Notwithstanding the ravages of all these insects in connection with a very dry summer, our crops have fallen but little below the average year, and at the present time everything appears in first rate condition.

As would naturally be supposed, from data received last year, locusts are again on the increase at various points both southward and northward. During the months of April and May I visited, under your instructions, central Texas, where several species of these insects had become so numerous as to endanger the crops in that particular locality. Upon these I reported at the time. We have since learned that crop prospects in that portion of the State were good, and that the locusts were diminishing in numbers. On the other hand, in Montana and northwestern Dakota, advices stated that the Rocky Mountain Locust (*Melanoplus spretus*) with several other species, were even more numerous than they were in these places last year. This being a new and sparsely settled country it has been very difficult to obtain reliable data as to their numbers, movements, and injuries, if any.

Judging from occasional newspaper reports during the season it is quite evident to my mind that scattering swarms of locusts have reached eastward at least as far as the James River, along the line of the Northern Pacific Railway, and southward of this point probably 75 or 100 miles. These swarms have certainly left their eggs scattered over the country passed through while migrating, and will evidently be heard from next spring, providing the winter is favorable to their preservation. We do not, however, look for any extraordinary increase in these insects over an extended scope of country next year.

In southwestern Nebraska and portions of northern Kansas the Chinch Bug (*M. leucopterus*) became very numerous during June and early July, and did a considerable amount of injury to crops—especially to small grain. This undue increase was mainly due to the excessive drought in that particular region. A reference to the accompanying telegraphic crop reports will be sufficient proof of the magnitude of the injury done and the area overrun. Soon after harvest heavy rains in this region diminished the numbers of the insect.

The Striped Cottonwood Beetle (*Plagiodera scripta*) has also been quite numerous in several portions of the West during the year, and did much injury to both Cottonwoods and Willows upon high land. Especially was this true with respect to the young trees upon tree claims in newly settled areas. There has been considerable vexation at the United States land offices on account of the injuries of this insect and of a species of Saw-fly, the larvæ of which attack the foliage of our various species of Ash trees, causing them to die. When the time comes for "proving up" there are too few trees growing upon the tract of land, and the result is its probable loss to the enterer.

The Colorado Potato Beetle (*Doryphora 10-lineata*) and Cabbage Butterfly (*Pieris rapae*) have both been rather more abundant than usual during the year and have done much injury to their respective food-plants.

In addition to these, the Ash-gray Blister Beetle (*Lytta cinerea*) has been observed in several localities in northern Nebraska to entirely defoliate young hedges of Honey Locust. Until the present summer I have not observed this insect attacking the Honey Locust since the summer of 1876 or 1877. At that time a nursery of small trees of this kind were entirely stripped of leaves by them, as were also several larger ones standing alone.

The Corn Worm (*Heliothis armigera*) was very numerous and caused considerable injury by eating the ends of the ears of corn. It has also been found quite abundant in tomato patches, where it bored into the fruit, causing the tomatoes to rot.

We append a series of short extracts from western newspapers bearing on some of these topics.

"GRASSHOPPERS."

A cloud of grasshoppers stopped for a meal at Sanborn [Dakota] recently and chewed up a field of wheat in ten minutes.—*Omaha Daily Bee*, July 23, 1866.

Grasshoppers are reported in numerous quantities in Winneshiek County, Iowa, Howard County, Indiana, and in Athens County, Ohio.—*Omaha Daily Bee*, May 31, 1886.

Grasshoppers are reported at Fargo and Huron, Dak. Lawrence Bruner, who is authority on the subject, informs us that there is no doubt they are increasing yearly, and unless something is done to check them they will eventually be as numerous as ever. One consolation, however, is that they will never be able to do the same amount of damage in one locality as formerly, on account of the wider expanse of settled and cultivated land over which they will have to travel. Nebraska is forever more free from any serious ravages.—*West Point Progress*, Thursday, July 22, 1866.

CHINCH BUGS.

CHICAGO, *May* 30.—The following crop summary will be printed in this week's issue of the *Farmer's Review*: "As the season advances reports of the presence of insects in winter wheat fields grow more numerous, but beyond certain afflicted districts in Kansas, Illinois, Indiana, and Ohio the reports are of an isolated character and do not appear to seriously threaten the general outlook for an average crop yield. Southern Illinois continues to send in the most bugs. Alexander, Bond, Edwards, Jefferson, and Monroe Counties, all in Southern Illinois, report great injury in many of the fields. Grenola, Franklin, and Panorama Counties, in Kansas; Felton and Highland Counties, in Ohio, and Howard County, in Indiana, report considerable injury from chinch bugs. Looking over the entire winter wheat belt, the promise is still good for an average yield, but the early promise that the season was to bring forth a "bumper" crop will now be abandoned. The acreage would not warrant such an outcome, unless the conditions were everywhere extremely favorable.—*Omaha Daily Bee*, May 31, 1886.

CHESTER, NEBR., *July* 2.—[Special to *The Bee*]—The chinch bugs have been making great havoc with the spring wheat. Some fields are entirely destroyed, others greatly damaged, and scarcely any left untouched. When the bugs get through with the wheat they attack adjoining cornfields and are damaging them to some extent.

BELVIDERE, NEBR., *July* 2.—[Special to *The Bee*]—Prospects for all kinds of crops are good with the exception of wheat, which the chinch bugs are taking to some extent.

HEBRON, NEBR., *July* 2.—[Special to *The Bee.*]—Crops have needed rain badly for some time until last Saturday, when a copius downpour came to their relief. Wheat is suffering from the depredations of chinch bugs, many fields having been taken entirely and not considered worth harvesting. Corn is growing finely, and although small for the season of the year bids fair to make a good crop.—*Omaha Daily Bee*, July 3, 1886.

HASTINGS, ADAMS COUNTY, NEBRASKA, *July* 9.—Rye and barley harvest is showing about two-thirds of a crop. The yield of oats and wheat, on account of drought last month and the present ravages of chinch bugs, will not exceed two-fifths of an average yield. Corn is doing fairly well but needs rain.

CRETE, SALINE COUNTY, NEBRASKA, *July* 9.—The condition of wheat is bad. Chinch bugs and rust are the cause, and there will be only a half a crop. Oats will only be half a crop, on account of late planting. Barley will be a larger crop than last year. Rye is a heavy crop There has been no rain for ten days. Farmers are jubilant.

WAHOO, [SAUNDERS COUNTY,] NEBR., *July* 9.—Nearly all the corn is laid by. It is needing rain badly. A few more days of dry weather will work great injury, but a rain in a few days will help it wonderfully. Oats and spring wheat will be slightly injured by drought, and chinch bugs are doing some damage to wheat.

EXETER, FILMORE COUNTY, NEBRASKA, *July* 9.—Wheat will be a poor yield this year. Chinch bugs are reported from several places as very destructive. Corn was never better. It is two weeks since the last rain and more is needed, but no damage as yet. Farmers feeling o. k.

FAIRMONT, FILLMORE COUNTY, NEBRASKA, *July* 9.—Farmers need rain very much. Wheat, small acreage, is badly eaten by chinch bugs and injured by drought and heat. Corn and other small grains are suffering from drougth and heat. If dry spell continues one week more, farmers will raise only a small crop.

DANNEBROG, HOWARD COUNTY, NEBRASKA, *July* 9.—The hottest day so far this summer was yesterday, the temperature reaching 104° in the shade. No rain has fallen for five weeks and growing crops are suffering. Some fields of oats and spring wheat will be an almost total failure. Rye, winter wheat, and barley are ready for harvest, and the yield will be fair; chinch bugs are commencing to be very bad in some parts of the county. The prospect of a good corn crop heretofore has been good, but now it is discouraging on account of the drought.—*Omaha Daily Bee,* Saturday, July 10, 1886.

HEBRON, THAYER COUNTY, NEBRASKA, *July* 10.—Corn is in need of rain. The dry weather has continued for a period of two weeks or more. Small grain in general is suffering for want of rain. A rain any time within a week will help the corn in its growth and destroy the chinch bug, now playing havoc in many fields. Most of the small grain failed to fill out by reason of the dry weather, and its production won't reach that of last year's by one-half. Our farmer friends are somewhat discouraged over the present outlook for prospects of a good corn crop.

YORK, YORK COUNTY, NEBRASKA, *July* 10.—Chinch bugs are working on wheat and other small grain. Corn looks fair, but some of it is turning to a yellowish shade. Squash and melon vines are wilting and bugs working on them. No rain for nearly three weeks. If we have rain in a few days there will not be a great shortage on an average crop. Farmers feel blue, knowing that the crop will not be an average one.

YORK, YORK COUNTY, NEBRASKA, *July* 10.—The condition of the corn crop in York County is good, notwithstanding the dry weather of the past two weeks. Oats will be an immense crop. Spring wheat is an entire failure. The crop was very short and what remained is being rapidly destroyed by the chinch bugs. The dry weather has had a damaging effect on wheat and corn. Winter wheat and other crops are good. The York County crop will average about 60 per cent.

EDGAR, CLAY COUNTY, *July* 10.—Small grain has suffered badly from the drought in this part of Nebraska. There has been no rain in this section for two weeks, during which time the weather has been intensely hot and dry. Barley and rye are harvested, but there is not more than two-thirds of a crop. There was yielded about two-thirds of a crop. Spring wheat and oats are very short, and are being destroyed by chinch bugs rapidly. Unless rain comes soon, but little grain will be harvested on account of chinch bugs. Farmers are very much discouraged, though they still entertain hopes of a medium corn crop.

FAIRCHILD, CLAY COUNTY, NEBRASKA, *July* 10.—Wheat will make about one-half a crop, barley about three-fourths, and oats a good average yield. Dry weather in the early part of the season injured small grain most. We had good rains in the latter part of May. Since that time it has been dry, no rain at all since June 28. Corn is looking well in spite of dry weather. If we get rain in a few days there will be a good prospect of nearly a full crop. Lately chinch bugs have made their appearance in large numbers and are doing considerable damage. Farmers, as a rule, are feeling in good spirits over the crop prospects.—*Omaha Daily Bee,* July 12, 1886.

FORT DODGE, IOWA, *July* 16.—[Special telegram to *The Bee*]—A much needed rain fell in this locality yesterday. * * * The crops are slightly damaged by the drought. Chinch bugs have made their appearance in portions of the county and are getting their work in on grain and corn.

HEBRON, *July* 16.—[Special to *The Bee*]—Your correspondent has made a thorough investigation of crops in Thayer County and Southern Fillmore, arriving at this place to-day. The chinch bugs have entirely destroyed many fields of spring wheat and oats. Some fields have been burned on the ground, with the hope of killing the bugs to keep them out of adjoining fields of small grain and corn. At the best, small grain will not make over one-third of a crop throughout this section. Corn has looked well until within the past ten days, but the hot, dry weather of the last two weeks has put a different hue on the aspect and on farmers' countenances. The earliest plantings and most forward corn suffers the most, but on all sides can be seen, sprinkled through the fields, stalks of corn that are white as snow. With copious rains within a few days a fair crop of corn may be had, but a delay of wet weather for ten days will insure anywhere from one-third of a crop to nothing. Pasture and hay lands are also showing the effects of the drought.—*Omaha Daily Bee*, July 17, 1886.

GRAND ISLAND, HALL COUNTY, *August* 5.—The wheat crop throughout Hall County is turning out much better than was expected. In some precincts the farmers report the yield better than it has been for years, while in other localities it was damaged by drought and chinch bugs, but the average yield will be about 12 bushels per acre. The recent rains have done much toward bringing out the corn crop, which is in a splendid condition, and in some places it will make 60 to 80 bushels to the acre, and without any more rain it will average about 40 to 50 bushels to the acre. Farmers are feeling good generally, and think the entire crop, on an average, is better than it has been for years.—*Omaha Daily Bee*, August 6, 1886.

TESTS WITH INSECTICIDES UPON GARDEN INSECTS.

By William B. Alwood, *Special Agent*.

LETTER OF TRANSMITTAL.

Columbus, Ohio, *October* 30, 1886.

Sir: I inclose herewith a summary of my tests with different insecticides. These are not written in the style of a report, but to acquaint you with the results I have obtained. My work is just begun, and I do not feel as though anything creditable in the way of a report could be furnished so far. I trust this will be satisfactory and furnish you with what information you desire concerning the progress of the work thus far. If you desire it I can furnish a copy of the original notes from which this summary is made up; however, many of my serial tests were noted in bulk instead of keeping an individual record of each test. This was done because of sameness and lack of importance in the individual record. This matter would have reached you a week sooner had I not been ill for several days. I will forward some notes about machinery in a few days.

Very respectfully,

WM. B. ALWOOD

Prof. C. V. Riley,
U. S. Entomologist.

KEROSENE EMULSION.

Formula.—Kerosene, 67 per cent.; water, 33 per cent.; whale-oil soap sufficient to form a stable emulsion.

This preparation was used on several insects with somewhat varying results, the chief features of which are condensed in this note.

On Cabbage Worms.

The first series was begun before *Plusia brassicæ* was numerous, hence only *Pieris rapæ* is spoken of. The emulsion was used in different dilutions, ranging from equal parts of water and emulsion to 16 parts of water and 1 of emulsion. It was in all cases applied as a spray, and when the worms were numerous and eating vigorously. Several hundred plants were used in the field tests. Weaker solutions than 1 of emulsion to 3 of water were of no avail unless applied very heavily, and then they caused considerable injury to leaves. In the proportion of 1 to 3 it was quite effective where the worms could be reached, *i. e.*, were not under the leaves, and destroyed about 75 per cent. of them. It did not injure the leaves in this strength if properly sprayed. Where solution of 1 to 5 was put on excessively it killed and also injured plants. Stronger solutions than 1 to 3 were not more efficacious and injured plants seriously. The weaker solutions would sicken the worms and affect them unpleasantly for a short time, but they would uniformly recover, and either proceed again to eat or crawl away to another plant. In no case were worms injured unless spray was delivered directly upon them. Eating of the plants after they had been sprayed did not affect them. These experiments occupied several days and were duplicated.

Tests in small Jars.—This was a duplicate test on *Plusia brassicæ* and *Pieris rapæ.* The liquid was applied with a feather and in sufficient quantity to moisten the entire body of the worm. In dilutions up to 1 to 5 it killed both; weaker solutions occasionally killed one or more *rapæ* but not *brassicæ.*

In breeding Cages.—In this test the above was duplicated on larger scale. Liquid was applied as spray and until all worms were thoroughly drenched. They were placed on parts of a small cabbage-head, so that each box very nearly represented an out-door experiment and enabled me to be much more certain of results obtained.

Up to 5 dilutions 80 per cent. of *rapæ* were destroyed and 10 per cent. of *brassicæ*, there not being much difference in the strength of liquid as to efficacy. Weaker solutions did little or no injury to either. *P. brassicæ* was not treated with emulsion at all in the field, but from effect on *rapæ* am sure that the conditions were essentially those of outside experiments. The amount of drenching with this liquid which *brassicæ* could stand was certainly remarkable. In previous test jars were covered. Liquid in each case was taken from same jar of emulsion. I had no trouble in making a good emulsion that was stable in whatever dilutions I chose to use it.

On Cabbage Plant-louse.

Wherever used on this insect, even in weakest solutions (1 to 16), the emulsion destroyed all that were touched by it.

On White Grubs.

A solution of 1 part emulsion to 4 parts water was used quite extensively on the larvæ of the May beetle, *Lachnosterna fusca.* The results were far from satisfactory. Where used on the lawn the grubs descended 2 or 3 inches and were unharmed. Some few appeared a little sick, and occasionally a black spot was observed on some of them, but none were destroyed. After conducting this test for twenty days it was abandoned. Several boxes were arranged with loose soil and grubs placed in these for experiment. Here where they were only lightly covered with loose soil the emulsion destroyed nearly every one in twenty-four hours. The liquid was sprinkled on in these tests sufficiently to moisten the surface thoroughly.

Lime and salt were also tried over the lawn and in boxes. On the lawn where they washed through, the grubs immediately descended out of reach. None were actually killed on the lawn that I could observe, In boxes lime was nearly as efficacious as emulsion, and so also was salt; however, to do good execution, salt must be applied in quantity sufficient to injure the soil. I think there is no doubt but these insects can be easily destroyed if they can be reached, but how to reach them under the soil is the question. Their large, soft bodies are very susceptible to injury.

PYRETHRUM.

This powder was purchased from a local wholesale dealer, and to all appearances was of high grade. It was used in various tests to experiment on its use, and as a check on other substances it was used in all tests of whatever nature.

On Cabbage Worms.

My earlier experiments lead me to believe that *brassicæ* was much harder to destroy than *rapæ*, and this I still believe to be the case to some extent, but not to such an extent as at first supposed. Quite a large series of tests were made in the field and also in jars and cages to test the above supposition, the result in the main being very satisfactory. Pure and up to 3 dilutions it killed *rapæ* with a precision and certainty that was remarkable, the powder after the 3 dilutions acting nearly as well as if stronger. The time required was variable, but usually the worms were well used up in two hours. Above 3 dilutions its action was uncertain and not to be depended upon, although 5 dilutions will kill a fair percentage if thoroughly applied. With *brassicæ* the results were quite similar up to 3 dilutions. A large quantity of powder was used of this strength on these worms after *rapæ* had nearly disappeared. It was very effective, killing fully 90 per cent. of all worms, although the time required is somewhat longer than with *rapæ*. Above 3 dilutions it is not efficacious on *brassicæ*, killing scarcely any, and from the whole experience of my experiments I am satisfied that 3 dilutions are all that can safely be made for out-door work.

In Jars.—A large number of tests were made in jars, with very minute quantities of powder on both worms. Jars were covered. These were very successful, causing death in from forty minutes to two hours. The only exception to this was a full-grown larva of *brassicæ*. In this test dilutions up to twenty times the weight of powder were quite efficacious on *rapæ*, but a few of the last did not destroy *brassicæ* with certainty.

This series was also repeated in breeding cages with, in the main, corroboratory results. After 5 dilutions its action on *brassicæ* was quite uncertain, depending somewhat upon the amount used; 15 dilutions would not kill them at all under any method of treatment. *Rapæ* was killed up to 20 dilutions if thoroughly applied, although in such cases they were more severely treated than would be possible with powder bellows in field work. Experiments with minute portions of pure powder would indicate that it is not the amount of powder that proves fatal but that it is the fact of a few grains of powder coming in contact with the body of the worm. All of my dilutions above 5 times the weight of powder show that its efficiency is thus very much impaired, and I am satisfied that while almost infinitesimal doses are sufficient to produce death when powder is pure, they will not suffice in the presence of adulterations. I am quite convinced that 5 dilutions is the limit of safe adulteration, and think that I should hesitate to recommend over 3. The age of the worm when treated is of considerable importance in this connection, as young worms are destroyed with much greater certainty than older ones. Pure powder exposed on the leaves of cabbage plants for periods of thirty minutes, fifteen hours, and twenty hours, killed with as much certainty as fresh powder. Old powder, which had stood one year in a candy jar without cover, killed as well as fresh powder. This last was used, diluted 3 times, in field work and did good execution.

One pound of powder diluted with 3 pounds of flour and carefully used in a Woodason double-cone bellows was sufficient to dust one acre thoroughly. Four was the only adulteration used.

EXTRACTS OF PYRETHRUM.

Water extract—1 ounce pyrethrum; 1 pint water.

Alcholic extract—1 ounce pyrethrum; 1 pint alcohol.

These were thoroughly tested and the tests repeated several times, with very unsatisfactory results.

The water extract was made by stirring together the ingredients. Only the liquor was used which was kept in a tightly closed jar.

This extract destroyed *rapae* at an average rate of 50 per cent. up to 4 dilutions, and at 5 dilutions failed entirely. In full strength it was not nearly so efficacious as dry powder, even on *rapæ*, and it did not affect *brassicæ* at all.

The alcoholic extract was made by repercolation with about 80 per cent. alcohol. This I anticipated would bear a large number of dilutions, and it was used in an extensive series of tests in the cages and jars. Up to 5 dilutions it killed fairly well and a few were destroyed above this, but not enough worth mentioning, only a small or weak worm dying. This test was repeated several times and a new extract was made, but with little better results. The new extract killed about 50 per cent. very slowly at 10 dilutions. Both extracts spoken of above were applied as spray, except that in jars a feather was used and the worms thoroughly wetted.

On Aphis brassicæ.

Pyrethrum in several forms was used on this insect with unsatisfactory results, the action being, when applied pure or in strong mixtures, to dislodge but not destroy them. Pure powder applied with a bellows quickly dislodged them, but did not kill over 10 per cent. Those not killed soon recovered and crawled back upon the plant.

On Potato Beetle.

Used in the field pure it destroyed about 50 per cent. of the larvæ, principally younger ones. Adults were not injured though heavily treated, but when confined in breeding cage and thoroughly dusted they were all killed. I am quite sure pyrethrum is not a satisfactory remedy for Potato Beetle where London purple or Paris green can be used with safety.

On Tomato Worms.

Several species of Sphingids were quite numerous on the tomato vines, principally *quinque-maculata.* On these the powder was used pure and also diluted three times. I did not observe an instance where thoroughly applied that it did not produce death in from two to three days.

On Squash Bugs.

Diabrotica vittata and also 12-*punctata* were treated with the powder both pure and diluted three times. It destroyed them very effectually, although I am not certain that they could be so successfully treated in the spring when the plants are small and the beetles very active. This treatment was late in the season when they were feeding on pollen in the bloom of squashes.

On Fall Web-worm.

Not enough of these could be found for thorough tests, but pure powder used on one colony made them immediately break from the web, fall to the ground, and scatter in all directions, but two days' observation failed to show any dead ones.

Several times woolly caterpillars were treated both with powder and solution without in any instance producing death.

The powder used throughout was the *roseum*, and from one package.

BUHACH (*Pyrethrum cinerariæfolium*).

I was ordered to obtain this powder direct from dealers, and finally sent to Stockton, Cal., for it. It did not arrive in time for full comparisons with *P. roseum*, but I tested it quite thoroughly on *P. brassicæ.*

Used in minute particles it kills in one to three hours, was decidedly slower in action than *P. roseum*, but the weather was cooler. Exposed on leaves of plants it killed up to three days' exposure though very slow at last trial. Weather cool as before mentioned.

Diluted with flour it kills in small jars up to 30 dilutions, but in cages was not effective after 10 dilutions, and I think most of these would have recovered had they been where they could have crawled away to fresh leaves. The season was so late when received that I was unable to give it a test out of doors with anything like satisfaction.

Alcoholic extract.—One ounce powder, 4 fluid ounces alcohol (repercolated).

This killed slowly at 10 dilutions; above that was not effective.

BENZINE.

This was used on several insects. Early in the season when the *rapæ* worm was plenty a large number of infested plants were sprayed with very unsatisfactory results. Where it was used lightly not 1 per cent. of worms was killed, used heavily a few more were killed, but the plants were also slightly injured. Tests in the field were repeated several times with no better results. A number of tests were made in breeding cages and there they resisted it equally as well. Of one lot, after being thoroughly sprayed four times in quick succession, only 16 per cent. died. It usually sickened the worms, but they soon recovered. Of the lot above mentioned two had pupated in twenty hours. Only by the most thorough drenching was I able to kill cabbage worms at all with this remedy. The injury to leaves was not nearly so great as at first would be supposed, and in fact only extremely heavy applications did any lasting injury.

On Potato Beetle.

Thorough spraying did not injure these at all. Leaves were not injured.

On Tomato Worms.

The most thorough treatment was unavailing. Leaves slightly injured.

On Squash Bugs.

Were not injured. Leaves slightly burned.

On Cabbage Lice.

These were destroyed where the spraying was thoroughly done.

ALUM WATER.

This was first used in solution of 1 ounce to 1 quart of water, but as this had no effect whatever on cabbage worms or lice a strong solution was made by boiling water with a quantity of alum in it. Part of the alum crystallized out on cooling, but left the solution as strong as could be made. This was used very thoroughly with no result whatever. In every respect it was a complete failure.

ICE WATER.

This was used in spray and poured upon the plants in quantity, also worms were submerged in the water for periods of time up to ten seconds. Every trial showed this to be utterly valueless as a remedy. Occasionally a small worm would be injured but in no case that I observed were any killed outright. Temperature of water during trials varied from 35° to 38° Fah., air from 90° to 95° Fah. A hot day was purposely selected for the work.

TANSY WATER.

Strong decoctions of this were made both by soaking and boiling the leaves. In both cases it was apparently as strong as could be made. Used in the field, no result whatever. On worms confined in closed jars they died in about six hours. In cages no effect whatever, though tested repeatedly and very heavily applied.

TOMATO WATER.

A strong decoction of this was made by boiling and used as above with quite similar results. In many instances the substance has destroyed the worms in jars (small wide-mouth bottles) and not under exposed conditions. The larvæ were not drowned but only moistened. This is important as showing that the manner of using a substance is quite important.

DREER'S INSECT TERROR.

This powder was used both in the field and in cages. In no instance of the field trials were any of the larvæ injured, though it was thoroughly applied, lightly with bellows and heavily by hand. Used in cages it had no effect whatever except that in one instance 20 per cent. of *rapæ* were killed where it was applied to food so heavily as to completely coat it over. *P. brassicæ* was not affected by its use though confined from four to five days where food plant was completely coated with powder. I feel perfectly safe in saying, after abundant tests, that this substance is perfectly worthless.

HAMMOND'S SLUG SHOT.

This was used only on Cabbage Worms (*rapæ* and *brassicæ*). In field tests several hundred plants were used and tests made very thoroughly. At first the powder was dusted on lightly and was almost an entire failure, but with repeated and heavier dustings better results were obtained; however none of the results were sufficiently successful to commend its use. Where used heavily not over 20 per cent. of *rapæ* were killed, and *brassicæ* were not injured. In none of the field tests was I able to find dead *brassicæ*. Worms of both species were frequently noticed forty-eight hours after application feeding as usual though themselves and the leaves were coated with powder. In breeding cages better results were obtained. Light applications did but little good as outside, but heavy applications, where plants were completely covered with powder, were quite effective, both species being destroyed to the extent of 80 per cent. to 90 per cent. (No substance was more carefully or thoroughly used than this in the above experiments.) In solutions the effect was about the same. It was used up to 8 ounces to 1 pint of water, making almost a thick mixture. In this manner about 25 per cent. of *rapæ* were killed in the field; not tried in cages.

All of my work points to the conclusion that *brassicæ* is more difficult to deal with than *rapæ;* especially is this true where the poison is a powder to be eaten. They are easily disturbed and will move away to the under side of the leaves until disturbing cause has disappeared. This powder cannot be successfully applied with a bellows, because of its characteristic of accumulating in little balls or masses which cannot pass the bellows, and, also, it must be applied heavily to accomplish any results whatever. Heavy applications by hand will probably prove the only means of doing any good with it.

TOBACCO SOAPS.

Of these several were used, Wolf's Vermin Soap and different brands from the Rose Manufacturing Company, of New York, known as sulfo-tobacco soaps. Also two brands made by the above company were sent me by the Division, viz, a soda and a potash tobacco soap. These two packages seem not to be the same grade of goods the company at present manufacture, as evidenced by the difference in strength shown by my tests. The samples sent by the Rose Company were a plain and scented soda soap and a scented potash soap. The sample of Wolf's soap was received from the Milwaukee Soap Company, Milwaukee, Wis. It is a stiff soda soap strongly scented with tobacco and very offensive to handle. The potash soaps above mentioned were much softer than the soda soaps. They all dissolved readily at 100° Fah., and the Rose soaps remained in solution, but the Wolf's soap solidifies the whole solution even when very weak, forming a jelly-like mass. This is a very objectionable point if this soap is desired to be used as spray, as it necessitates heating every time before using.

On Cabbage Worms.

The two samples received from the Division were thoroughly tested on both species previously mentioned in this report. The solutions were made of different strengths up to 4 ounces to 1 pint of water, at which strength the soda soap destroyed slowly but thoroughly all larvæ of both species, and the potash soap was sure death to all larvæ which came in contact with it. These solutions improved with age as did all the soap solutions.

Of the samples received direct from the Rose Company the plain and scented soda soap were of the same strength, the only difference being that the scented soap is much more pleasant to handle. This and the potash soap were of about equal strength and destroyed readily all larvæ where thoroughly applied in solution of 1 ounce to 1 pint of water.

These soap solutions were used in a large number of tests which were duplicated several times, and in the strength stated gave good satisfaction, and are, I think, among the best liquid, non-poisonous applications I have ever used.

Wolf's soap, in solution of 2 ounces to 1 pint of water, did fairly good execution, but was not safe at that strength. In most of the tests it was used 4 ounces to 1 pint of water, at which strength it was sufficient to destroy all worms. After standing for two or three weeks the jelly formed by this soap when first dissolved breaks up into liquid, and its destructive power seems to be enhanced.

On Cabbage Plant-lice.

The Wolf's soap and the two samples received from the Division were used on the lice in several strengths, and one-half ounce to 1 pint was perfectly efficient, destroying all lice immediately. The samples received from the Rose Company direct were not used on lice, but their efficiency on *rapæ* and *brassicæ* would indicate that they would bear still greater dilution.

The circular of the Rose Company is, I think, quite misleading where they state that the essential principle of their soaps is a gum taken from tobacco in an aëriform condition and condensed in a vacuum. The only destructive principle which I am aware is contained in tobacco is a liquid alkaloid (never solid) known as nicotine. It is my opinion that the destructive effect of all these soaps, when used on the bodies of worms or soft insects, is entirely due to the caustic principle of the alkalies used. Potash, being the strongest alkali, will, I think, give best results where used in equal quantity with other alkalies. I proved to my entire satisfaction that none of these soaps are poisonous when eaten on the food plant. Of course, insects will not eat them readily. (A sample of carbolic-acid soap was used in various strengths without any results whatever.)

SEVERAL REMEDIES IMPORTED FROM LONDON.

These were used only on Cabbage worms. The results were entirely unsatisfactory.

The whole series of tests were conducted in breeding cages. The quantities used were double what directions advised, and the tests were repeated several times: Moore's compound, in solutions of one-half ounce to 1 ounce in 1 pint of water: Only two worms killed after several trials. Fir-tree oil solutions of 1 to 2 teaspoonfuls in 1 pint of water:

During repeated tests two worms were killed. Gishurst, in solutions of 1 to 2 ounces in 1 pint of water: This sickened many worms, but only three were destroyed. Bridgeford's Antiseptic, used pure, sickened the worms and destroyed several.

These remedies were entirely worthless. They are of foreign manufacture, and are not specially recommended for cabbage worms, but are advertised as insecticides of great merit; hence my notion of testing them on cabbage worms.

REPORT ON OHIO INSECTS.

By WILLIAM B. ALWOOD, *Special Agent.*

LETTER OF TRANSMITTAL.

COLUMBUS, OHIO, *October* 21, 1886.

DEAR SIR: I forward to-day a few pages of notes on insects observed during the few months I have been at work.

Yours, very truly,

WM. B. ALWOOD.

Prof. C. V. RILEY,
U. S. Entomologist.

THE STRAWBERRY LEAF-BEETLE.

(*Paria aterrima.*)

This insect began about the middle of August to feed upon the foliage of the strawberry beds in the University garden. It was first noticed upon the old beds, but soon spread to the new ones, and has done considerable damage, in some places completely riddling the leaves with its minute round holes. At the present date (October 12) it is yet busily at work.

THE STRAWBERRY ROOT-BORER.

(*Graphops pubescens.*)

Since the 1st of September the larva of this beetle has been doing considerable damage to the strawberry beds, attacking both old and new beds, and in some spots destroying as many as 10 per cent. of the plants. The grubs are found in numbers varying from two to eight per plant either in or near the roots. They work all the way from the crown to the lower part of the roots, eating in slight channels, which are left full of chips and castings. The grubs never, so far as I have noticed, bury themselves deeply in the fleshy part of the root, but prefer to work along the sides. Frequently a dead plant may be taken up whose roots show their work plainly, yet none of the larvæ are present in it. Examination of the soil around the plant will, however, reveal the little fellows. I have observed a great number in position feeding. Up to date (October 20) no pupæ have been found.

THE STRAWBERRY CROWN-BORER.

(*Tyloderma fragariæ.*)

This insect has done slight damage to one old bed. I have not in a single instance observed them in young beds.

THE PLANTAIN CURCULIO.

(*Macrops* sp.)

This insect was received from Medina County, the first specimens arriving July 21. With them came several specimens of plantain which were so thoroughly tunneled by the little grub that they had died. There were from two to six grubs in a single plant, and they completely exhausted the fleshy portion of the root. From this lot, received July 21, several adult beetles issued August 7. These were left in the cage several days, and I think must have deposited eggs on fresh plantain growing in the cage, as several days later, when examining this cage preparatory to cleaning it up, I found several young larvæ in the fresh plantain I had put in the cage on receiving first supply. These were observed closely. They pupated August 25 and issued September 3 to 4. Another lot of specimens was received August 6, placed in a different cage, began pupating 16th and issued 25th to 29th of August. From the account of the gentleman sending them they were quite destructive over a limited area.

A NEW OAT FLY.

(*Oscinis?* sp.)

This insect was discovered while visiting the northern part of Union County, some 50 miles from Columbus, to investigate another insect which had appeared in the wheat. (This insect proved to be *Meromyza americana*, and was confined to a very limited area, though it took the plants clean so far as it went.) The date of this visit was June 15, and the farmers had first noticed the attack upon the oats about June 9. The oat plants were 6 to 8 inches high and where attacked appeared as though a fire had swept over them just low enough to scorch the upper blades. Eggs and larvæ were both present at this time as described in my letters. The injury was confined to spots of several rods in dimension, but several fields in the neighborhood were affected. At my last visit, June 25, I estimated the damage to be about 40 per cent. in spots affected. A quantity of the plants were brought home and placed in breeding cage. On June 20 the first imagos, two in number, issued. From this cage they issued afterwards almost daily until July 7.

On my second visit I also brought home material in which larvæ and pupæ were quite abundant, but found no eggs. Flies issued from this batch in great numbers up to July 12.

THE CABBAGE PLANT-LOUSE.

(*Aphis brassicæ* L.)

This insect was quite troublesome this season from about the 1st of August to 1st of September. After the latter date they could only be found in scattering colonies. During the worst period of attack they were so plentiful as to nearly ruin many plants.

I mention them more for the purpose of speaking of the insects which preyed upon them than anything else.

Of these the larvæ of the Syrphus flies (two species were reared) were the most persistent and literally swept the lice off by thousands. It was very interesting to watch these blind maggots in their work of destruction. There were also present the larvæ of Lady-birds and Lace-winged flies. These, however, did not do anything like the execution of the first-named insects. I noticed where lice were very numerous that a large per cent. became winged, while on other portions of the field it seemed that a much larger per cent. were apterous.

CABBAGE WORMS.

(*Plusia brassicæ* and *Pieris rapæ*.)

August 3 a few larvæ of *brassicæ* were noticed in a patch of a couple of acres of Cabbage where *rapæ* were already quite abundant and doing considerable injury. They were so few that it was hardly thought possible they could do much harm the present year. On this date the *rapæ* as above stated were already numerous and doing much harm. A series of experiments was at once begun looking towards their destruction. However, many of this brood pupated, and from the 10th to the 15th of August I never saw the *rapæ* butterfly so abundant as they were over the cabbage beds in the University garden. These deposited their eggs in great abundance, and after several days disappeared. Among the first brood of worms (*rapæ*) I had noticed a few larvæ affected by *Apanteles glomeratus*, and also several pupæ which had been stung by *Pteromalus puparum*. These did not appear to be abundant, but probably many were not noticed. As this second brood of *rapæ* developed it was hardly possible to find a larvæ not affected by one of these parasites. *A. glomeratus* was most abundant, as it stings the young larvæ, but should one be so fortunate as to escape this insect, *P. puparum* was sure to find it. I noticed that the last named always stings the larva just before it makes the last molt or immediately after the pupa is formed. So well did these parasites do their work, that after the large brood of butterflies previously mentioned not an adult was seen except that now and then a straggling individual would sail over the field. In all of my experiments in boxes, during which I confined a great many worms for days at a time, not a healthy pupa of *rapæ* was formed.

Neither of these parasites nor any other affected the *Plusia* in the least.

About August 20 the *Plusias* began to appear in greater numbers, not formidable as yet, but so numerous that I began to collect them in separate cages for experiment. From this time on until the 1st of October this insect multiplied at an astonishing rate. About the middle of September a late bed of cabbage, of perhaps a little more than one acre, which had almost escaped *rapæ*, was found to be literally alive with these larvæ, from ten to forty or fifty being found on a single plant. They destroyed it very rapidly, until the gardener put a man under my direction to kill them, which was done very successfully. The moth was not observed to move about at all during daytime, but was frequently found hidden among the leaves of the plant. When disturbed it flew rapidly in a zigzag manner and soon alighted.

It deposits its eggs irregularly over the lower side of the leaf, varying from a few in number to twelve or twenty. This habit makes it a worse enemy, in my estimation, than *rapæ*, as they deposit their eggs singly, and never in my observations do they happen to get so many on one plant as *brassicæ* does. The latter, from my observations, is much the more prolific, and is also more hardy.

THE CORN APHIS.

(*Aphis maidis.*)

The only injury I have ever known to be done by this insect occurred this year, about 6 miles northeast of this city. A gentleman planted his corn early in May. The weather was quite favorable, and it came up promptly and looked well for a few days, and then began to turn yellow and wither away. On examining he found what he rightly called a "small louse" in great abundance, and associated with it a great many small ants. He could not conclude that the louse was the cause of injury, so laid it to the ants. The injury became so great in a few days that he concluded to plant the field all over again, which he did with a two-horse check-row planter. This planting was taken the same as the first, and the field again planted over. This last planting was not much injured, and with the remnants of first two plantings made quite a crop. On the 11th of July, being in the neighborhood, my attention was called to the field. I still found the Aphis present in considerable numbers, but the corn was doing fairly well. A large number of insects were examined, yet none but apterous forms were observed. The first field is black-loam bottom-land, extending partly up on upland, lying beside a creek of considerable size; it is well drained, and the soil is loose and friable.

THE CLOVER-SEED MIDGE.

(*Cecidomyia leguminicola.*)

Quite serious complaints came to me concerning this insect, principally from counties lying north of the central portion of the State. It was not noticed at all in this vicinity, and so far as I know has never been found here or in the southern part of the State. Last year it was quite destructive in the same region reported from this year.

Definite facts as to extent of injury were not to be obtained, yet good farmers reported it as destroying a large part of the crop in their sections.

THE MAY BEETLE.

(*Lachnosterna fusca.*)

The larva of this beetle has destroyed a large portion of the sward on the university campus during the present summer. The attack began some three years ago and has become worse each year, until this season a large part of the lawn was left bare and brown, not even the first growth of bluegrass coming to maturity. From the spots where attack is most severe the sod can be rolled up in bundles. Clover is not injured and is consequently spreading spontaneously over the lawn. Examinations frequently showed as many as a dozen grubs to the square foot. There were three broods plainly to be noted; the two-year and one year were the most numerous, there being comparatively few grubs from eggs laid the past spring.

A large number of examinations showed no case of disease. Grubs began descending to winter quarters about September 20, but October 20 there are yet quite a number to be found. They were reported at work in lawns and strawberry gardens from many localities around the city, but were nowhere so numerous as here.

PTEROMALUS PUPARUM AND APANTELES GLOMERATUS.

A few observations on these two parasites may be of interest. Many specimens of each were bred. *P. puparum* issued on an average in fifteen days from date of ovipositing. From one pupa of the Cabbage Worm I bred fifty-two flies and from another one hundred and eleven. These last issued in just sixteen days from the time the females oviposited. This I considered a remarkable number to issue from one pupa, but of the fact there is not the possibility of a doubt. I observed three of the females ovipositing in one larva on the afternoon of August 24. These I watched for some time, intending to take the larva when they had done with it, but as they were still at work late in the afternoon I marked the spot and visited it the next morning to find a pupa formed. From this issued the flies, as noted above. In two instances where I disturbed females the flies hatched ten and twelve in number, respectively, and were all females.

