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A MANUAL OF PHILIPPINE SILK CULTURE

BY

CHARLES S. BANKS

(From the Entomological Section, Biological Laboratory, Bureau of Science, Manila, Philippine Islands)

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A MANUAL OF PHILIPPINE SILK CULTURE.

By CHARLES S. BANKS.

(*From the Entomological Section, Biological Laboratory, Bureau of Science, Manila, Philippine Islands.*)

INTRODUCTION.

The Bureau of Science made the first attempt to import and to propagate mulberry silkworms in the Philippine Islands six years ago. Since that time various experiments have been undertaken in order to test the adaptability of these insects to the conditions of climate, altitude, food supply, disease, and natural enemies found in this Archipelago.

Incidentally, limited data have been gathered as to the cost of producing a given amount of silk, the quality of Philippine silk, the probable demand for raw material in this country, and the best methods to be used in starting and maintaining a silk farm.

Some of these results already have been given to the public [1] but only in a very general way, intended more to stimulate inquiry and to interest possible investors than to give a detailed account of the question from an experimental standpoint.

It is the purpose of the present paper to collate all data thus far accumulated and to make them accessible to the person who desires to study the question with the end in view of entering upon the commercial production of silk.

Many sources have been consulted on the general question and the experience of other writers has been utilized where conditions of which they wrote were found to be identical or similar to those in the Philippines. A book by Percy N. Braine,[2] dealing with the subject from the standpoint of one who has devoted many years to silk culture in Ceylon, and from whom the greatest amount of help has been received in the matter of introducing the Bengal-Ceylon silkworm here, has been freely used in the preparation of the present paper.

[1] C. S. Banks, Silk Culture, *Manila Daily Bulletin* (1907), **16**, No. 103, 31, 3 plates; Silk Culture in the Philippines, *Phil. Agr. Rev.* (1910), **3**, No. 3, 186, pl. VII.

[2] The Cultivation of Silkworms, Colombo, 1904.

A thorough theoretical knowledge, as well as a predilection for the work, is necessary for the successful propagation of silkworms, and those engaging in the industry must also be prepared to learn from daily experience in the silk house.

The Filipino possesses an infinite patience in small things and is quick to learn by seeing them done, so that he would seem to be well qualified for engaging in the business under discussion. The women and children are available for the indoor labor and the men for mulberry cultivation. This would assure the success of silkworm raising in almost any portion of the Archipelago.

Individuals who undertake this work should always remember that "cleanliness, regard for detail, and perseverance," form the keynote of success and those who are not willing to devote intelligent, constant care to the oversight of the process should hesitate before investing money or planting mulberry trees.

The original, wild silkworm, *Bombyx mori* Linn., is supposed to have spread from somewhere in western China and indeed it is said that even at the present day it may be found there. Centuries of care have developed certain well-marked strains with the following characteristics: Variation in number of broods, fecundity, shape and color of cocoons, quality and quantity of silk, and immunity from or susceptibility to disease, although the last has more to do with neglect or carelessness in methods than to an intentional process of breeding. Of all these characteristics none is more remarkable from the biologic standpoint than that of the variation in the number of broods.

Most insects yield no more than two broods a year, very many only one, and, where three or more occur, it will be noted that the insects are either strictly parasitic or else find their source of food supply in some artificial condition created by man. Such is the case with the house fly, the mosquito, human and animal parasites, and grain and stored-food pests.

Insects which live under conditions that lack what we might term man-made uniformity and protection, find the food supply too limited, or other natural influences too rigorous to insure a multiplicity of broods during a year. With many, producing but one or two broods a year, the so-called hibernation period is passed either as larva, pupa, or adult. A number of wood-boring beetles pass one, two, or even more years feeding within the tree; other insects, such as the wheat midge, the codling moth in America, and the ylang-ylang moth (*Attacus atlas* Linn.) of the Philippines, pass the longest portion of their lives in the pupa. House flies in temperate climates winter as adults. Remarkably few species of insects spend the longest period of their life cycle in the egg. The original, wild race of the silkworm is undoubtedly among these and also the monovoltine race, cultivated by the Japanese and described

below.[3] However, the silkworm, by taking precocious individuals and breeding from them, has been brought, in certain regions to the point where it will produce from two to nine generations in a year.

HISTORICAL.

We are indebted to the early missionaries for the first attempts at the importation of silkworms and the mulberry into these Islands.

José Montero Vidal in his El Archipiélago Filipino (1887) says:

The mulberry (*Morus alba* Linn.) has existed in the Philippines since 1593 in which year the Jesuit Father Antonio Sedeño planted great numbers in the Visayas. Afterwards, in 1780, the Agustinian Missionary, Father Manuel Galiana, sent this plant from China and at the time remitted the silkworm eggs (seed). The Royal Economic Society of the Friends of the Country endeavored to promote this industry but the agriculturists of those days never lent themselves willingly to the growing of the silkworm, because of the *great care which it demanded*, and now it is entirely abandoned, a fact due also in a measure to a lack of financial backing. During the time of Governor-General Basco y Vargas, there existed in the Camarines four and a half millions of (mulberry) plants.