I was not able to take the females of *A. glomeratus* in the act of ovi positing, as they seem very sly. Several times I thought I caught them in the act, but was not sure. After pupating they were eight to ten days before issuing. They issued from twenty to possibly fifty in number, although I was never positive of breeding more than thirty-eight from one specimen.

This parasite did much more good than *P. puparum*, as it seemed to get the first chance.

APANTELES CONGREGATUS.

This insect was very destructive to the Sphingid larvæ on tomatoes. There were no less than four species of these worms, of which *Macrosila quinque-maculata* was most abundant. All were attacked, scarcely any escaping. I took one hundred and eighty cocoons from the body of one worm.

A RECORD OF SOME EXPERIMENTS RELATING TO THE EFFECT OF THE PUNCTURE OF SOME HEMIPTEROUS INSECTS UPON SHRUBS, FRUITS, AND GRAINS, 1886.

By F. M. WEBSTER, *Special Agent.*

LETTER OF TRANSMITTAL.

LA FAYETTE, IND., *October* 15, 1886.

SIR: I herewith give results of my experiments with Hemiptera, principally *Lygus pratensis* L.

F. M. WEBSTER.

Prof. C. V. RILEY,
U. S. Entomologist.

The object of the following experiments was to determine the effect of the punctures, or the withdrawing of sap from shrubs, the juices from berries, and the milk from ripening grain; and if possible to settle the point as to whether or not these Hemiptera, in thus partaking of their food, eject a poisonous saliva into the wounds which they necessarily produce, and thereby cause the death of the punctured object.

All insects were confined upon these shrubs, fruits, and grains by means of a sack of Swiss muslin, drawn over the object and tied, the stem being protected from undue pressure by cotton placed in the mouth of the sack.

EXPERIMENT 1.

Pœcilocapsus quadrivittatus.

May 22, a number of adults were confined upon two or three inches of terminal portions of a young pear shoot.

Result.—Within one week the shoot withered, and afterwards the leaves and buds died, and turned black as far down as the muslin sack extended, but below that point no effect was noticeable. Later, after the insects had also perished, new leaves were put forth within the sack.

EXPERIMENT 2.

Lygus pratensis L.

May 20, placed adults on shoots of Concord grape.

Result.—May 28, no effect could be noticed.

Experiment 3.

Lygus pratensis L.

May 25, confined adults on young shoots of Gooseberry.
Result.—May 30, no effect perceptible.

Experiment 4.

Lygus pratensis L.

Tried same experiment as No. 3, leaving adults on shoots for twenty days.
Results.—Same as in the preceding. Insects all dead.

Experiment 5.

Lygus pratensis L.

June 25, placed twelve adults on young shoots of Pear.
Result.—July 10, both the insects and that portion of the shoot upon which they were confined were dead. The plant withered and turned black, as in Experiment No. 2, but in this case died.

Experiment 6.

Lygus pratensis L.

May 21, placed a number of larvæ on a Charles Downing strawberry which was just turning to the white color which precedes the final red or ripe color.
Result.—May 28, berry fully ripe and uninjured. Not "buttoned." Several larvæ dead, and one advanced to pupa.

Experiment 7.

Lygus pratensis L.

May 25, placed ten pupæ on nearly full-grown Crescent strawberries.
Results.—May 31, berries no larger than when insects were placed on them, but are withered and prematurely ripe. No indication of "buttoning." Some of pupæ dead; others now grown to adults, alive and active.

Experiment 8.

Lygus pratensis L.

May 26, placed larvæ on a half-grown Sharpless strawberry.
Result.—June 7, berry not more than half as large as when insects were placed upon it; withered and black. Five of the larvæ now pupæ and still alive.

Experiment 9.

Lygus pratensis L.

May 29, placed twelve larvæ and pupæ on three Crescent berries, varying from less than one-fourth to about one-third grown.

Result.—June 6, all three berries withered up, black, and dead. In one case only was there any indication that, had the berry continued to grow rapidly, a buttoned berry might have been formed. A few insects alive and either in pupal or adult stage.

Experiment 10.

Lygus pratensis L.

May 31, placed twelve larvæ on cluster of three Crescents, respectively one-fourth, one-third, and one-half grown.

Result.—June 7, cluster killed.

Experiment 11.

Lygus pratensis L.

May 31, placed four larvæ on a one-third grown Crescent.

Result.—June 6, killed also.

Experiment 12.

Lygus pratensis L.

May 31, placed fourteen larvæ on a one-third grown Crescent.

Result.—June 4, killed.

Experiment 13.

Lygus pratensis L.

June 1, placed ten larvæ and pupæ on a one-third grown Downing.

Result.—June 5, withered and drying up.

Experiment 14.

Lygus pratensis L.

June 1, placed nine pupæ on a rather more than half-grown Kentucky.

Result.—June 11, this berry made some growth after insects were confined upon it, and exhibits a tendency to "button," which, however, might or might not be due to the attack of the bugs. At this date the insects were all dead, although several had reached the adult stage.

Experiment 15.

Lygus pratensis L.

June 1, placed seventeen pupæ on a nearly full-grown Kentucky.

Result.—June 5, dried up.

EXPERIMENT 16.

Lygus pratensis L.

June 1, placed six pupæ on a less than half-grown Kentucky.
Result.—June 7, killed.

EXPERIMENT 17.

Lygus pratensis L.

June 1, placed six pupæ on Kentucky of about the same size as the preceding.
Result.—June 7, seriously withered.

EXPERIMENT 18.

Lygus pratensis L.

June 5, placed five pupæ on a one-fourth grown Jersey Queen.
Result.—June 21, berry seriously injured by being dwarfed, and it appeared to wither instead of ripen, although the plant was frequently watered. No indication of "buttoning." Insects dead, but they had lived to reach the adult stage.

EXPERIMENT 19.

Lygus pratensis L.

June 5, placed four pupæ on Jersey Queen as near as possible like the one used in Experiment 18.
Result.—June 21, berry attained nearly full growth, not deformed, except by a few slight depressions in surface which could not be said to indicate buttoning. Does not look as fresh and healthy as those not under experiment. Bugs dead, but as adults.

EXPERIMENT 20.

Lygus pratensis L.

June 5, placed three pupæ on Jersey Queen of same size as the preceding.
Result.—June 14, berry smooth, ripened in normal condition, and seems uninjured. The insect escaped from this after being confined upon it for about one week.

EXPERIMENT 21.

Lygus pratensis L.

June 5, four larvæ had, for several days previous, been clustered upon a Jersey Queen about the size of those used in the three preceding experiments. These bugs are now confined upon the berry.

Result.—June 21, being ripened in perfect condition, so far as form and freshness are concerned. Was a very little smaller than No. 20. Insects all dead, except one, which was in last larval stage.

Note.—During June, 1885, three larvæ, to all appearances of the same species as the preceding, took up their abode on a full-grown Crescent and remained there, voluntarily, until the latter was fully ripe, the young bugs being observed to feed upon the juices. No injury to the berry was in any way apparent.

Experiment 22.

Calocoris rapidus Say.

June 8, confined four adults on as many heads of Fall Wheat, placing two insects together upon each two heads of grain, and covering as with the berries.

Result.—June 24, kernels as plump as those ripening freely in the fields. The insects died some time between the 16th and 24th.

Experiment 23.

Euschistus fissilis Uhl.

June 8, placed same number of adults upon same number of heads of wheat and in same manner as in Experiment 22.

Result.—June 24, a few kernels badly shrunken, but these do not amount to over 6 per cent. Bugs now dead, but were alive up to the 20th.

Experiment 24.

Lygus pratensis L.

June 8, placed four adults as in the preceding experiment.

Result.—June 24, kernels do not differ from those grown elsewhere in the field. One set of insects died on or about the 12th, the others between 16th and 20th.

Experiment 25.

Siphonophora avenæ Fab.

June 8, placed a number of adult females on heads of wheat as in the preceding.

Result—June 24, kernels shriveled, discolored, and nearly worthless.

NOTES FROM MISSOURI FOR THE SEASON OF 1886.

By Mary E. Murtfeldt, *Special Agent.*

LETTER OF TRANSMITTAL.

Kirkwood, Mo., *December* 1, 1886.

Sir: I submit herewith the more important of my notes on the injurious insects of this locality, for 1886.

MARY E. MURTFELDT.

Prof. C. V. Riley,
U. S. Entomologist.

Climatically the past season was characterized by excess of moisture during May and June, followed by unusual drought and heat throughout July and August. That these extremes had a certain effect on the development of insect life is not to be questioned, and, in a general way, may be attributed to them the unusual numbers of all sorts of leaf-feeding and sap-sucking species early in the season, and a corresponding dearth of Lepidoptera and some families of Coleoptera later in the year. So great was the scarcity of nocturnal Lepidoptera in August and early September that one might sit evening after evening in a brightly-lighted room with open windows and not a single moth would appear.

Tenthredinid larvæ were especially conspicuous during May and June. These included not only such familiar pests as the Rose, the Raspberry, and the Cherry slugs, the Birch and Willow False caterpillars, but several species on Ash, Oak, Elder, White-fringe, &c., which I have not yet reared to the perfect state. A peculiar and interesting species, determined by Professor Riley from the larvæ as *Lyda cerasi*, appeared in large numbers, in July, on Wild Cherry. This is a gregarious web-worm, and its colonies covered quite large branches with their brown, viscid webs, in which were mingled the castings and exuviæ, forming, altogether unsightly and disgusting masses, which greatly disfigure the trees.

Another species of somewhat unique habit bores the new shoots of Roses, and for the past two years has proved quite injurious, especially to Hybrids and Teas. Its effects may be seen, late in June and early in July, in the blackened stems and withered leaves of the second growth, and the consequent destruction or prevention of the midsummer blooming. The larva is one-third of an inch in length, when full grown, by about one-twelfth inch in diameter, nearly equal throughout, except that it tapers abruptly toward the head. Color cream white, immaculate. Surface finely wrinkled transversely, but without piliferous warts or pubescence. Head small, round, amber-yellow with dark-brown, triangular or V-shaped spot on each side. Anal plate orbicular, slate-gray. Thoracic legs same color as general surface; prolegs imperfectly developed. It bores from the tips of the shoots downward for an inch and a half or two inches, devouring everything but the cuticle and packing the frass at the upper end. When full grown it makes its exit through a round hole which it cuts at the lower end of its burrow, and, entering the earth, incloses itself in a tough, silken cocoon, in which it remains dormant until the following spring. The single fly which I have thus far succeeded in rearing issued in May, and is of the same size and very similar in appearance to the common Rose Slug fly (*Selandria rosæ*). Professor Riley says of it that "it appears to belong to the genus *Ardis* of the *Selandriidæ*."

Climbing Cutworms were a prominent feature of the entomological developments of the spring. These attacked the Oaks, Elms, and other shade trees, as well as Apple, Pear, and Cherry trees and a variety of vines and shrubs. Among the species detected in their work of destruction were *Agrotis saucia*, *A. scandens*, *A. alternata* and *Homohadena badistriga*. The grass under shade and fruit trees would often in the morning be thickly strewn with leaves and buds that had been severed during the night. This was especially noticeable under the various Oaks and Sweet Cherries. On a large, isolated specimen of the latter, up which a Trumpet vine had climbed, I took early in May a great number of the larvæ of *Agrotis alternata*. These mottled gray worms were found during the day extended longitudinally on the trunk, closely appressed to the stems of the Trumpet vine, where, protected by their imitative coloring, it would be impossible for an unpracticed eye to detect them and where even birds failed to find them. When ready to transform they descended to the earth and inclosed themselves in an ample, tough, dingy-white cocoon, under any slight protection that might be convenient. I also took this species from crevices of oak-bark and occasionally found one feeding in a rose.

Canker Worm (*Anisopteryx vernata*, Peck).—Not for several years has this pest appeared in such numbers in the orchards of this locality as during the past spring. Nor did the apple trees seem to recover from the excessive defoliation during the remainder of the season. The worms were especially numerous on trees around which the soil had not been stirred for a year or more.

I noted this year a habit of this insect that has not, to my knowledge, been previously recorded, viz, that the worms, with great regularity, desert the leaves during the middle of the day and hide in the forks of the branches and on the trunk in crevices and under loose scales of the bark. As I did not at once discover this propensity in these larvæ, it puzzled me for some time to account for their scarceness about noon, whereas in the mornings and evenings the foliage would be crowded with them. Happening one day, while standing under an apple tree, to detach a loose scale of the bark I was surprised to find more than a dozen of the worms on the under side stretched out side by side in a close cluster. An examination of the bark revealed the fact that almost every scale harbored a larger or smaller company of the worms. Nor was there any evidence of their having sought these retreats merely for the purpose of molting, as they were of all sizes and ages, and besides an examination a few hours later disclosed them rapidly looping themselves up into the tree, as though in haste to begin their nightly banquet. Observation for several successive days established the fact of their habitual desertion of the foliage during the hottest hours of the day and of their return to it as evening approached. As the infested trees had not been smoothed for some time, and the trunks were rather "shaggy," advantage was taken of this discovery to have them cleaned about noonday and thousands of the sluggish worms were thus scraped off with the scales of bark and burned.

The Codling Moth was more than usually destructive to the apple crop throughout the West, destroying in many localities fully 75 per cent. of the fruit, and in not one orchard in a hundred were any measures taken to destroy the pest or prevent its spread.

The Broad-necked Root-borer (*Prionus laticollis*, Drury) proved considerably destructive to young nursery stock in some parts of the State. In some sections of young apple trees sent me it was found to have worked up into the trunk for a distance of 4 or 5 inches.

Leaf-hoppers of various kinds were noticeably abundant during midsummer. Of these, two species of Fulgorids, *Flata conica*, Say, and *Poeciloptera pruinosa*, Say, attracted much attention on shrubs and herbaceous plants, some of which were seriously injured by them.

The former species I observed chiefly on Osage Orange and Lilac. The larvæ are scarcely distinguishable from those of *P. pruinosa*, being of the same bug-like form and greenish-white color and thickly covered and surrounded by the white-tufted, sweetish secretion peculiar to the group. The pupæ of the two species differ widely, that of *pruinosa* retaining the pale color and flattened form of the larva and continuing to cover itself with the fibrous exudation. The pupæ of *F. conica*, on the contrary, assume an angular, humped, somewhat beech-nut-like form, a grayish-brown color, and a more horny texture, while the white secretion is limited to two feathery tufts at the tail. The perfect insect of this species is a deep yellow-green, and with its broad moth-like wings and crimson eyes it is a beautiful object. It is always gregarious, but especially so in its perfect state, and I have often seen shoots of the Osage Orange crowded with this insect ranged in close ranks for a distance of 18 inches or 2 feet and presenting a most unique and not unattractive appearance. The *pruinosa* species is somewhat smaller and is also pretty in its powdery suit of pearl-gray and white. It attacks almost all kinds of vegetation; but was found last summer to be especially destructive to the foliage and stalks of the Dahlia in one garden in Kirkwood, injuring the plants beyond recovery. As it inhabits the under side of the leaves, for the most part, and its punctures cause these to curl somewhat, it is difficult to reach it with insecticides, but applications of air-slacked lime and spraying with an infusion of Pyrethrum will kill or dislodge it.

Halticus pallicornis is becoming every year more of a pest in this locality on Clover and many kinds of garden plants. Its punctures cause the leaves to turn yellow and present an appearance similar to those infested by Red Spider.

The Flea-like Negro-bug (*Corimelæna pulicaria*) also this year attacked Compositæ and Hollyhocks with great virulence.

Acoloithus falsarius—a congener of the well-known *Procris americana*—appeared on all varieties of the Grape in July in such numbers as to merit some attention from the economic entomologist. The larvæ are not found in companies feeding in regular ranks, as is the habit of *P. americana*, although several are often seen on the same leaf. This species feeds exclusively on the upper surface, gnawing off the parenchyma in irregular patches. The handsome little larva, when full grown, is about three-eighths of an inch in length by rather more than one-eighth inch in diameter. The form is depressed, almost rectangular. The surface is velvety and prettily checkered in dull orange or fulvous, yellow, and two or three shades of purple. Medio-dorsal line fine, interrupted, dark purple, on each side of which is a broad stripe of orange outlined in pale yellow, the dark color being most intense in the center of each square, where, under the lens, is situated a little tuft of silky hairs. The lateral stripe is similar, but contains a larger proportion of purple. A purple band extends transversely across the fourth and ninth segments. The depth of this coloring is quite variable, some larvæ being very much paler and less distinctly variegated than others. The under surface and legs are translucent, velvety, white, with a tinge of green. Head very small, brown and retracted under the projecting edge of first segment. It incloses itself when ready to change in a fold of a leaf or between two leaves in a flat flesh-tinted silken cocoon covered externally with lime-like granulations. The moth escapes in about two weeks and is dull black with orange collar like *P. americana*, but it is considerably smaller than the latter. A slight dusting with Pyrethrum powder caused the larvæ to drop from the leaves, and this will probably prove one of the best remedies where this insect has become unduly abundant.

The Saddle-back Caterpillar (*Empretia stimulea*) is known to feed on a variety of trees and other plants, but I have seen no record of its occurrence on Soft Maple.

Late in August of the present year I found quite a colony, probably ten or twelve, on a single leaf of the above-mentioned tree. They had but recently hatched, but tiny as they were—not more than an eighth of an inch in length—they had all the tubercles and other characteristics of the mature larva, except that the saddle-cloth-like spot was deep yellow instead of green and the central dorsal spot pinkish-gray. They had perforated the leaf with small irregular holes. Not thinking that they would readily loosen their hold on the leaf, I carried it carelessly in my hand, and when I reached the house was much disappointed to find that but two larvæ remained on it. As these thrived and perfected their development to the point of inclosing themselves in cocoons, it is evident that Maple may be included in the list of their food-plants.

The Cottony Maple Scale (*Pulvinaria innumerabilis*). This insect has not been troublesome in this part of Missouri since 1884; but in and around Rockford, Ill., I learned that it had been so abundant on the Soft Maples for three successive seasons as to kill many young trees outright and greatly injure the older ones. I was told that the sidewalks shaded by these trees became so defiled and slippery from the exudations of the scale insect that it was difficult and unpleasant to walk on them. The citizens had consequently conceived a prejudice against the Soft Maple, and many were being cut down or dug up and replaced by other trees.

A new Leaf-bug on Maple (*Lygus monachus* Uhler, n. sp.).*—This bug came under my notice for the first time late in the spring of 1882 infesting the growing points of young Soft Maples (*Acer dasycarpum*). Most of the insects were at that time mature, but two or three pupæ were found, enough to indicate that the leaves of the maple had been their breeding place. A few specimens were taken, but, as the insect was not present in sufficient numbers to give it importance as an injurious species, not much attention was paid to it. During several succeeding springs I occasionally came across a mature specimen—which, from its exceeding agility, both in running and flying, generally evaded capt-

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* Mr. Uhler has given us the following description of this new Lygæid:

LYGUS MONACHUS n. sp.—Long-oval, pale green or testaceous, coarsely punctate above, sericeous pubescent. Face convex, highly polished, bald; base of vertex with a longitudinal impressed line, towards which a similar line runs obliquely each side from the inner corner of the eyes; antennæ sparsely and minutely pubescent, basal joint thickest, a little longer than the head, tapering at base, second joint thrice as long as the basal, infuscated and a little enlarged towards the tip, third and fourth setaceous, together not as long as the second. Pronotum highly polished, convex, coarsely punctate in transverse wavy lines, each side with a dark brown vitta, or long spot; lateral margin smooth, callous at base, the humeral angles subacute, callosities prominent, convex, almost confluent on the middle; lateral flap of pronotum irregularly punctate. Pectoral pieces pale, impunctate. Legs pale green, feebly pubescent; apex of posterior femur usually with one or two fuscous bands, tip of tarsi and the nails black. Scutellum moderately convex, excavated at base, transversely obsolete-punctate, more or less infuscated. Corium coarsely, transversely rostrate-punctate, the clavers more or less infuscated, sometimes with all but the ure—but it was not until the present season that the maples were infested to such an extent as to injure and disfigure them.

Just as the leaves were beginning to put forth, close observation revealed the fact that they were all more or less stippled with transparent spots, some mere dots, others a tenth of an inch or more in diameter. As the leaves expanded the delicate cuticle of the upper surface would give way and they presented the appearance of being perforated with holes and much torn and tattered along the margin, marring their beauty for the entire season. If, about the 1st of May, the leaves were carefully examined, there would be found on the under surface of each from two or three to a dozen or more very delicate bugs of a very pale translucent green color, the embryo wing-pads being almost white. They were further characterized by very long and slender legs, beak and antennæ, body flat and broad oval in outline; head small, eyes relatively large, oblong and bright red-brown in color. The larvæ varied in size from one-twentieth to one-eighth inch in length, and so far as I could discover there were but two larval molts. Scattered about over the leaves were small, round, translucent green eggs rather larger than a Portulaca seed. The pupal form was precisely like the larval, except in point of size and relative development of the wing-pads. When the under side of a leaf was turned up for examination the bugs, large and small, would dart, on their hair like legs, to the reversed surface, moving with the greatest rapidity and sometimes dropping to the ground in their evident desire to escape observation. The final transformation occurred about the middle of May, after which the companies dispersed. The species is a pretty one, although, from the glassy texture of the entire hemelytra and the general delicacy of coloring, it always has a somewhat immature appearance.

This bug happily lacks the disagreeable odor so common to the species of this suborder and which pertains even to most of its closest allies.

Absence from Kirkwood after the middle of May somewhat interrupted my observations on this insect. On my return, early in June,

margins covered with dark brown; corium usually with a transverse, dark-brown arc next the posterior border; cuneus long and wide, the incised base fuscous, and the inner margin brown; membrane pale testaceous, with two or more dark clouded spots, the inner submargin of the principal areole, a spot at its tip and the base next the cuneus all more or less fuscous. Venter pale greenish.

Length of body, female, 5^{mm}; to tip of wing covers, 7^{mm}; width of pronotum, 2^{mm}. Male, length of body, 4^{mm}; to tip of wing covers, $5\frac{1}{2}^{mm}$; width of pronotum, $1\frac{3}{4}^{mm}$.

This has proved to be a very common insect in various localities.

Mr. Cassino collected numerous specimens around Peabody, Mass. Mr. Bolter sent to me a pair from Illinois and Missouri; and I have taken it from Alders, Maples, and many other kinds of small trees and shrubs on Cape Ann, Mass., also near the base of the White Mountains, and in New Hampshire, and near Quebec, Canada.

Mr. Forbes has also forwarded to me specimens from near Normal, Ill.

It resembles *Lygus invitus* Say, and presents several of the color varieties common to that species; but it is a much larger insect, of a longer figure, and has a more flattened upper surface.—P. R. UHLER.

only a few of the mature bugs remained among the curled and torn leaves on which they had developed. Occasionally throughout the summer a specimen would be met with, as often on the foliage of any other tree as on maple, but there was no second brood. This species, unlike *Capsus oblineatus*, is never to my knowledge found on flowers. It probably secretes itself early in the season and becomes dormant until the following spring.

The only remedial applications experimented with were Pyrethrum powder and air-slacked lime, both of which were measurably effective, judging by the small scale on which they were tried.

APICULTURAL EXPERIMENTS.

By Nelson W. McLain, *Special Agent.*

INTRODUCTORY NOTE.

The following article is extracted from Mr. McLain's annual report for 1886, the major part of which is published in the Annual Report of the Department for that year.

C. V. R.

PREPARING BEES FOR WINTER.

Bees instinctively begin to make preparations for winter somewhat earlier in the season than is commonly supposed. In preparing for winter, as in all other matters relating to bee-keeping, the apiarist should see to it that the method of management is as nearly as possible in agreement with the instinct and habits of the bee. When bees build their combs after their own design, as in box hives, spaces are left between wide enough to admit of elongating the cells in order that a large share of the winter stores may be placed in the top of the hive, easily accessible in the severest weather. I find it good practice to widen the spaces between the comb-frames near the close of the honey-gathering season, in order that the bees may, by elongating the cells, place a large share of the winter store above the cluster.

As soon as the storing of surplus honey is done the condition of every colony should be examined, the amount and character of the winter food ascertained, the number of comb-frames, and the size of the apartment should be determined by and adapted to the wants of each colony. After the supply of winter stores has been equalized among all the colonies, if the supply is insufficient, feeding should be done before the advent of cold nights.

Bees expected to perform the function of hibernation should not be too old nor yet too young. Both queen and worker bees should be in full physical vigor. The bees constituting the colony, when placed in winter quarters, should be such as are hatched after the midsummer working season is past, and before the bees cease flying freely in the fall.

Towards the close of the working season the workers instinctively cease stimulating the queen for oviproduction ; gradually the bees cease flying, and the cluster is formed for winter. After the cluster is formed the colony should remain undisturbed. If the bees are to be packed on the summer stand the work should be done with care, and without disturbing the bees, and before the temperature at night reaches the freezing point. If the bees are to be placed in a damp or in cellar or winter repository, great care should be taken not to disturb the cluster when the hives are removed from the summer stand. I have found woolen quilts or woolen blankets the best covering for winter. Wool, better than any other material which I have tried, prevents the radiation of heat, and permits the escape of moisture, thus securing warmth and dryness. Hives should be placed 18 inches above the bottom of the cellar or winter repository, and in tiering them up one above another it is better that they rest on a rack prepared for the hive rather than one upon another.

My report for 1885 covers the period from June 1 to November 25, when the severity of the weather forbade further out-of-door experiments. As nearly all the colonies in the apiary had been subjected to very frequent, almost daily, disturbance and annoyance incidental to the experimental purposes for which they had been used, they were, almost without exception, in very poor condition for passing into winter quarters. November 25 I packed twenty colonies for out-door wintering. Notwithstanding the lateness of the season, and the altogether unsatisfactory condition of the bees when packed, eighteen of the colonies wintered fairly well. These twenty colonies were provided with dry sawdust packing 8 inches thick on the sides, and covered with a quilt and dry forest leaves to the depth of 8 inches on top of the frames. A rim 2 inches wide is placed under the body box of the hive, making a 2-inch space under the bottom bar of the comb-frames. A covered tunnel leads from the hive entrance through the packing. This packing is left on the hive until warm weather is assured, thus guarding against danger from chilling of the brood when building up the colonies rapidly in early spring. The hive should incline from back to front permitting the moisture to flow out at the entrance.

I placed ten colonies in the cellar from which the hive covers were removed and the frames covered with woolen and cotton quilts. These were used for observation and experiment during the winter. Eight of the ten came through the winter alive, but being subjected to a wider range of temperature, and being very frequently annoyed and disturbed, their vitality was very low, and the old bees, of which most of these colonies were composed fell easy victims to spring dwindling.

HIBERNATION.

For the purpose of determining the degree of temperature in a dry cellar necessary to secure the minimum of functional activity within the hive during the period of hibernation, I framed comb-frames across each other at right angles, and into these frames I fitted and fastened combs filled with choice sealed honey. These were suspended in hives having glass sides and top, exposing the cluster to view from all sides and from the top. Removable wooden doors covered the glass.

My observations covered a period of ninety days from December 1, 1885, and included a range of temperature from zero to 65° F. The hives were placed in a dark apartment, and an oil stove with a radiator was used for heating. Different degrees of temperature were maintained for several consecutive hours, and, as occasion required, for consecutive days, and careful observations were taken.

At a range of temperature from 48° to 52° F., according to the humidity of the atmosphere in the cellar, bees, according to a rule of nature, enter into the hibernating state. After repeated trials over a wide range of temperature, at 41° F. I found the shape of the cluster most permanent. While that degree of temperature was maintained, little change in the shape or location of the clusters could be seen, and functional activity on the part of individual bees, and of the whole colony as well, seemed to have reached the minimum degree of manifestation, even respiration seemed to be suspended. The change in the form of the cluster was determined by outline drawings on paper. The colonies presented substantially the same outline for days together when a uniform temperature of 41° was maintained. I placed some colonies in a darkened building late in the fall of the year, and when the temperature was 40° F. natural heat on a dry day above ground, the same phenomena were observed.

The temperature of the cellar was lowered by admitting the air through an outer room, so that no perceptible currents entered the apartment where the bees were kept. The degree of unrest and activity increased in proportion as the temperature neared the zero point. Thirty-seven degrees F. in a very dry cellar is a danger point, the danger increasing in proportion as the temperature is lowered or the humidity of the atmosphere is increased.

The degree of activity shown by bees when the temperature in the repository or cellar is 44° F. is not much greater than at 41°, all other conditions being the same.

At intervals of about one week the bees arouse to activity, the form of the cluster changes, and after three or four hours of cheerful and contented humming, having in the mean time appeased their hunger, the cluster is reformed into a compact body, the humming ceases, respiration becomes slow, profound silence reigns in the hive until change of temperature or the demands of hunger rouse the bees from the coma in which they have been bound. The more perfect the conditions for hibernation the longer the periods of inactivity.

As the activity of bees is not much greater when the temperature in the cellar or repository is steadily maintained at 44 degrees than it is at 41 degrees, and as 41 degrees is too near the danger point, I find it safer to keep the temperature in dry winter repositories, whether above or below ground, at 44° F., and I find it better that the variation from the standard degree of 44° F. should be in proportion of 2 degrees above rather than 1 degree below. If the repository be damp a degree of temperature higher in proportion to the dampness should be maintained. The hive should incline from back to front, and the entrance should be left wide open.

It has been the practice of many to raise the temperature in winter repositories in order to stimulate breeding toward the close of the hibernating period. I have tried this, and in my experience I find it better to maintain as nearly as possible an even temperature until the bees may be safely placed on the summer stands. What is gained in early breeding is more than lost in the waste of vitality on the part of the older bees. In the case of bees wintered on the summer stands or in a clamp, the packing of dry forest leaves, chaff, or sawdust placed above the quilt should be closely packed about the edges, and should be from 7 to 12 inches in thickness. Indeed it would be difficult to get the packing above the cluster too deep, provided the ventilation above the packing is sufficient to carry off moisture.

SPRING DWINDLING.

For preventing spring dwindling, and building up colonies to maximum strength and efficiency at the beginning of the working season—for success in honey-producing largely depends on having strong colonies ready for work at the very time when efficient work may be done—I prepared a bee-food containing the elements essential in brood-rearing. This food is prepared after the following formula:

To 10 pounds of sugar I add half a pint of dairy salt, 2 tablespoonfuls bicarbonate of soda, 2 tablespoonfuls rye flour, 2 tablespoonfuls finely powdered bone-ash, and 1 tablespoonful cream tartar. Mix thoroughly, then add 2 quarts hot water, and stir until thoroughly dissolved, and let the mixture boil, but only 2 or 3 minutes. I feed this food in the hive as honey or sirup is usually fed, thereby keeping all the bees at home to aid in keeping up the temperature in the hive, thus reserving their vitality for performing the functions of brood-rearing, instead of speedily wearing out their remaining strength in roaming the fields in search of the elements essential to larval growth.

The bone ash is prepared by burning dry bones to a white ash, which I pulverize and sift through a sieve made from fine wire strainer cloth. As this food is not intended for use until after the bees have had a good flight in the spring, almost any grade of sugar or dark low-grade honey may be supplied for brood-rearing.

The rapidity with which a colony consisting of a mere handful of bees may be built up to full strength and working efficiency by using this preparation is surprising. Only as much as is needed for immediate consumption should be frequently supplied, and it should be fed only to prevent spring dwindling, or when it is desirable to quickly increase the numerical strength of the colony in anticipation of a honey harvest, or to recruit the vigor and strength of the colony by rearing young bees after the working season, and prior to going into winter quarters.

BEES VS. FRUIT.

I have, according to your instructions, repeated my experiments of last year for testing the capacity of bees, under exceptional circumstances, to injure fruit; adding such other tests and observations as the very severe and protracted drought permitted. The house used last season, 10 feet by 16 feet in size, having sides partly covered with wire cloth and large screen doors in each end, was used again this year. Two colonies of Italian bees, two of hybrids, one of Caucasians, and two of Syrians were confined in this house.

These colonies were without food in their hives and at intervals of three or four days were fed a little sirup for the purpose of keeping up their vigor and to prevent dying from starvation. A wood-stove was placed in the house and a high temperature was maintained for a number of hours each day.

The conditions incident to an unusually severe and protracted drought were present within and without. The bees were repeatedly brought to the stages of hunger, thirst, and starvation, the test continuing for 40 days.

Through the favor of Mr. T. T. Lyon, president of the Michigan State Horticultural Society, I obtained thirteen varieties of choice grapes from A. G. Gulley, of South Haven. Every inducement and opportunity was afforded the bees to appease their hunger and thirst by attacking the fruit which was placed before them. Some of the bunches of grapes were dipped in sirup and hung in the hives between the the combs, some placed before the hives on plates, and grapes were suspended in clusters from the posts and rafters. The bees lapped and sucked all the sirup from the skins, leaving the berries smooth.

They daily visited the grapes in great numbers and took advantage of every crack in the epidermis or opening at the stem, appropriating to their use every drop of juice exuding therefrom, but they made no attempt to grasp the cuticle with their mandibles or claws. I removed the epidermis carefully from dozens of grapes of various kinds and placed them on plates before the hives. The bees lapped up all the juice on the outside of the film surrounding the segments of the grape, leaving this delicate film dry and shining, but through and beyond this film they were not able to penetrate. I punctured the skins of grapes of all kinds by passing needles of various sizes through the grape and placed these before the bees. The needles used were in size from a fine cambric needle to a packing needle. The amount of juice appropriated was in proportion to the size of the opening in the skins and the number of segments of the grape broken. The same was true in the case of grapes burst from over-ripeness. Bees are not only unable to penetrate the epidermis of the grape, but they also appear to be unable, even when impelled by the direst necessity, to penetrate the film surrounding the berry even after the epidermis is removed. Grapes so prepared without exception laid before the hives until dried up. If but one segment of a grape be broken by violence or by over-ripeness, the bees are unable to reach the juice beyond the film separating the broken from the unbroken segments until further violence or decay permits an entrance for the tongue. Clusters of sound grapes which I hung between the comb frames in hives occupied by strong colonies were unbroken and sound after fifteen days' exposure in the hives. The skins were polished smooth, but none were broken. I also stopped up the entrance to several hives—containing good-sized colonies—in the apiary and in the wire-covered house, by pushing sound grapes into the opening, so close together that the bees could not pass through. By this means the bees were confined to the hives for days in succession, not being able to break down and remove the grapes, and although the skins of the grapes next the inside of the hive were polished smooth none were broken or injured.

The past season furnished an excellent opportunity to observe the capacity of bees, under so exceptional circumstances, to injure fruit, for the drought was very exceptional both in duration and severity, and I was called to several places by fruit-growers to witness the proof that bees were "tearing open the skins of the grapes" and otherwise behaving in a manner altogether unworthy of an insect enjoying a wide reputation for virtue and orderly living. In each instance I succeeded in convincing the fruit-grower that the bees were simply performing the office of gleaners; that violence from other sources, or over-ripeness and decay had preceded the bees, and that he would be acting the part of wisdom in following the example of the bees in gathering the grapes before further violence, or the action of the elements, rendered them worthless.

After grapes have been subjected to such violence, or have so far burst open and decayed as to make it possible for bees to injure them, and the circumstances are so exceptional as to lead the bees to seek such food, unless they are speedily gathered they would soon become worthless if unmolested. During the past season I made many visits to vineyards, one located near the apiary I visited every day, and my observations and experience with bees in confinement and those having free access to the vineyards furnishes abundant proof to convince me that bees do not and cannot under any circumstances injure sound fruit. If from any cause the pulp is exposed, such as the attack of birds or wasps—the most common source of injury—or from the ovipositing of insects, or bursting of the berry from over-ripeness, and if no other resources are available, the bees appropriate and carry away the juice, and the extent of the injury depends upon the degree to which the pulp is exposed, the sweetness of the juice, and the number and necessities of the bees.

BEE FORAGE.

If excellence in the bee is the chief factor in successful honey producing, next in logical order is abundant, persistent, and cheap bee-pasturage. Abundant pasturage is the amount necessary to satisfy the requirements of the number of colonies kept within a given area. Persistent pasturage is that which contemplates a variety of perennial honey bearing flora of hardy constitution and rugged habits whose terms of blooming follow each other in succession continuously from early spring to late fall, thus lengthening out the season in which bees may gather surplus honey. Cheap bee-pasturage may be such as is furnished from natural sources produced in forests or by self-propagating plants growing in waste places or upon lands of little value and requiring little or no labor. Or cheap bee-pasturage may be secured by cultivating fruits and field crops, the blossoms of which are valuable for honey bearing.

As the forests of the country disappear and the waste lands are being reclaimed, as the necessity for other honey-producing resources is felt, as the industry assumes more importance and as the influence of competition is more sharply felt, great interest is shown in the subject of bee-pasturage. The number of days in each year in which bees can gather and store surplus honey will not average, except in exceptionally favored localities, above thirty or thirty-five days; the remaining time and energies of the bees being employed in gathering sufficient for the sustenance of the colony, and enforced idleness or non-productiveness. Enforced idleness, and the consequent waste of time, stores, and energies sometimes result from a failure of the flowers to secrete nectar, even though honey-bearing flowers are blooming in abundance, but usually the reason why the time is so short in which bees are able to store surplus honey is the lack of abundant pasturage. I have not had the time or the means to devote to bee-forage that the importance of the subject demands, but I have made a beginning in this department of experimental work which I hope to continue. Among all the trees and shrubs which are cultivated generally throughout the United States by fruit-growers, the raspberry is commonly conceded to possess more value to bee-keepers than any other. A quarter of a mile from this station a market gardener has 4 acres of raspberries. These bushes continued to bloom for ten days, and during that time, with the exception of two or three rainy days, a continuous procession of bees could be observed going and returning to and from the apiary, and a fine showing of honey was made in the hives and the honey was of superior quality.

On account of the superior quality of its nectar, the ease with which the plant is propagated, its adaptation to all kinds of soil and its value as a forage plant for grazing, white clover has, until of late years, stood without a rival in the estimation of honey-producers. About twenty years ago Alsike or Swedish clover was introduced into this country, and since then has been thoroughly tested both as a honey plant and also for hay and pasture for all kinds of stock.

Mr. J. M. Hicks, of Battle Ground, Ind., says: "Alsike Clover has no superior as a honey-producing plant, yielding the best and richest honey known, and as a hay crop it is not surpassed, often producing 3 tons of good hay per acre. The stems and stalks are much finer than those of common red clover, and cattle, horses, and sheep feast on it, eating it clean without waste. As a pasture of all kinds of stock it has no equal. It will grow on all kinds of land, clay, or sandy, and does not freeze out as easily as red clover. It is quite similar to red clover in appearance. The first crop each season is the seed crop. The seed is about one-third the size of red clover and 4 pounds is sufficient to sow an acre. The bloom is a beautiful pale pink color. I have no hesitancy in saying that Alsike Clover will produce 500 pounds of the richest and best honey per acre in a good season. I would recommend every bee-keeper to sow at least a few acres of Alsike Clover." Mr. W. Z. Hutchinson, of Rogersville, Mich., says that it will pay to raise Alsike Clover for honey alone upon land worth $50 per acre.