Covantes, in Episodios Históricos de Filipinas (1881), adds:

Father Sedeño, knowing the revenues which China derived from silk, made large plantings of mulberries for feeding the worms that produce the silk, to the end that the country might have the advantage of this richness; and considering the irrigation of the land as inseparable from all that pertains to good agriculture, taught also how easy it was to take advantage of it. Having made this advance and placed the industry at the height demanded by social conditions of the time and having noticed that the Indian suffered much from lack of proper clothing, especially at the time of the northeast monsoons, and moreover being opposed to their going practically naked, he made looms with his own hands, taught them to weave cloths, and gave them thread of various colors, dyed with plants of the country.

The Indian, better and more abundantly fed, better protected from the inclemencies of the weather and liking these innovations very much, followed most willingly his true civilizer, Father Sedeño.

The silkworm develops very easily and repeated experiments prove the possibility of getting two or three crops of cocoons [a year].

The species which lives upon Tañgantañgan (*Ricinus communis* Linn.), the castor plant, resists storms and typhoons and its silk, although less fine, has assured value.

Father Pedro Chirino says of Father Sedeño:

He was the first to burn lime there, he made the first tiles, he built the first house of stone. He was desirous that silk be cultivated in the Philippines, because in this way, having the industry already within the country, the money returns from it could be used at home instead of going to China.

[3] This insect remains from ten to ten and a half months in the egg, eighteen to twenty days in the larva, ten to twelve days in the pupa, and three to four days in the adult stage.

With this end in view he planted mulberries, investigated other things and even went so far as to teach the Indians to sew according to European methods.

From the year 1780 to the beginning of the 20th century, we hear no more of attempted introductions of silkworms into the Philippines.

EXPERIMENTS WITH JAPANESE SILKWORMS.

In the latter part of 1904, I had an opportunity to study the methods of silk culture prevailing in the Imperial Experiment Station in Tokyo. After a conference with Professor Kuwana, entomologist at the station, I was convinced that a trial of silkworms in the Philippine Islands would be well worth repeating with a view to encouraging their introduction and culture on a large scale.

As there were mulberry trees growing in the Province of Batangas and in Manila, all we lacked was a sufficiently large planting of trees to insure an abundance of leaves when the eggs should arrive and begin to hatch.

Returning to Manila, I learned that Mr. W. S. Lyon, then of the Bureau of Agriculture, had written for eggs which he expected early in 1905; and that in anticipation of their arrival he had sometime previously transplanted cuttings from mulberry trees near the laboratory building of the Bureau of Science, to the experiment station at Singalong, where the young plants were doing exceedingly well, under irrigation.

On February 14, 1905, Mr. Lyon's eggs arrived from the Japanese Experiment Station. He gave me approximately one-half of the lot, the remainder having been turned over to Don Vicente D. Fernandez for experiment at his hacienda in Nasugbú, Batangas.

THE MULBERRY SILKWORM.

Bombyx mori Linnæus.

THE JAPANESE RACE OR VARIETY.

The two principal races of silkworms produced in Japan for commercial purposes are the monovoltine, which produces one generation a year in the spring and the bivoltine, giving two crops, one in the spring and the other in the autumn.

In the year 1905 attempts were made to propagate the monovoltine race of Japanese silkworms in Manila, but the results were not satisfactory for several reasons, the chief of which is the decided difference in climate between the Philippine Islands and Japan. In the latter country the silkworm eggs hatch in early April and by the middle or end of May the insects will have finished their life cycle, laid their eggs and died. These eggs are collected by agents of the government, examined bacteriologically, assorted, placed on uniform sheets of specially prepared cardboard and then packed in air-tight receptacles either of wood or tin, and buried in pits or placed in special cellars. They remain for a period of approximately 10 months in an inert condition, suffering practically no shrinkage. A few weeks before the time when they should hatch they are taken from the packages, reëxamined and distributed to the individual silk raisers, who either place them in artificially heated rooms if the weather is cool, or else simply leave them at air temperature if it is warm. The period of

hatching is practically simultaneous all over the silk region and within 45 or 50 days from hatchings the whole crop has been disposed of for the year.

Should anything like drought or unusually cold weather occur to retard the mulberry trees in putting forth their foliage, the eggs are kept in cold storage to allow further time for the developing of their food supply, but it occasionally happens that a whole crop will be lost in a given district where the leaf supply fails.

Probably in no other country, with the possible exception of China, has the silkworm been so thoroughly artificialized in its habits and manner of development as it has in Japan and, therefore, this insect in the latter country has suffered from the attacks of all the principal diseases to which it is subject. As it yields only a single crop a year, any extensive attack of disease among the silkworms means a loss of one year's efforts on the part of the grower.

Undoubtedly, Japan produces the best grade of silk in the world, but any country where more crops could be raised in a given time would have an advantage, provided its silk were not materially inferior to the Japanese product and the grower had no diseases to contend with.