Mr. C. M. Goodspeed, of Thorn Hill, N. Y., says: "I have grown Alsike on my farm and watched its habits closely. It is very hardy, of extra quality as hay and a heavy seeder, reaching in rare cases 10 bushels per acre. In this locality the second growth seldom yields much honey, but the first growth just swarms with bees for about three weeks, or from the time the rich blossoms open until the seed is ripe. In my locality it begins to yield honey shortly after white clover and continues well into the bass-wood season. It yields twice as much honey as white or red clover." Mr. D. A. Jones, of Beeton, Ontario, says: "I think too much can scarcely be said of Alsike as a hay and honey crop, and many of our farmers are waking up to the fact that it is to their interest to cultivate it largely in preference to almost any other crop. Red Clover will soon be a thing of the past, as Alsike seed is now in great demand, not only for seeding purposes but also for use in dyeing. I am informed that large quantities are being shipped to Europe for that use." Mr. A. I. Root, of Medina, Ohio, and Mr. L. C. Root, of Mohawk, N. Y., both speak of Alsike as the most valuable variety of clover for hay and pasturage and recommend its cultivation as being of the first importance to bee-keepers. Statements testifying to the unequaled value of Alsike Clover, both for hay and grazing purposes, and as a most valuable honey-bearing plant, might be indefinitely multiplied. I cannot too strongly urge the bee-keepers of the United States to provide abundance of this forage for their bees, both by sowing the seed on their own premises and also by inducing their neighbors to cultivate this variety of clover as the best for all purposes.

Sweet Clover (*Mellilotus alba*) abounds in this locality. This is a hardy plant, of wondrous persistence, continuing in bloom from about July 1 until killed by frost. It is adapted to almost any kind of soil.

In this part of Illinois it grows in rich soil by the wayside, or in deserted stone quarries with equal luxuriance. As the plant will grow without any cultivation in by-ways and waste places, wherever the seed can obtain a foothold, and is a perennial, it is rightly reckoned among the number of excellent and cheap bee-forage plants. Sweet Clover will endure drought well. During the long drought of last season bees in this neighborhood would have been entirely without resources for many weeks together had it not been for Sweet Clover. The quality of the honey is excellent, and under ordinary conditions the yield is altogether satisfactory. Much apprehension has been felt among farmers lest it become a noxious weed. Observing how readily the seed is carried in the mud on wagon wheels and horses' feet in the spring, when the roads are bad and the entire space in the highways is used for travel, belief has obtained that the fields would soon be invaded. Careful and continuous observation of the facts for five years past has convinced me that fears of trouble from this source are groundless. In but one instance have I seen Sweet Clover invade a plowed field, and that was for a distance of 3 rods on both sides of an old road leading into the field and the seed had been carried in on wagon wheels. This plant being a biennial is easily exterminated when desirable. I would recommend bee-keepers to provide abundance of this forage by scattering the seed in waste places and by the roadside. Sweet Clover is much more sightly and useful, and less objectionable, in every way, than the weeds which ordinarily cover the roadsides.

Pleurisy-Root (*Asclepias tuberosa*) is a honey-bearing plant indigenous to nearly all parts of the United States, but its growth has not been encouraged for the reason that its value to the honey-producer has not been generally known. The plant is a perennial; the top dies and rots, a new growth springing up each year. It is commonly regarded as a harmless prairie weed. The deep red blossoms hang in clusters. The plant is very hardy and of a rugged growth, growing luxuriantly in all kinds of soil. The honey is of the finest quality both as to color and flavor. Mr. James Heddon, of Dowagiac, Mich., speaking of Pleurisy, says: "If there is any plant, to the growing of which good land may be exclusively devoted for the sole purpose of honey production, I think it is this; I would rather have one acre of it than three of Sweet Clover. It blooms through July and the first half of August, and bees never desert Pleurisy for bass-wood or anything else. The blossoms always look bright and fresh, and yield honey continuously in wet and dry weather. Bees work on it in the rain, and during the excessive drought of the past season it did not cease to secrete nectar in abundance." I have had some observation and experience with the plant, and, having secured seed, I expect to test it in different kinds of soil next season.

For two years past I have cultivated a plot of Motherwort (*Leonurus cardiaca*), and I prize it highly as a honey plant. Bees work on it continually all day, and every day, unless it is raining quite hard. The summer of 1885 it continued in bloom six weeks. Last summer it bloomed but was soon ruined by drought. At the annual meeting of the North American Bee-Keepers' Association held in Detroit in December, 1885, a committee, of which I was a member, was appointed by the association to investigate the merits of a new plant being cultivated by Mr. Chapman, of Versailles, N. Y., who was present and represented that the plant was of unusual value to honey-producers. Being instructed by you so to do, I met with other members of that committee at Versailles on the 28th of July. I herewith inclose a copy of the report which I prepared in behalf of that committee, together with a letter of Mr. A. E. Manum, president of the Vermont Bee-Keepers' Association, which I presented to the North American Bee-Keepers' Association at its annual meeting held in Indianapolis, Ind., October 12, 13, 14, 1886.

My experience with the plants furnished for observation at this station was nearly identical with that of Mr. Manum. Fifty-two plants arrived here by express, fifty-one of which came to maturity. Plants were furnished to Prof. A. J. Cook, Lansing, Mich.; T. F. Bingham, Abronia, Mich.; W. F. Clarke, Guelph, Ontario, and Mr. Van Dom, Omaha, Nebr., each of whom highly recommend it as possessing unusual value as a bee-forage plant.

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 14.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., May 30, 1887.

SIR: I have the honor to submit for publication Bulletin No. 14 of the Division of Entomology, containing certain reports of agents and other matter additional to that contained in Bulletin 13, and excluded from my annual report from lack of space.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

CONTENTS.

INTRODUCTION.

This Bulletin contains matter referring to the season of 1886, additional to that already published.

Mr. Ashmead's report on insects affecting garden crops in Florida is necessarily very incomplete, as it represents only four months' field observations, and as the subject is one of no inconsiderable magnitude. Mr. Ashmead's work was stopped September 1st on account of the reduction in the appropriations.

Mr. Webster's report on Buffalo Gnats is in the main the results of work in March and April, 1886. It contains many interesting details in addition to the more important observations which are quoted in our own article on the subject in the annual report. It is also due to Mr. Webster to say that the investigations since made, and especially those by himself the present year, have added materially to our exact knowledge on the subject.

In reference to Mr. Wier's article on the curculio-proof nature of the native plums and his explanation thereof we wish to be understood as in no way indorsing either the statements or conclusions of the paper. Mr. Wier is an old friend and correspondent and has written much of late upon this question. He claimed to have abundant personal evidence of the wild plums being proof against *Conotrachelus nenuphar* by virtue of the eggs failing to hatch therein. This was an important matter, bearing directly on economic entomology, and, as we have often been asked for our opinion as to the immunity of these wild plums, we engaged Mr. Wier to prepare a statement of his evidence. His two main claims are (1) that these wild plum trees are unfruitful, except where the flowers receive the pollen from other varieties; (2) that the female Curculio prefers their fruit for purposes of oviposition, but that the egg fails to hatch therein or the larva perishes after hatching. The first point belongs to economic botany, or rather pomology, and while we consider that it is disproved alike by historical and botanical evidence and general experience we leave it with the horticulturist to deal with more fully. With regard to the second point we confess that the reading of Mr. Wier's essay has brought no sense of his theory being well sustained or of its general truthfulness. Yet, for the reasons stated, we have decided to publish the paper very much as received, omitting only such portions as dealt with well known and trite entomological facts, as also a dissertation on grafting, and entering our dissent in the form of foot-note where the statements are unjustified from the entomological side.

The description of the principles and mechanism of the Serrell automatic silk-reel has been prepared by Mr. Philip Walker, assistant in charge of the reeling experiments and machinery at the Department. It will be found useful in explaining the advantages which that delicate and remarkable invention has over the ordinary reel as a labor-saver, though no amount of description will impress the fact on the mind so forcibly as a few moments' observation of the reel at work.

C. V. R.

REPORT ON INSECTS INJURIOUS TO GARDEN CROPS IN FLORIDA.

By WM. H. ASHMEAD, *Special Agent.*

LETTER OF TRANSMITTAL.

JACKSONVILLE, FLA.,
September 2, 1886.

DEAR SIR: I have the honor to submit herewith, in pursuance to your instructions, my report on "insects injurious to garden crops" in Florida, comprehending field-work and studies on these pests from May 15 to August 31, 1886.

My time was too limited to do full justice to the subject; moreover, it will take several years of the most laborious, painstaking industry to thoroughly work up the life histories of the destructive insect pests affecting our garden crops in this State.

Yours, very respectfully,

WM. H. ASHMEAD.

Prof. C. V. RILEY,
U. S. Entomologist, Washington, D. C.

INTRODUCTORY.

The insects depredating "garden crops" in Florida are legion, and the time at my disposal, May 15 to August 31, was too limited to begin to do the subject justice.

Daily rains, too, from latter part of June and all during July greatly interfered with my field-work. During the months of March and April early vegetables are raised in great quantities for northern shipment and consumption, and it is then that the greatest activity exists among certain destructive pests depredating these crops. That is the time investigation should begin. However, considerable work has been accomplished, and in the following pages will be found descriptions of some of the more injurious insect pests injuring these crops; moreover, to make the report of practical value to our vegetable growers, I have given the best remedies known, extracted principally from the writings of Professors Riley, Fitch, Lintner, Packard, Forbes, Thomas, &c.

INSECTS AFFECTING THE CABBAGE.

Probably there is no garden crop in Florida that is so preyed upon and so seriously threatened from the attacks of insect pests as the cabbage and its numerous varieties.

To well-known imported European insect pests, now thoroughly established here and depredating this crop, may be added many indigenous species that attack and destroy it in different ways, and the injury and loss is very great.

Necessarily I have given considerable time and study to unraveling the life histories of some of the more important ones, giving them that prominence in my report that their importance to the grower seem to warrant.

THE CABBAGE PLUSIA.

(*Plusia brassicæ* Riley.)

This is one of the most serious and destructive of cabbage insects. Prof. C. V. Riley first described it in his Second Missouri Report, 1870, page 110.

Distribution.—While, undoubtedly, originally indigenous to the Southern States, it is now very generally distributed over most of the Eastern and Western States. In U. S. Agricultural Report for 1883, Professor Riley states that he has received it from Mississippi, Georgia, Florida, the Carolinas, Alabama, Texas, New Jersey, Missouri, Kansas, Nebraska, Virginia, and Maryland.

Food Plants.—The food plants of the larvæ, as given in same report, are Cabbage, Kale, Turnip, Tomato, Mignonette (*Reseda*), Dandelion (*Taraxacum*), Dock (*Rumex*), *Crepis*, *Chenopodium*, Clover, *Seneçio scandens*, Lettuce, and Celery. Professor Riley also says: "We have also found it in Florida feeding upon the Japan Quince (*Cydonia japonica*), and it has been found in Washington upon same plant."

Life History.—The life history of this insect is treated in the Annual Report of the Department for 1883, pp. 119–122, and it is figured at Plate I, figs. 2 and 2*a*, and Plate XI, figs. 2, *a*, *b*, *c*. The different stages are described in Professor Riley's Second Missouri Entomological Report, pp. 111–112.

Number of Broods.—Professor Lintner, State Entomologist of New York, in treating of this species in his second report, page 92, says: "In its more northern extension there are two annual broods, for, from larvæ taken in August, after about two weeks of pupation, Dr. Thomas has had the moths emerge on the 1st of September, which deposited their eggs for a second brood in October. In the Southern States there are probably four broods, for Mr. Grote took examples of the moths in Alabama during the last of February."

Here in Florida there are certainly not less than six broods, for I have taken the moths every month but the winter months, November, December, and January.

Its Injuries.—Not a cabbage patch visited by me this spring and summer but was more or less damaged by the attacks of this terrible cabbage pest, and the injury it does and the loss sustained by the trucker is immense.

The very young begin by eating the fleshy portion of the leaves; as they grow in size and strength they gnaw irregular holes through the leaves, until they are completely riddled or honey-combed and the cabbage rendered thereby unmarketable.

Natural Enemies and Parasites.—Comparatively few natural enemies have been observed preying upon this insect, although carabid beetles and others are supposed to destroy it at the North.

A European chalcid fly, *Copidosoma truncatellum* Dalman, has been reported as parasitic on this species at Washington, by Mr. L. O. Howard; twenty-five hundred and twenty-eight specimens of this parasite were actually counted as coming from a single parasitized worm.

Professor Riley has also bred an ichneumon fly, *Apanteles congregatus* Say, from larvæ.

Here, in a single instance, I bred from a chrysalis an ichneumon fly (*Limneria*, sp.) a common parasite of the Cabbage Plutella, and it will be found treated further on under the parasites of that insect.

From the egg, however. I bred a pretty little chalcid fly (*Trichogramma pretiosa* Riley). It was first described by Professor Riley in Canadian Entomologist Vol. XI, page 161, from specimens bred from the eggs of the Cotton Worm (*Aletia argillacea* Hübn.).

Besides the above parasites, three larvæ were brought under my observation, attacked by the parasitic fungus (*Botrytis Rileyi* Farlow).

REMEDIES.—*Pyrethrum.*—Professor Lintner recommends pyrethrum: "A tablespoonful of good fresh powder, diffused through 2 gallons of water and sprinkled over the plants, would destroy the larvæ."

Hot Water.—Every worm visible upon the cabbages may be killed by the use of water at the temperature of 130° Fahrenheit, or 55° centigrade. The water may be boiling hot when put in the watering-can, but it will not be too hot when it reaches the cabbage leaves. The thick fleshy nature of the leaves enables them to withstand considerable heat with very little injury. The sacrifice of a few heads of cabbage will soon teach an experimenter how far he can go with the hot water. It may be sprinkled over the plants from a fine rose watering-can or poured on with the sprinkler removed. If it is very hot it will color some of the leaves, but even where the cabbage is considerably sorched it will recover and renew growth from the heat. (Prof. C. V. Riley).

Kerosene Emulsion.—The kerosene emulsion, as formulated by Mr. H. G. Hubbard for scale insects, will also be found valuable for cabbage worms.

Lime and Carbolic Powder.—This is also good. Take 20 parts superphosphate of lime, 3 parts fresh air-slaked lime, and 1 part carbolic powder; mix, and scatter a small quantity upon each cabbage head three or four times at short intervals about three days apart. The carbolic powder is made by taking sawdust and thoroughly impregnating it with carbolic acid.

THE CABBAGE PLUTELLA.

(*Plutella cruciferarum* Zeller.)

Second only in importance to the Cabbage Plusia is another cabbage worm, the "Cabbage Plutella," the larva of a small moth, and which may easily be confounded with the very young larva of the Cabbage Plusia.

This insect was treated at some length in Professor Riley's Annual Report as Entomologist to the Department for 1883, and it will therefore be unnecessary to go into detail here. I may state, however, that while at the North there are probably but two annual generations, there are at least four here in Florida. The larvæ are quite plentiful on cabbage from the last of February to July, and again in the fall. The damage done is very similar to that of the Plusia and is almost as great, although it seldom attacks other than the outer leaves.

I have bred a parasite, additional to those mentioned by Professor Riley, which agrees with the description of Cresson's *Limneria obscura.*

THE CABBAGE APHIS.

(*Aphis brassicæ* Linn.)

The Cabbage Aphis (*Aphis brassicæ*) first described by Linnæus, in his "Systema Naturæ," is quite widely spread throughout this country and Europe. It was undoubtedly imported into this country at a very early day, for Dr. Fitch shows, by reference to the Transactions of the New York State Agricultural Society for 1791, that it was already known as a cabbage pest at that early date, and at this day it has spread to most parts of the world where the cabbage is cultivated.

Food Plants—It is found on the Turnip, Raddish, Field-cress (*Isatis tinctoria*), Shepherd's-purse (*Capsella bursa-pastoris*), Charloch (*Brassica arvensis*), Cabbage, and other cruciferous plants.

Here I found it on Cabbage, Turnip, and Raddish.

ITS LIFE HISTORY.—*The Young.*—These are oval, about .01 inch in length, and of a greenish-yellow color, without the mealy coating of the older ones.

Buckton, the British authority on the Aphididæ, thus describes the different forms:

Apterous Viviparous Female.—Body long, oval; plentifully covered with a whitish mealy coat, both on the upper and under sides. When this is removed by a drop of spirits of wine the body below is grayish-green, with eight black spots ranged down each side of the back, which increase in size as they approach the tail. Antennæ green with black tips, shorter than the body. Eyes and legs black. Cornicles very short and black. Tail also small and black.

Winged Oviparous Female.—Head, neck, and thoracic lobes black. Antennæ and nectaries dark brown. Eyes black. Rest of the body yellowish-green. Abdomen with a row of fine punctures on each lateral edge, with several obscure transverse dorsal marks. Legs dusky brown, pilose. Tail dark green or brown; hairy. Cornicles short and brown, as also is the tip of the rostrum. This last organ reaches to the second coxæ. Wings rather short, with stout coarse veins and stigma.

Its Injuries.—The injuries this species does are more apparent in early spring and late fall than at any other time, for it is then that they are most plentiful, and less subject to the attacks of their numerous natural enemies.

They are found in colonies, on the upper and lower surface of the leaf; often hidden in the wrinkles and folds of the leaf, deep down at its base and on the leaf-stalk.

Buckton says: "Both the upper and under sides of the foliage of which last plant (*Brassica oleracea*) it often crowds in such numbers that the leaves become hidden by the living mass. Indeed sometimes, weight for weight, there is more animal than vegetable substance present. The leaves then become putrid, offensive in odor, and quite disgusting to the eye."

It is seldom that plants are so badly infested in Florida as described by this author, although some years ago I did see old cabbage-stalks that had been left go to seed in an old cabbage patch so affected.

Every stalk was literally covered, promiscuously piled one upon another, with living, pumping, slimy aphids, rendered such by the exuding sap of the plants. I was unable to touch a portion of the stalk without my fingers being covered with the slimy, viscid mass.

Natural Enemies and Parasites.—Fortunately, in Florida, the species has very many natural enemies and parasites which keep it from increasing very rapidly.

In Europe, too, it has several parasites. Buckton mentions a *Coruna*, a *Ceraphron*, and a *Trionyx* (*T. rapæ* Curtis) as having been bred from it in Europe; also "several species of Syrphidæ and Ichneumonidæ act effectually as checks upon the increase of *A. brassicæ*. The larvæ of the former dipterous flies, living in the midst of such plenty, soon gorge themselves and become of great size."

Trionyx rapæ Curtis has also been bred from it in this country. It was received at the Department February 27, 1880, from Norfolk, Va., and redescribed by Mr. Cresson in the Annual Report, U. S. Department Agriculture for 1879, page 260, as a new species, *Trionyx piceus*. Professor Riley bred it at Saint Louis, Mo., as early as 1871, and I have bred it here in great quantities in May, June, and July.

It is one of the principal checks in keeping this pest within bounds, and but few of the Aphids escape its sting.

But there are other parasites; and below I give descriptions of several others bred here which are apparently new and as yet undescribed.

The rearing of a parasitic Cynips from this species is quite interesting, inasmuch as the habits of but few of our species are known. Up to the present time *Allotria avenæ*, *A. tritici* Fitch, and *A. lachni* Ashm. are the only Cynipids bred from Aphids in North America.

THE CABBAGE APHIS ALLOTRIA—*Allotria brassicæ* n. sp.—FEMALE.—Length .05 inch. Black, highly polished, face and vertex of head testaceous; cheeks broad, convex; antennæ 13-jointed, long, pale yellowish-brown or yellowish towards base, becoming brownish or infuscated at tip; thorax smooth, parapsides distant; scutellum small, round, convex, with a deep transverse groove at base; wings clear, pubescent and fringed with short cilia; veins yellowish, the radial area closed; abdomen globose, with the second segment but slightly longer than the third, highly polished black, but more or less testaceous at base and at vent, and a clump of whitish hairs at base; legs honey-yellow; in dry specimens tawny-yellow.

MALE.—The male is of the same size or slightly smaller than the female, and is easily recognized by the 14-jointed antennæ; the third, fourth, and fifth joints almost equal in length, and all are excised outwardly; the testaceous spot on vertex of head is not so apparent; the pleura are more or less testaceous and the abdomen is ovate.

Described from several specimens bred from June 6th to July 15th.

THE CABBAGE APHIS PACHYNEURON—*Pachyneuron aphidivora* n. sp.—FEMALE.—Length .04 to .05 inch. Head metallic green suffused with purple and purplish black on vertex; shagreened, the sculpture coarser beneath eyes; mandibles large, tridentate; eyes purplish-brown; antennæ brown, pubescent, scape and pedicel darker; thorax purplish-black with bronzy and cupreous reflection, finely reticulately sculptured; scapulæ, golden green; scutellum prominent, convex, rounded; metathorax finely wrinkled; abdomen flat, oval, blue-black, metallic at base and with bronze tingings towards apex, darker beneath; wings hyaline, iridescent, pubescent excepting at base; veins pale yellow, the thickened marginal vein brownish, the stigmal slightly longer than marginal; along outer edge are seven long hairs; legs pale yellowish, coxæ black, anterior and middle femora d usky near base and along upper and lower surface, at least two-thirds their length.

Described from several specimens bred June 6th.

THE CABBAGE APHIS ENCYRTID—*Encyrtus aphidiphagus* n. sp.—FEMALE.—Length .06 inch. Blue-black. Head shagreened, face and mouth parts blue, the facial impression is very deep, eyes brown; ocelli region greenish; antennæ brown; thorax shagreened in wavy curved rugosities, hind margin metallic green; abdomen bronzed, blue-black; wings hyaline, marginal vein short; legs honey-yellow, all femora brown except at tips, a large brown blotch near base of tibiæ, terminal tarsal joints dusky.

Near *Encyrtus sublestus* Howard but the color of the legs will at once distinguish it. Described from several specimens.

THE CABBAGE APHIS SYRPHUS FLY—*Allograpta obliqua* Say.—The larva or maggot of this fly has been taken feeding on the "Cabbage Aphis," and below I give description of its various preparatory stages:

The Egg.—Pearly white, long oval; .03 inch in length, deposited on the leaves among the Aphids.

The Maggot.—It is difficult to distinguish this from many other Syrphid larvæ. The full grown larva measures .25 inch in length, cylindrical, tapering anteriorly to point; it is perfectly smooth, a translucent green, and the viscera are plainly discernible, variously shaded, dark green, yellowish or brownish; the jaws are black; the air vessels, which are visible on either side through the body walls, become contiguous on last segment, where they are connected externally with two small warty spiracles.

The Puparium.—The puparium into which the maggot transforms resembles a cone, with the side attached to the leaf, flattened and held in place by a viscid substance secreted by the larva; its anterior end broad and well rounded, gradually narrowing posteriorly; at the end are still to be seen the two warty tubercles. Color yellow-brown, with occasionally darker shadings.

From the puparium of this fly I have bred the following parasite:

THE SYRPHUS FLY PACHYNEURON—*Pachyneuron allograptae* n. sp.—FEMALE.—Length .08 inch. Black, rather coarsly punctate, with a slight metallic luster. Head large, face and cheeks full; eyes brown; antennæ brown, scape rufous; legs tawny yellow, a large brown blotch on fore and middle femora, while the hind femora are almost entirely brown; abdomen flattened, oval, shiny black; wings hyaline, veins pale brown; the bristles on submarginal vein are not long and are difficult to count.

MALE.—Length .0[illegible] inch, otherwise similar to female.

Described from several specimens. The large size of this species and color of legs will distinguish it from others in our fauna.

Besides the above parasites there is a small Coccinellid that preys on the Cabbage Aphis, viz, *Scymnus cervicalis.*

OTHER INSECTS FOUND ON CABBAGE IN FLORIDA.

A Centipede (*Julus multistriatus*) Say, a Cricket (*Tridactylus minutus* Scudder), the Southern Cabbage Butterfly (*Pieris protodice* Boisd.), the Large Cabbage Butterfly (*Pieris monuste* L.), the Cabbage Mamestra (*Mamestra chenopodii* Albin.), the Zebra Cabbage Worm (*Ceramica picta* Harris), the Cabbage Pionea (*Pionea rimosalis* Guen.), the Cauliflower Botis (*Botis repetitalis* Grote), the Harlequin Cabbage Bug (*Murgantia histrionica* Hahn.), and others.

INSECTS AFFECTING CORN.

The lateness of the season at which I began my investigations precluded me from studying insects depredating this crop in its earlier growth; consequently nothing can be reported of the cut-worms and borers that do so much injury to this crop in early spring.

THE CORN WORM.

(*Heliothis armigera* Hübn.)

This well-known insect has been very plentiful and injurious in Florida during the past season. Not a field of corn was free from its attacks, and but few perfect ears could be found that were not bored into by this pest.

From ears taken from a field near Jacksonville I obtained from eight to a dozen worms in each ear, and out of the whole patch hardly an ear could be found that had less than two or three worms in it.

The insect is treated in full in the Fourth Report of the U. S. Entomological Commission, and a repetition of its life-history, habits, and remedies are unnecessary here.

Its Injuries.—Enormous injuries are committed by this worm, whole fields of corn being almost entirely destroyed by it. The eggs are laid on the leaves, and the young larvæ, which hatch therefrom, begin by eating the leaves, but they soon leave these and bore into the tender ears, gnawing and eating them in all directions, so that frequently hardly a perfect ear can be found. At times it is also found at the base of the tassel, feeding on the accumulated saccharine juice, found there, just before the tassel emerges from its sheath.

The worms will not only gnaw irregular burrows and feed on corn while in the milk, but the mature larvæ are known at times to continue feeding on mature hard corn.

I have taken on corn two hemiptera or bugs which probably prey on the worm, although not detected in the act—the Wheel Bug (*Prionidus cristatus* L.) and *Euschistus servus* Say. From the egg I bred *Trichogramma pretiosa* Riley, already noticed; but no other parasite has been bred from it by me.

THE CORN MINING FLY.

(*Diastata* sp?)

A mining fly larva is quite frequently met with, making long irregular mines on corn leaves, and while I have not been able to rear the perfect fly, yet I am satisfied it is the same species mentioned by Prof. Comstock, in U. S. Agricultural Report for 1880, page 245, as *Diastata* sp. Several specimens of a parasite, agreeing tolerably well with Mr. Howard's *Entedon diastatæ*, reared from it at the North, were also bred from it here.

MISCELLANEOUS CORN INSECTS.

A Hemipteron (*Oebalus pugnax* Fabr.) was found in considerable numbers feeding on corn pollen, along with a Capsid and several flies. A fly (*Ortalis* sp.) is common on the stalk, but was not observed to do any injury. A common beetle (*Allorhina nitida* Linn.) was taken, with head immersed in the ear, feeding on corn while in the milk.

OTHER INSECTS INJURING CORN IN FLORIDA.

The following insects also injure corn here: The Corn-stalk Borer (*Diatræa saccharalis* Fabr.); the Corn Bill-bug (*Sphenophorus robustus* Horn.), and the Angoumois moth (*Gelechia cerealella*) and several Cut Worms. From the tassels I have taken the larvæ of *Nola sorghiella* Riley, and in the crib the Corn Weevil (*Calandra granaria*).

INSECTS AFFECTING THE TOMATO.

The cultivation of the Tomato for Northern markets is a rapidly growing industry in Florida, particularly in the southern portions of our State; and thousands of boxes are now forwarded by our growers to Northern commission men every season.

It behooves us, therefore, to keep a watchful eye on the insect depredators of this fruit, for we may naturally expect, with the extension of any horticultural industry, a corresponding increase of insect pests.

Fortunately, no serious damage done this plant by insects has been reported this season, and, while I have been unable to visit West and

South Florida, the sections in which the Tomato is more extensively cultivated, yet studies on insects infesting it in gardens near Jacksonville will, I feel assured, prove of interest.

THE TOMATO WORM.

(*Sphinx Carolina* Linn.)

This is a well-known insect, common in all tomato patches, although the moth into which it transforms is seldom seen, and remains totally unknown to the great majority of our farmers. When you tell them that the worm will change into a large moth, nine times out of ten they express surprise and think it a most wonderful piece of information.

Distribution.—It is quite generally distributed throughout the United States, Mexico, the West Indies, and is not uncommon in South America.

Food Plants.—It feeds on Tomato, Potato, Jimpson weed (*Datura stramonium*), Egg-Plant, Tobacco, and other plants. I took specimens the past season feeding on Poke-berry (*Rivina lœvis*).

ITS LIFE HISTORY.—*The Egg.*—The egg is spherical, perfectly smooth, and green or yellowish-green in color; diameter about .05 inch.

The Larva.—When full grown it measures over three inches in length. The head and body are dark green, interspersed with greenish-white dots; it is transversely wrinkled; oblique white or greenish-white lateral bands extend from dorsum to spiracles, edged above with bluish and short transverse black lines. The spiracles, excepting the first and last, are blackish, with a yellow dot above and below, all edged with blue, the first and last orange yellow. The shield and terminal prolegs edged below with yellow; the caudal horn is reddish-brown towards tip, and the feet are white, edged with black.

The Pupa.—Length one inch and a half. Dark reddish-brown, with coarse punctures on abdominal segments, and a detached cylindrical thick tongue-case, not quite reaching to tip of abdomen.

The moth is a mottled gray species, with orange spots along the body, and has too often been figured and described to need description here.

Its Injuries.—When plentiful the injury done is considerable, and great care should be taken to remove and destroy them. They eat the leaves and tenderer and terminal shoots, frequently stripping the plant bare, whereby the plant is unable to breathe or mature fruit.

Natural Enemies and Parasites.—I have observed a species of Wasp carrying off the young worms to provision its nest. It is also probable that the Microgaster and Blacas that attack its nearest ally (*Sphinx 5-maculata*) will be found parasitizing this worm.

A Tachina fly, a species of *Mascicera*, has been bred from it in the North by Prof. Riley (Fourth Missouri Entomological Report, page 129). In June I bred from its eggs *Trichogramma pretiosa* Riley, a general egg parasite already noticed, and a species of *Teleas*. Of the former three to six specimens issued from each egg; from the latter two to four.

I submit a description of the Teleas, which is apparently new:

THE SPHINX EGG TELEAS—*Teleas sphingis* n. sp.—Length, .04 inch. Black, smooth, and polished. Head large, much broader than thorax; antennæ 12-jointed, dark brown, sparsely pubescent, the scape barely reaching to the head; pedicel much stouter and larger than first funicle joint, which is small; other joints slightly increase in size to club, which enlarges and widens considerably, and comprises five joints; the antennæ in male are more flagellate. The thorax is ovate, smooth, convex, and sparsely covered with microscopical pubescence.

Under a very high power the head and thorax show a microscopical reticulated scratched surface.

No parapsidal grooves; the scutellum is separated by a deep groove at base and has some wrinkled ridges; metathorax rugose. The abdomen is very flat ovate, and somewhat carinate laterally; on first segment there are three deep transverse, punctate grooves, and the second segment occupies most of the upper surface; surrounding the tip are a few hairs.

Legs clavate; femora and coxæ black or very dark brown; tibiæ brown, with tips; tarsi and trochanters yellowish or tawny; wings hyaline, hairy, and with a distinct, rather long, stigmal vein.

Described from numerous specimens bred in July.

Remedy.—For destroying this worm no better method need be wanted than hand-picking.

The worms are large and conspicuous, easily seen, and no difficulty will attend their destruction. The best time for searching for them is in the early morning and evening; during the middle of the day the majority of them will be found hidden under trash and in the ground at the foot of the vine.

THE TOMATO-STALK BORER.

(*Gortyna nitela* Guen.)

This insect is comparatively rare in Florida, although I have noticed it several times the present season. It has been so often treated in the reports and in popular articles as to need no extended notice here.

THE TOMATO APHIS.

(*Megoura solani* Thomas.)

In some cases brought under my observation this year, this Aphid did considerable damage to tomato vines, particularly in the early spring.

Distribution.—It is pretty generally distributed throughout the United States, although it has not been reported, that I am aware of, west of the Rocky Mountains.

Its Natural History.—Prof. Cyrus Thomas described the species in the Eighth Illinois Report as follows:

Winged Female.—Antennæ 7-jointed, a little longer than the body; first and second joints short; third and seventh longest, nearly equal; fourth a little shorter than the third; the fifth not quite as long as the fourth; sixth about half or less than half the length of the fifth; tubercles prominent. Honey tubes extending beyond the abdomen, excessively enlarged in the middle, and expanding at the tip in trumpet shape. Tail of moderate length, about one-third as long as the honey tubes, conical. Wings as usual in *Siphonophora;* fourth vein strongly and regularly curved; second fork about equally distant from apex and third vein; stigma elongate, slender and pointed, size large.

General color greenish; tail greenish-yellow at the base, darker at the tip; body greenish or pale greenish-yellow; antennæ dusky. Another winged specimen, probably a male, varies considerably from the above description; the second fork of the third vein is very short and near the apex, and in some cases absent in one wing and present in the other. Honey tubes with the enlargement less than the preceding, and carried nearer to the apex; antennæ also differ slightly in the respective length of the joints. Head and abdomen olive green; thorax and eyes black; antennæ dusky, legs pale, dark at the knees and tarsi.

Pupa.—Elongate oblong in form; very pale with a dark green stripe along the middle of the back, with apparent whitish powder speckled sparsely over the body. Head whitish; base of antennæ greenish-white, rest pale fuscous, dark at the tip of the joints and at the tip of the antennæ; eyes brown; femora greenish-white; tibiæ fuscous; tarsi darker. Honey tubes long, slender, pale at base and dusky at the tip. Tail short, conical, greenish.

The summer broods of this species are viviparous, but there must be a fall sexual brood, containing oviparous females which deposit eggs, from which hatch the early spring broods.

Its Injuries.—This species was first detected in the garden of Col. L. W. Spratt.

The Colonel drew my attention to some sickly tomato vines and showed me others that had died and asked me what was the matter with them. An examination revealed the Aphids along the stem stalk and on some of the leaves, and I feel convinced that these little creatures were the cause of the trouble. Their puncture has a blistering and blighting effect on the vine, and the leaves curl and wither.

Natural Enemies and Parasites.—I detected the larvæ of a Lace-wing (*Hemerobius*) and certain Scymni feeding upon them; also bred from them two internal parasites as follows:

TOMATO APHIS ALLOTRIA—*Allotria megouræ* n. sp.—FEMALE.—Length .03 inch. Black, shining. Face testaceous; antennæ long, 13-jointed, subfiliform, dark honey-yellow, infuscated from two-thirds its length to tip; thorax smooth, shining; scutellum oval, convex; abdomen globose, slightly testaceous in certain lights; legs dark honey-yellow; wings hyaline, ciliated, veins yellowish.

Described from one specimen bred May 26th.

THE TOMATO APHIS ENCYRTID—*Encyrtus? megouræ* n. sp.—MALE AND FEMALE.—Length from .02 to .03 inch. Blue-black. Head finely punctate; eyes large with coarse facets; mouth piceous; antennæ 11-jointed, covered with short pubsecence in female, in male with two whorls of hairs on each joint; the flagellum gradually widens towards tip in female, narrower in male; scutellum slightly metallic in female, brighter in male, with some long hairs; abdomen blackish or brownish, short, stout, with long hairs at sides; wings hyaline; veins yellowish; marginal vein very short; legs yellowish, coxæ, femora except at tip, and a broad annulus on upper half of tibiæ darker.

Described from three specimens.

Remedies.—Those recommended for "Cabbage Aphis" will be just as effectual for this species.

INSECTS AFFECTING THE EGG PLANT.

The egg plant is comparatively but little cultivated in Florida, and no serious injury is done it by insect pests.

The "Tomato Worms," *Sphinx carolina* and *Sphinx 5-maculata* are both found on it eating the leaves; also a Tortricid and a Tineid.

A Membracid (*Acutalis calva* Say) is found on the stalk, a Blister Beetle (*Epicauta cinerea* Först.) in blossoms, and occasionally eating the leaves; at times a small black jumping bug (*Halticus bractatus* Say) is very plentiful on both stalk and leaves, as well as *Stictocephala inermis* Fabr., and on the under surface of the leaves an Aphis.

THE EGG PLANT APHIS.

(*Siphonophora cucurbitæ* Middleton.)

Distribution.—This species was first detected on Squash vines at Carbondale, Illinois, May, 1878, by Miss Nettie Middleton, and described in Eighth Report Illinois Insects, page 67, and I know of no other reference to it. The specimens found here on Egg Plants agree perfectly with her description, and it is probably extensively distributed over the Eastern United States on various plants belonging to the Cucurbitaceæ.

I quote her original description:

Winged Specimens.—Large and green. Antennæ very long, reaching to or beyond the tip of the tail; third joint a little longer than the fourth; fourth about the same length or very slightly longer than fifth; sixth not more than one-fourth or one-third the length of the fifth; seventh longest; wings transparent; veins slender; the first fork makes a very acute angle with the third vein; second fork rather nearer the third vein than the apex; fourth vein curves sharply and approaches somewhat closely in its middle to the first fork; stigma elongate and narrow; honey tubes long, slender, and cylindrical, extending beyond the tip of the abdomen, but not to the tip of the tail, about one-fifth the length of the body; tail long, subconical, more than half the length of the honey tubes (in the wingless specimens). The form of the body in both the winged and wingless specimens is elongate and fusiform, the latter being slightly broader than the former. Length of body .10 inch, to tip of wing .18 inch, and some appear to even exceed this size; body green; head paler, more or less yellowish; thorax pale brownish or fawn colored or tinged with this color; abdomen green, with a darker green median line; first and second joints of the antennæ pale, third dark, seventh light, shades of light and dark more or less alternating; honey tubes green at base, changing to fuscous at the tip; tail greenish; eyes brown; stigma pale.

Wingless Specimen.—Green, with few markings: Body slightly broader than winged specimens, and elongate ovate; the abdomen tapering posteriorly to the elongated tail, which is elongate conical, its length more than half and almost equal to that of the honey tubes. The honey tubes are long, somewhat robust and cylindrical; they extend beyond the tip of the abdomen, although the posterior tapering segments are much drawn out, but not to the tip of the tail. In most of the specimens examined under a strong magnifying power they appear slightly and minutely wrinkled transversely, or what may perhaps better describe the appearance, pustulate or scaly. The length of body is usually rather greater than of the winged specimens. In both the antennæ and front of the head are hairy, and many of the hairs appear to be capitate.

Its Injuries.—It is only in early spring that the plant suffers much from this Aphid, and then almost any wash would destroy it; later the rains and natural enemies almost totally destroy it.

Parasites.—Enemies that are usually found destroying plant-lice—Coccinellidæ and Hemerobiidæ—were also observed associated with this species; but besides these I bred from it a parasitic Cynipid as follows:

THE EGG PLANT APHIS EUCOILA, *Eucoila siphonophoræ* n. sp.—MALE.—Length, .05 inch; dark, piceo-black; polished; in shape somewhat linear; antennæ longer than body: 15-jointed; filiform, red; third joint longest, excised; following joints long, moniliform; scutellum cupuliform; abdomen slightly compressed, with hairy girdle at base; legs red; posterior coxæ rather large, somewhat pale; wings hyaline, pubescent, and ciliate.

Described from one specimen, bred May 30.

INSECTS AFFECTING THE PEA.

There are several insects destroying the Pea in Florida, but it was too late in the season when I began my work to study them in the field, the Pea crop being about over.

Crickets, grasshoppers, beetles, and caterpillars cut and eat the leaves and pods; but by far the most destructive is a root-mining Anthomyid fly, which preys upon the roots.

Its existence is entirely unsuspected by the grower, and I hope another season will enable me to thoroughly work it up.

The maggots bore into and burrow the roots near the crown, and in a short time flourishing and luxuriant vines are killed.

Our people attribute the cause to the hot weather, and would be surprised could they see the larvæ at work.

INSECTS AFFECTING THE BEAN.

The same general remarks made in regard to insects of the Pea will apply to the Bean also, and I have only been able to work up the life history of one "Cut-worm," taken while in the act, in June.

THE BEAN CUT-WORM.

(*Telesilla cinereola* Guenée.)

The moth of this species has long been known to collectors, but the caterpillar, I believe, up to the present time, remains unidentified and undescribed.

Distribution.—Found generally spread over the United States east of the Rocky Mountains and in Canada and the West Indies. Professor Snow reports it common in Kansas; in Florida it is rare.

Its Life History.—*The Egg.*—Unknown.

The Larva.—This in shape and size very much resembles the Cabbage Worm (*Plusia brassicæ,*) and, like it, when disturbed draws itself up and has the appearance of a geometrid larva. When full grown it measures one and one-tenth of an inch in length. Pale green, with a wavy, yellow stigma line and a supra-stigma creamy white line and two pale dorsal lines, 8 transverse black warty dots on segments with two more on dorsum back of these, from all of which issue pale hairs; on either side of the dorsal black warty tubercles is an irregular yellowish line, and an indistinct yellowish oblique line extending from the outer line obliquely between the first pair of tubercles and last pair to the dorsal lines. The six true legs are pale, glassy, and there are prolegs on ninth, tenth, and anal segments. Head green, with sutural edges dark and a few hairs at sides.

The Pupa.—Length, .42 inch; greatest width, .15; wing cases, .21 inch; pale yellow brown, the fifth segment rather strongly constricted anteriorly and widest; the edges of all the segments anteriorly dark brown.

The Moth.—Wing expanse from one inch and ten-hundredths to one inch and fifteen-hundredths. The fore wings are grayish brown, with a few short, indistinct, wavy, lighter grayish lines interspersed; transversely across the fore wing near the outer margin is a light gray or slightly yellowish band.

The hind wings are uniformly gray, fringed with short cilia; beneath, silvery gray with numerous brownish gray scales at anterior margin and on fore wing.

Its Injuries.—The worm feeds on the leaves and the bean pods, sometimes stripping the vine bare.

OTHER BEAN INSECTS.

A Katydid (*Phylloptera oblongifolia* Dels.), a Butterfly larva (*Eudamus proteus* Linn.), and a Tineid are also found damaging this crop.

INSECTS AFFECTING THE SQUASH.

In Florida there are many insects found feeding on this plant; the Cucumber Flea-beetle (*Crepidodera cucumeris* Harris), the 12-spotted Diabrotica (*Diabrotica 12-punctata* Oliv.), a jumping bug (*Halticus bractatus* Say), the False Chinch (*Triphleps insidiosus* Say), a Mining Fly (*Oscinis*), and an Aphis (*Aphis cucurbitæ* Buckton) are common on the leaves and stems, but have not been observed to do much injury. The life histories of and observations concerning the more injurious are given below.

THE SQUASH BUG.

(*Anasa tristis* DeGeer).

When this bug exists in quantities probably there is no more injurious insect known to squash and pumpkin vines. The mature bug hibernates in the winter under débris, old vines, dry grass, boards, &c., and from early spring to late fall there is a continual succession of broods.

I have taken some specimens in mid-winter, on warm days, in old fields and on fences.

Distribution.—It is found generally throughout the United States and in Canada; *Anasa uhleri* Stal., found in Mexico, will probably prove to be nothing but a climatic or varietal form of this well-known insect:

ITS LIFE HISTORY—*The Egg.*—Length, .04 inch; oval, flattened on three sides, so that when viewed from either end it has a triangular appearance; in color it is dark golden bronze. To the unassisted eye it is smooth and shining, but when viewed under a high-power lens the surface is reticulated.

The Larva.—When first hatched the young bug is broadly oval, with long antennæ, the joints of which are flat, hairy; the head, thorax, and wing-scales blackish, while abdomen is a bright ocher yellow. Length, .08 inch.

Its Injuries and Food Plants.—It confines its attacks almost exclusively to the Squash and Pumpkin, although it is not improbable that other cucurbitaceous vines also suffer from it.

The bug punctures the leaves and the stem of the vine, causing them to wrinkle and wither; also the fruit.

The eggs are laid in patches, twenty or thirty together, on the upper or lower surface of the leaves, fastened to the leaf with a sticky or gluey substance, at night or just before dark, for during the day these disgusting bugs seek shelter in the ground or under trash at the base of the vine stalk.

It is curious to watch them come forth from their hiding places as the sun sinks and darkness begins to fall. Brood after brood march up the vine, led by an older one, like the different corps of an army march to the parade ground at roll call. They come from everywhere—in the ground, under grass, trash, and boards. Indeed, it is astonishing to see how soon vines will be crowded with these bugs, where but a few hours before not one could be found.

Natural Enemies and Parasites.—Birds and fowls, on account of their peculiar odor, will not feed on them, and beetles, wasps, and spiders, which attack caterpillars and other insects, shun it as a foul thing. Fortunately, however, there are parasites that prey on the egg, and thus greatly diminish it, although no author that I am aware of mentions this fact. It was therefore a surprise and a gratification for me when I bred three distinct parasites from the eggs the past summer—a Eupelmid, an Encyrtid, and a Telenomid.

THE SQUASH-BUG EGG TELENOMUS—*Telenomus anasæ* n. sp.—MALE AND FEMALE.—Black, very coarsely irregularly reticulately punctate, with white pubescence; antennæ in female clavate, 12-jointed, brown; in male flagellate, 14-jointed, pale brown; legs, pale brown or yellowish brown; coxæ, black; abdomen in female, ovate, sub-convex above, highly convex beneath, and with a light carina at sides; in male somewhat fusiform. Wings, hyaline, with a slight fuscous tinge, pubescent, the marginal vein very short, post marginal long, while the stigmal is about two-thirds as long as post marginal; all yellowish.

Described from numerous specimens bred in June and July.

About thirty per cent. of the eggs collected were parasitized by this insect.

THE SQUASH-BUG EGG ENCYRTID—*Encyrtus anasæ* n. sp.—FEMALE.—Length, .05 inch; robust; head and thorax blue-black; abdomen and tip of scutellum cupreous; the very large pleura and cheeks are decidedly blue; antennæ and legs pale brown; the scape at base and tarsi yellowish. The femora have a large bluish-black blotch in the middle.

Described from two specimens.

The Reduvius Egg Eupelmid—*Eupelmus reduvii* Howard.—Seven specimens of what I have identified as this species were bred from Anasa eggs in July.

For a description of the species see Canadian Entomologist, Vol. XII, page 207.

THE SQUASH BORER.

(*Eudioptis nitidalis* Cramer.)

The worm so commonly found with us boring into squashes, at the North goes under the name of "Pickle Worm." There it is found eating the leaves and boring into the fleshy portions of the Cucumber.

Distribution.—It is found in the West Indies, throughout the United States, and in Canada.

Food Plants.—As a borer it is found in Squash, Cucumbers, and Melons, but it will also feed on the leaves of all of these vines. The moth is very common and it must have other food plants; Guenée mentions a species of Potato as its food plant.

Its Injuries—The worms bore cylindrical holes into the Squash, and feed on the fleshy pulp, causing it to rot and decay.

Parasites.—From one of the pupæ I bred a Chalcid fly, *Chalcis ovata*, Say, but no other parasites are known to infest it.

Remedy.—Professor Riley, Second Missouri Entomological Report, p. 70, suggests "overhauling the vines early in the summer, and destroying the first worms that appear, either by feeding the infested fruit to hogs or cattle, or by killing the worms on the spot."

THE SQUASH VINE BORER.

(*Melittia ceto* Westw.).

This well known insect, unlike *Eudioptis nitidalis*, does not bore into the Squash or fruit, but into the stem of the vine, often killing it.

I have taken two or three borers at a time from a single stem, and in confinement they proved to be cannibalistic—feeding upon one another—as was exemplified with some I attempted to rear this summer.

No borers were observed in the vine until July.

Distribution.—Found generally throughout the United States.

Food Plants.—Its attacks are almost strictly confined to the Squash, although it has been reported to bore at times into Pumpkin vines.

ITS LIFE HISTORY.—*The egg.*—The egg is oval and of a dull red.

The Larva.—Full grown larvæ measure from one inch to one inch and a fourth. Somewhat depressed, fleshy, soft, tapering at each extremity; segments ten in number, very distinct, the incisions being deep; the eleventh or last segment minute, and hardly distinct from the tenth. Head retractile, small, brown, paler on the front, and with the usual V-like mark on it. First segment or collar with two oblique brown marks on the top, converging behind. A dark line, occasioned by the dorsal vessel seen through the transparent skin, along the top of the back, from the fourth to the tenth rings inclusive. True legs six, articulate, brown; prolegs wanting or replaced by double rows of hooks in pairs beneath the sixth, seventh, eighth, and ninth rings, and two single rows under the last ring. Spiracles brown. A few very short hairs on each ring, arising singly from little hard points or pit-like, warty substances.

The Pupa.—This is inclosed in a cocoon made of the squash stalk, tied together with a few silken threads.

The Moth.—The wings expand one inch and one quarter. Opaque lustrous, olive-brown; hind wings transparent, with the margin and fringes brown; antennæ greenish black, palpi pale yellow, with a little black tuft near the tip; thorax olive; abdomen deep orange, with a transverse basal black band, and a longitudinal row of five or six black spots; tibiæ and tarsi of the hind legs thickly fringed on the inside with black, and on the outside with long orange-colored hairs; spurs covered with white hairs. (Harris.)

Its Injuries.—The female moth lays an egg on the vine near the roots; the worm which hatches therefrom bores into and feeds on the soft succulent interior of the stem, particularly at its origin near the ground, and at the base of the leaves; frequently when small the worm bores even into the larger leaf-veins. It may easily be detected at work by the withering of the leaves and stem.

Parasites.—I know of no parasites bred from this borer; although I have a large, beautiful, golden green Pteromalid, captured on the vines, that may possibly prove to be its parasite; others were seen on the vine or its vicinity.

Remedies.—The following suggestions and remedies will be found useful in destroying the pest:

Cutting out the larvæ.—This method has been long in use by gardeners, and with a little practice one soon becomes quite expert in detecting and removing the larvæ.

Bisulphide of Carbon in the Ground.—Prof. C. V. Riley first suggested the use of this insecticide in destroying grape phylloxera and Prof. A. J. Cook has since used it successfully in destroying this borer. He says: "A small hole is made in the earth near the main root of the plant by the use of a walking-stick or other rod, and about a teaspoonful of the liquid poured in, when the hole is quickly filled with earth and pressed down by the foot." In every instance the insects were killed without injury to the plant.

Gas-lime.—Fresh gas-lime, liberally distributed, after the removal of the crop, will kill the larvæ within the cocoons. It is well also to follow Professor Lintner, who says: "An infested crop should not be followed by another upon the same ground."

Treatment with Saltpeter.—"Four tablespoonfuls dissolved in a pail of water, and about a quart applied to each hill where an attack was noticed and the leaves were wilting, at the time when the vines were just beginning to run nicely, effectually arrested the attack and a fine crop followed." (*Country Gentleman.*)

INSECTS AFFECTING THE MELON.

There are two insect pests which seriously damage this crop in Florida—a borer and an Aphis—both damaging the crop annually to the extent of thousands of dollars.

THE MELON BORER.

(*Eudioptis hyalinata* Linn.)

In July the melon crop (Cantaloupes and Musk-melons) is almost totally destroyed by the injuries committed by this worm. By the end of the month hardly a melon can be found that has not been bored into by this destructive pest.

Distribution.—It is a common and extensively distributed species over North America, the West Indies, and South America. Guenée also records having received it from French Guiana.

Its total annihilation is devoutly wished for by growers and lovers of good melons, and a preventive from its attacks greatly desired.

Food Plants.—In several instances I have taken the larvæ in Squash, but it is almost exclusively confined to the Melon. From two to six worms have been taken from a single nutmeg melon. Guenée states it is found in Pumpkins, Watermelons, and other cucurbitaceous plants. Now, I have never yet found a borer in Watermelons, and the statement that this worm is found in this fruit must be taken *cum grano salis.*

The Larva.—Length eight-tenths of an inch. Color translucent green or pale greenish-yellow, with the head and cervical shield yellowish; the jaws and surroundings of mouth parts black; from both sides of head issue some fine hairs; the stigmata are yellowish; the warty tubercles on the different segments are arranged as in the larva of *Eudioptus nitidalis*, its nearest ally, only they are neither so prominent nor black, but green, and the hairs issuing therefrom are very fine and almost invisible to the naked eye; the legs are the same in both species.

The Pupa.—This is long and slender, seven-twelfths of an inch in length, yellow-brown, darker, and tapering to a point at tail; the wing cases are long and rather narrow, and the antennal case is very long, projecting beyond the base of the 8th ventral segment. All the segments are well separated, microscopally rugose and wrinkled. The pupa is generally inclosed in a loosely-woven web or cocoon made by drawing a leaf together. But this is not always the case. In two instances I found the pupa loose in the soft pulp of the melon, in the juiciest portion, and it was quite lively, twisting its abdomen from side to side and wiggling about like a thing of life.

The Moth.—Wing expanse from one inch and one-sixth to a little over. The wings are translucent, pearly white, iridescent, and with a glossy brown-black border; the abdomen is also pearly white, excepting the last two segments above, which are blackish, and ends in a tuft of hairs or expanded brush, of a buff color, tipped with white and black; the head and the thorax above are brown-black, glossy; the legs are white excepting the fore-thighs and tibiæ, which are discolored above with buff-colored scales; middle tibiæ armed with two spines, one longer than the other; posterior tibiæ similarly armed, but with an additional pair in the middle, beneath.

Its Injuries.—The larvæ begin by eating the leaves, and the diet of the first brood of worms must consist almost exclusively of phyllophagous food. It is only as the melons begin to mature that the worms bore into them; for comparatively few green melons were found affected.

Of the large melons examined, from four to six worms were taken from each, and in every case where this happened the melon had reached its full growth and was undergoing the process of ripening.

This worm does not always bore directly into the interior of the fruit, sometimes confining itself to the outer rind or boring irregular galleries just beneath it; when it attacks the inner or fleshy portions it is most destructive, excavating long galleries filled with its soft excrements, in which the worm wallows and crawls backward and forward, and the fruit then soon sours and decays.

Parasites.—Two parasites were reported on the worm in the Agricultural Report for 1879. An Ichneumonid fly (*Pimpla conquisitor* Say), and a Tachina fly are represented in Plate III, Fig. 6, of said report. No parasites were bred from it by me, the majority of the pupæ in my breeding boxes having been destroyed by a small red ant.

Remedy.—See Squash Borer.

THE MELON PLANT-LOUSE

(*Aphis citrulli* Ashmead.)*

My first acquaintance with this plant-louse was made while on an entomological tour to extreme South Florida in April, 1880, on Metacombie Key, where it had completely devastated the melon patch of a Mr. Sands.

Mr. S., who was a native of the Bahamas, termed the disease "Curled Leaf," and was not aware it was caused by an insect, until I convinced him of that fact by showing him the insects through my pocket lens.

Distribution.—At times the species is very injurious to melon vines in Florida, Georgia, and places in the West. Prof. S. A. Forbes treats of this same insect under the name of "the Melon Plant-louse," (*Aphis cucumeris* n. sp.), in the Twelfth Report of the State Entomologist of Illinois, page 83. It was first briefly described by the writer in the Florida Dispatch, New Series, Vol. 1, page 241, July 7, 1882, more than a year previous to the description by Professor Forbes.†

Food Plants.—Its attacks are confined generally to the watermelon vines, although occasionally found on Squash and other Cucurbitaceæ.

In the West its habits seem to be similar. Dr. Cyrus Thomas, in

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* Synonym, *Aphis cucumeris* Forbes, Ill. Insect Rep., XII, p. 83.

† Mr. Ashmead disregards the well-known rules of zoological nomenclature in insisting upon the priority of his *A. citrulli*, as a name attached to a description published simply in the *Florida Dispatch* cannot hold. This species should be known as *A. cucumeris* Forbes.—C. V. R.

the Farmers' Review for September 2, 1880, says: "There has been great complaint among our gardeners this season in reference to a plant-louse that is doing much injury to the nutmeg and muskmelon vines, and also to the cucumber vines. In some instances they have almost entirely destroyed the entire fields of vines."

ITS NATURAL HISTORY.—*Very Young.*—Length, .02 inch; greenish yellow; eyes, brown; tips of honey tubes brown; legs pale.

Wingless Female.—Length, .04 inch; yellow; eyes dark brown; honey tubes slightly conical, black; cauda distinct, dark green; legs pale; extreme tips of tibiæ and tarsi black.

Winged Females.—Length, .05 inch, ovate; head and thorax shining black, sometimes with the prothoracic segment green or yellowish; the antennæ are dark and do not reach the honey tubes; abdomen dark-greenish yellow, spotted along sides; honey tubes black, thickest at base, gradually tapering to tip; cauda distinct, greenish yellow or dark green; wings hyaline, with stigma and veins pale yellowish; legs pale, with tarsi and extreme tips of tibiæ and femora black.

Its Injuries.—The viviparous female breeds very rapidly and is soon surrounded by young in various stages of growth. In a brief time these reach maturity, wander off to new leaves and shoots, and begin colonies of their own. When these lice become too numerous they exhaust the vitality of the vine, distort the leaves and cause them to curl up and wither. The growing terminal shoots are also crowded with them, and then the vine can make no headway; it is fruitless and dies.

It is one of the most destructive plant-lice. To illustrate its destructiveness I cannot do better than quote from an article I wrote in Florida Dispatch, July 27, 1882, after investigating its injuries in Georgia:

Some figures here in regard to the damage done by the "Watermelon Aphis" will not be amiss, and will show our planters the necessity for prompt and united efforts in its destruction.

In Georgia the estimated yield of the watermelon crop this year (1882) for shipment was 900 car-loads, or 900,000 melons. Many at the beginning of the season bring $40 and $50 per hundred. However, to keep within a fair valuation and rather below the true amount, we will say they bring $25 per hundred, which equals, in round numbers, for the crop $225,000. Now, what has been the yield? The shipments are nearly over, and they have not yet reached 600 car-loads, a falling off of 33⅓ per cent., or a total loss of $75,000, due mainly to the ravages of an insect!

The above statistics of loss are founded upon data of the estimate yield for but three counties, principally Thomas, Brooks, and Lowndes, in Georgia. In Florida the crop has from the same cause met with a loss still greater, and we are considerably below the estimate when we say the total loss to the planters of the two States is not less than $150,000.

Natural Enemies and Parasites.—These have not been specially studied, but the enemies and parasites will be found to be similar to those of the "Cabbage Aphis"—flies belonging to the family Syrphidæ, the Lace-wings (*Chrysopidæ*), Chalcid flies (*Chalcididæ,*) and Lady-birds (*Coccinellidæ.*)

Remedies.—An important help in their destruction, and to which the planters' especial attention is requested, and which is equally applicable to other crops, is the following, which, if universally carried out, would materially assist in the destruction of all noxious and destructive insect pests:

Never plant watermelons two successive years in the same field. Plant always in an entirely new field and as far off as possible from ground in which they were grown the previous year.

My reason for recommending this is obvious on account of the peculiarity in the development and propagation of the Aphididæ. The spring and summer broods in the majority of the species are viviparous, while the fall brood of females are oviparous. The last, therefore, lay the eggs, which lie dormant in the ground all winter and hatch with the first warm breath of spring; now, then, if this field is plowed up and other crops planted, the young aphids have nothing to feed on and so perish.

My observation on this species, too, has been, that it is only troublesome in fields planted in melons two or three years in succession; new melon fields are not affected by it, or to such a small extent as to be unnoticeable.

Spraying with a dilute emulsion of kerosene will doubtless prove an effectual remedy as with other plant-lice. The emulsion should be sprayed from the ground up so as to reach the under sides of the leaves, Professor Riley has figured and described devices for this method of spraying in his report as entomologist to the Department for 1883, pp. 136–138, and Plates IV and V.

REPORT ON BUFFALO-GNATS.

By F. M. Webster, *Special Agent.*

LETTER OF TRANSMITTAL.

Lafayette, Ind., *April* 30, 1886.

Sir: I herewith transmit a report of my investigations of the habits of the Southern Buffalo-gnat.

In accordance with your instructions I left my home in La Fayette, Indiana, on February 18, reaching Vicksburg, Mississippi, on the 20th. Learning here that these gnats appeared every season in greater or less numbers in the vicinity of Somerset Landing, Tensas Parish, Louisiana, in company with Mr. T. C. Bedford, of Vicksburg, one of the leasers of Somerset Plantation, I left for that locality on the 22d, reaching our destination on the same day.

On the 23d, the weather being very pleasant, the day was spent in riding about among the teams at work on the plantation, in the hopes of observing some of the earliest appearing gnats.

During the afternoon swarms of a species of *Anthomyia* were observed in the air, and I was informed that these were the insects that killed cattle and mules. The following day was both cold and rainy, and, in fact, during the two weeks following there were but two days of sunshine.

During this inclement weather the lakes and bayous about Somerset were carefully examined, no trace of the true gnat being found. In the meantime larvæ of *Anthomyia* were found in considerable abundance about decayed logs and among decayed leaves in the woods, and, as the planters to whom I applied for information almost unanimously agreed that these adult *Anthomyia* were the depredators, it really seemed that the term Buffalo-gnat here might, like the Tent-worm and the Weevil in other localities, include a variety of insects.

Wishing to make the best possible use of time, I utilized the bad weather also by visiting our correspondent, Mr. Robert E. Craig, at Luna Landing, Chicot County, Arkansas, spending a few days there, and at Greenville, Miss., returning to Somerset March 8.

The 9th and 10th being pleasant, the *Anthomyia* again appeared, but, although very demonstrative, none were observed to alight upon the teams at work. This fact led to the impression that my information had been incorrect, and that I was on the wrong track. This proved true, for during my entire stay I never saw one of these *Anthomyia* alight on stock.

On the 11th word came that mules were being harassed by gnats on a plantation six miles to the northwest, and, on the following day, I rode out to that locality and found the true gnat in considerable numbers.

Four days were now spent in a fruitless search for the adolescent stages in the bayous and ditches adjacent to the locality where the adults had now appeared, and as many more were lost on account of bad weather.

During this time, and up to noon of the 20th, no adult gnats had appeared on the Somerset plantation. A strong northwest wind had, however, set in during the morning, and by evening the gnats were quite abundant. The next day (Sunday) the wind blew still stronger from the same quarter, and Monday morning, the 22d, found them abundant enough to cause some considerable uneasiness among the teams at work.

Fully satisfied now that these gnats did not breed in the vicinity of Somerset, I started out on horseback, and after riding for about eight miles toward the northwest reached a small stream known as Mill Bayou. Following this down stream, through the woods, the current soon became quite rapid, the banks being more or less grown up with brush and bushes, to below the water's edge. The gnats, too, whose numbers had been continually increasing, now became numerous enough to worry my horse considerably.

Finding that little could be accomplished in the way of inspecting the stream without a boat, and it being too late in the day to procure one, I returned to Somerset.

On the next day, the 23d, procuring a dugout, a thorough examination was made, not only of Mill Bayou, but of two others, tributaries to it, one of which had no perceptible current, the result being that where there was no current no larvæ of gnats could be found. As the current became sluggish a few were observed, the number increasing in proportion to its rapidity, reaching the maximum in numbers in the swiftest current of Mill Bayou; always provided, however, there was sufficient material to which to attach themselves. Thus, the larvæ would occur abundantly on one side of the stream, where a bend caused it to run very swiftly, while on the opposite side, in comparatively still water, few could be found.

Upon inquiry and personal investigation, this bayou was found to be receiving water from the Mississippi River through Lake Palmyra and Bayou Vidal, and also that its water rose and fell with that of the river itself, until the height of the latter fell below 25 feet on the gauge at Vicksburg.

It now seemed quite important to learn to what extent, if any, the other inland bayous were influenced in this manner, and, as the country is of difficult access, I thought best to visit our correspondent, Judge A. A. Gunby, of Monroe, Louisiana, whose circuit I knew comprised the entire infested territory of the northwestern portion of the State, and whom, I learned, was then at home on a short vacation.

Leaving Somerset on the 25th, and returning again on the 31st, I was, by this journey, enabled not only to obtain much valuable information from Judge Gunby, but also to examine the Washita River, and also, but very superficially, on account of recent heavy rains, the country between it and the Mississippi River.

Finishing my labors at Somerset on the 7th of April, I bade a final adieu to the country and turned homeward.

To Maj. T. C. Bedford, of Vicksburg, and Mr. J. B. O'Kelley, of Somerset Landing, I am under very many obligations. From first to last—and I made the latter gentleman's home my headquarters for over a month—both left nothing undone that could aid me in my work, or make my stay pleasant.

To Judge F. H. Faner, of Bayou Sara, Judge E. D. Faner, and other gentlemen of Vicksburg, to General Furgerson, of the Mississippi Loan Board, Judge Gunby, and Messrs. Robert E. Craig and John M. Lee, I am under obligations for both personal courtesies and aid in my investigations.

And lastly, I have had your own kindly advice and counsel, the more valuable from your personal knowledge of the country and of the insect.

Respectfully,

F. M. WEBSTER.

Dr. C. V. RILEY,
Entomologist.

There is no authentic record of the occurrence of the Southern Buffalo-gnat in Louisiana prior to the year 1850, when there seems to have been some complaint of their harassing domestic animals, but no fatality is known to have resulted. A vague rumor exists to the effect that they had previously appeared in 1846; but this lacks confirmation. The earliest record I have been able to obtain of stock being killed by gnats was related to me by Mr. Jacob Alexander, present mayor of Greenville, Miss., who states that he observed cattle being killed by gnats at Clarendon, Ark., in the spring of 1859.

A colored man, formerly an overseer, states that mules were killed by gnats near Refuge, Miss., in 1861 and 1862. General Furgerson, who came to Greenville, Miss., in 1862, with a battery of Confederate artillery, states that gnats were exceedingly troublesome to horses and mules during the spring of that year. They were also observed in Concordia Parish, Louisiana, during the spring of 1862.

In 1863 and 1864 the gnats were very abundant about Shreveport, La., and also Chicot County, Arkansas. No trouble is reported during 1865, but in 1866 the alluvial country between the Arkansas and Red Rivers lying east of the Washita was literally overrun with the pests. Mr. T. S. Coons, an intelligent planter living at the time near New Carthage, Tensas Parish, Louisiana, preserved a written memorandum made at the time the gnats first appeared.

From this record we learn that up to the afternoon of April 11 no gnats had been observed, but towards evening they came in hordes, settling upon and biting the mules and horses and throwing them into the greatest agony. Of 6 mules and 2 horses belonging to Mr. Coons, all of which were as well as usual on the morning of the 11th, the morning of the 12th found only one mule alive. In the meantime, a neighboring planter had lost 30 mules, and Mr. Douglas, on Somerset plantation, a few miles below, had lost 75 mules.

The mortality throughout the parishes of Madison, Tensas, and Concordia, within a few days, amounted to upwards of 4,000 mules and horses, principally the former.

Although frequently causing more or less trouble and loss, the gnats did not again appear, generally, and in such countless myriads until 1882, although they caused serious injury in Tensas Parish in 1873 and 1874, and doubtless in other localities also.

But in 1882 they were more destructive to stock than ever before. The deer were driven from the woods, and frequently took refuge from their tormenters in the smokes, built by planters for the protection of their cattle; when in their agony they would allow people to rub the gnats from their bodies, and would even lay down in the glowing embers, or hot ashes, in their frantic endeavors to seek relief.

In 1884 the gnats again appeared in great numbers, and were fully as destructive as in 1882. Throughout Franklin Parish, Louisiana, within a week from their first appearance, they had caused the death of 3,200 head of stock. And for the first time in the history of the pest, they attacked horses and mules on the streets, and in the stables, in the city of Vicksburg, Miss.

No general outbreak took place in 1885, yet they appeared in Tensas and Franklin Parishes in sufficient numbers to kill quite a number of mules.

During the present season, although the gnats appeared pretty generally throughout the country between the mouth of the Arkansas and that of the Red River, and westward to the Washita, and along the Yazoo River in Mississippi, no fatality to stock had been reported up to April 10, and there had been little or no suspension of work on plantations on account of gnats.

Generally speaking, the Southern Buffalo-gnat may be said to infest the low, flat, wooded country adjacent to the Mississippi River and its tributaries, from the mouth of the Red River in Louisiana as far north at least as Southern Missouri.

I have found nothing to indicate that these gnats originate in large streams, or even in small ones in hilly localities, although the latter may have both a swift current and a rocky bed. The fact of adult gnats occurring in such localities, even in destructive numbers, is not of itself sufficient proof of their having originated there, as they may be carried long distances, and in immense numbers, by a strong wind. Furthermore, I have found no indication of their origin in other than perennial streams, although many intermittent bayous and small lakes were closely examined with this point in view.

From the foregoing, we are forced to the conclusion that these gnats follow the tendency of others of the genus, and breed exclusively in the running water of small streams. But besides this, there is another equally essential element, viz, something to which the insect can attach itself during the adolescent stages. As no rocks are found in these bayous and small streams, we find the larvæ utilizing wholly or partly submerged stumps, brush, bushes, or any other material of like nature, clustering upon or making their way upward and downward with a looping gait, or attached by a minute thread-like spider web, they sway with the ripples at or near the surface of the water, often half a dozen being attached by a single thread. While these larvæ make their way up and down these submerged objects with perfect freedom, they do not venture above the water, and when about to pupate select a situation well down toward the bottom of the stream. In deep water they were found 8 to 10 feet below the surface, and also much higher up. But in shallow water they may be found in the pupal stage, clustered, one above the other, just above the bottom of the stream, their instinct having evidently taught them to provide for a sudden fall in the water. Notwithstanding this, with the water falling at the rate of 1 foot per day, I found many pupæ had been left high and dry.

These pupæ are at first of a light brown color, afterwards changing to a pinkish cast, and, just previous to the emerging of the adult, to black. During the first of these coloral epochs they are attached to these vegetable substances by the thoracic filaments, by threads about the body and at the anal extremity, somewhat after the manner of some Lepidopterous chrysalids; but during the last two the pupæ hang by the short anal attachment alone, and in this way swing about freely in the current, the adult issuing from beneath the water after the manner of others of the genus.

The time and exact place of oviposition as well as the exact length of time required for the insect to pass through either the larval or the pupal stage I was unable to determine. But when I left Mill Bayou, on March 24, the larvæ were nearly all of a uniform size and probably nearly full grown, a few only being one-fourth to one-half as large. On returning, on April 1, nearly all larvæ had passed the pupa stage, and the adults had emerged; all of those larvæ now remaining being as large as the majority were on March 24. This, besides indicating that the breeding season was nearly ended, also leaves some grounds for the inference that several broods may be thrown off, during early spring, in rapid succession; some strength being added to this theory by the fact that, as I now learned from those residing near this bayou, the cattle had been driven from the woods in the vicinity of the stream about the 20th of February. These are points which the necessarily limited period during which I had the adolescent stages under consideration, and the sudden, and to me rather unexpected, termination of the breeding season, prevented my settling.

The adult gnats are usually observed in the vicinity of places where they breed, during the first warm days of spring, and they remain from ten days to three or four weeks, seeming to prefer a moderately cool temperature; and hence, during warm weather, are more numerous in the early morning and towards evening, frequently being as troublesome during bright moonlight nights as during the day time. They are said to spend the night among grass and like herbage. They are exceedingly active, and no sooner have they gained a foothold on an animal than they are busy at their bloody work, selecting the breast, flanks, ears, nose, or wherever the skin is the most easily punctured.

Very inconspicuous in their flight, making little noise, seldom arising more than a few feet from the ground, they often bite mules working in the fields, sufficiently to cause death before their presence in considerable numbers has been discovered. This will, perhaps, account for the prevailing notion that the bite of these gnats first appearing is the most poisonous, for inclement weather and adverse winds may cause them to appear, for the first, at any time during the breeding season, in localities where they do not actually originate, and, as will be shown farther on, the same wind that holds them back from one locality may convey them to another. It would appear as rather more probable, however, that the poison introduced into the animals' system by the bites of the first gnats, unless sufficient to prove fatal, may to some extent serve as an antidote for that introduced by those appearing later; and should this poison remain in the system with considerable stability, the fact would also account for acclimated stock being less susceptible to poison from the bites of these gnats than those unacclimated. Except in the case of great numbers, death does not necessarily follow the bite of these gnats, and even then it is not suddenly fatal. Mules that at night do not appear to be seriously injured will often be found dead next morning.

Stock, and mules especially, that have been fatally bitten by gnats are affected in much the same manner as with colic, and, in fact, many think the bites bring on that disease. But Dr. Warren King, of Vicksburg, who has made a large number of *post mortem* examinations, states that he has never been able to obtain any facts which would justify such a conclusion.

Dr. King opines that the effects of these bites from gnats are on animals much the same as that of the rattlesnake on the human system; and this seems to be the generally accepted opinion among the more intelligent planters.

In regard to artificial methods of counteracting the poison of gnats, there is of course no end, apropos to which, one planter remarks that if the gnats failed to kill the mule the remedies used certainly would. Be this as it may, I could learn of no measures that had been generally tested and proved effective, and no opportunity was offered me to make any experiments in that direction.

Dr. King recommends rubbing the affected animal thoroughly with water of ammonia, and administering internally a mixture of 40 to 50 grains of carbonate of ammonia to one pint of whisky, repeating the dose every three or four hours until relieved. The doctor claims to have never lost an animal under this treatment, although they were sometimes apparently beyond recovery. This measure I do not think is generally known, but it certainly contains sufficient merit to warrant a thorough and careful trial. Various external applications, such as decoctions of Alder leaves, tobacco, pennyroyal and other herbs, have been tried with a view of preventing gnats from biting mules while at work, but all of these have proven ineffective. A mixture known as Gnat Oil is now the chief protection, but this is apt to remove the hair and is considered injurious to the mules. Fish-oil, and also a mixture of Kerosene and Axle-grease, are both useful, but none of these can be used to advantage on stock running at large.

Smokes made about the fields serve as a partial protection, both to teams at work and stock in pasture. Smoldering fires of cotton seed are also made in tin cans and like objects, and these are hung about the teams at work.

While these protective agencies are of considerable service when there are comparatively few gnats, they are of little value in seasons of great abundance, for then stock can only be protected by placing them in dark stables, the gnats having a great aversion to entering dark places. I am told that to look for relief from simply killing the gnats would be worse than hopeless, for, though millions were destroyed, they would not be missed.

Judging from the results of some experiments made with insecticides by myself upon larvæ of the gnats, it will be nearly if not quite impossible to reduce their numbers by killing them in the streams.

These experiments were made by confining the larvæ in glass tubes and submitting them to a current of the decoctions or solutions indicated below.

Larvæ remained in a decoction of China berries for half an hour without apparent effect, and the same larvæ immediately withstood a brine of salt water, composed of a heaping handful of salt to seven quarts of water, for twenty minutes, and still remained alive. Lime-water and sulphur and water had no effect. Strong tar-water killed them, but diluted it proved harmless. Kerosene emulsion, diluted to contain 5 per cent. kerosene, was effective, but it would be impossible to get a strength of even 1 per cent. in the stream. About an ounce of Bisulphide of Carbon was placed in seven quarts of water, but half an hour in this failed to affect the larvæ. About three ounces was placed in same amount of water, and this proved fatal within ten minutes.

From this it will be seen that while the larvæ are susceptible to ordinary insecticides, it will be next to impossible to place a sufficient amount in a stream to affect them. At the time, too, when remedial measures are the most needed these streams are swollen, and are often from ten to twenty yards wide and half as deep. Besides, both men and beasts are dependent upon these streams for their water-supply, and cutting this off by introducing poisons would cause almost as much trouble as the gnats.

Notwithstanding all attempts to combat this pest have so far been discouraging, there is yet some hope of relief, and that, too, from quarters little expected, by myself at least, when these investigations began.

But, in order to fully understand the matter, it will be necessary to bring together, not only chronological data relating to the insect in question, but to the height of water in the large streams during the past thirty-five or forty years. Also, we must understand something of the nature of the country which these gnats inhabit, as well as the elements necessary to their production. And not only must these facts be weighed independently, but very carefully with relation to each other, for it is more than probable that it is through a combination of circumstances that the pest holds its sway.

A very noticeable feature connected with the occurrence of the Buffalo-gnat is, that below the Arkansas River there is no record of any fatality to stock, attributable to gnats, previous to the outbreak of the war, even in seasons of high water. But since that time the two have occurred in connection with such regularity that the fact has been noted by even the most unobserving; that is, in season of low water during the first three or four months of the year, there have been few gnats, but with high water during these months they were abundant, reaching the maximum during an overflow.

The banks of the rivers of this alluvial district are peculiar, in that the country slopes from instead of toward the streams. Hence water, escaping through the banks first runs inland, and then more or less parallel with the parent stream, until it can empty its waters into a larger tributary. Of this characteristic of the Mississippi, Red, and Yazoo Rivers, whether considered individually or collectively, I do not think it would be too much to say that it is one of the primary causes of the production of the gnats in such destructive numbers.

My own observations were almost wholly confined to the country lying between the Arkansas and Red Rivers on the one hand and between the Mississippi and Washita on the other. This section is of difficult access, and I have relied for my information principally upon civil engineers and other people familiar with topography of the country, as my own time was largely occupied in studying the gnats themselves in Tensas Parish.

With the exception of a low, wide ridge of country lying between Bœuf River and Bayou Mason, and extending from Franklin Parish to Southern Arkansas, and known as the Bayou Mason Hills, this whole region is very flat; and the streams, with only rain and sewage water to carry off, would naturally have a sluggish current. A glance over the map of this section will show that it is traversed by Bayous Bartholomew and Mason, and Rivers Bœuf and Tensas, the last two really not materially differing from bayous.

Three of these will be observed to originate in extreme Southeastern Arkansas, and running south-southwest, finally unite together, and form Black River, which is a tributary of the Washita.

Besides these main bayous there are innumerable smaller ones which often intersect them and each other, so that if one of the main streams becomes suddenly swollen, the water escapes from it into all of the others, and if continued, affects the whole internal water system.

These bayous all differ from the rivers, in that the descent from the top of the bank to the water is much more gradual, and this slope is apt to be more or less overgrown with brush and bushes to below low-water mark. Hence, it will be seen that whatever contributes to the volume of water in these bayous not only adds rapidity to the current, but brings it more and more in contact with the second element, viz, material to which the larvæ can attach themselves, and we have the same state of affairs as in Mill Bayou.

In Louisiana there is but one locality where water from the Mississippi gets through the bank into these inland bayous, and that is by way of Bayou Vidal and Mill Bayou, although in very high water it runs into Roundaway Bayou a couple of miles above Bayou Vidal at Diamond Bend. The next opening is at Master's Bend, a short distance north of the Arkansas line, and the water coming in through it enters both Bayou Mason and Tensas River. The next break is just above Luna Landing, and is known as Whisky Short; another, Panther Forest, is just below Gaines's Landing. Of the effect of these last two openings extracts from a letter received from Mr. Robert E. Craig, who resides on Point Chicot, in the immediate vicinity, will fully explain:

"If you will examine your map you will find Lake Mason lies at right angle across head of 'Tensas Basin.' The recent rise in the river was high enough to run into Lake Mason, the southern bank of which is high. There are two or three bayous through this bank which let the water into all bayous east of Bartholomew, but not enough water to overflow the lower banks of any one of them. Lake Chicot also filled at the same rise in the river, and is gradually being emptied through the Mason and Boeuf." Mr. Craig also adds: "When you were here, bayous were all receiving Mississippi River water through Lake Mason and Lake Chicot." It was during "the recent rise" to which Mr. Craig refers that I was his guest at Point Chicot. And on March 2d, the day after my arrival, the water measured 27.8 feet on the gauge at Memphis, and 38.2 feet at Vicksburg, as the signal officer at the latter city informed me.

It will be proper to state here that up to the breaking out of the war, owing to the perfect levee system, water was prevented from escaping into these bayous. During the war, these levees were destroyed by the caving of the river and through other causes, and the places where water now escapes from the Mississippi River and runs inland are breaks that have never been rebuilt.

As the season of high water usually occurs during late winter and early spring, the effect of this influx of water is not only to fill these inland bayous, but to keep them full during the breeding season of the gnats. Hence the effects, if any occur, should be noticeable in the number of gnats and the amount of damage done by them in the vicinity of the streams thus influenced.

They appear in the vicinity of Mill Bayou every year in greater or less numbers, and I have twice observed them being carried from them to Somerset plantation by a heavy northwest wind, and as often observed them gradually disappear under winds blowing equally strong from the north, northeast, and south.

Strong winds, blowing from a northwesterly quarter, bring gnats suddenly and in great numbers to the neighborhood of Lake Saint Joseph, six to eight miles below Somerset. Judge Gunby states that they appear at Monroe with an east wind; Mr. Craig observes them at Point Chicot with a west or southwest wind, and at the time they appeared in the city of Vicksburg they came with a westerly wind.

Probably the worst afflicted parish in Louisiana is that of Franklin, which is situated between and at the junction of Bœuf River and Bayou Mason. Judge Gunby and others well acquainted with the country through which these two streams flow state that gnats appear with more regularity and in greater numbers in that vicinity than elsewhere. Mr. Craig states that they occur to some extent every year along these streams in Arkansas, being observed the most numerous the present season near Bayou Mason. This is in accordance with all reliable information which I have been able to obtain, and, aside from the country about Mill Bayou, coincides with my own observations.

In connection with this evidence we can also observe that these gnats are yearly being produced in numbers close up to the danger line, only an overflow being required to furnish the conditions suitable for carrying them far beyond. Soon after these investigations began I learned that the Buffalo Gnat did not occur below the mouth of the Red River. Wishing definite information on this point, I addressed a letter to Judge F. H. Farrer, of Bayou Sara, La., whose reply is given herewith, and I will only say that the facts embodied therein have since been corroborated by planters whom I have met from that region:

BAYOU SARA, LA., *March* 9, 1886.

DEAR SIR: Yours of the 4th instant was received day before yesterday, Sunday. Court being in session, a great many farmers were in town, and I had plenty of old, experienced men to apply to for information in regard to the Buffalo-gnat.

Many had been familiar with the mischief it did farther north, but all agreed that, except to young turkeys and other poultry, it worked little or no harm in this region, either in low or high lands. A few indeed asserted that the one here was a different insect, known by the name of "turkey gnat," but the large majority maintained that it was the same humpbacked individual so destructive in North and Northwest Louisiana. I presume that it never appears in such numbers here as there.

My own experience, as far as it goes, agrees with that of the majority with whom I spoke on the subject, viz, that the genuine Buffalo-gnat is to be seen here every spring for a few weeks, but is by no means the dangerous pest to cattle, horses, &c., that it is in Northern Louisiana.

Respectfully, yours, &c.,

F. H. FARRAR.

F. M. WEBSTER, Esq., *Vicksburg, Miss.*

In summing up the matter we find that so long as this influx of river water was prevented no damage occurred by reason of gnats, even in the district now the worst infested, and we also find that in other parts of the same State, where this influx is still prevented, no trouble is experienced.

Hence it seems but reasonable that, if this protection was restored, the trouble would, within a few years at most, subside to its former state. This time would be materially hastened by the removal of underbrush, &c., which would come in contact with the current in portions of these inland streams where it runs the most swiftly. This last remedial measure might also be applied to bayous affected by high water of the Red, Yazoo, and other smaller rivers.

From the fact that the gnat breeds during the season when the water is cool, and ceases as it gets warmer, it seems not impossible that the infusion of the icy current of those rivers flowing from the north into those breeding places might serve to prolong the breeding season. The truth of this point can only be obtained by future study.

It is also possible that a more extended study of the Buffalo-gnat and the entire country it infests might, to some extent, modify the conclusions arrived at in this report; but with the evidence now before me they appear correct.

THE NATIVE PLUMS—HOW TO FRUIT THEM—THEY ARE PRACTICALLY CURCULIO PROOF.

By D. B. WIER, Lacon, Ill.

During the past forty years, in the vast region of North America lying west, north, and south of Lake Michigan, and the west line of the State of Indiana, it has been impossible to succeed in fruiting the fine, large, delicious Garden Plums (*Prunus domestica*) of Western Europe, for the reasons that the trees were not hardy in this fierce Western climate. The fruit was destroyed by the Plum Curculio (*Conotrachelus nenuphar*), and of late years, if not so destroyed, "rotted," particularly south, before maturity.

Long and persistent trials of this species of plum in the West, by the most careful and expert cultivators, have proven that it is folly to longer attempt to cultivate the old and well known varieties of these plums, for in the northern part of this region neither the trees nor their roots will withstand the severity of the winters, and south, if we protect the fruit from Plum Curculio, it seldom escapes total annihilation by "rot" before arriving at maturity, and, as a rule, for many years all intelligent cultivators have given up its cultivation, and have been anxiously seeking for a substitute, and have repeatedly selected for this purpose the finer varieties of our two most common species of

NATIVE PLUMS.

The Chickasaw Plum (*Prunus chickisa*) found indigenous from Northern Illinois to the Gulf of Mexico, and the wild yellow or red plum (*Prunus americana*) found indigenous over nearly the whole continent. These are two quite distinct races (for they cannot be regarded as distinct species) of the subgenus *Prunus* of the Almond family (*Amygdalea*), order Rosaceæ. And a typical tree of either so-called species is very distinct in fruit, foliage, and general appearance from a typical tree of the other. But so far as we are concerned in this study of them they are practically the same, except that the fruit of the *P. americana*, or Northern type, has much the thicker, tougher, and more acerb skin, and that some of the Chickasaw, or Southern type, do not prove hardy far North, *i. e.*, some of the named varieties, while others do, and the same would undoubtedly prove true of *P. americana*. But as this last is found growing wild, and with good varieties, at least as far north as the northern limit of Dakota, these native plums are a fruit in some of their varieties perfectly adapted to every part of the United States and Territories and pre-eminently the fruit of the great Northwest.

Yet, as a rule, those who have taken these wild plums from their native thickets and planted and carefully cultivated them, in hope of finding at least a poor substitute for the Garden Plum, have met with a complete, decisive failure. They got no fruit. We, the older settlers of the West (Illinois), knew the wild plums as the most plentiful and useful of the wild fruits when the country was first settled and when our "tame" plums failed (for it is a fact that in this part of Illinois as early as 1845 we fruited many varieties of the Garden Plum, Nectarines, Peaches, and Apricots in abundance, with no injury from the Plum Curculio, or "rot"). We began to hunt out and plant the finer varieties of the "wild" ones, some of which were most beautiful, large and fine, and of very good quality. But after years of patient waiting we found that these gave no fruit in their new homes, except very rarely. We found that the young fruit developed to the size of a little pea, or a little larger, and indeed often to more than half its full size, and then all fell off.

This fallen fruit, if examined, showed very generally the ovipositing marks of the Plum Curculio, made when laying her eggs.

It is not necessary here to give the complete natural history of this insect, because all the more important facts and their practical bearings have been recorded by competent writers, and especially by Walsh in his first report as State entomologist of Illinois, and by Riley in his third report on the insects of Missouri; but it will be sufficient to say that it is a small insect of the Curculio (*Curculionidæ*) or snout-beetle family that deposits its eggs under the skin of the young fruit of all the smooth-skinned species of the Almond family, or nearly all of them, and some other fruits as well. The eggs are deposited in little holes eaten through and under the skin of the fruit by the mother beetles, and so soon as deposited she cuts around and under the egg, leaving a crescent or new-moon shaped mark on the fruit, with a round dot (hole where the egg was laid) between the two horns of the crescent. In the Garden Plums, Nectarines, Peaches, Apricots, late Cherries, &c., these eggs soon hatch and bring forth white, footless grubs, which burrow through the pulp of the fruit and live and grow fat on its substance, and at the time when the fruit should mature, instead of a fine, delicious fruit, one finds, though perhaps quite fair without, a mass of rottenness within, with a nasty grub wallowing around in its own excrement, and the rotten pulp of the fruit, thereby completely destroying it for any purpose whatever as a fruit.

That the numbers of this pest have grown less each year for the past ten years, and more especially during the last three years, is the evidence of all careful observers. This grand result has evidently been brought about by the continuously-increasing numbers of its natural enemies, in the form of other insects, &c., and if this rate of decrease and increase keeps on, we may in the near future be so relieved of this pest as to be able to have fair crops of the stone fruits without using preventive measures.

So much about the Plum Curculio is necessary for the general reader in understanding this paper, and it is well to continually bear in mind that, until a very recent date, the native plums were considered as one of the fruits totally destroyed by the Plum Curculio by *all*, unless it was "Curculio proof" or protected from the parent beetle. But this belief was not and is not true, for we shall find as we proceed that all, or nearly all, of the native plums are practically curculio proof. And what is of very much more value, we will find that instead of breeding and multiplying the Plum Curculio, they scarcely breed them at all, and that if these plums are planted in sufficient quantity they will greatly reduce its numbers and protect other fruit from its ravages.

Then, of course, when we found nearly every fallen fruit marked with the peculiar marks made by the Curculio when laying her eggs, we all of us, professors of entomology, professors of horticulture, fruit-growers, and "clod-hoppers" at once jumped to the conclusion that the "Little Turk" (so called from her ovipositing mark being crescent-shaped) was the cause of the loss of our plums. We all believed this to be true; we looked for no other explanation; we had no data on which to base a search for any other explanation, so we sheathed our weapons and retreated from the field vanquished.

In the mean time what few matured plum thickets were left, the few that had escaped the farmer's grubbing hoe, continued to give annually bountiful crops of fruit, the Curculio to the contrary notwithstanding, and, whether stung or not by that insect, matured and ripened their fruit.

It is true that the trees in these wild plum patches were not as vigorous and healthy as they were when we gray-headed chaps were boys, for their surroundings had been changed, greatly changed. Their old companion plants were nearly all gone; new plants, usurpers, had taken their places and their environment was changed.

These new plants were many of them very injurious and detrimental to the vigor of the trees, and with the advent of man had come his herds; they tramped the ground down hard over their roots; they laid bare the surface of the soil to the direct rays of the sun by eating the herbage. Things injurious to the foliage and fruit of the trees, in the shape of new insects and new diseases, were introduced, but with all of this a few wild plum thickets survived and matured plums. Why these did mature fruit under these adverse circumstances, and why the selections we made of a few fine plums from perhaps some of the most fruitful of these same thickets could not be made to mature a plum with all the care and petting we could give them, when planted in our garden or orchard, to explain this, to give the reasons why, and to show how easily all can have this valuable and delicious fruit in abundance, is the motive of preparing this paper for publication.

And now I will begin my task. I was born here (Marshall County, Illinois) in 1834, and can therefore well remember the country as it was, and the wild plums as they were before the Plum Curculio made its first destructive showing here in 1845. Then we had these plums everywhere; "the woods were full of them." The valleys of the smaller streams were almost one continuous and unbroken plum thicket from source to mouth. The edges of the prairies were skirted with them. They were the most plentiful and useful of all our wild fruits.

As a boy I was passionately fond of fruit of all kinds, and the location of all good wild fruits that I could find was stored up in my memory for future use.

Many of the wild plums, as I remember them, growing in our woods were very poor in quality—many good, a few very good, and a still smaller proportion of them very good and very handsome.

About the year 1844 I found growing in the edge of a plum thicket a beautiful young tree, with a few large bright golden plums on it, kissed by the sun until their cheeks blushed crimson, and, when ripe, of delicious, honeyed perfumed flavor, large, oblong, and most beautiful. The next fall it was fairly loaded with its glorious fruit. I determined to secure this prize and have it all my own. I took it up very carefully, transplanted it into the garden, and tended it with the greatest care; it grew finely in its new home, but never matured a fruit; it bloomed and set fruit freely, but it soon all fell off, but they were *not stung by the Plum Curculio!* It was before the advent in great numbers of that now numerous pest.

I next tried the European or Garden Plum; they bloomed, fruited, but every plum was destroyed by the Plum Curculio before maturing.

At last a dry autumn, followed by a severe winter, cleaned these out, roots and all.

I next heard of a variety of the Native Plums called the Miner; heard a great mass of testimony as to its being thoroughly hardy, entirely "curculio proof," and yearly productive of good, large, salable fruit. I procured 500 trees of this variety and planted them in an orchard, the spring of 1862, and, with the exception noted farther on, these trees have not to this day matured one peck of fruit. This variety is about half way between or a hybrid between the extreme types of the two species first mentioned. I next learned of the celebrated plum of the Southern or Chickasaw type, known as the "Wild Goose" plum, in 1867. I procured a few scions of it, and top-grafted them in the center of the Miner orchard. Five of these grafts grew, and the next spring the grafts bloomed freely and set a large amount of fruit, nearly every one of which matured fully. The great, bright red oblong fruit hung on ropes on these grafts, and I was so excited over them that I nearly went plum crazy. They ripened the first half of July and they were snapped up in our little town at 25 cents per quart. In my dreams I saw golden visions; a fortune from plums stared me in the face. Thinking all was right with this plum, so soon as I could obtain trees I planted 800 of them in orchard. They grew and flourished grandly, bloomed, and they set fruit profusely, but it all fell off when quite small. Both these Miner and Wild Goose orchards were planted in a solid mass, no other trees of the almond family being among or near them, except as hereafter noted.

I have said the grafts set in Miner bore profusely, so did the trees in which they were grafted, *i. e.*, of Miner Plums, as did the trees next adjoining, and matured their fruit perfectly. These plum orchards were both a continuation of a large orchard of hardy cherries. The rows of both varieties of these plums next to the cherries have *every year matured more or less plums*, some seasons quite a crop. With these exceptions, no other trees in these orchards have ever brought one plum to maturity. These two orchards were some distance away and so were not observed very closely. In carrying on a general Nursery I gathered here many varieties of Native Plums, and propagated them quite extensively for sale. Trees of the leading varieties on their own roots were planted isolated from other plums, so as to obtain suckers. The varieties so planted were Wild Goose, Miner, Forest Garden, DeSoto, Weaver (though not to be true to name), Langdon, Newman, and many others, none of which have as yet matured a plum except the Newman. About the same time, or sixteen to eighteen years ago, I planted the varieties named above, together with several others, thickly in rows, the rows four feet apart, with the several varieties intermingled or "all mixed up," but at some points in the rows all of one variety with no other quite near, and *these trees* have not failed of bearing and maturing a full crop each year during the last twelve years. Again soon after this I planted in nursery rows for budding 2,000 one-year-old seedlings of the Americana type, from seed grown in Wisconsin. These were planted in two blocks and were budded over once with the varieties last named, and some others. The rows were four feet apart and the seedlings one foot (or less) apart in the rows. But a small percentage of the buds grew, the best of the resulting budded trees were sold, but more or less trees of all the varieties so budded were left among the seedlings and all grew up together and are yet, to-day, to be seen in the same condition.

Of the trees planted not near other trees of the Almond family, numbering some hundreds, not one of them ever matured a fruit during the sixteen years they have been old enough to produce, until last season, when a few of the varieties ripened a very high crop of fruit, the Miner being second only to the Newman in point of productiveness.

The Newman as an exception to the other varieties has given a fair crop each season during the sixteen years, except one, when it failed entirely. Ten years ago I was ready to retire beaten, and give up the whole plum and plum-tree business in disgust, in fact the whole Almond family, for the Plum Curculio seemed determined to destroy all the cherries also. I had followed every hint and theory that I had ever heard of. I carefully examined the flowers of all the varieties, and found them, so far as I could see, perfect in all their parts. The first grafts of the Wild Goose in the Miner trees continued to bear each year, as did the trees in which they were grafted. The isolated trees, scattered over the plantation, were vigorous, healthy, and each year bloomed profusely and set fruit freely, but it all fell off when quite small, except a very small proportion of that on the Wild Goose; some of the fruit of this variety would attain half, two-thirds, or even full size, ripen prematurely and then fall off. But in all such instances there were other trees of the Almond family planted not far away, and I can safely say that during the twenty years or more that I have had this variety old enough to bear, the hundreds of trees of it in my orchards have not matured one fruit if completely isolated from other trees of the Almond family.

One day, when examining the fruit of this variety for Curculio young, I was surprised not to find a live grub in them at all, and at that time could not find a fruit in which the larvæ had ever fed. And I was still more surprised upon cutting through the shell to find that the seed had not developed and was imperfect. This fact led me to believe that the flowers of this variety were not perfect, that the pollen was not good.

Some years ago I received from its disseminator, O. M. Lord, of Minnesota City, Minn., scions (grafts) of a fine new hardy plum found in his neighborhood, named the "Rolling Stone." Five of these I grafted into a tree of Wild Goose of bearing age by splice grafting on the terminal twigs of the main branches. All five of these grafts grew; one of them gave three clusters of bloom the same spring it was grafted, and matured three plums. I was very greatly surprised this same season, in July, to find near this graft, and in the same tree, about twenty-five perfectly matured Wild Goose plums, all very close to the Rolling Stone graft and none any distance from it, and the Wild Goose did not ripen prematurely or fall off before fully developed. The three plums matured by the graft ripening about a month later.

Three of the Rolling Stone grafts grew finely the first summer after grafting, and the next spring bloomed profusely. The tree in which they were grafted grew at the south end of a row of the same variety (Wild Goose) about 30 rods long. This second season after the grafts were inserted the tree in which they were growing matured a full crop of fruit; the one next north 4 feet from it was full of fruit on its south side; the fruit was scattering. The next tree 10 feet north of the grafts matured three plums; not one other tree in the row out of perhaps a hundred matured a plum that season.

The extreme cold of the following winter destroyed the Wild Goose below the grafts, and the following spring they did not bloom. Twenty feet east of this row of Wild Goose stood a row of cross-bred seedlings. The following summer (of 1885) this row of seedlings bloomed and fruited enormously, and the row of Wild Goose fruited very heavily on the east side of the trees, with scarcely a plum on the west side of the row.

And to close the record of these two rows, I will add that during the spring of 1886 I made a record of the time of blooming of all the plum trees on the place, and of the force and direction of the wind during the time of blooming, and find, by referring to that record, that a gentle east wind prevailed for three days during the time when the row of native plums were in the height of bloom, and the row of Wild Goose matured an enormous crop of very fine fruit, but with very much more fruit on the east than on the west side (the row of seedlings furnishing the pollen which was wafted to them by the east wind.)

The first year that the Rolling Stone grafts bloomed gave me the long-hidden secret of the failure in productiveness of the native plums, which has proved itself to be that a great majority, or nearly all of them, are not fertile with their own pollen; or, in other words, from some not as yet fully explained cause or causes the pollen of, say, the Wild Goose or Miner will not pollenize the ovaries of their own flowers. Why it will not does not become material; the fact remains, nevertheless.

After a pretty thorough investigation my conclusion as to the reason is, that the pollen matures and is flown away and wasted before the stigmas are mature enough to receive it; or, it may be true that the pollen of some varieties is impotent to their own stigmas, or possibly even poisonous to them. That this latter condition of facts may exist has been fully and satisfactorily proven by the most carefully conducted experiments by the great Darwin, and the results given in detail in his

"Plants and Animals under Domestication," and the same theory has to some extent been handled in works by other eminent scientists. I found that the Rolling Stone variety would pollenize the Wild Goose and render it fruitful. I found that other varieties would do the same when twenty feet away, if the wind blew from the right direction when they were in bloom. I found that in every instance where I had trees of the Miner and Wild Goose near each other, both varieties were very productive, and also that when the Newman and Wild Goose were near together neither was fully productive, and that where Miner and Newman were contiguous both were enormously and regularly productive.

I also found that where I had Newman growing isolated from other varieties, that it was yearly productive of moderate crops of good fruit, but scarcely a seed from such trees would grow; but where the Newman and Miner were planted near together the Newman was not only enormously productive, but the fruit was larger, later, darker colored, and thicker skinned, and the seed all good, and the resulting seedlings strong and vigorous, the Miner being also very productive in this case.

Further, I found that where I had nearly all the named varieties of both types of these plums growing together in the two blocks of seedlings, that all of them (including the seedlings) were, with the exception of the Wild Goose, very productive each year since old enough to bear. Trees of the Wild Goose were growing in both blocks of these seedlings, but none of them have ever fruited so heavily as those growing near Miner, showing, I think, that the Miner is its best consort. The trees in these two blocks of seedlings are about one foot apart in the row, and the rows four feet apart. Growing in this way much in the same manner as the natural plum thickets of the earlier days of this country, they have all of them matured a full crop of plums each year for the past seven years, and the trees have remained more vigorous and healthy than isolated trees of the same varieties. The number of varieties in these two blocks may be safely estimated at 5,000, running through all grades of the northern wild plum, from the poorest to the very best. During the whole period in which these plums have been fruiting, nothing whatever has been done to protect the fruit from or to destroy the Plum Curculio, and this insect has been present in large numbers during the whole time. No hogs or other stock have been allowed to run among the trees, and, until the last three seasons, all the "wormy" fruit has rotted on the ground, undisturbed.

The history of these plum trees tells my readers exactly how to fruit the native plums everywhere in abundance. Heretofore when writing on this subject I have qualified the above by saying how they will fruit *here* abundantly. But during the past two years I have corresponded with the owners of or visited a great number of plum orchards throughout nearly the whole country and find the same results everywhere, namely, wherever these plums have been planted with several varities near together (or near trees of several other species of the almond family) they have been constantly productive, but when planted with the varieties isolated they have proven barren, except in the South.

While the Wild Goose will pollenize its own stigmas south of the Ohio River, and will not north, may seem a little strange. But this fact is easily explained. Here, or North, fruit trees burst suddenly into bloom, and in three or four days the sexual organs of the flowers have matured, performed their functions, and lost their sexual force. South, the peach is often in continuous bloom for four months, the plum for two months, and therefore there is a continuous supply of ripe pollen and ripe (stigmatic) stigmas to receive it. Here the Wild Goose plum, for instance, opens its flowers one day, ripens and sheds most of its pollen the forenoon of the next day (the pollen of the plum, which is the male element of their sexuality, consists of very minute roundish, egg-like cells, very light and produced in great abundance, and may be carried by the wind for miles under favorable circumstances and their potency remain unimpaired), and not until the afternoon of this day do the stigmas take on the sexual heat and become ready to receive it. These and the other fully established facts, that to many varieties and species of plants their own pollen is neither acceptable nor fertile to their own flowers—stigmas—and to the more common fact that in many plants a flower is not fertile with pollen of that flower, but fully fertile with pollen from another; why we have failed to get fruit from many varieties of Native Plums when not growing near other Plum trees (or other trees of the Almond family), and why these same varieties are very productive when planted near others; the reason for this seems to be that nature abhors "in and in breeding," or, in other words, she has carefully guarded nearly all forms of life from unnatural unions or a too close consanguinity of offspring.

But in our Almond family the different species seem freely to fertilize each other sexually in many instances, and the resulting hybrids are, so far as observed, fully fertile with all. For, as before intimated, I have absolute and incontestable proof that the flowers of the Wild Goose and Miner plums are fertilized to a limited extent by the pollen of our cherries, which belong to a different genus of the same order. Also, the proof is absolute that the pollen of the peach freely fertilizes the flowers of the Chickasaw plums, at least some of them. The new early peaches, such as Hale's Early, Amsden's June, Alexander, &c., are such hybrids nearest the peach in their generalities; and the Blackman, Golden Beauty, and other so-called plums are such hybrids more nearly resembling the plums.

The plums of Europe freely fertilize our native plums, and *vice versa*. So far there is no proof that the sub genus, *Padus*, to which our wild cherries belong, is sexually fertile with other members of the sub order, but it is very probable that it is not.

We have now, if we have read understandingly, learned how we may everywhere in abundance. How? Simply by planting several varieties near together or commingled, or by grafting or budding barren trees with one or more different varieties as above explained. Planting the different varieties near together is most practical, and easily done by selecting such two (or more) varieties as will pollenize each other, and planting them alternately in rows 4 to 6 feet apart, the rows running in the direction of the prevailing winds at the blooming time of the plum. If we do not know what varieties will pollenize each other, we will be safe if we plant several varieties in close proximity, so as to have the so-called species alternate in the rows. The rows may be 15 to 30 feet apart.

We now take up the

PLUM CURCULIO (*Conotrachelus nenuphar*)

understandingly. But why need I add one more word about it, for the proof is absolute here, and I have the same complete proof from nearly every State and Territory, that it has no effect on the fruiting of the great majority of our native plums whatever. If their flowers are pollenized they give regular crops of valuable fruit as any fruit in any climate, with no material damage to the fruit, except rarely to a few varieties, by this pest. In fact, I will here put it on record: I believe that after carefully investigating the subject throughout three seasons, that what effect this curculio has on these fruits tends to benefit the tree and fruit rather than injure, for, where these plums are fully pollenized their tendency is to overbear—to set more fruit than they can or should bring to maturity. The most material injury to this fruit by the curculio is that the cuts through the skin of the young fruit, made by her when laying her eggs, sometimes forms a *nidus* (breeding place) for "fruit-rot." The varieties will be affected by this very differently in different locations and climates, but this rot does not, as is the case with some other fruits, so far as is known prevent our securing full crops of some varieties everywhere. (Curiously the evidence is that *P. chickasa* is more subject to rot South than *P. americana*, and *vice versa*. But my observations here prove that this "fruit rot" in the native plums more often finds a *nidus* or origin in the minute punctures of leaf lice (*Aphididæ*) and plant bugs (*Hemiptera*). The most injurious of the bugs to the fruit of our native plums, and perhaps the most injurious insect of North America, is the now notorious tarnished plant bug (*Capsus oblineatus*, Say.). This pernicious bug is abundant nearly everywhere, is an omnivorous feeder, and not only depletes trees and plants of their juices, but the puncture of its beak is very poisonous to them, causing many young fruits to drop soon after being punctured, on others leaving wounds for the entrance of the spores of the sporadic diseases or "rots." Therefore it will not do to give the plum curculio credit as the destroyer of all fruit that falls before maturity; and, further, it is a fact that the injury to the young fruit by this curculio when laying her eggs does not cause such fruit to fall while small, but the contrary is true. Therefore, when we find all our young plums on the ground early in June, notice if every one of them shows the ovipositing mark of the Little Turk. She or her work was not the cause of their fall. But cut them open and you will invariably find the seed embryo dead, or the lice or bugs before mentioned had caused their death.

Then it remains to give a short summary of the facts gathered, showing the true status of the Plum Curculio in regard to fruit growing generally and the Native Plums especially.

The first and most important is that all evidence shows that this insect seeks the Native Plums in preference to all other fruits in which to deposit her eggs. This is a queer, a strange fact in biology, which naturalists will be inclined to dispute, namely, that an insect should seek and use, seemingly by preference, a fruit in which to lay her eggs wherein but very few of them will hatch and in which but few of such larvæ as do hatch can be nourished on its substance to maturity.

The reason why the Plum Curculio does seek the Native Plums to oviposit in seems to be because of their very early and very fragrant bloom. This beetle, unlike some others, is a ravenous feeder while in the imago or beetle state, and flies toward the nearest inviting food. With what result, now becomes the important question. I have shown that the depositing of the eggs of the Curculio in the young fruit does not cause it to fall before reaching maturity; that it does not materially injure the fruit, for I have marketed a Miner plum on which were eighteen of the ovipositing marks of this beetle, and yet it was a passable plum for use (eating or canning). But the facts are best given in figures and percentages.

During the past two seasons I have gone over the great mass of native plums in bearing here twice during each season, or four times systematically, and very carefully, with practically the same results each time, and I will here give my results in figures.

I found that for every egg that hatched and the larvæ had fed noticeably, that there were from 1,500 to 1,900 ovipositing marks of the Curculio, and that only one living curculio maggot was found in 3,100 to 3,500 plums examined and in which her eggs had been laid. These percentages are from the June observations of these two years and coincide with previous observations. In the two observations made during the latter part of July and first of August the percentages were not materially changed or different. Another study was made to find out how many larvæ that had hatched had fed to well advanced maturity as larvæ. To get at this I selected the fruit of the Wild Goose and Newman, in which I had found more living larvæ than in any other variety here (as yet I have not found any living larvæ of considerable size in the Miner, but strangely I found more living, well fed, healthy looking larvæ in *P. americana* in the woods, to the number of plums stung than I have in any other plum, a not very careful survey of this tree showed that about one in twenty-five of the eggs laid in the fruit has produced well-grown, healthy looking larvæ). I selected first 100 plums of the Wild Goose variety, in which eggs had seemingly been laid. (I am well aware that in many species of insect life the females will continue to form proper *nidi* for the reception of her eggs long after her supply of eggs has become completely exhausted; in fact, as a rule the "grim messenger" finds her busily at work, with feeble effort, trying to lay eggs and reproduce her kind, and it is quite probable that our "Little Turk" possesses this instinct, which continues to its fatal termination. Therefore my percentages are not so correct as if I had been able in each instance to locate an egg, *in situ* within the ovipositing mark.) At least the ovipositing mark was apparent on each fruit. These were placed in a vessel, and taken out one at a time and cut under the ovipositing mark to ascertain if the larvæ had fed. If it had not fed noticeably, it was thrown aside and another taken up, and so on until I had obtained a hundred plums in which the egg had hatched and the larvæ had fed. Two trials of Wild Goose plums, in this way, gave respectively 22 and 23 living, sickly looking, attenuated larvæ. Two trials of the same number of Newman gave respectively 24 and 26 of the same kind of grubs. Whether any one of these sickly looking larvæ would have matured into beetles I do not know, but I have the best of reasons for believing that none of them would. And here are my reasons, and they are of the greatest value, if I have made no mistakes. The autumns of 1884 and 1885 I gathered the fallen fruit from all the trees for seed, and of course in this way I got all the fruit with living larvæ in them, and when selecting what good fruit there was for market, all wormy and imperfect fruit was thrown on the surface of the ground in the shade of trees, day by day as gathered, and on and convenient thereto were placed several contrivances, such as the young beetles are known to seek as soon as they emerge from the ground for shelter. These shelters were carefully examined until cold weather without finding a single beetle.

The next spring this seed was gathered up early and planted. A good portion of the ground it had occupied was at once covered with strong canvas, with its edges so covered and fastened down that it was improbable that the beetles could escape from under it.* Now, if this 80 bushels of plums selected from the 264 bushels marketed on one season, and of course including practically all the wormy plums, bred no Curculios, and it takes 3,200 eggs to produce one well-matured larva, and if we give it all the Native Plums it may require in which to lay all of its eggs,

* This experiment was very poorly conducted and proves nothing. If the plums referred to were wormy, it is safe to say that at least a portion of the larvæ were in healthy condition and went through their transformations under ground. We have

this is the pertinent question: Does it not seem conclusively to show that when this great western region, the timbered portion of it, was, we may say, one vast Plum thicket, that there were then plums enough to hold the Plum Curculio entirely in check? And, further, does it not also show conclusively that if we now plant a sufficient number of these plum trees to produce fruit for the beetles to feed on and lay all of their eggs in, and such eggs do not hatch, as we have seen, that they, the plums, will again reduce its numbers below the point of practical injury, and in this way protect all our other fruit from its depredations? Again, do not our facts show, that if it is true that the Plum Curculio is attracted by these plums early in the season, and being there on the plums she will therefore lay her eggs in them exclusively, and that by planting these plums unstintedly among and around our Peaches, Apples, Cherries, and other fruits liable to injury by her, that we will protect these fruits from damage by this beetle?

We have but one question of importance to answer, which is, Are the Native Plums a fruit worthy of extended cultivation? I can answer this question emphatically, *Yes*, they are. They are one of the most certain of the fruits in the regularity of their crop, and the yield is usually abundant, the fruit wholesome, attractive, and easily gathered, and can be shipped any reasonable distance to market. When thoroughly ripe it is delicious, eaten in a natural state—that is, some varieties of it; others are among the finest of fruits for preparing in the various ways known to the culinary art—stewing, canning, drying, preserving in sugar, sweet pickling (spicing), &c. And many of the varieties of the Northern type will keep perfectly throughout the winter if simply placed in an open earthen jar and covered with water. They all make most

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had some experience with the larvæ of this insect, but should scarcely venture to discriminate between sickly and healthy individuals as Mr. Wier has done. The precautions taken to observe and count the beetles emerging from the ground were entirely insufficient for the purpose, as the tendency to secrete under traps is manifested chiefly in cool weather in spring.

Moreover, Mr. Wier's statements that the planting and cultivating of the Wild Plum will protect our peaches, apricots, cultivated plums, &c., and effect a decrease in the numbers of the Curculio, are mere assumptions and contrary to experience. The fact that these cultivated fruits were badly infested by the Curculio as soon as they were introduced is a sufficient proof that the Curculio shows a decided preference for these plants. While we would not discredit the correctness of Mr. Wier's observation that a large proportion of Curculio eggs laid in Wild Plums fail to hatch (because they often thus fail in cultivated varieties and in cherries, pears, and apples), yet we do not believe this fact has much influence on the general decrease of the Curculio. The Wild Plums were the original food-plant of the insect and it has "existed as a species" on this plant from time immemorial. The cultivation of peaches, apricots, cherries, &c., simply furnished the means for it to increase, and only the complete abandonment of their cultivation would re-establish the original relative scarcity of the Curculio. The state of affairs would be quite different if Mr. Wier could show us how to compel the insect to oviposit in the fruit of the Wild Plum, or could even prove by satisfactory scientific evidence the truth of his assertion that it has a preference for said wild fruit.—C. V. R.

beautiful and delicious jellies. Such are the principal uses of the fruit. The trees will thrive on any soil that will support common trees, but do best on a deep, rich, moist soil; they thrive finely in the bottoms of deep, steep, narrow ravines and along drains, on lands too rough for cultivation, if reasonably rich. The trees are natural to crowded situations, crowded by each other, and by other trees; their roots do best rambling through moist soil, shaded from the sun, and the trees do very much the best in a location sheltered from the strong winds of spring (which blow away the pollen). The trees are easily propagated; they throw up young trees (suckers) freely from their roots; therefore when planting these plums on the thicket plan in waste places it is best to have them on their own roots. Or, if we do not wish them to produce suckers, they may be budded on the Chickasaw variety known as Mariana, which variety grows freely from cuttings, is quite hardy, and seldom, if ever, throws up suckers from its roots. In the South these plums do finely when budded or grafted on peach (which do not sucker), but care must be taken to prevent injury from the Peach Borer (*Ægeria exitiosa* Say). North they do nicely if "root-grafted" on peach. Generally, as the reader will have learned from this paper, the Native Plums have no very noxious insect enemies or diseases here or over the country at large, and it is safe to say that they in some of their varieties or tribes can be grown profitably in every part of the country. There is a vast amount to be learned about them as yet, and some very important facts to determine. The most valuable one is this: I have some proof that certain varieties of these plums will breed the Plum Curculio freely; if so, such varieties should be searched out and destroyed, and we should be sure not to plant these varieties for fruit, be that ever so fine.

THE SERRELL AUTOMATIC SILK REEL.

By Philip Walker.

In previous reports the new Serrell automatic silk reel has been frequently mentioned, but owing to the incomplete condition of the patents upon it, it has been considered unwise to publish even such a general description as that which follows. Now, however, that these machines are in operation in Washington, it is possible to gratify the laudable curiosity of persons interested in this machinery, of which so much has been said but so little known in this country.

An understanding of the mechanical principles of ordinary non-automatic reels and of the Serrell serigraph are so necessary to a thorough comprehension of the automatic reel that, although they have already been described by Professor Riley in Bulletin No. 9 of the Division,* it is deemed wise to insert an account of them here. The quotations

* The Mulberry Silk-Worm, by C. V. Riley, M. A., Ph. D., Washington, 1886.

which follow are from that pamphlet. A further word on some of the properties of the cocoon filament and the general process of reeling is also given in order to make the descriptions which follow more intelligible.

The silk-worm occupies, in general, about thirty days in passing through the period comprised between its birth and the fabrication of its cocoon. Most of this time is employed in eating, but about five days being consumed in passing through the molts. The food consumed during the last ten days is almost entirely employed in the formation of a fluid which fills the silk ducts and which goes ultimately to the fabrication of the silken thread of the cocoon.

In the body of the larvæ there are two of these ducts, each of which is connected with an orifice called a spinneret, which is situated in the lower lip of the insect. The larva in the formation of its cocoon throws out from these orifices two fine filaments covered with a natural glue. This glue serves to stick the two filaments together and to form them into what appears to the naked eye to be one compact thread. An examination of this thread under the microscope, however, shows its double nature and its flattened section, whose width is three to four times its thickness.

The first step taken by the worm, after it has found a convenient place to make its cocoon, is to throw out a system of threads designed to form a founda ion to the more compact pod. The tissue of this system is loose and is not apparently woven after any fixed plan. Once this foundation completed, the larva begins the construction of the stronger wall of its resting place, which is constructed of a firm felting laid on in figure-eight loops and in many distinct layers. Of these layers it is easy to recognize at least a dozen and to tear them apart but it is probable that in reality these might each be subdivided into many more but for the lack of instruments of sufficient delicacy.

Taking the yellow Milanese races as a type, we find that it requires about 250 fresh cocoons to make a pound and that each contains about one thousand yards of thread. These cocoons, with the inclosed chrysalides, contain, however, 66 per centum of water, which in the course of three or four months' drying will effectually evaporate. Of the total weight of these cocoons, again, but about 15 per centum is formed of silk, the balance being composed of chrysalides and the skins cast by the larvæ in their transformation. Thus, were we to recover all of the silk contained in a lot of cocoons, it would not exceed 15 per centum of the total weight when fresh, or 33 per centum of the weight when dry. It is not, however, possible to accomplish such a result, both on account of the loss caused in getting hold of the end of the thread and from the fact that it is impossible to finish the reeling of a cocoon to its very end. Manufacturers rarely obtain more than one pound of silk for each three and one-half pounds of dry cocoons employed, and it is not uncommon for them to consume at least four pounds of raw material in the formation of each pound of their product.

Before reeling the cocoons must be cleaned by the removal of the outer system of threads which, under the name of floss, is one of the waste products of the industry.

In the filature the "cocoons are first plunged into boiling water, whereby their gluten is softened in such a manner as to render the unwinding of the filaments an easy matter. This done, they are brushed with a small broom, to the straws of which their fibers become attached. The bundle of filaments is then taken and they are unwound until each cocoon hangs by but one clean thread. These three operations are called 'cooking,' 'brushing,', and 'purging.' The first two can be accomplished mechanically, and are currently so performed in Italy and largely in France. But purging is a process to which the accuracy of the human eye and the delicacy of the human touch have so far been found necessary." The thread unwound in these processes is also a waste product, called "frisons," and has about one-fifth the value of reeled silk. In good working about four times as much silk as frisons is produced.

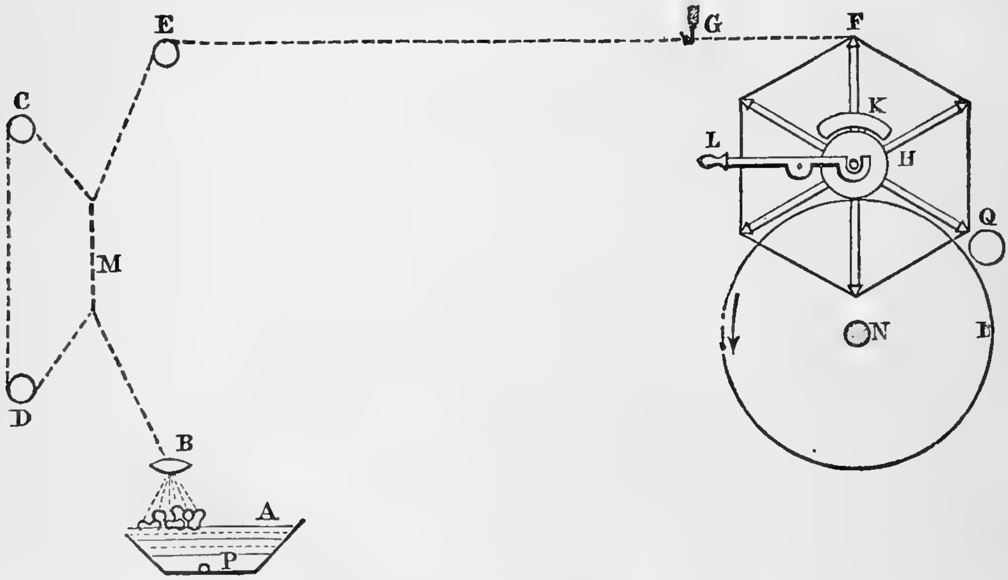


FIG. 1.—Elements of the mechanism of a modern silk reel.

"The elements of the mechanism of all modern silk reels are essentially the same. They are shown in Fig. 1, and consist, in general, of a basin, A, in which is a perforated steam-pipe, P, by means of which the water in the basin may be heated. A few inches above the surface of the water is placed a perforated agate, B. The cocoons having undergone the three operations mentioned, the ends of the filaments of four or more of them are twisted together into a thread, which is passed through the hole in the agate. From this it runs through the "croisure" M, which will be hereafter explained, and over the guide E to the reel at F. Between E and F the thread passes a guide, G, moving to and fro (in a line perpendicular to the plane of the paper), which distributes it in a broad band over the surface of the reel. This facilitates the drying of the silk, without which the gluten would bind together the threads of the skein as it does those of the cocoons, and thus ruin its commercial value. The shaft of the reel carries at one end a friction-wheel, *H*, which rests on the large friction-wheel I, that constantly revolves on the shaft N, and thus motion is imparted to the reel. In order to stop the reel it is only necessary to raise the wheel H from its bearings by means of the lever L. This movement presses the wheel against the brake-shoe K, and its motion is at once arrested.

"As has been said above, the thread is passed between the agate and the reel through the croisure. The making of the croisure consists in twisting the thread around itself or another thread so as to consolidate its constituent filaments and wring the water from it and thus aid in its drying. The mode of the formation of this croisure forms the principal distinguishing mark between the French and Italian systems of reeling. The former is called the 'Chambon system.' Each reeler manages two threads. These are passed through separate agates, and after being brought together and twisted twenty or thirty times around each other are again separated and passed through guiding eyes to the reel. The other system, called 'tavellette,'* consists in passing the thread up over a small pulley, *C*, down over another, *D*, and then twisting it around itself, as shown at *M*, in Fig. 1, and thence to the reel.

"The cocoon filament is somewhat finer in the floss or beginning, thickens at the point of forming the more compact pod, and then very gradually diminishes in diameter until it becomes so fine as to be incapable of standing the strain of reeling," the mean sections at these points being about proportional to the figures 30, 40, and 25. "Therefore a thread which is made up of five new filaments becomes so small when the cocoons from which it is drawn are half unwound as to require an addition. This addition might also be made necessary by the rupture of one of the constituent filaments. It is here that the skill of the operator is called into play. When her experience tells her that the thread needs nourishing from either of these causes, she takes the end of the filament of one of the cocoons which lie prepared in her basin, and, giving it a slight snap or whip-lash movement with the index-finger, causes it to wind around or adhere to the running thread, of which it from this moment becomes a constituent part. This lancing, as it is called, of the end of the filament, although in hand reeling performed in the manner described, is also accomplished mechanically, several devices having been invented for this purpose. They consist, in general, of a mechanism (occupying the place of the agate *B*), which causes a small hook to revolve in a horizontal plane about the running thread, and to twist around it any end of the filament that may be placed in the path of the hook. The reeler, seeing that a new filament is needed, holds the end of one in the way of the attaching device, and it is automatically caught."

* The trade name of the small pulley mentioned.

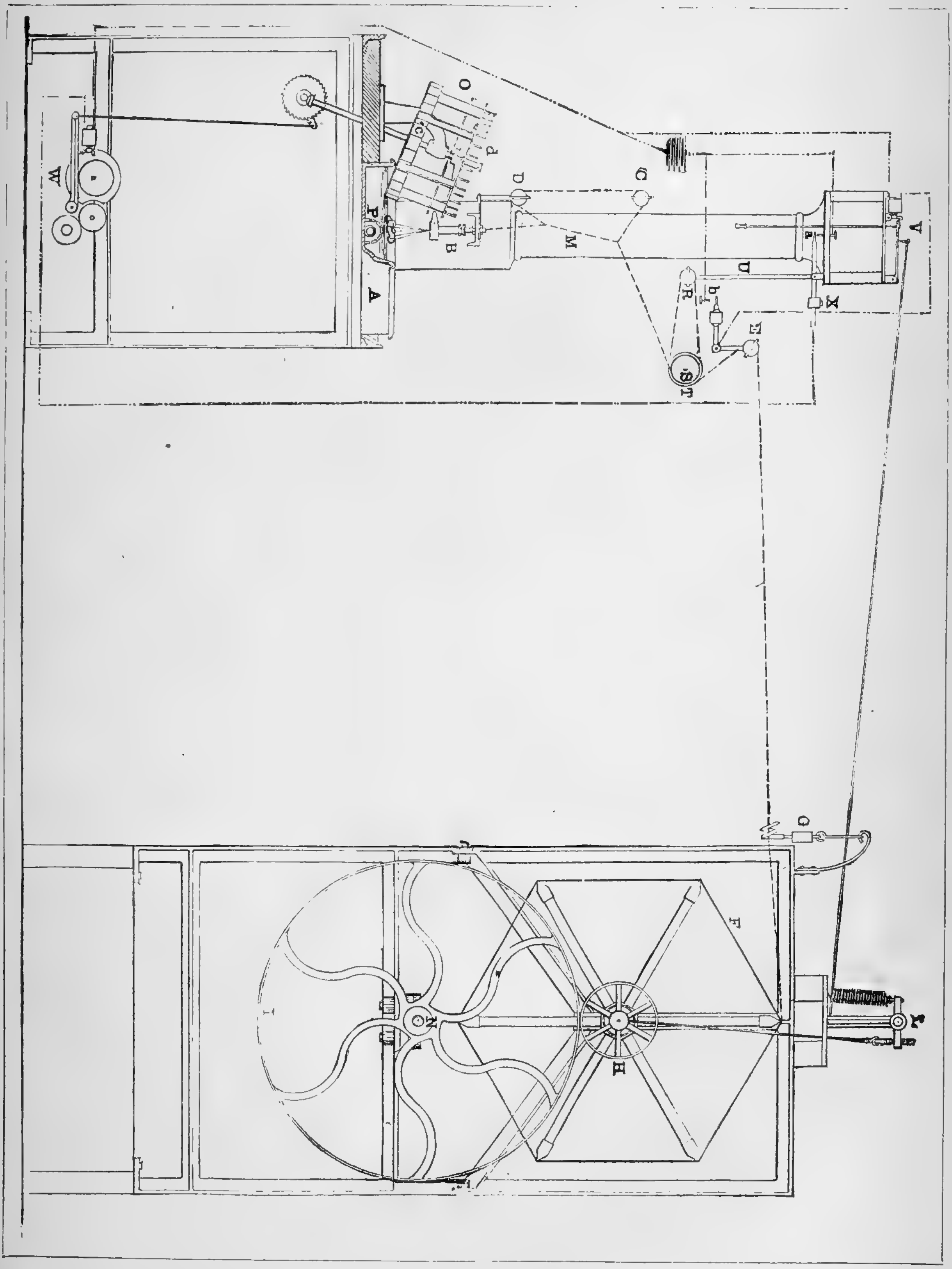
The thread of "raw" or reeled silk is excessively strong, ductile, and elastic. As has been seen, it is composed of several double filaments, drawn from as many cocoons. In common with other elastic threads, a given length of one of silk will resist a tendency to stretch to an extent proportionate to its mean section. This is the underlying principle of the *serigraph*. The mode of determining the irregularities existing in a thread of raw silk by means of this machine is as follows: The end of the thread is brought from the reel or bobbin on which it is wound

FIG. 2.—The principle of the serigraph.

around a drum, *S*, (Plate I), thence over a pulley, *R*, and back around another drum, *T*, mounted on the same axis as *S*. From the drum *T* it is wound on a reel. The drum *T* is larger than *S*, so that the former winds on the thread somewhat faster than it is paid off by the latter, and thus stretches it. In this manner we apply a constant force to the pulley *R*, tending to draw it from its normal position. This pulley is attached to the base of a pendulum, *U*, which, under the action of the force mentioned, is drawn from the perpendicular. The weight of this pendulum overcoming the force thus applied to an extent inversely proportional to the mean section of the length of thread submitted to the test, the position of equilibrium taken by the pendulum depends upon and is an indication of that mean section. The portion thus tested is that between the two drums *S* and *T*, and as, through the constant action of the machine, successive lengths of thread occupy the position indicated, the pendulum oscillates through a course which depends upon the irregularities of the thread. These irregularities are graphically recorded by a pencil, attached to the pendulum, upon a band of paper, which moves constantly under its point.

The serigraph, it will be seen, is an apparatus for continuously measuring the relative size of any thread passed over its drums and recording the irregularities in its size on a band of paper.

From this machine to the automatic reeler was but a slight transition, easily accomplished. It has been in working out the details of the desired mechanism that the greatest difficulty has been met with. The result is attained in general by causing the pendulum *U* to close an



PRINCIPLES OF THE SERRELL AUTOMATIC REEL.

electric circuit whenever the thread becomes so weak as to permit of a certain amount of stretching under the tension applied to it. The electric current due to this circuit-closing is then employed in releasing the detent of a suitable feeding device, by which a new cocoon filament is added to the main thread and its size augmented.

In the operation of the automatic silk-reel the thread is made as in an ordinary hand-reel, and passed through the centre of a filament-attaching device, *B*, thence through the croisure *M*. Thence, as in the serigraph, it is passed around a small drum, *S*, around a pulley, *R*, situated at the end of a pendulum, *U*, which is called in the reeler the control-lever, thence around the larger drum *T*, and in the ordinary way over the guiding pulley *E*, to the reel. On the end of the control lever *U* is a circuit-closing contact piece, *a*, which acts when the pulley *R*, overcoming the resistance of the thread, recedes from the drums *S* and *T*. The tension thus resisted by the thread may be regulated by the movable weight *X*, or an equivalent device.

We will now suppose the thread to be running at the desired size, and that the tension due to the stretch imparted to it by the difference in the circumferential speed of the two drums is sufficient to keep open the circuit-closing device of the control lever. It continues in this condition until, through the diminution in the size of the constituent filaments, or the rupture of one of them, the thread falls below the standard, and the addition of a new cocoon becomes necessary. Then the pendulum falls back, and the contact at *a* is closed.

Just above the water of the basin, with its edge dipping beneath the surface, is a cocoon-holding device, *O*. This apparatus, usually called the magazine, rests on a support which is mounted on a shaft around whose axis the magazine may be rotated. The magazine consists of a number of compartments, *c*, situated around the circumference of a lower disk and a number of small pins, *d*, mounted on a parallel disk a short distance above the lower one. In each compartment is placed a cocoon previously prepared for reeling, while its filament is conducted upwards and wound around one of the pins *d*. A magazine thus filled is set upon its support in readiness to furnish cocoons to the running thread as desired. Its position is such that the hook of the filament-attaching device passes just below the disk holding the pins *d*, and in such a way that a thread passing from its cocoon to the pin, which for the moment is opposite the attaching device, will fall in the path of the hook and be caught by it in its revolution.

The shaft on which the magazine turns is connected with a suitable feed movement, *W*, which consists in general of a cam to which a rotary motion may be given by a proper connection with the shafting of the filature, of a lever to which the cam imparts a to-and-fro motion, and of a magnet to whose armature is attached a detent which, when no current is passing, prevents the rotation of the cam.

Now, as we have seen above, no current passes through the electric circuit while the thread is at its standard size; for under such conditions the lever is so held by the thread that the contact at *a* is kept open. As soon, however, as the thread diminishes in size the lever recedes, the contact at *a* is closed, and the current passing through the magnet of the feed movement *W* causes the attraction of its armature and the release of the detent holding the cam in place. Upon this occurring the magazine is advanced one step and brings a new cocoon filament into the path of the hook on the filament attaching device, which catching it up twists it around the running thread and, with the help of its natural gum, attaches it firmly thereto, at the same time cutting off the loose end. The rotation of the cam is so timed that its detent will not arrive at the stop on the armature until the new filament has reached the controlling drums and had its effect upon the position of the control lever. In the reeling of fine sizes the addition of one filament will generally be found sufficient to bring the thread to its normal size, though it is less apt to be so with larger sizes. In any case, however, if, when the rotation of the cam is completed, the electric circuit still remains closed the action of the feed movement is repeated and continued until the thread is again brought to the normal size.

Owing to the irregularities in a thread of raw silk it is impossible to obtain any measure of its size by means of a caliper or even, with any degree of ease, by a microscopical examination. Merchants are therefore obliged to content themselves by approximating its size in the following manner: They measure off upon a suitable real a skein of a given length (476 meters) and obtain its weight in the terms of an arbitrary unit called the *denier*. If such a sample skein, for instance, is found to weigh ten deniers it is called a "ten-denier silk." Now it is found that the exterior thread of a cocoon of the yellow Milanese races has a value of about two and a half deniers, so that it takes four such new cocoons to make a thread of ten deniers. When these cocoons are half unwound the size of the thread formed from them would be but about eight deniers. Now, in order to augment the thread and bring it to the normal size we are obliged to add another cocoon which, with its new thread, would increase the combined thread to ten and one-half deniers, and it will be seen that from cocoons of this race it is impossible to augment the thread by smaller increments than that mentioned. For this reason no attempt is made to produce an absolutely regular thread of silk, but reelers are content if the variation from the desired mean does not exceed two deniers in each direction. In hand-reeling, where the regularity of the thread depends entirely upon the ability of the reeler to estimate its present size and to add a new filament at the proper time, only the most expert operatives are able to make silk within the limits named. In the automatic reel, however, all this is taken out of the hands of the operative and the indication of the need of a new thread is made by the delicate serigraphic measuring device of the control movement. Its delicacy is such that when working under good conditions it will sometimes run off an almost theoretically perfect thread. A great advantage exists in this fact, as the beauty of a piece of woven goods depends very largely on the regularity of the raw silk entering into its composition.

In addition to the devices mentioned above, the automatic reel contains an electrical stop movement by which the motion of the reel is arrested upon the rupture of the running thread. It consists of a small faller on the end of which is mounted the guide-pulley at *E*. When the thread is running the pulley is drawn in the direction of the reel and an electrical contact, *b*, placed on the faller, is kept open. Upon the rupture of a thread, however, this contact is closed and a suitable mechanical device at *V* is set in operation by an electro-magnet. The releasing of the lever of this apparatus enables the spring on the bell crank *L* to act on the shaft of the reel and draw its friction drum away from its bearing on the large drum *I*, and thus stop its motion so quickly that the end of the broken thread will rarely be drawn into the skein. When this apparatus works promptly and well there results a very considerable saving of time in the knotting of the thread, and less waste is produced thereby.

INDEX.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 15.

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OTHERWISE KNOWN AS THE

COTTONY CUSHION-SCALE.

[REPRINT OF SOME RECENT ARTICLES BY THE ENTOMOLOGIST AND OF A REPORT FROM THE AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF CALIFORNIA.]

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CONTENTS.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.
Washington, D. C., June 27, 1887.

SIR: I have the honor to submit for publication Bulletin No. 15, from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION.

This Bulletin consists, 1st, of a reprint of an address delivered at Riverside, Cal., on the treatment of Scale-insects, and more particularly of the Icerya of the Orange, known variously as the "Australian Bug," "Cottony Cushion-scale," "White Scale," "Fluted Scale," &c.; 2nd, a subsequent communication as to its possible origin and synonymy; 3rd, a recent important bulletin from the State University of California on the use of gases against Scale-insects. These papers need no further introduction and are all supplementary to an extended article upon the Icerya, which will appear in my annual report.

The importance of this insect and of all the different scale-insects affecting the Orange in California is such as to justify the republication of these papers, as there is a constant demand for copies of them. The report by Professor Morse on the use of gases is a valuable contribution to the advancement of our knowledge and means of protecting trees from these scale-insects. It may be looked upon as a direct outgrowth of the experiments made for the Department by Mr. D. W. Coquillett, as he had just begun to experiment with gases when his commission ended for want of funds. He subsequently continued these experiments in a private capacity with more or less success, and that which Professor Morse found most satisfactory is, I believe, essentially the same as that previously adopted by Messrs. Coquillett, Craw, and Wolfskill and referred to in my Riverside address. What is said in that address under the head of "Fumigation" will, nevertheless, hold true, no matter how satisfactory the use of these gases may become, and Professor Morse's experiments rather confirm the difficulties which I have indicated in the way of producing a gas which will destroy the Icerya *and its eggs*, as also the danger attending the use of any poisonous gas and the greater expense attending the use of gases, as compared with washes, especially for those who have few trees to treat. Some excellent improvements have been made in the cyclone nozzle, whether for facilitating the change of direction or amount of spray, or whether for ease of cleansing, and I would especially call attention to those of John Croften and L. D. Green, of Walnut Grove, Cal., and of Vermorel, of France.

As Vermorel's arrangement for cleansing is as yet unknown in this country, we may briefly describe it as follows:

The nozzle is pierced below by a circular orifice of from five to six millimeters in diameter, which can be closed by a fly-valve. The regulating fliers of the valve project on the outside of the apparatus: In the middle of the valve a needle is welded which occupies the axis of the cylinder, and which, when the valve is raised, may be lodged in the aperture with which the stopper of the cylinder is provided. In this way, when the valve is raised up and the lower orifice unmasked, the upper orifice is closed by the needle. When, on the contrary, the valve closes the lower orifice, the aperture of the stopper is uncovered and allows the liquid to pass out.

C. V. R.

THE SCALE-INSECTS OF THE ORANGE IN CALIFORNIA, AND PARTICULARLY THE ICERYA OR FLUTED SCALE, *ALIAS* WHITE SCALE, *ALIAS* COTTONY CUSHION-SCALE, ETC.

[Address by Prof. C. V. Riley before the California State Board of Horticulture, at its semi-annual session at Riverside, Cal., April 12, 1887, as reported in the Pacific Rural Press, April 23, 1887.]

Afternoon session.

The convention met in the afternoon at the Pavilion. It being customary to appoint from the fruit-growers at large two honorary vice-presidents at each meeting, L. M. Holt, of the Riverside Daily Press, and S. C. Evans, of Riverside, were elected to fill those positions. Mr. B. M. LeLong, of Los Angeles, was invited to act as assistant secretary.

The organization having been fully effected, Mr. Cooper, the president, gave a brief statement of the work of the board since its organization. He referred to its previous sessions, and stated that it was the expressed wish of prominent fruit-growers of Los Angeles that its next session be held either in San Diego, Santa Barbara, or Riverside. He had accordingly, in the hope that the well-known interests of the people of this section in horticulture would lead to a better attendance than was sometimes obtained, arranged for the meeting here. The previous session had brought out valuable information, which was being printed, and would be distributed. It was necessary that the mass of newcomers to this portion of the State should be furnished facts which might save them from making expensive blunders. The insect pests are not being overcome as could be wished. He referred to the presence of Professor Riley, one of the most prominent entomologists in the country, and stated that he would give us some valuable information at a subsequent session. He urged co-operation among fruit-growers, and hoped an effort would be made to modify the effect of the interstate commerce bill.

The president then introduced Mr. H. J. Rudisill, a prominent horticulturist of Riverside, who gave an eloquent and very appropriate address of welcome.

At the conclusion of this address the secretary read a well-written and valuable essay prepared by Mrs. H. H. Berger, of San Francisco, on Japanese fruits.

At the conclusion of the essay, Mr. Wilcox, of Santa Clara, suggested that the convention consider the points in Mrs. Berger's paper, and referred to the high character of our fruits exhibited at New Orleans, making special mention of the persimmons there exhibited. They could be grown successfully over the larger portion of the State, and were really a very fine fruit.

Mr. Klee spoke of the fact that most of the Japanese persimmons were grafted on inferior stock, but that we have a better stock upon which to graft in the European persimmon, and that with it we may expect an improvement in the fruit. He had an idea that while the persimmon would grow well in all sections, it would do better in the more humid portions of the State. He suggested that it would be well to experiment with the Japanese oranges in Riverside. Didn't think they would grow of large size, but had excellent points in their favor.

Mr. Klee said the loquat could be grafted on the quince, but did well on its own root. Said the Chinese had better varieties than those with which we are familiar. This fruit could be dried like the fig.

Mr. Starr, of Lugonia, said the persimmon did excellently in the sandy soil of his neighborhood, bearing freely and regularly.

Mr. Holmes thought experience in Riverside had demonstrated the correctness of Mr. Klee's theory that a more humid climate was preferable for this fruit, although it fruited satisfactorily here.

Tuesday's session.

The convention assembled at 9.30 a. m. The first business on the programme was the address of Professor Riley on Scale-insects. He was introduced by President Cooper in a very off-hand but happy and appropriate manner, alluding at some length to the efficient manner in which the professor had conducted the labors of his office, in studying the habits of some of the most destructive insects which have afflicted the farmer and horticulturist, and in devising ways and means to get rid of them.

The professor, on taking the floor, very modestly disclaimed the eulogy which the president had pronounced, and proceeded at once with his address, which was full of valuable information, and which, though quite lengthy, was listened to with the most marked attention throughout.

Professor Riley said:

Mr. President, Ladies, and Gentlemen: When I left Washington it was with the intention of resisting all invitations to speak, as I have been suffering for some time from the effects of overwork and desired quietly to pursue some investigations in relation to insects injuriously affecting fruit culture here and at the same time get rest from exacting office duties. But it was impossible to refuse the urgent appeal of your president, Ellwood Cooper, to address this meeting. I have, however, no formal address to offer you.

The subject announced, namely, "Entomology in its Relation to Horticulture," is one chosen by some enterprising member of your Board, and is altogether too comprehensive to be dealt with without more time and more thought than I have had at command. I shall endeavor to confine my remarks to scale-insects, and particularly to what you know as the White Scale. This is the insect which undoubtedly most concerns you just now, and I have an elaborate article upon it now going through the press at Washington. This, however, would require two or three hours to read, and I will pass over the purely historical and entomological details and touch only upon such points as will probably interest you.

NOMENCLATURE.

There is no doubt whatever about this insect being the *Icerya purchasi*, of Maskell, and its scientific name is, therefore, fixed.* In reference to its popular name, there are several in use, and as between "Australian Bug," "White Scale," and "Cottony Cushion-scale" there is very little choice, and it is, as a rule, useless to endeavor to change popular names that have once come into vogue. So far as they can be changed, however, and with a view of inducing unanimity in the adoption of a single name, it were better to reject all these names and call it the Fluted Scale. There are many Australian bugs and many white scales, some of which, belonging to the genus *Pulvinaria*, equally well deserve that cognomen. Cottony Cushion-scale is both too long to be acceptable and would likewise apply to the species of this last genus, whereas no scale-insect injurious to fruit or other trees, at present existing in this country, secretes its white, waxy matter in such a perfectly *fluted* mass as this. The generic term, Icerya, if once popularized like Geranium, Phylloxera, &c., has the advantage of brevity and still greater accuracy.

GEOGRAPHICAL DISTRIBUTION.

Historical evidence all points to Australasia as the original home of this insect, and its introduction from Australia to New Zealand, Cape Town, South Africa, and California. Nothing was known or published upon the species prior to the seventh decade of this century, and it seems to have first attracted attention almost simultaneously in Australasia, Africa, and America. The evidence as to whether it is indigenous to Australia or New Zealand, or to both, is not yet satisfactory. The first personal knowledge which I had of it was from specimens sent to me in 1872 by Mr. R. H. Stretch, then living in San Francisco, and all the evidence points to its introduction into California by the late George Gordon, of Menlo Park, about the year 1868, and probably from Australia, on *Acacia latifolia*.

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* This statement is, of course, based on the assumption that Maskell's *purchasi* is a good species. It may yet prove to be synonym of *sacchari* Signoret.

More light is, however, yet needed on this point, as in a recent letter received from Baron von Müller, of Victoria, he claims that it could not have been imported on Acacia into this State, as all the Acacias in the State have been grown from seed. This is a matter upon which I should like to have definite information from members of this body, if such information is extant.

It is at present widely distributed in the State, and a very full account of its distribution kindly furnished to me by Mr. Matthew Cooke shows that there are some ten infested districts, namely, six in the counties of Marin, San Mateo, Santa Clara, Sacramento, Sonoma, and Napa, and four in the counties of Santa Barbara and Los Angeles. I find that it has also obtained a foothold in a few isolated places around San Diego, from which it may yet be stamped out.

FOOD PLANTS.

A very long list of plants might be enumerated upon which this insect is either found accidentally or upon which it can live more or less successfully. But the list of plants, especially of trees important to us for their products, which are seriously affected by it is comparatively limited, and will include the Acacias, Lime, Lemon, Orange, Quince, Pomegranate, and Walnut. Some few other trees might be added, and it is particularly partial to the Rose and the Nettle; but it is doubtful whether the species could permanently thrive and multiply to an injurious extent on many other trees than those mentioned.

CHARACTERISTICS OF THE INSECTS.

The genus *Icerya* was founded by Signoret, a French entomologist, in 1875, being based upon the single species, *Icerya sacchari* (Guérin), which lives on sugar-cane in the island of Bourbon. This species and the one we are now dealing with are the only two species of the genus, and the diagnosis as given by Signoret, and subsequently elaborated by Maskell, of New Zealand, is incomplete and does not include the characteristics of the male.

In the report already alluded to I have given a very full characterization of the species in all conditions and stages, but the only facts that I need draw attention to on this occasion are, first, that the female undergoes three molts and the male two; *i. e.*, each has one more stage than has hitherto been recognized by entomologists and observers; secondly, that it differs from all other members of its family (Coccidæ) in its extended powers of locomotion in most of its stages; in its extreme hardiness or power of surviving for a given period without food, and in its polyphagous habit, or the ease with which it accommodates itself to so great a variety of plants. These are the three characteristics which most concern you as fruit-growers, and which make it one of the most difficult species to contend with.

MODE OF SPREAD AND DISTRIBUTION.

All young scale-insects are quite active when they first hatch, and most of them at this time are extremely small, and when very thick upon a tree, instinctively, or at least very easily, drop from the terminal twigs and branches. Their specific gravity at this time is so light that they are easily wafted with the wind in their descent. This general truth applies with equal force to the Icerya, which is readily carried from tree to tree and from orchard to orchard by the agency of wind, by running water, or by birds or other insects. Another local means of transport not to be ignored, is upon the clothing of persons engaged in cultivating, upon packages, and upon all implements used, whether in cultivating or harvesting the crop. This particular species also has quite a habit of crawling over the ground, and its local spread is very materially enhanced thereby.

It is carried long distances, however, chiefly by high winds, birds, and commerce, and its introduction from one continent to another has undoubtedly been effected by the latter method upon young trees or cuttings.

NATURAL ENEMIES.

No bird is known yet to attack this insect in California, and but one is mentioned even in Australia, and that upon very slight evidence Of predaceous insects, a species of Lace-wing (genus *Chrysopa*) has been observed to feed upon it, as also the Ambiguous Lady-bird (*Hippodamia ambigua*). The larva of a little moth, which I have described as *Blastobasis iceryæella*, is also known to feed upon the eggs. Among the Heteroptera, or true bugs, quite a number have been found upon the trees infested with the insect, but none have yet been noticed to feed upon it. The most important of its insect enemies are a species of earwig not yet identified, and a number of mites not yet carefully studied.

Of true parasites, none have hitherto been reported, whether in Australia, Africa, or America, but I am glad to announce that two specimens of a minute Chalcid-fly have been bred by me from specimens around Los Angeles, and will be described by my assistant, Mr. L. O. Howard, who makes a specialty of the family, under the name of *Isodromus iceryæ.* The genus is new to our fauna, and the probability is that this little friend was introduced from Australia with its host.*

PREVENTIVE MEASURES.

Most of the members of this society are doubtless aware that for some four years I was conducting a series of very careful experiments with a view of controlling the scale-insects and other insect pests that injuriously affect the orange trees in Florida. This work was carried

* Mr. D. W. Coquillett informs me that he has since reared a Proctotrupid, probably of the genus *Cosmocoma,* from the male pupa.

on through the instrumentality of Mr. H. G. Hubbard, and the Department of Agriculture has published a special report prepared by him upon this subject. All that is said in that report in reference to the value of preventive measures against the scale-insects of that part of our country will apply with equal force here in California.

The value of cleanliness; of thorough cultivation; of pruning judiciously so as to get rid of all dead wood, open the top of the trees to the light and to the sun, and facilitate the spraying of the trees need scarcely be emphasized. There may be some difference of opinion as to the value of pruning, while different kinds of pruning, or no pruning, will have their advocates here as they have had elsewhere. The orange makes, naturally, a very dense head, and in the moist climate of Florida, where they have a much larger average of shade, cloudiness, and moisture than you have here, judicious pruning has all the advantages stated, and whether needed or not in California for the purpose of more fully ripening and maturing the fruit, I am quite satisfied from what I have seen that it is just as much needed to facilitate proper spraying of the trees and to prevent overproduction.

Some years ago, and prior to the discoveries resulting from the investigation in Florida just referred to, the inadequacy of most washes caused many of the orange-growers of that State to cut back their trees most rigorously, leaving little more than the main trunk, in the hope of thus being able to kill out or exterminate the scale-insects that troubled them there. I find that many of your orange-growers are going through the same sad experience and resorting to the same sad means. It is a pity to find men thus re-enacting a farce which has been proved in another part of the country to be quite unnecessary. Such wholesale lopping of limbs requires much labor, and even with the greatest care, which is seldom bestowed upon it, the tree receives an immediate and material injury, and is destined to suffer still more in years to come. Moreover, this radical means often proves futile so far as the results aimed at are concerned, and unless the greatest precaution is taken to properly cover and heal the stumps and to absolutely kill all the insects upon the remaining trunk, as well as those upon the severed branches and the ground, the new growth will soon be as effectually infested as was the old. Many of your own growers have thus lopped or are now cutting back their trees in a very blind way and without the precautions here indicated, on the popular but erroneous supposition that without such precautions they will get rid of the troublesome scales.

The value of shelters in the form of surrounding trees and wind-breaks is, I am sure, just as appreciable here, if not so much to protect from frost and winds, fully as much to protect from infection from scale-insects. A row or tall hedge of coniferous trees, such as your cypress, upon which the scale-insects will not thrive—or, better still, a belt of the same—will often serve as an effectual screen to prevent the young insects from being carried from an infested to an uninfested grove.

Preventing its Introduction.—But, before passing this subject of preventive measures, I must not omit the importance of any effort looking to preventing the introduction of this insect from one section of the country or from one neighborhood to another. No insects so easily bear transit as these scale-insects, and it is eminently true of this particular Icerya.

All the worst species from which they suffer in Florida have been introduced from abroad. Their Long Scale (*Mytilaspis gloverii*) was introduced about the year 1835, their Chaff Scale (*Parlatoria pergandii*) from Bermuda some twenty years later, and their Red Scale (*Aspidiotus ficus*) from Havana in 1879.

We have already seen how this Icerya was introduced into your State from Australia, and the next worst species which you have to deal with, namely, your Red Scale (*Aspidiotus aurantii*), was likewise introduced, so far as the evidence goes, from the same country.

To enumerate merely the different species of insects destructive of your fruit interests that have been introduced from other parts of the country or from other parts of the world would consume too much time, and I cannot attempt to do so. But I would lay stress upon this conviction, which has forced itself upon me after a pretty extended experience in all parts of the country, namely, that however much you should encourage all co-operative efforts to prevent such transferring and spread of injurious pests, they cannot be fully exterminated when once they obtain a foothold, and in the end each individual fruit-grower must depend on his own efforts.

REMEDIES.

It follows without saying that what we should seek in any direct remedy is, first, perfect killing power, or, to be more exact, perfect insecticide quality associated with harmlessness to the tree; second, reasonable cheapness.

Different Washes.—I will not detain you with any general remarks on the subject of insecticides, because it has received full attention in my official reports. Dry insecticides have been found, in the main, unavailable here, and we must depend upon washes or materials in solution that may be sprayed upon the tree. Here, again, I would remind you of the careful and extended experiments made by Mr. Hubbard in the orange groves of Florida with a view of solving the important question as to what is, on the whole, the most satisfactory liquid application, cheapness and efficiency considered. Carbolic acid, creosote, sulphurated lime, silicate of soda, sulphuric acid, sulphuret of iron, bisulphide of carbon, and many other materials have been thoroughly tried, as well as whale-oil soap, potash and soda lye and their various combinations; but in the end nothing proved equal to emulsified kerosene. Whale-oil soap is an excellent wash for destroying some insects upon some plants, but it fails to kill the eggs of our scale-insects, so that, however good it may be for scrubbing the trunks and branches of a tree, I cannot conscientiously urge it as, on the whole, satisfactory, particularly as it is known to stain the fruit, and because of the many different grades, varying in their effect and in their value, which are upon the market. Potash and soda lye injure the tree more than kerosene does and do not destroy the insects as well, admirable though they are as washes in weaker solution for some other purposes. The action of sulphurated lime (flowers of sulphur boiled in milk of lime) is very similar to that of caustic potash.

Notwithstanding the kerosene emulsions, in proper proportions, have proved so satisfactory against the scale-insects of the Orange in Florida, they have, as a rule, failed to win the good opinion of the orange-growers in California. I have always believed the want of success in this State with the kerosene emulsions was due to imperfect preparation of them, or to imperfect application. I was inclined to give some credence to the theory advanced by my old-time friend, Prof. E. W. Hilgard, who is so keenly alive to everything that interests you, and whose services have been so invaluable to the agriculture and horticulture of the State, namely, that the dryness of the atmosphere in California induced a more rapid evaporation of the kerosene, which may partly account for the difference in experience between the Atlantic and Pacific. For these reasons I had long desired to make a series of experiments in California, and finally, last year, did have such a series carried on by Messrs. D. W. Coquillett and Albert Koebele. It were difficult to find in the whole State two gentlemen combining in the one instance more care and reliable entomological capability, and in the other more industry, earnestness, and enthusiasm, and this I say without desire to flatter, but as evidence that their experiments, so far as they went, were trustworthy—in fact, I may say, the most careful and thorough that have hitherto been made. These experiments extended over a period of three months in the spring and three months in the autumn, and the detailed reports which these gentlemen have made will be published in connection with my forthcoming annual report. They show that the kerosene emulsions must still be placed at the head of the list of washes, not only for ordinary scale-insects, but for this Icerya or Fluted Scale. Among the different substances thoroughly experimented with were caustic potash, caustic soda, hard and soft soaps, tobacco, sheep dip, tobacco soap, whale-oil soap, vinegar, Paris green, resin soaps and compounds, and so on. It is impossible to give even a digest of the very many experiments, and the varying results obtained with the different washes. It suffices to say that the kerosene emulsion diluted with from eight to ten parts of water was found to kill all the eggs as well as the old females, and that, even when used still stronger, it left the tree uninjured. Mr. Coquillett reports with reference to the much-praised caustic soda, that it has no effect on the eggs of this scale even when applied so strong as to burn the bark and kill all the leaves.

Similarly, the whale-oil soap does not kill the eggs directly, though it may harden the egg-mass so as to prevent the hatching of a large proportion of young larvæ.

Resin Soaps.—Mr. Koebele experimenting through August, September, and October, found similarly good results from the kerosene emulsion, but that the crude petroleum, although much cheaper, was more apt to injure the tree. His attention was, however, directed mainly to the preparation of resinous soaps and compounds on account of their greater cheapness. He succeeded in making a number of these mixtures which, when properly diluted, need not cost more than one-half to one cent per gallon and which produced very satisfactory results, killing the insects or either penetrating or hardening the egg masses so as to prevent the hatching of the young. One of the most satisfactory methods of making a resin soap is to dissolve one pound caustic soda in 1½ gallons water to produce the lye; then dissolve 2 pounds resin and one pound tallow by moderate heat, stirring in gradually during the cooking one quart of the lye, and then adding water until you have about 22 pints of a brown and thick soap. This will make 44 gallons of wash, costing less than one-half cent per gallon.

There is some slight difference between the experience of Mr. Koebele and Mr. Coquillett as to the value of soap washes, and the greater success which the former had with them as compared with the latter was probably due to the fact that his experiments were made during the dry or rainless season. The great point of interest, however, in these experiments is that they confirm in a remarkable manner the experience had in Florida. And I think you will agree with me that they justify the opinions which I have expressed in official writings. Such observations as I have been personally able to make during my brief sojourn among you have greatly served to confirm me in those opinions, and while the resin soaps experimented with by Mr. Koebele are a valuable addition to our insecticides for the scale-insects, I find the experience in Florida repeated here, and all the more satisfactory washes have kerosene as their effective basis. There has been, however, a very great waste in applying it, and it is in this direction that reform is most needed.

The fact cannot be too strongly urged that in the case of this Icerya, as of most other orange-feeding scale-insects, it is practically impossible, with the most careful and thorough spraying, to reach every one of the myriads on the tree. Some few, protected by leaf-curl, bark-scale, or other shelter, will escape, and with their fecund progeny soon spread over the tree again if left unmolested. Hence, two or three sprayings, not too far apart, are far preferable to a single treatment, however thorough. And this is particularly true of the pest we are considering, which lives on so many other plants, and which in badly infested groves is frequently found crawling over the ground between the trees.

Value of Kerosene Emulsion.—It is now the custom to use the time of a team and, say, two men for fifteen or twenty minutes or more, and 30, 40, or 50 gallons of liquid on a single medium-sized tree. In this way the tree is sprayed until the fluid runs to the ground and is lost in great quantities, some growers using sheet-iron contrivances around the base of the tree in order to save and re-use the otherwise wasted material. Now, however much this drenching may be necessary, or has come into vogue, in the use of soap, and potash and soda washes, it is all wrong, so far as the oil emulsion is concerned, as the oil rising to the surface falls from the leaves and wastes more, proportionately, than the water.

The essence of successful spraying of the kerosene emulsion consists in forcing it as a mist from the heart of the tree first and then from the periphery, if the tree is large, allowing as little as possible to fall to the ground, and permitting each spray particle to adhere. It is best done in the cool of the day, and, where possible, in calm and cloudy weather. There has been no morning since my sojourn among you that I have seen the sun rise in a clear sky. Cloudiness has prevailed for some hours after dawn, and in this regard you are favored, as this would be the time of day, of all others, to spray. Proper spraying should be done with one-fifth of the time and material now expended, or even one-tenth of that which I have seen wasted in some cases, so that three sprayings at proper intervals of from four to six weeks in spring and summer will be cheaper and far more satisfactory than one as ordinarily conducted. In this particular neither Mr. Coquillett's nor Mr. Koebele's experiments were entirely satisfactory, as I was too far from the field to permit of the detailed direction necessary.

I cannot emphasize the fact too strongly that it is practically impossible to eradicate, by any system, every individual insect and egg upon a tree in one spraying. It is almost futile to attempt to do so.

Improved Wash recommended.—Let us now see whether the kerosene emulsion, pure and simple, can be improved upon by the addition of any other material. It is plain to be seen from the circulars and documents, both official and unofficial, that have been published in the State and distributed among you, that, in many cases, the proper use of kerosene has been entirely misunderstood. Having already seen that it destroys the eggs of Icerya only when used in the ratio of one part of kerosene to about seven or eight of the diluent, it follows that any lesser amount will give less satisfactory results. Moreover, it is extremely important to prepare the emulsion properly. This has usually been done by the use of milk or of soap, because they are cheap and satisfactory. Raw eggs and sugar, and other mucilaginous substances may be used. Experience has shown that the best proportions are two parts of the oil to one of the emulsifying agent, whether milk or soap, *i. e.*, for instance, two gallons of the oil to one of milk or one of the soap-water made by dissolving half a pound of soap in one gallon of water. So long as these proportions are maintained a large quantity can be emulsified as rapidly as a smaller quantity, and violent agitation through a spray-nozzle at a temperature of 100°, and as frequently described in my reports, gives the quickest results.

Take, for instance, the mixture recommended by your county board of horticultural commissioners. You will find that with the soap and wood-potash there are twenty-five parts of the diluent to one of the kerosene recommended, and there is every reason to believe that the kerosene in this wash might just as well be thrown away, and that it adds comparatively little, if any, to the efficiency of the wash, at least for the fluted scale. If, on the contrary, we could add to the ordinary emulsion any materials that would give greater adhesiveness, such an addition will prove an advantage. Such we get, to some extent, in the soap emulsion, for which reason it has a slight advantage over the milk emulsion. And after examining the trees treated with resin washes, I am strongly inclined to recommend that these resin washes be used as the diluent to the soap emulsion made after the usual formula. Something similar was tried some years ago by one of my agents in Florida, Mr. Joseph Voyle, who used fir balsam in place of resin, in connection with the oil emulsion, and obtained most satisfactory results. A certain amount of dextrine, or, yet better, flour, if mixed with the wash, would prove valuable for the same purpose.

Again, if permanency can be given to the effect of a wash so that the few insects escaping the first application, or which would hatch out thereafter, would succumb, such addition would be invaluable; and though the arsenites are, as a rule, effective chiefly against mandibulate insects, or those which masticate their food (in other words, although the action of these poisons is mainly through the stomach), yet I happen to know from experience that they have also a direct effect by contact. Therefore I recommend, with considerable confidence, that in this dilute kerosene emulsion there be added a small proportion of arsenious acid, say from 2 to to 3 ounces to every 50 gallons of wash. This arsenious acid may be prepared and added in various ways. Probably one of the simplest would be to take half a pound of arsenic to half a pound of sal-soda, boil this in one-half gallon of water until the arsenic is dissolved, and mix this with about 100 gallons of the diluted emulsion. A quarter of a pound of London purple to 50 gallons of the diluted emulsion, or even a still greater amount, would, perhaps, serve the same purpose and be less likely to injure the tree.

I am aware of the danger of making recommendations that have not yet had thorough trial, but I have already made a few limited experiments (and intend making more) which would seem to justify these, and at all events if care be taken not to use too large a quantity of the arsenic no harm will result from it, either to the tree or to those who use the fruit.

Kerosene is not so cheap as the resin compounds, nor as some of the soap and lye washes, but it has this great advantage, that it can be used in much less quantity. It permits a great reduction in the amount of material and the cost of labor. At the rate of 20 cents per gallon wholesale, the effective wash will cost 2½ cents per gallon, and from one to two gallons are sufficient, if properly sprayed, on a medium-sized tree.

SPRAYING APPARATUS.

Just as there is a great wastage of time and money in drenching a tree with kerosene emulsion, so the spraying nozzle most in vogue with you is also somewhat wasteful. That most commonly used is the San José nozzle, in which the water is simply forced through a terminal slit in a narrow and rather copious jet of spray. It is the force and directness of the spray which gives this nozzle its popularity under the mistaken spraying notions that prevail, and to this I should probably add the fact that, being a patented contrivance, it is well advertised, and on the market, for somehow or other people rarely value a gift as much as what they buy, and too often rate value by price. The Cyclone nozzle, or Riley atomizer, as it is called in France, which has proved so satisfactory in the East as well as to my agents at Los Angeles, has scarcely had such trial among you, so far as I have been able to see, as to properly impress its advantages. That originally made and sent out by the late G. N. Milco, of Stockton, was patterned in size and form after one which I sent him, and which was designed to spray from near the surface of the ground.

What I would use for the orange grove, or for trees, is a bunch of nozzles of larger capacity, the size of the outlet to be regulated by the force of the pump. I have witnessed all forms and sorts of spraying devices, and while there are many that are ingenious and serve a useful purpose, I can safely say that there is no form which will produce a spray so easily regulated and altered to suit different conditions, and which is so simple and so easily adjustable to all purposes. Since among you I have endeavored to get a bunch nozzle, such as I would recommend, made at Los Angeles, and the difficulties I have had in getting it made properly illustrate, perhaps, some of the reasons why this nozzle has not become more popular on this coast. All the parts must be well fitted; the inlet must be tangential and the outlet so made as not to overcome the whirling or cyclonic action of the water. The breadth, directness, force, or fineness of the spray are all regulated by the form and size of the outlet, and if a thick cap be used it must be gradually countersunk on both sides until the thickness at the outlet does not exceed one-sixteenth of an inch or less. A bunch of four nozzles, one arranged so as to have the outlet distal or from the end of the piping, which may be ordinary gas-pipe, and the other three in bunches, so that the outlet is at nearly right angles, each about an inch below the other, and so placed that they are one-third the circumference of the main pipe apart, will be found, I think, most serviceable in your groves. Such a bunch working from the center of an ordinary-sized tree will envelop it in a perfect ball of mist.

For tall trees a more forcible stream might be had from the end by substituting an ordinary jet with a wire extension. This is a recent device first brought to my attention by Mr. A. H. Nixon, of Dayton, Ohio, and for sending a fine spray for a great distance it has advantages. It is simply an extension screwed over an ordinary nipple, the end of the tube being covered with wire netting, which breaks up the liquid forced through it. The brass nipple should be about one inch in length, the perforation very true and varying in diameter according to the force of spray desired. The nipple screws on the discharge pipe, and upon a shoulder threaded for the purpose is screwed a chamber or tube about one inch in diameter and three inches long, to the outer end of which is soldered a piece of wire gauze varying in size of mesh to suit the force of pump and the size of aperture in nipple.

Finally, if a service of blind caps and several sets of cyclone nozzle caps of varying aperture are kept on hand, the spraying may be adjusted at will to condition of wind, size of tree, &c.

Your worthy president has very well remarked that what we want is not generalization, but hard facts and experience presented in the simplest and briefest manner. If I have dealt somewhat with principles rather than with details, I shall look for your excuse in the fact that extended experience presents such a multiplicity of details as to warn me from entering into them.

FUMIGATION.

Fumigating trees will always have, *cæteris paribus*, some disadvantage as compared with spraying. The mechanism is more cumbersome; the time required for treatment and the first cost in making preparation greater, and these facts will always give spraying the advantage with small proprietors and those who are dealing with young trees. Sulphur fumes have been tried, but they burn the leaves and injure the tree. Tobacco smoke and vapor fail to kill the eggs. Ammonia is excellent, but fails to kill all, though I have known the most beneficial results from the ammonia arising from sheep manure used as a fertilizer in apple orchards. Bi-sulphide of carbon has been tried, and with great care in getting the right quantity its vapor will kill the insects without killing the tree; but its application requires too much time and is fraught with more or less risk to man. This is equally true of cyanide of potassium and of other substances the vapors from which are known to be very deadly to insect life. It will be difficult, therefore, to find a mode of fumigating that will be harmless to the tree and deadly to the insects, and at the same time as rapidly and easily applied as a spray.

Many of you already know that Mr. Coquillett, in connection with Mr. Alex. Craw and Mr. Wolfskill, of Los Angeles, have for some time been conducting a series of experiments which lead them to believe that they have discovered a gas which possesses the requisite qualities. The trees which I have examined that have been treated with this gas, both there, at San Gabriel, and at Orange, lead me to the conclusion that they are fully justified in this belief, and several ingenious contrivances have been perfected in Los Angeles County which give promise of great utility and feasibility. Whether the trees are left uninjured, it is perhaps premature to say. That they are affected is evident in some cases, and what the ultimate effect will be time alone will decide. Let us all hope that the promise of this gas will be abundantly fulfilled. Let me add, however, that even if it be found that no solitary insect or egg will escape treatment with this or any other gas, fumigation will yet no more fully exterminate or free the orchard than the proper spraying of the kerosene emulsion, but, for the reasons already stated, will have to be repeated. In other words, one application, however perfect in destroying insect life, cannot and should not be depended on. The disadvantage about this gas in my estimation is that it is kept so far a secret. We cannot perhaps blame the gentlemen for endeavoring to realize something out of what they consider a valuable discovery that will compensate them for the time they have devoted to the purpose; but I am always suspicious of secret or patent insect remedies. My friend, Mr. Coquillett, perfected this gas after his employment by the Department of Agriculture ceased. But it is a general truth that the moment any person or persons become interested in a patent or in any remedy they desire to control, from that moment their judgment can no longer be depended on as to the value of other remedies.

I have been asked why Mr. Coquillett was not continued in the service of the Department for a longer period, and it is perhaps due to the fruit-growers of California and to him to explain why the experiments which he began were interrupted. It had been my desire to have two agents permanently located on the Pacific coast to carry on the work of my Division here, for I have long felt that your fruit interests, to say nothing of the other agronomic interests of the State, demanded such recognition at the hands of our National Government. It so happens that in my desire to aid other investigations that bear upon the promotion of agriculture, I took part in urging the creation of a Division of ornithology and mammalogy for the purpose of investigating the habits of birds and mammals so far as they affect agriculture and horticulture. The friends of ornithology were successful in getting that Division created, but were unable to get an appropriation to carry on the work, except by taking it out of the appropriation for the Entomological Division; and during my absence from the country last June, and after all my arrangements had been made for work on the Pacific coast on the basis of the appropriation bill passed by the House of Representatives, the amount was cut down in the Senate and part of it given for the ornithological work, thus requiring the discharge of a number of those already engaged, and restricting the work of the Department in entomology.

BANDAGES AROUND THE TRUNK.

There is always danger that a tree once sprayed or disinfected will get reinfested from the insects that have not been reached upon adjacent plants or upon the ground, and which in time may crawl upon the trunk. Any of the sticky bandages used for the canker-worm will check this ascent, but when the sticky material is placed directly on the trunk it may do more harm than good. It should, therefore, be placed upon strips of tar paper or other stiff paper, tied by a cord around the middle, the upper end flared slightly outward, and the space between it and the trunk filled with soil to prevent the young insects from creeping beneath. Cotton should not be used for this purpose, as birds, for nesting purposes, carry away particles of it which may contain the young insects and may thus help to disseminate them.

LEGISLATION.

Next to the destructive locusts which occasionally ravage our grainfields no other insect has perhaps been more thoroughly legislated against than this Icerya in California. Indeed, the manner in which the people of this State have taken hold of this insect question and have endeavored by all legislative means to enforce such action on the part of fruit-growers as best subserve the interests of the whole State, is highly commendable. Yet, while much good has undoubtedly resulted, the laws have too often proved inoperative, either through the negligence or ignorance of those appointed to execute them, or still more often through the indifference or opposition of individual growers, or unwillingness of the courts to enforce the laws with vigor. And while the greatest co-operation should be urged, and, if possible, enforced, in battling with these insect pests, yet, so far as this particular species is concerned, no human endeavor can now exterminate it from the country. It has come to stay, and nothing has more fully forced itself upon my conviction than that, in the end, with all our laws, each orange-grower must depend upon his own exertions. It is, therefore, fortunate that the pest may be controlled by such individual exertions. While, however, we must admit that it is beyond our power to fully eradicate it from those districts in which it has obtained a foothold, the case is quite different when it comes to restricting its spread, and it is in this direction that wise legislation, and the strict carrying out of the legislative measures you have adopted, or may adopt, will be productive of much good.

Recent history has furnished very good evidence of the power of stringent measures adopted by governments, whether to prevent the introduction of an insect pest or to stamp it out when first introduced and before it has acquired a strong foothold. Several European nations have, in this way, averted, so far, the Grape Phylloxera, and the German Government, on one occasion at least, effectually stamped out our Colorado Potato-beetle, which became established in a restricted locality.

The danger which threatens orange-growing districts in this State not yet affected, as well as the orange belt on the Atlantic seaboard, is great, and we cannot too earnestly appeal to the authorities that be for means to employ still greater vigilance to avert it.

RIVERSIDE.

What a relief it is to get from a scale-infected region, with the attending evils of blighted and withering growth, smuttiness, and unmarketable fruit, into a neighborhood yet exempt from these pests, like this enterprising locality in which you meet! What a joy in contemplating by contrast the bright and cleanly aspect of the trees! And what is there more beautiful in nature than a perfect orange grove at this season, and yet untainted by Coccid or Aphid, or other insect enemy? In all my travels I have nowhere felt nearer the ideal Garden of Eden than in some of your lovely valleys, yet unvisited by these destroying atoms. The profusion and perfection of fruit and flower, the elysian character of the landscape, the genial sun—all appeal to the higher esthetic feeling in man, and one is moved to enthusiastic contemplation and admiration of the glories of nature and the bounties of Heaven under such favoring conditions!

STATE ENTOMOLOGIST.

You know better than I do how your laws have acted in the past and are acting now, and how far your State inspector and your different county inspectors have succeeded.

But, before passing this matter of legislation, I should be derelict in my duty if I did not urge upon you the value of one form of legislation which has not yet been tried. Without abating one iota the work already being done, whether by individuals or boards, it does seem to me that if you had a State Entomologist, *i. e.*, an officer appointed to devote his entire time to this subject of economic entomology in the State, much additional good might be accomplished, provided he were properly supported and given the means to carry on his work effectually. You should not commit the same error that has been committed by some of the Eastern States, in which the cultivators of the soil have desired to have such a State entomologist appointed. In three cases which I now have in my mind there has been quite a disposition on the part of the legislature to pass a proper bill, but it has failed in each case because of the conflicting interests which aimed to control the office. Either the State Board of Agriculture, or a State Horticultural Society, or a State Agricultural College, or some State university, or some other

State institution, desired to have the honor and the privileges pertaining to the office, and, between them all, failure has resulted. I should like to see California with a competent State Entomologist appointed, under a bill carefully drawn up providing his duties, by the governor, upon recommendation of the professor of agriculture in your State university, and the president of such other State horticultural and agricultural bodies as may exist. In this manner the interests of all these bodies might be considered, and the State could not, in my judgment, make a more profitable investment than in the creation of such an office.

IMPORTATION OF PARASITES.

It has doubtless occurred to many of you that it would be very desirable to introduce from Australia such parasites as serve to keep this fluted scale in check in its native land. We have already seen that there is one minute parasite which has, in all probability, been brought over with it from Australia, and there is no question but that it is very desirable to introduce any such of its enemies and parasites as can be introduced. This State—yes, even Los Angeles County—could well afford to appropriate a couple of thousand dollars for no other purpose than the sending of an expert to Australia to devote some months to the study of these parasites there and to their artificial introduction here. But the agent must be an expert entomologist, and his selection should be left to some competent authority. The result for good, in the end, would be a million-fold, and I have no fear but what you, as orange-growers, will appreciate the force of this statement. I would not hesitate, as United States Entomologist, to send some one there with the consent of the Commissioner of Agriculture, were the means for the purpose at my command; but unfortunately, the mere suggestion that I wanted $1,500 or $2,000 for such a purpose would be more apt to cause laughter and ridicule on the part of the average committee in Congress than serious and earnest consideration, and the action of the last Congress has rendered any such work impossible by limiting investigation to the United States.

REMARKS CONFINED TO THE ORANGE.

Let me, in closing, lay stress on the fact that I have, in all that has been said relating to remedies, had reference solely to the orange and the scale insects affecting it.

The Fluted Scale is undoubtedly the most difficult to master, and the means I have recommended against it apply equally to your other orange scales, as experiment has already demonstrated. Your Red Scale, in some respects even worse than the Icerya, and of which I should like to say something in detail did time permit, succumbs to it. But when it comes to the treatment of deciduous trees, much that I have said will not apply, and each tree needs separate consideration and is affected differently by different washes.

PROSPERITY VS. INSECT PESTS.

In passing from place to place since I have been in the State, and more particularly in visiting the different parts of Los Angeles County, I have been struck with the wonderful activity everywhere manifest in real estate. Land is "booming" in all parts of the country, but nowhere has it reached such proportions, it seems to me, as right here in this part of California. There does not, at first, seem to be much connection between the real estate boom and the scale-insects of the Orange. But I am quite sure that the rapidity with which your orange orchards have been and are being converted into town blocks and town lots has a marked influence on the spread and increase of these scale insects; for no sooner does the owner of a grove subdivide and sell it than the different new owners allow it to "run to grass," so to speak, and for miles around all your thriving and growing centers of population may be found neglected orchards upon which the insects are reveling and multiplying and scattering into those which are more carefully cultivated. To this cause is, in my judgment, due very much of the rapid reinfesting of these cultivated orchards, so that your insect troubles are, in a measure, connected with your unprecedented growth and prosperity.

NOT AN UNMIXED EVIL.

Finally, let me say, before taking my seat, that your scale insects are not an unmixed evil. With your lovely climate, rich and varied soil, and the many other advantages which your beautiful country possesses for the cultivation of the orange and most other fruits, the business would soon come to be overdone and rendered unprofitable, could every one, before planting his trees, feel sure of an abundant and fair crop without having to contend with difficulties. Under these circumstances, it seems to me that even the dreaded scale-insects, by driving the thriftless to the wall and giving the careful and intelligent man who persists in destroying and defeating them better prices for his product, may, after all, prove a blessing in disguise. One thing is sure, it is pure folly to talk of giving up the battle and abandoning the field to these, your tiny foes. There is no insect that is invulnerable, or that we may not overcome, if we but attack it at the right time, in the right place, and with proper means and ability. You will, ere long, feel yourselves masters of the situation, and if what I have said will aid in ever so little to give you the victory I shall feel abundantly rewarded. I have already occupied more of your time than I intended to, and though much is left unsaid, even about this single insect, I must close in order to leave time for discussion. In doing so, permit me to congratulate you as a Board for the good work already done, and to prophesy that in future years when the fair and unrivaled fruit of this coast shall have multiplied beyond the most sanguine vision of any of us, and have found its way in one form or another to consumers in all parts of the world, the people of California will gratefully remember the work you instigated and the battles you fought. Ladies and gentlemen, I thank you.

NOTES ON ICERYA—ITS PROBABLE ORIGIN THE ISLANDS OF BOURBON AND MAURITIUS.

C. V. RILEY in *Pacific Rural Press*, June 11, 1887.

I have just read with a great deal of interest the letter of W. M. Maskell to State Inspector Klee, in your issue of the 7th instant. This letter really brings up quite an important question, so far as our White or Fluted Scale is concerned. In an article in my forthcoming report, as United States Entomologist, of which I have sent you advanced page proofs, I have, without question, assumed that *Icerya purchasi* Maskell was a good species and distinct from *I. sacchari* Signoret, because Maskell, in his second article on the former species (Trans. New Zealand Inst. for 1883, page 140), after an examination of specimens of *I. sacchari*, sent him by Signoret, says that he finds the "Mauritian species undoubtedly and markedly distinct." This letter to Mr. Klee brings up, however, the whole question of the accuracy of his determination. He admits that he has never seen Signoret's *I. sacchari* alive. The only differences which he made in 1883 between *I. sacchari* and *I. purchasi* are as follows: "*I. sacchari* does not seem to form an ovisac with longitudinal grooves, nor does the body of the insect, although somewhat hairy, show the great tufts of black hairs and the curious projecting glassy tubes springing from large brown coroneted bases which are marked features of *I. purchasi*. The number of circular spinneret orifices are much smaller in the Mauritian insects."

Now Signoret knew only two stages, the full-grown female and the newly hatched larva, while Maskell gave careful descriptions of the egg, the young larva, the second stage, and the full-grown female, but had not seen the male larva, cocoon, or adult. It is for this reason that I have given a very full characterization of the species in the article already alluded to.

Signoret's description, so far as it goes, applies thoroughly well to *I. purchasi* in some of its forms. His female had not formed the cottony or fluted-egg covering, at least he makes no reference to it. His figure, while showing a short truncated mass, does not indicate the flutings because the few lines upon it are evidently intended by the artist for the long, fine, glassy hairs. Maskell, following Signoret's description, rightly says that *sacchari* "does not seem to form an ovisac with longitudinal grooves." But Signoret himself says that *sacchari*, in the island of Bourbon, "is confounded with *Lecanium gasteralpha*, under the name of louse-with-the-white-pocket." Whether Signoret assumed such confounding by the islanders because of erroneous supposition that this *sacchari* had no ovisac, or whether the islanders designate both the *Lecanium* and the *Icerya* under the characteristic vernacular, is not plain from the language, and is immaterial. On the principle of unity of habit in the same genus, I feel morally sure that Signoret's *Icerya* must produce her eggs in such an ovisac, and the Bourbonese are doubtless well aware of the fact, otherwise they would not so indicate it or confound it with *Lecanium*. We are justified in assuming that the female which my friend Signoret described and figured had only just begun forming its sac, and that its flutings had become effaced and the secretion unnatural in appearance. Maskell's second reason, viz, that *sacchari* "does not show the great tufts of black hairs and the projecting glassy tubes," will also lose force from the facts that Signoret particularly describes these glassy tubes as "long filaments, waxy, very fine, delicate, transparent," and that these tufts of black hairs are extremely variable in quantity, sometimes making the insect look quite dark and bringing out in strong relief the few smooth, orange-red or brick-red elevations, and particularly the series of about twenty-two around the border; at other times being so scarce that the insect has an almost uniform reddish-brown appearance.

It would appear, therefore, that, notwithstanding the differences in Signoret's and Maskell's characterizations, there is room yet for grave doubt as to the specific difference in the two insects, especially as upon restudying Signoret's description it accords in every other particular with *I. purchasi*.

You will pardon me, I know, for going into these technical details, because it is evident that the solution of these questions has a very important bearing. My own impression now is that future investigation will prove that the two insects are identical. The truth will in time be ascertained by getting all the different stages of *sacchari* from the Island of Bourbon or from Mauritius, and comparing them more carefully with *purchasi*, the different stages of which I have fully detailed in my report.

Let me say in this connection that there is a great variability in *purchasi* as to the amount of matter secreted on the scale itself, which may very easily mislead, especially in dried specimens. In the orange groves of Southern California the general colorational aspect of the insect is, in all its stages, reddish-brown, the surface exudation being rarely excessive and never obliterating the reddish-brown color. This exudation is, in fact, more noticeable upon the male larva, which, together with his narrower, more elongate form, renders him easily distinguishable from the female. In the more northern parts of the State, however, I found that the general colorational aspect was quite different, owing to the greater excess of the surface exudation, which frequently covers the body in little globular masses and gives it a whitish and even greenish aspect, and which often rises along the middle of the body into a tufted ridge. This form corresponds more nearly with what Signoret has described, and it follows that this waxy surface exudation becomes denser and still more noticeable by contraction in the dried or cabinet specimens or whenever the insect has shrunken.

This question of the synonymy of the species bears directly on its original source; for if we have but one species of the genus, or even if there be two, and *I. purchasi* is found to occur on the sugar cane in the islands of Bourbon and Mauritius, then the presumption will be that it originally came from these islands. In my address at Riverside, I called attention to the fact that this Fluted Scale seems to have become notably injurious almost simultaneously in Australia, South Africa, and California, and on the assumption that it infests the sugar cane on the islands mentioned, it is much more easy to understand its introduction to the other countries. Sugar is exported from those islands into many parts of the world. The sugar, as it leaves those islands, is very coarse, and all the molasses or sirup is not extracted, centrifugals not being in use. For the purpose of draining, the sugar-makers are in the habit of putting a piece of cane in every hogshead, and, in addition, the top is sometimes covered with pieces of cane. In point of fact, I am informed that an insect, known in the trade as the sugar-louse, is of quite frequent occurrence in such sugar, and Professor Wiley, of the Department of Agriculture, upon being shown specimens of *Icerya purchasi* (and he is quite familiar with the so-called sugar-louse), informed me that he thinks them identical.

On this hypothesis the initial spreading point is from some of the Pacific islands, and the insect probably made its way first to Cape Town and thence to Australia, New Zealand, and California. This does not preclude the possibility of its importation upon other plants, but I think it highly probable that the chief method of distribution of an insect which is so tough as to bear long survival without food was upon sugar-cane in sugar hogsheads, or bags, as it could be much more safely carried in this way than upon living plants. The determination of the original source of the pest is of vital concern in any study of its parasites, as such would be more apt to be found in its native country than in any countries of its introduction.

I have been quite anxious to settle definitely this question of its original home, and have lately had some correspondence with parties in Australia, New Zealand, and Africa. The following extracts from such correspondence will prove of interest to the people of California. Mr. Kirk's statement will add weight to the hypothesis that I have ventured, while Baron von Mueller's statement also strengthens it. It may perhaps be impossible at this late day to definitely settle the question of this original source, especially as there may have been not one but several introductions (indeed we have evidence that such was the case) into all three of the countries in which it now occurs; but we can much easier understand its travels if it started as a sugar-cane insect. I have italicized those parts of the following letters which particularly bear on the subject of this communication.

The sketch of the Dipteron, which Mr. Crawford found attacking Icerya, shows a great likeness in the body to some hymenopterous Encyrtids; but the wings indicate its Dipterous character and that it belongs to the Dolichopodidæ near *Diaphorus*. So far as their larval habits are known, these flies are predaceous and live in the larva state in the ground. Perhaps Mr. Crawford has used the term "parasitic" synonymically with "predaceous," but I will not further anticipate what Miss Ormerod may report.*

EXTRACTS FROM CORRESPONDENCE.

[The following are the extracts from the correspondence to which reference is made above.—EDITORS PRESS.]

Letter from Roland Trimen, of Cape Town, to Professor Riley.

As regards the evidence as to the Australian habitat originally of this insect, I regret that I have nothing to add to what has been already supplied to you.

*　*　*　*　*　*　*

Since the commissioner's report in 1877, the orange industry of the western districts has suffered most severely, scarce, very inferior, and exceedingly dear fruit being now only obtainable where it used to be abundant, good, and cheap. Where, however, the kerosene and alkaline solutions have been constantly applied by individual proprietors here and there, the result (as I am informed by Mr. MacOwan, director of the botanical gardens) has been very encouraging. In the eastern districts the effects of the Icerya's attacks do not seem to have been nearly so serious, but whether this is due to a less suitable climate and other conditions, or to more vigilance and exertion on the part of cultivators, I cannot at present determine.

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* Since this was written I have received two specimens of the insect itself through the courtesy of Miss Ormerod. These specimens are so much mutilated that it is almost impossible to accurately place them. The enlarged figure sent by Mr. Crawford was very misleading, the venation of the wing being wrong and also the antennæ. It has no second cross vein on the wings and no sort of resemblance to the actual antennæ, while the two basal cells on the wings are lacking. It is quite likely that this fly belongs to a new genus. The specimens were sent to Dr. S. W. Williston, who reports that he considers them Oscinids, but that further than that he could venture no opinion as he can locate them in no genus with certainty.

In reference to natural enemies of the Icerya, it is of interest to note that a little lady-bird, *Rodolia iceryæ*, of which Miss Ormerod has sent me a figure, has been found to do good work and to destroy the pest in Australia, while news comes from California that *Chilocorus cacti* is doing such excellent work that the trees in some localities are being entirely freed through its instrumentality and the lady-birds are actually being sold to orange-growers at so much per ounce. C. V. R.

The bug spread to Natal within the last few years, and last year I received specimens of them, found on the common black wattle. Only yesterday I was sorry to receive a lot found there on the orange.

No public action in the matter has been taken since the legislative assembly, in 1887, threw out the attempted legislation on the subject. [Roland Trimen, South African Museum, Cape Town, Cape of Good Hope, February 8, 1887.

F. S. Crawford, Adelaide, to Professor Riley.

Last year I entirely lost my colony of Icerya, owing to the attacks of a fly. A rough tracing of an unfinished drawing of the same I also forward. I know nothing about the Diptera and should be obliged if you can determine the insect from the drawing. I may say that I sent Miss E. Ormerod specimens of the fly about two months back, but, of course, have not had time to hear what she makes of it. This is the only instance I know, or have read of, of a true Dipteron being a Coccid parasite. [Frazier S. Crawford, surveyor-general's office, Adelaide, South Australia, February 21, 1887.

Letter from Baron von Mueller, of Melbourne, to Professor Riley.

* * * I beg to inform you that the *Icerya purchasi* (or a closely allied species) although occurring on *Acacia mollissima* and some congeners in the colony Victoria, has not attacked here (so far as I can learn or had occasion to observe), destructively attacked, the orange orchards. I will, however, make further inquiries as well in this colony as in New South Wales, South Australia, New Zealand, and let you know the results.

Possibly the Icerya develops more readily in a moister clime than that of Victoria, and thus becomes more mischievous in California than here.

The introduction of this destructive insect into your States by means of Acacia seems to me very unlikely, because the various species of Acacias are so easily raised from seeds that no one will think to introduce them by living plants. Moreover, it could not have been the Acacia latifolia, which was the host of Icerya, because that species is a native only of the north coast of Australia, and as yet nowhere existing in horticulture. Acacia armata certainly is grown for hedges, but always raised from seed, chiefly obtained from North Australia. It seems, therefore, more likely that when Acacias are grown anywhere, they would afford—particularly in humid climes—a favorable opportunity for the Icerya to spread. A similar circumstance occurred in Ceylon, and another in some parts of Brazil, where an indigenous insect plague became aggravated, when Eucalyptus, on which that insect preferably seized, became reared.* Whether the Icerya was originally an inhabitant of Victoria or merely immigrated, I will endeavor to ascertain; but such a subject of inquiry is surrounded with difficulty now after half a century's existence of the colony, particularly as the Icerya drew no attention here by any extensively injurious effects on any cultivated plants, though it may have caused on some plants minor or transient injury. [Ferdinand von Mueller, Melbourne, Australia, March 21, 1887.

Letter from L. M. Kirk, of Wellington, New Zealand, to Professor Riley.

On returning from a protracted tour of forest inspection in the South, I find your letter of 22d December awaiting reply. My friend Baron von Mueller is mistaken in supposing that I have written recently on the *Icerya purchasi*. In a report on Fruit Blights printed two years ago, I drew attention to the pest, intending to treat at greater length at an early date; but my duties as forest conservator have prevented the intention from being carried out.

The insect is a native of the Fiji and other Pacific islands, from whence it has migrated, probably with orange trees, to Australia, New Zealand, and California. Mr. Maskell states,

* Always from seed.

I believe, that it is a native of Australia, and was introduced from that country on mimosa plants; but this is an error, and Acacias are rarely or never introduced as living plants, owing to their being so readily propagated from seed.

The Icerya is abundant in the northern and middle parts of the Auckland district, and usually prefers citraceous fruits; it is, however, found in large quantities upon some of the wattles, evincing a decided preference for the silver wattle (*Acacia dealbata*). It is, however, occasionally found on furze, manuka (*Leptospermum scoparium*), peach and apple, but on these fruits only in small quantities, and not, so far as I am aware, doing serious damage; in fact it is only found upon these plants when growing in the neighborhood of infested Citrads. It is occasionally found on a few native trees, but it is not causing any great injury.

It is also found in Napier and other parts of Hawke's bay, on the eastern coast of North Island, and in Nelson, and the northwestern corner of the South Islands. It is also said to be found in Canterbury, but I have no direct evidence of its occurrence in that district.

It is not found either in Taranaki or Wellington, in the North Island, except Nelson and possibly Canterbury.

There can be no question that it is a serious foe to citraceous fruits and to wattles. In the vicinity of Auckland, and in many other parts of that district, it is abundant. I have seen trees greatly injured by its ravages, but cannot say that I have seen any killed. At present orange culture has not attained large dimensions here, but there can be no question that Icerya is the worst foe our orange-growers will have to encounter.

I have not seen an Acacia killed by this pest, although the under surfaces of branches are frequently covered. In a few established orange grounds the yield of fruit is materially diminished by the ravages of this insect.

No official documents have been published respecting the Icerya except the Fruit Blights report already mentioned, of which a copy of a Queensland reprint is inclosed herewith. The forest department has purchased Mr. Maskell's account of Scale Insects and is about to publish the same with colored plates. A copy shall be forwarded as soon as it leaves the press. [L. M. Kirk, General Crown's Land Office, Forest and Agricultural Branch, Wellington, New Zealand, March 25, 1887.

From an article by E. J. Dunn, in Melbourne Argus, August 1886.

I desire to call attention to a species of Coccus known as *Dorthesia. This destructive pest was first observed on the island of Bourbon. Thence it spread to Mauritius, about* 25 *years since. In Mauritius it destroyed the orange and lemon trees, many of the ornamental shrubs and Acacias, and wrecked most of the beautiful plantations and shrubberies. At Port Louis it still exists in loathsome masses on the handsome Talipot palms.*

About 12 years ago it was noticed for the first time in the Botanical Gardens, Cape Town, and most probably arrived there from Mauritius with plants sent to the Botanical Gardens. During the first summer it spread about three miles into the suburbs along the railway. Its fearfully destructive character now became evident, for the orange trees, the Australian wattles, the pittosphorums, and the blackwoods became loaded with this disgusting parasite, and the trees slowly but surely succumbed to its attacks. * * *

All trees of the orange kind, such as lemon, citron, shaddock, &c , proved especially suitable food for the Dorthesia, and once a tree became infested no amount of syringing or washing prevented its destruction. The disastrous results of its arrival at the Cape are all too evident.

Formerly in Cape Town itself, and throughout the suburbs, the orange tree lent a charm to the gardens that no other tree could give, and in the Western Province orange-growing formed a most important sorce of wealth, many farmers netting several hundreds a year from their orange groves. Some of these groves, planted by the

Huguenots and their descendants, were of great age, and, besides being profitable, were objects of great beauty. Those of the Pearl, French Hock and Wagenmaker's Valley were especially famous.

To-day this is all changed, and, except for a few dead stumps, these fragrant groves and this valuable asset in the country's wealth have disappeared.

Not so the Dorthesia; it is still advancing steadily, and leaving destruction in its wake, and will continue to do so as long as suitable food is within reach.

THE USE OF GASES AGAINST SCALE-INSECTS.

[Reprinted from Bulletin No. 71, Agricultural Experiment Station, University of California.]

Some time ago the Agricultural Department was requested by Messrs. A. B. and A. S. Chapman, Mr. L. H. Titus, and Mr. J. C. Newton, prominent orange-growers of Los Angeles County, to conduct experiments with the view of determining the efficacy of certain gases as insecticides, with special reference to the White Scale, *Icerya purchasi*. The following is a summary of results, of which a full report will be published hereafter:

The use of gases for this purpose has been long contemplated, and various appliances have been suggested for the ready application of any efficacious gas. The ease with which gas penetrates to all parts of the tree naturally suggests its use as preferable to washes, which at best leave many parts of the foliage and infested branches untouched, even when sprayed with the greatest care. In order that the gas may be an efficient insecticide it must be so poisonous that even when applied in small quantities it produces fatal results; for in the application the air confined in the tent covering the tree dilutes the gas to a great extent. Again, the gas must be capable of being generated quickly in sufficient volume. The record below shows that only one of the gases employed fulfilled these conditions to a satisfactory extent. Preliminary experiments with some others having shown their unfitness for the purpose, either on account of expense or because of injury to the foliage, or imperfect action on the insects, their study was not pursued further.

APPLIANCES FOR APPLICATION.

The tent for covering the tree is made of heavy bed-ticking, thoroughly oiled with linseed oil. This cloth serves the purpose best, as it is very closely woven, is pliable and easily folded.

The support of the tent, devised by Mr. Titus, is a very ingeniously contrived scaffolding mounted on wheels, which serve to move it from one tree to another. Its dimensions are 26 feet high, with a base 20 by 20 feet. Its upper part is 20 by 12, and carries upon the top a roller made of galvanized iron (6 inches in diameter and 12 feet long), upon which the tent is rolled when taken from the tree. Side guy-ropes are attached to the bottom of the tent and run through pulleys at the upper corners of the scaffold. They are used to open the tent when it is to be dropped over the tree, and to fold it up when it is removed. The lightness of the apparatus allows of its being easily removed by two men, who operate the whole. If necessary, two or more tents can be handled by the same scaffolding, one tent being left over the tree while the scaffolding is moved to the next.

In adjusting the tent, the bottom is placed on the ground about 3 feet from the tree and covered with earth. This brings the gas to bear upon the base of the tree and the surrounding soil.

The Generator in which the gases were produced consists of a heavy sheet-iron cylinder, 11 inches in diameter and 13 inches high. The bottom rests on a plank, and to the top is fitted a movable cover suspended in a frame by a bench-screw. Into the cover are fitted two pieces of gas-pipe, one for the exit of the gas toward the tent and the other, connected with a pump, carries the gas which returns *from* the tent. Two small reservoirs are also inserted in the cover; in these are contained the solutions which are to flow into the generator for the production of the gas.

In order to establish circulation and to force the gas into the tent, a pump is used which also serves to exhaust the gas from the upper part of the tent and to force it again through the generator. It is proposed to replace the pump by a small fan-blower, which is much more expeditious than the common pump which was used.

THE GASES EXPERIMENTED WITH.

Among the gases used were chlorine, sulphureted hydrogen, ammonia, carbon bisulphide, carbon monoxide, carbonic acid, hydrocyanic acid, and carbolic acid vaporized by heat.

Chlorine.—Some preliminary experiments were made in small vessels into which this gas had been introduced. Some infested branches were allowed to remain in them for times varying from five to thirty-five minutes without any noticeable effect being produced on the insect. Atmospheres more strongly saturated with the gas proved fatal to the insect in a short time. In other treatments extending over eighteen hours, with less saturated atmospheres, only a small percentage of the insects was killed. No decided effects were noticeable on the foliage unless the gas was very concentrated.

Carbon Bisulphide.—A lime tree, 12 feet in diameter of top, was treated with the vapor of 2½ pounds of sulphide of carbon for forty-five minutes. At the end of this time the insects were lively, and during the treatment had crawled up and collected around a rope surrounding the tree at the point where the gas was being injected from the hose. It proved that the gas thus used injures neither the insects nor the foliage.

It is upon record, however, that in cases where the vapor has not been thoroughly diffused, but was allowed to flow down from an open vessel placed in the top of the tent, serious injury was done to the foliage at points where the undulated vapor flowed down.

Sulphureted Hydrogen.—Several treatments with this gas were made on a small scale, the application lasting from five to thirty-five minutes. The effects produced either with diluted or concentrated gas were similar to those produced by chlorine, except that even the concentrated sulphureted hydrogen did not injuriously affect the foliage. An experiment in which a whole tree was treated in the tent for forty-five minutes with quite concentrated sulphureted hydrogen gas, showed clearly that the effect was far from being satisfactory; the insects for the moment were stupefied, but in the course of an hour and a half the majority of them were again moving about.

Ammonia.—The vapor from one pound and a half of strong ammonia water was applied to an 11-foot lime tree for 30 minutes. The results were disastrous to the foliage; the leaves were all scalded, and in a few days all dropped from the tree, and even the newer growth of wood was injured. The insects, however, were not perceptibly harmed.

Carbon Monoxide.—Very strong hopes have been entertained by many for the successful application of this gas. Its apparent cheapness and easy production, when the necessary plant is once erected, would recommend it. Unfortunately our experiments show that it is not sufficiently effective to warrant its use. The gas was obtained by forcing air through a small furnace filled with red-hot charcoal, care being taken to cool and to measure the gas before applying it. No appreciable effect was noticeable after 40 minutes. In a duplicate experiment, in which the charcoal was more strongly ignited and continuously introduced into the barrel for 30 minutes, only slightly better results were obtained.

Oxalic Acid.—It was thought that the production of carbon monoxide by decomposition of oxalic acid by heat might be substituted for the previous method of generating this gas. One-quarter of a pound of oxalic acid was ignited, and the gases applied in a manner similar to that of the preceding experiment. Neither the insects nor the foliage were harmed in the least. This experiment has incidentally shown that the vapor of formic and oxalic acids, also produced during the heating of the latter, is likewise ineffective.

Carbolic Acid.—It had been suggested that carbolic acid vaporized by heat would prove fatal to the insect. A dose of half a pound of liquid acid was volatilized in the furnace, and the vapor blown in the vessel containing the infected branch. At the end of 20 minutes all the old insects were still alive, and some of the young ones, just molted, were moving about. An hour later the foliage appeared as if scalded.

Hydrocyanic Acid.—It was only with hydrocyanic or prussic acid (generated by the action of sulphuric acid on potassium cyanide) that sufficiently fatal effects were secured to warrant a more thorough determination of the time of exposure and quantities of material which would produce the best results. Numerous experiments were carried on for this purpose, and it was shown that even small amounts were effective. It was also shown that even in these small quantities an injurious effect upon the foliage was produced. In the beginning of the experiments, "mining cyanide" of potassium was used. It is a very impure material and contains along with the cyanide a considerable amount of carbonate of potassium. For this reason many of the first treatments were practically ineffective.

Later treatments with pure cyanide were more successful in destroying the insects, but the foliage was proportionally injured. Treatments varying in dose from 4 to 12 ounces of cyanide, and in time from 15 to 60 minutes, showed that the effect produced on the foliage by longer treatment was not proportionally greater than that produced by short treatment. Neither was the effect of longer treatments proportionally more fatal to the insects. It was thus clearly shown that the gas mixture should be of considerable strength in order to insure rapid action.

The effect of the gas was so disastrous to the foliage that it became necessary to find some means of remedying this trouble. This was sought in applying a second gas, which might preserve the foliage. Sulphureted hydrogen was therefore injected into the tent, together with the cyanide gas, both from the same generator; a portion of the sulphureted hydrogen being introduced before the cyanide was generated. It was found that the insects appeared stupefied when the tent was raised, but large numbers revived in a few hours. The effect of the cyanide seemed therefore to have been decreased by the sulphureted hydrogen. The foliage was not preserved, although not so badly affected as by treatments with cyanide alone.

Carbonic acid gas was next tried. Trees were treated with larger doses of cyanide than heretofore used, and the carbonic acid from 1½ pounds of carbonate of soda was at the same time introduced with these doses. The insects were killed and the foliage of a 12-foot tree remained unharmed, while that of a 14-foot tree with the same amount of carbonic acid was slightly injured. Thus it was shown that it would require 1½ pounds of bicarbonate of soda to preserve tree tops 12 feet in diameter, and that with this protection the deadly cyanide could be successfully used.

The regulation of the doses for the different sized trees so as to produce uniform treatments is calculated on the basis of the results of the experiments which determined the amount of each constituent for a 12-foot tree. The following table indicates the amounts for trees of different dimensions of top, based upon the rates of cubical contents:

Size of tree.	Cyanide of potassium.	Bicarbonate of soda.	Sulphuric acid.
Feet.	*Fluid ozs.*	*Pounds.*	*Fluid ozs.*
4	.7	.05	.4
5	1.6	.11	.3
6	2.5	.20	1.3
7	4.0	.29	2.1
8	6.0	.44	3.1
9	8.5	.63	4.5
10	11.5	.87	6.2
11	15.5	1.14	8.2
12	20.0	1.50	11.6
13	25.4	1.90	13.5
14	31.6	2.50	16.6
15	39.2	2.92	20.7
16	47.5	3.55	25.2
17	57.5	4.23	30.1
18	67.7	5.05	35.8
19	70.9	5.93	42.1
20	90.5	6.93	49.2

In order to apply the doses easily they are prepared so that the required amounts of each ingredient can be directly measured. The cyanide solution is prepared by dissolving, say, 10 pounds of the solid salt in about 2¼ gallons of water, warmed nearly to the boiling point, stirring at intervals, cooling, and then diluting to 2½ gallons. This solution will contain about one ounce of cyanide of potassium to 2½ fluid ounces of the liquid.

The bicarbonate of soda is pulverized finely and measured off in a vessel marked, so as to designate pounds and fractions of a pound of the solid material. It is then placed in the generator, and the dose of cyanide mixed with it, and, if necessary, a little water added to make it into a thin paste. After adding the measured dose of sulphuric acid, the pump is worked slowly at first, and more rapidly after the gas has passed into the tent. The time for each treatment must be determined by future experiments; fifteen minutes seemed to be quite sufficient when the cyanide alone was used, but it may be desirable to extend the treatment to thirty minutes when the foliage is protected by the carbonic acid gas.

It is advisable that the treatments should follow cultivation after about four days, so that all weeds and places where the insect may find lodgment would be destroyed. The insect will then be on, or very near, the tree; the fitting of the tent to the ground is thus also much easier.

The eggs of the insect remained apparently uninjured wherever protected by the woolly covering. A second treatment, to destroy such as may afterward hatch, will, therefore, be necessary.

It must not be understood that these experiments definitely settle the mode of operation and the size of the doses to be used. They are merely suggestive of a general plan which can be so perfected in the future that the application of this remedy to other kinds of trees and insects must be attended with good results. It simply remains for the ingenious cultivator to devise the necessary appliances for its use, on a small scale, on all sorts of fruit trees, shrubs, and plants.

It must not be forgotten that extreme care in the handling both of this deadly gas and of the cyanide itself is necessary. To inhale the one or to taste or touch a wound with the other may lead to serious consequences.

F. W. MORSE.

BERKELEY, *June* 12.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 16.

THE ENTOMOLOGICAL WRITINGS OF DR. ALPHEUS SPRING PACKARD.

BY

SAMUEL HENSHAW.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., *July* 5, 1887.

SIR: I have the honor to submit for publication Bulletin No. 16 of this Division, being a list of the entomological writings of Dr. A. S. Packard, with systematic and general index, prepared by Mr. Samuel Henshaw. Dr. Packard has been so long and favorably known as a writer upon insects both in their structural, biologic, and economic relations, and has been for so many years connected with Government entomological work, that this Bulletin will be welcomed by all interested in the subject and of great aid in the divisional work.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

THE ENTOMOLOGICAL WRITINGS OF ALPHEUS SPRING PACKARD.

By Samuel Henshaw.

Alpheus Spring Packard was born in Brunswick, Me., February 19, 1839. His father was Alpheus Spring Packard, D. D., for over sixty years a professor in Bowdoin College. His mother was Frances E. Appleton, daughter of Rev. Jesse Appleton, president of Bowdoin College. After graduating from Bowdoin College in 1861, he spent three years at the Cambridge Museum of Comparative Zoology as a student of Prof. L. Agassiz. For a part of one year (1863–'64) he was the private assistant of Professor Agassiz.

Two summers (those of 1860 and 1864) were passed upon the coast of Labrador, where collections of marine invertebrates, insects, and quaternary fossils were accumulated for future investigations. In 1861–'62 he was assistant to the Maine Geological Survey. In 1864 he took the degree of Doctor of Medicine at the Maine Medical School. In September of the same year Dr. Packard was commissioned assistant surgeon First Maine Veteran Volunteer Infantry, and served in the Sixth Corps until mustered out with the regiment in July, 1865. In 1865–'66 he was acting custodian and librarian of the Boston Society of Natural History. Dr. Packard spent eleven years (1867–'78) in Salem. Appointed in 1867 one of the curators of the Peabody Academy, he was for about two years (1877–'78) the director of its museum. At Salem he established a summer school of biology, and in March, 1868, the first number of the American Naturalist was issued. Dr. Packard was one of the originators of this magazine, and for twenty years its editor-in-chief.

In 1867 he married Elizabeth Derby, daughter of Samuel B. Walcott of Salem, and has had four children, of whom a son and two daughters are living. As lecturer or instructor Dr. Packard has been connected with the Anderson School of Natural History, Bowdoin College, and the Maine and Massachusetts State Agricultural Colleges; as assistant he has been attached to the Kentucky Geological Survey, to Hayden's United States Geological Survey of the Territories, and to the United States Fish Commission. When in search of material for his studies

Dr. Packard has visited many parts of the United States and Mexico, and has dredged upon the coast of Labrador, in the Gulf of Maine, in Massachusetts and Buzzards Bays, off Beaufort, N. C., and upon the coast of Florida.

In 1871–'73 he served as State entomologist of Massachusetts, and from 1877–'82 was a member of the United States Entomological Commission. In 1878 he accepted the professorship of Zoology and Geology in Brown University, and still retains the position.

Dr. Packard was elected a member of the National Academy in 1872 and honorary member of the Entomological Society of London in 1884, and at home and abroad a number of societies have elected him to membership.

The entomological writings of Dr. A. S. Packard, recorded in Part I of the present list, form but a portion of his contributions to science. His memoirs in other branches in range cover the field of zoology, with occasional papers in allied sciences, and bear testimony alike to his versatility and the energy of his mind.

As a rule only the original place of publication is recorded, though a few reprints and reviews are included, as of possible value in case the original is inaccessible.

Dr. Packard's contributions to the natural history of *Limulus* are included in the present bibliography, because much of the discussion concerning the anatomy, genealogy, &c., of this animal bears directly upon the *Arachnida* and other *Arthropoda.*

Part II contains a systematic list of the new names proposed by Dr. Packard, and I have endeavored to note the collection containing the type, but in many cases have been unable to do so.

A number of the types noted as present in the collection of the Museum of Comparative Zoology are, however, in a very poor state of preservation, so that a word of explanation should be added.

The bulk of Dr. Packard's types were accumulated during his connection with, and formed part of the collection of, the Peabody Academy of Science at Salem.

From the year 1880 the Academy was without the services of an entomological assistant, so that the collections, "in spite of what care could be given them, were rapidly going to ruin," when, fortunately, in 1885, their valuable collections of insects were deposited without conditions in the museum at Cambridge, where their preservation is assured.

Dr. Packard has aided me throughout the preparation of the list, and I am indebted to Messrs. Edwards, Fernald, Hulst, Riley, and Smith for assistance in determining the value and position of many of the *Lepidoptera.* Mr. Howard has rendered a similar service with some of the parasitic *Hymenoptera.*

PART I.

CHRONOLOGICAL CATALOGUE.

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Chapter 9. Anatomy and embryology, pp. 257–279.
Chapter 17. Uses to which Locusts may be put, pp. 437–443.
Chapter 19. Locust ravages in other countries, pp. 460–477.
Appendix IX. Narrative of the first journey made in the summer of 1877, pp. 134–138.
Appendix X. Narrative of a second journey made in the summer of 1877, pp. 139–144.

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Chapter 9. The air-sacs of Locusts, with reference to their powers of flight, pp. 178–183.

Chapter 11. The brain of the Locust, pp. 223–242.

Appendix VII. Notes of a journey made to Utah and Idaho in the summer of 1878, pp. 69–71.

Appendix VIII. Yersin's researches on the functions of the nervous system of the Articulate animals, pp. 73–74.

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Chapter 8. The Hessian fly, pp. 198–248.

Chapter 9. Descriptions of the larvæ of injurious forest Insects, pp. 251–262.

Chapter 10. The embryological development of the Locust, pp. 263–285.

Chapter 11. The systematic position of the *Orthoptera* in relation to the other orders of Insects, pp. 286–345.

Chapter 12. Note on the geographical distribution of the Rocky Mountain Locust, illustrated with colored zoo-geographical map of North America, pp. 346–347.

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Part II.

SYSTEMATIC INDEX OF THE NEW NAMES PROPOSED.

The first number following the name refers to the number of the paper in Part I; the second, to the page where the species is first described. The following abbreviations are used in locating the types:

A. E. S. = Collection of the American Entomological Society, Philadelphia, Pa.
A. S. P. = Collection of A. S. Packard, Providence, R. I.
B. S. N. H. = Collection of the Boston Society of Natural History, Boston, Mass.
C. H. F. = Collection of C. H. Fernald, Amherst, Mass.
H. E. = Collection of Henry Edwards, New York, N. Y.
J. A. L. = Collection of J. A. Lintner, Albany, N. Y.
M. C. Z. = Collection of the Museum of Comparative Zoology, Cambridge, Mass.
N. M. = Collection of the National Museum, Washington, D. C.
P. A. S. = Collection of the Peabody Academy of Science, Salem, Mass.
S. H. S. = Collection of S. H. Scudder, Cambridge, Mass.

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*Types not preserved. A. S. Packard.

THYSANURA.

Scolopendrellidæ.
Scolopendrella americana, 125–111.
=immaculata, Newp. A. S. P.
Campodeidæ.
Campodea americana, 84–96; 97–409.
=staphylinus, Westw.
cookei, 91–747. M. C. Z.
mexicana, 311–383.
Japyx subterraneus, 145–511. M. C. Z.
Poduridæ.
Achorutes boletivorus, 127–30. M. C. Z.
marmoratus, 127–30. M. C. Z.
pratorum, 127–31. M. C. Z.
texensis, 127–30. M. C. Z.
Anura gibbosa, 127–27. M. C. Z.
De Geeria decemfasciata, 127–40. M. C. Z.
flavocincta, 64*b*–pl. 10.
=decemfasciata, Pack. M. C. Z.
griseo-olivata, 127–39. M. C. Z.
perpulchra, 127–38. M. C. Z.
purpurascens, 64*b*–pl. 10. M. C. Z.
Isotoma albella, 127–32. M. C. Z.
belfragei, 127–33. M. C. Z.
besselsii, 179–52.
glauca, 127–33. M. C. Z.
leonina, 127–32. M. C. Z.
nivalis, 127–31. M. C. Z.
plumbeus, 64*b*–pl. 10. M. C. Z.
purpurascens, 127–34. M. C. Z.
tricolor, 127–34. M. C. Z.
walkeri, 94–19; 98–14.
Lepidocyrtus albus, 127–37.
bipunctatus, 127–37. M. C. Z.
marmoratus, 127–36.
metallicus, 127–36. M. C. Z.
Orchesella carneiceps, 127–40. M. C. Z.
flavopicta, 127–41. M. C. Z.
Papirius marmoratus, 127–42. M. C. Z.
texensis, 127–42. M. C. Z.
Smynthurus roseus, 127–43. M. C. Z.
quadrisignatus, 127–44. M. C. Z.
Lepismatidæ.
Lepisma domestica, 127–48. M. C. Z.
mucronata, 127–49. M. C. Z.
quadriseriata, 127–47. M. C. Z.
spinulata, 127–48. M. C. Z.
Machilus brevicornis, 127–49.
orbitalis, 127–50.

NEUROPTERA.

Panorpidæ.
Boreus californicus, 97–408. M. C. Z.

PSEUDONEUROPTERA.

Psocidæ.
Amphientomum hagenii, 97–405.

ORTHOPTERA.

Locustaridæ.
Ceuthophilus ensiger, 227–882. M. C. Z.
sloanii, 130–93. M. C. Z.

HEMIPTERA.

Liotheidæ.
Colpocephalum lari, 67–96.
Menopon picicola, 134–731.
Philopteridæ.
Docophorus buteonis, 67–93.
hamatus, 67–94.
syrnii, 134–733.
Goniocotes burnettii, 67–94.
Goniodes mephitidis, 134–732.
merriamanus, 134–731.
Lipeurus corvi, 67–95.
elongatus, 67–95.
gracilis, 67–95.
Nirmus buteonivorus, 134–733. P. A. S.
thoracicus, 67–94.
Trichodectes capræ, 67–96.
Coccidæ.
Aspidiotus. *See* Mytilaspis.
Coccus. *See* Mytilaspis.
Lecanium platycerii, 78–260.
Mytilaspis citricola (Aspidiotus), 64*a*–527.*
gloveri (Coccus), 64–527.*

DIPTERA.

Hippoboscidæ.
Hippobosca. *See* Olfersia.
Olfersia bubonis (Hippobosca), 64–47.
=americana, Leach. M. C. Z.
Ephydridæ.
Ephydra californica, 80–103.
gracilis, 80–105. A. S. P.,
halophila, 60–46.
Chironomidæ.
Chironomus halophilus, 133–539.
oceanicus, 60–42.
Cecidomyidæ.
Diplosis pini-rigidæ, 196–527.

LEPIDOPTERA.

Pterophoridæ.
Lioptilus sulphureodactylus (Pterophorus), 122–266. M. C. Z.
Platyptilia cervinidactyla (Pterophorus) 122–266, =ochrodactyla, S. V. M. C. Z.
Pterophorus pergracilidactylus, 122–265.
=monodactylus, Linn. M. C. Z.
See Lioptilus; Platyptila.
Tineidæ.
Aspidisca saccatella (Lyonetia), 64–355.
=splendoriferella, Clem.
Bucculatrix curvilineatella (Lithocolletis), 64–354. =pomifoliella, Clem.
thuiella, 100–373.
Coleophora cerasivorella, 78–239.
Depressaria robiniella, 64–349.
Gelechia abietisella, 263–150; 273–296.
caryævorella, 321–331.
trimaculella, 30–61.
=continuella, Zeller.
Lithocolletis. *See* Bucculatrix; Lyonetia; Ornix.
Lyonetia nidificansella (Lithocolletis), 64–354.
See Aspidisca.

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* Based on Glover's unpublished figures.

Tineidæ—Continued.
Micropteryx pomivorella, 78–238.
Œcophora frigidella, 30–62.
Ornix geminatella (Lithocolletis), 64–353.
Tortricidæ.
Anchylopera. *See* Rhopobota.
Cacœcia gossypiana (Lozotænia), 64–335.
=rosaceana, Harris.
v-signatana (Tortrix), 78–238.
=argyrospila, Walk.
Conchylis chalcana, 30–56, =deutschiana, Zett.
Eudemis vitivorana (Penthina), 64–336.
=botrana, Schiff. M. C. Z.
Grapholitha. *See* Steganoptycha.
Lozotænia. *See* Cacœcia; Ptycholoma.
Pandemis. *See* Phoxopteris.
Penthina frigida, 30–57. M. C. Z.
fulvifrontana, 30–59.
=septentrionana, Curtis. M. C. Z.
murina, 30–60. M. C. Z.
tessellana, 30–58.
=intermistana, Clem. M. C. Z.
See Eudemis.
Phoxopteris leucophalerata (Pandemis), 30–56.
=tineana, Hübn. M. C. Z.
Ptycholoma fragariana (Lozotænia), 64–335.
=persicana, Fitch. M. C. Z.
Rhopobota vacciniana (Anchylopera), 64–338.
M. C. Z.
Sciaphila niveosana, 30–55. M. C. Z.
Steganoptycha nebulosana (Grapholitha), 30–69.
M. C. Z.
Teras oxycoccana (Tortrix), 64–334. M. C. Z.
vacciniivorana (Tortrix), 78–241.*
C. H. F.
Tortrix. *See* Cacœcia; Sciaphila; Teras.
Pyralidæ.
Acrobasis. *See* Phycis.
Anerastia roseatella (Nephopteryx), 123–270,
=hæmatica, Zeller. M. C. Z.
Botis borealis (Pyrausta), 30–53. M. C. Z.
californicalis, 122–260.
mustelinalis, 122–262. M. C. Z.
perrubralis, 122–264. M. C. Z.
profundalis, 122–261. M. C. Z.
semirubralis, 122–263. M. C. Z.
subolivalis, 122–261. M. C. Z.
syringicola, 78–250.
unifascialis, 122–261.
=subolivalis, Pack. M. C. Z.
Calaclysta metalliferalis, 122–265.† M. C. Z.
Crambus argillaceellus, 30–54. M. C. Z.
carpenterellus, 157–548. M. C. Z.
unistriatellus, 30–54. M. C. Z.
Dakruma grossulariæ (Pempelia), 64–331.
=convolutella, Hübn. M. C. Z.
Eromena californicalis, 122–264. M. C. Z.
Eudorea. *See* Scoparia.
Eurycreon occidentalis (Scopula), 122–260.
=rantalis, Guen. M. C. Z.
Myeolois albiplagiatella, 123–269. M. C. Z.

Pyralidæ—Continued.
Nephopteryx edmandsii, 8–120. M. C. Z.
fenestrella (Pempelia), 122–259.
M. C. Z.
latifasciatella, 123–269.
=ovalis, Pack. M. C. Z.
leoninella (Pempelia), 122–259.
M. C. Z.
ovalis (Pempelia), 123–269. M. C. Z.
See Anerastia.
Pempelia. *See* Dakruma; Nephopteryx.
Phycis rubrifasciella (Acrobasis), 123–267.
M. C. Z.‡
Pyrausta. *See* Botis.
Scoparia albisinuatella (Eudorea ?), 30–53.§
M. C. Z.
frigidella (Eudorea ?), 30–53.§
Scopula glacialis, 30–52. M. C. Z.
See Eurycreon.
Geometridæ.
Acidalia albocostaliata, 176–336. M. C. Z.
californiata, 96–390.
=sideraria, Guen. M. C. Z.
candidaria, 128–72.
=ordinata, Walk. B. S. N. H.
granitaria, 96–390. M. C. Z.
longipennata, 128–71.
=peralbata, Pack. M. C. Z.
okakaria, 30–43.
=inductata, Guen. M. C. Z.
pacificaria, 96–391.
=sideraria, Guen. M. C. Z.
peralbata, 128–70. M. C. Z.
perirrorata, 128–71. M. C. Z.
productata, 176–334. M. C. Z.
punctofimbriata, 128–70. M. C. Z.
quadrilineata, 176–345. M. C. Z.
quinquelinearia, 96–389. M. C. Z.
rotundopennata, 176–337. M. C. Z.
rubrolineata, 124–28.
=magnetaria, Guen. M. C. Z.
rubromarginata, 96–391.
=hepaticaria, Guen. M. C. Z.
subalbaria, 124–28. M. C. Z.
Anagoga californiaria (Ellopia), 96–384.
=occiduaria, Walk. M. C. Z.
Anaplodes, 176–392.
pistaciaria, 176–392. M. C. Z.
Anisopteryx autumnata, 176–400.
=pometaria, Harris. M. C. Z.
Annemoria, 176–375.
unitaria (Eunemoria), 124–30.
M. C. Z.
Antepione, 176–483.
sulphurata (Heterolocha), 128–79.
M. C. Z.
Aplodes approximaria, 128–73. J. A. L.
brunnearia, 176–388. M. C. Z.
coniferaria, 280–933. M. C. Z.
latiaria, 128–74.
=*var. of* mimosaria, Guen. J. A. L.

*According to Riley this is a seasonal dimorphic form of *oxycoccana;* Fernald considers this = *minuta* Rob., and that *oxycoccana* should remain distinct.

†According to Professor Fernald this is not a Calaclysta.

‡ *Pinipestis abietivorella*, given by Grote (Check List, 1882, p. 55) as one of Packard's species, was described by Grote (Bull. U. S. Geol. Surv., v. 4, p. 701).

§ Probably varieties of *S. centuriella*, Schiff.

* Described as a *Bombycid;* see Ent. Amer., 1885, v. 1, p. 167, for Hulst's reasons for placing here.

Geometridæ—Continued.

Halia. *See* Thamnonoma.
Hemerophila latifasciaria, 124-33. M. C. Z.
Hesperumia, 124-37; 128-79.
ochreata, 124-37. M. C. Z.
sulphuraria, 128-79.
=ochreata, Pack. M. C. Z.
Heterolocha edwardsata, 96-383. M. C. Z.
See Antepione.
Heterophleps harveiata, 176-193. M. C. Z.
Hydriomena albifasciata (Hypsipetes), 154-41. H. E.*
californiata (Hypsipetes), 96-396. M. C. Z.
glaucata (Cidaria), 124-20. H. E.
nubilofasciata (Hypsipetes) 96-398. M. C. Z.
quinquefasciata (Hypsipetes), 96-397. M. C. Z.
speciosata (Hypsipetes), 124-22. M. C. Z.
viridata (Hypsipetes), 124-21. M. C. Z.
Hypsipetes. *See* Hydriomena.
Hyria. *See* Eois.
Larentia. *See* Epirrita; Eupithecia.
Lithostege rotundata, 154-39. M. C. Z.
triseriata, 154-39. M. C. Z.
Lobophora inequaliata, 176-180.
montanata, 154-40. M. C. Z.
vernata (Eupithecia), 128-57.
= limitaria, Walk. M. C. Z.
viridata, 128-56. M. C. Z.
Loxofidonia, 176-223.
acidaliata (Fidonia), 154-48. M. C. Z.
Lozogramma atropunctata, 154-50. M. C. Z.
ferruginosaria (Tephrosia), 96-388. M. C. Z.
nigroseriata (Tephrosia), 124-32.
= ferruginosaria, Pack. M. C. Z.
Lythria rilevaria, 176-221.
= chamæchrysaria, Grote. M. C. Z.
snoviaria, 176-222. M. C. Z.
Macaria. *See* Phasiane; Semiothisa.
Marmopteryx, 176-259.
marmorata (Tephrina) 96-393. M. C. Z.
tessellata, 157-552. M. C. Z.
Melanippe. *See* Rheumampteryx.
Melanthia. *See* Rheumampteryx.
Metanema carnaria (Caberodes), 128-80. M. C. Z.
See Tetracis.
Metrocampa viridoperlata, 124-38.
=*var.* perlaria, Guen. H. E.
Nemoria gratata, 176-373. M. C. Z.
Ochyria californiata (Coremia), 96-398.
= munitata, Hübn. M. C. Z.
carneata (Phibalapteryx), 154-43, M. C. Z.
gueneeata, 176-141. M. C. Z.
labradorensis (Coremia), 30-46.
=*var. of* munitata, Hübn. M. C. Z.
lacteata, 176-143. M. C. Z.

Geometridæ—Continued.

Ochyria lignicolorata (Coremia), 154-42. M. C. Z.
nigrofasciata (Cidaria), 30-49.
= abrasaria, H. S. M. C. Z.
rubrosuffusata (Cidaria), 96-402. M. C. Z.
strigata (Cidaria), 30-50.
= munitata, Hübn. M. C. Z.
Odezia californiata (Baptria), 96-404. M. C. Z.
Orthofidonia, 176-235.
Pachynemia psi, 128-61.
Panagra. *See* Phasine.
Paraphia piniata, 78-246. =subatomaria, Guen.
Parennomos, 78-248, =Caripeta, Walk.
See Caripeta.
Petrophora albolineata (Cidaria), 128-55. M. C. Z.
brunneata (Cidaria), 30-47.
=truncata, Hübn. M. C. Z.
disjunctaria (Cidaria), 128-53,
=cunigerata, Walk.
flavata (Eurhinosea), 124-35. M. C. Z.
leoninata (Cidaria), 96-401. M. C. Z.
montanata (Cidaria), 128-55.
=prunata, Linn.
nubilata (Cidaria), 30-48; 96-400.
=*var. of* prunata, Linn. M. C. Z.
subochreata (Cidaria), 96-400.
=mancipata, Guen. M. C. Z.
triangulata (Cidaria), 128-54.
=prunata, Linn.
Phasiane atrofasciata, 176-264. M. C. Z.
excurvata, 154-47,
=continuata, Walk. M. C. Z.
flavofasciata (Panagra), 96-394.
=neptata, Guen. M. C. Z.
irrorata, 176-273. M. C. Z.
meadiata, 154-47. M. C. Z.
nubiculata, 176-267. M. C. Z.
sinuata, 154-45. M. C. Z.
snoviata, 176-268. M. C. Z.
subminiata (Panagra), 124-25. M. C. Z.
subminiata (Macaria), 154-49.
=snoviata, Pack. M. C. Z.
trifasciata, 154-46.
=*var. of* mellistrigata, Gr. M. C. Z.
Phibalapteryx. *See* Ochyria.
Philereme albosignata (Scotosia), 128-61. M. C. Z.
californiata (Scotosia), 96-399. M. C. Z.
meadiata (Scotosia), 154-41. M. C. Z.
Plagodis keutzingaria, 176-468.
Priocycla. *See* Endropia.
Racheospila. *See* Aplodes.
Rheumampteryx brunneicellata (Melanthia), 154-42. M. C. Z.
kodiakata (Melanippe), 124-23. =lugubrata, Staud. H. E.
Scotosia. *See* Philereme.

* All the species described by Dr. Packard are probably varieties of *sordidata*, Fabr.

Geometridæ—Continued.
Selidosema californiaria, 96-394.
=juturnaria, Guen. M. C. Z.
Semiothisa californiata (Macaria), 96-392. M. C. Z.
dislocaria, 176-282. M. C. Z.
duplicaria (Macaria), 128-65.
=ocellinata, Guen. M. C. Z.
minorata (Macaria), 128-66. M. C. Z.
multilineata (Macaria), 128-65. M. C. Z.
pallidata (Macaria), 128-64.
=californiata, Pack. M C. Z.
punctolineata (Macaria), 128-64. M. C. Z.
sexmaculata (Macaria), 30-44.
=granitata, Guen. M. C. Z.
S-signata (Macaria), 128-63. M. C. Z.
Sicya crocearia, 124-36.
=macularia, Harris. H. E.
Stenaspilates, 176-212.
meskaria, 176-213. N. M.
Stenotrachelys permagnaria, 176-450. N. M.
Synchlora albolineata, 128-75.
=glaucaria, Guen. M. C. Z.
excurvaria, 128-76. M. C. Z.
gracilaria (Eunemoria), 128-77.
=glaucaria, Guen. M. C. Z.
rubrifrontaria, 128-75. M. C. Z.
tricoloraria (Eunemoria), 124-30.
=liquoraria, Guen. M. C. Z.
Tephrina. *See* Marmopteryx; Thamnonoma.
Tephrosia californiaria, 96-388. M. C. Z.
falcataria, 124-32. M. C. Z.
See Lozogramma.
Tetracis aurantiacaria (Metanema), 124-34.
=cervinaria, Pack. M. C. Z.
cervinaria (Metanema), 96-386. M. C. Z.
grotearia, 176-553. M. C. Z.
paralleliaria, 124-38. M. C. Z.
trianguliferata, 96-384. H. E.
Thamnonoma argillacearia (Tephrina), 154-48.
cineraria (Halia), 96-392.
=marcescaria, Guen. M. C. Z,
ferruginaria (Eupistheria), 128-78.
=brunnearia, Thunb. M. C. Z.
flavicaria, 176-256. M. C. Z.
guenearia, 176-252. M. C. Z.
quadrilinearia (Halia), 124-26. M. C. Z.
sulphuraria (Eupistheria), 128-77. M. C. Z.
tripunctaria (Halia), 124-26. M. C. Z.
Thera contractata (Cidaria), 128-56. M. C. Z.
Tornos approximaria, 176-215. M. C. Z.
Zerene. *See* Cleoria.
Noctuidæ.
Agrotis littoralis, 30-36. M. C. Z.
okakensis, 30-38. M. C. Z.
ortoni, 63-63. =saucia, Hübn. M. C. Z.
umbrata, 30-37. M. C. Z.
Anarta bicycla, 30-41.
=melaleuca, Thunb. M. C. Z.
nigro-lunata, 30-40.
=melanopa, Thunb. M. C. Z.

Noctuidæ—Continued.
Heliophila rufostrigata (Leucania), 30-36. P. A. S.
Leucania. *See* Heliophila.
Palindia geminata, 63-64. M. C. Z.
Platycerura, 6-373.
furcilla, 6-374. B. S. N. H.
Bombycidæ.
Actias azteca, 64-298.
Adoneta leucosigma (Cyclopteryx), 6-346.
Antarctia bicolor, 63-63. M. C. Z.
punctata, 6-123. M. C. Z.
Apatelodes, 6-353.
hyalinopuncta, 6-354.
=angelica, Gr. M. C. Z.
Arachnis picta, 6-126. M. C. Z.
Arctia pallida, 6-118.
Attacus amazonica, 102-85. M. C. Z.
Byssophaga grisea (Cisthene), 112-84.
=nexa, Boisd. M. C. Z.
Callarctia, 6-114.
ornata, 6-115.
Callimorpha vestalis, 6-108.
=*var. of* Lecontei, Boisd.
Callochlora, 6-339, =Parasa, Moore.
See Parasa.
Callosamia, 6-379, =Attacus, Linn.
Cecrita. *See* Coelodasys; Seirodonta.
Cisthene. *See* Byssophaga.
Clemensia, 6-100.
albata, 6-101. M. C. Z.
umbrata, 112-85.*
Clisiocampa californica, 6-387.
Coelodasys, 6-363.
biguttata, 6-365. B. S. N. H.
cinereofrons, 6-366.
=*var. of* biguttata, Pack. B. S. N. H.
edmandsii, 6-364.
harrisii, 6-365.
mustelina (Cecrita ?), 6-359. B. S. N. H.
Crambidia, 6-99.
pallida, 6-99. B. S. N. H.
Cyclopteryx, 6-344, =Adoneta, Clem.
See Adoneta.
Cyrtosia, 6-342, =Packardia, G. & R.
See Packardia.
Dasylophia, 6-362.
interna, 6-363. B. S. N. H.
Drepana. *See* Platypteryx.
Dryopteris irrorata, 6-377. P. A. S.
Ecpantheria permaculata (Leucarctia), 112-86.
=reducta, Gr. M. C. Z.
Edapteryx, 6-375, =Prionia, Hübn.
See Prionia.
Euchronia, 6-382, =Hemileuca, Walk.
Euclea bifida, 6-338. P. A. S.
ferruginea, 6-338. M. C. Z.
monitor, 6-337.
=querceti, H. S. B. S. N. H.
Euleucophæus, 112-88.
tricolor, 112-89. H. E.
Gastropacha californica, 112-91. M. C. Z.
ferruginea, 6-386.
Gloveria, 112-89.

* Type lost in the mail.—Hy. Edwards.

Bombycidæ—Continued.

Gloveria arizonensis, 112-90.
Gluphisia trilineata, 6-355. B. S. N. H.
Halisidota agassizii, 6-128.
=maculata, Harris. M. C. Z.
argentata, 6-129. M. C. Z.
edwardsii, 6-129. M. C. Z.
pustulata, 63-63. M. C. Z.
Hemileuca diana, 157-557. =juno, Pack. M. C. Z.
juno, 112-87. M. C. Z.
Hepialus argentata (Sthenopis), 6-392.
=argenteomaculatus, Harris.
B. S. N. H.
labradoriensis, 6-394. M. C. Z.
mustelinus, 6-393. B. S. N. H.
purpurascens (Sthenopis), 4-598; 6-392.
=argenteomaculatus, Harris.
Heterocampa cinerea (Lochmæus), 6-372.
P. A. S.
marina (Lochmæus), 6-373.
obliqua, 6-368. P. A. S.
olivata (Lochmæus), 6-371.
=biundata, Walk. P. A. S.
tessella (Lochmæus), 6-370.
=marthesia, Cram. A. S. P.
trouvelotii, 6-369.
unicolor (Lochmæus), 6-373.
P. A. S.
Heterogenea shurtleffi, 6-346. B. S. N. H.
Ianassa virgata (Xylinodes), 6-367.
=lignicolor, Walk. P. A. S.
Ichthyura indentata, 6-352. B. S. N. H.
inversa, 6-352. M. C. Z.
Isa, 6-347.
Lagoa crispata, 6-335. B. S. N. H.
Leucarctia, 6-124.
californica, 6-125.
=acraea, Drury. M. C. Z.
See Ecpantheria.
Limacodes biguttata, 6-341. B. S. N. H.
y-inversa, 6-341. M. C. Z.
Lithacodes, 6-345, =Limacodes, Latr.
Lithacodia graefii, 328-52. A. S. P.
Lithosia argillacea, 6-98.
=bicolor, Grote. B. S. N. H.
rubropicta, 328-52. A. S. P.
Lochmæus. *See* Heterocampa.
Lophodonta, 6-357.
ferruginea, 6-357. B. S. N. H.
Nadata doubledayi, 6-356.
Nemeophila modesta (Platarctia), 6-113. M. C. Z.
scudderi (Platarctia), 6-113.
P. A. S.
Oedemasia, 6-359.
badia, 6-361.
=nitida, Pack. B. S. N. H.
nitida, 6-360.
Orgyia definita, 6-332.
=*var. of* leucosigma. A. & S.

Bombycidæ—Continued.

Packardia albipuncta (Cyrtosia), 6-344.
elegans (Cyrtosia), 6-342. B. S. N. H.
fusca (Cyrtosia), 6-343.
geminata (Cyrtosia), 6-343.
Parasa vernata (Callochlora), 6-339.
=chloris, H. S. M. C. Z
Parorgyia, 6-332.
basiflava, 6-333. B. S. N. H
Pheosia rimosa, 6-358.
Phobetron nigricans (Thyridopteryx), 6-350.
Platarctia, 6-109.
See Nemeophila.
Platœciticus, 64-291.
gloveri, 64-291.* M. C. Z.
Platypteryx siculifer (Drepana), 112-87.
Prionia bilineata (Edapteryx), 6-376.
Psycho carbonaria, 328-51.
Pyrrharctia, 6-120.
californica, 6-121.
=*var. of* isabella, A. & S. M. C. Z.
Seirarctia, 6-119.
clio, 6-120.
Seirodonta bilineata (Cecrita), 6-359. B. S. N. H.
Spilosoma vestalis, 6-125. M. C. Z.
Sthenopsis, 6-390, =Hepialus, Fabr.
See Hepialus.
Thyridopteryx. *See* Phobetron.
Tortricidia, 6-347.
testacea, 6-348. B. S. N. H.
Xylinodes, 6-366, =Ianassa, Walk.
See Ianassa.

Zygœnidœ.†

Acoloithus sanbornii (Harrisina), 7-32.
=falsarius, Clem. B. S. N. H.
Anatolmis, 7-45.
grotei, 7-47.
Glaucopis tricolor, 63-62. M. C. Z.
Harrisina, 7-31. *See* Acoloithus.
Lycomorpha miniata, 112-84. M. C. Z.
palmeri, 112-84. M. C. Z.
Phryganidia, 6-348.‡
californica, 6-349. M. C. Z.

HYMENOPTERA.

Chalcididœ.

Anthophorabia megachilis, 8-134.
Copidosoma turni (Encyrtus), 231-32. S. H. S.
Derostenus antiopæ (Entedon), 231-36.
B. S. N. H.
Encyrtus montinus, 156-347. *See* Copidosoma.
Entedon. *See* Derostenus.
Eulophus. *See* Tetrastichus.
Tetrastichus saundersii (Eulophus), 231-34.
S. H. S.
semideæ (Eulophus), 156-347.
S. H. S.
theclæ (Eulophus), 231-34. S. H. S.
Trichogramma minutissimum, 231-37.

*Described from Glover's figures. *See* 328-51.

†According to Smith (Trans. Amer. Ent. Soc., v.12) none of the genera mentioned except *Glaucopis*, belong to the *Zygœnidœ*. It is more convenient however, to catalogue them here.

‡Originally described as a *Psychid*. Stretch (Ill. Zyg. & Bomby., p. 90) places near *Procris* and *Ctenucha* "chiefly because unable to assign it a more satisfactory position." Later, Packard accepted Stretch's view. Butler (Papilio, v. 1, p. 131) contends that the larva and pupa show no affinity to *Zygœnidœ* or *Psychidœ;* that the structure of the imago scarcely differs from *Hyrmina* of the *Dioptidœ*. Grote in his check-list (1882) follows Butler. Mr. J. B. Smith writes me that the genus is an abberent one and is "more *Lithosid* than anything else."

GROUP NAMES.

INDEX.