In the year 1905 in our experiment with Japanese monovoltine silkworms, we found that the cocoons, moths, and eggs produced in Manila from silkworms fed on the Philippine mulberry were all that could be desired, both as to quality and quantity. We met our first obstacle when we undertook to dispose of the eggs until the time for the next generation.

Ample facilities were at hand for keeping them in cold storage, but so doing would prove nothing beyond what was already known from years of experience elsewhere.

To be of practical advantage it was necessary to know whether Japanese eggs could be kept at air temperature for 10 months in the Philippines without deteriorating and two experiments were undertaken to determine this.

A part of our crop of eggs was put into cardboard boxes for protection from dust alone, while another was placed in sterile Petri dishes and then in sterilized, moderately tight tin boxes. All of these batches of eggs were left at room temperature in the laboratory. They were observed from time to time for signs of shrinkage or the growth of molds. Those kept in cardboard boxes were soon found to be infested with a tiny psocid which ate the shells and destroyed the contents of the eggs. Those kept in tin boxes began to mold during the rainy season in August and although they were frequently cleaned by the aid of small camel's hair brushes, they, like the eggs kept in the Petri dishes, began to shrivel and by the middle of January gave every evidence of desiccation. None of these eggs, some 70 batches in all, hatched nor showed any sign of incubation. They had all been laid upon sterilized filter paper, and were healthy at the time of being laid.

The conditions under which eggs of monovoltine silkworms would be kept at any place outside the city of Manila would be decidedly less favorable than those under which the above experiments were carried out, and so the chances of successfully carrying eggs over for 10 months would be fewer at such places.

Therefore, it would be very unwise to encourage the importation of Japanese monovoltine silkworms except for purposes which will be indicated below.

THE BENGAL-CEYLON MULTIVOLTINE RACE OR VARIETY.

The early experimental work with the Bengal race of silkworms in Ceylon demonstrated that there it regularly produced six to seven generations or crops in a year. Therefore, when the Japan race had not proved successful in the Philippines, we turned to Ceylon for a silkworm which already had demonstrated its prolific nature and its adaptability to a continuously warm or tropical climate and which, furthermore, had produced an excellent quality of silk.

Mr. Braine had been most successful in producing what has now been designated the Bengal-Ceylon race and through his courtesy the Bureau of Science obtained cocoons of four of his most promising types, namely, the golden-yellow, pale yellow, white, and dwarf white. The golden-yellow has flourished best under the influence of the Philippine climate. Thirty-five complete generations, an average of nine a year, have now been grown by us. Two other types slowly reverted to the yellow, but occasionally we obtain white cocoons, although there has been no attempt to regain them since they disappeared, inasmuch as all gradations of color may be found among the golden-yellow types, and, by a simple process of selection through three or four generations, they will produce uniformly colored cocoons of any desired tint of yellow.

Therefore, the best results have been obtained with the Bengal-Ceylon race in Manila, while experiments in the crossing of this race with the Japanese monovoltine white, have produced what we tentatively call a Philippine hybrid, or race. Of course, as it is a cross between individuals of the same species, it is technically not a hybrid.

INTRODUCTION INTO THE PHILIPPINES.

The Ceylon silkworms were received in Manila on March 11, 1907. The cocoons had been prepared for shipment by Braine in the following manner:

A dozen to fifteen of them were strung together upon a piece of sewing thread passed through one side near the middle of the cocoon in such manner as not to pierce the living chrysalis within. The ends of the thread were fastened to a strip of wood held within a small ventilated box, thus enabling the moths to emerge in the box without damage. When the package reached Manila the moths had emerged, paired, and laid a plentiful supply of eggs upon the blotting paper placed there for that purpose, and many of the young caterpilars had already hatched.

The varieties were kept separate and within two days after their arrival the eggs had all hatched. The caterpillars were cared for at the laboratory of the Bureau of Science for a few days and were then transferred to a specially built house at the Singalong experiment station distant one-half kilometer, where they could be continuously under the charge of the entomologist of the Bureau of Science and at the same time be subject to the same conditions which would prevail in any part of the Islands where they are to be grown.

A Filipina girl was put in charge and several Filipino workmen instructed as to the method of caring for the trees, gathering the leaves, and cleaning the trays and the silk house.

The work was continued at the experiment station until January, 1910, when a suitable, permanent silk laboratory was completed at the Bureau of Science.

THE LIFE HISTORY OF THE SILKWORM.

THE EGGS.

The Bengal-Ceylon silkworm remains in the egg stage, in Manila, for from 8 to 9 days, thus surpassing all known varieties of this species in shortness of egg-period. When these insects came to Manila they were producing not more than seven generations a year, because the feeding as well as the egg-period had been lengthened in Ceylon during the cold weather, the one a natural contingency, the other partially artificial, as they were bred in a cooler upland region, Peradeniya being about 520 meters above the sea.

The difference in temperature in Manila between the mean of the cool and warm seasons is so slight that the silkworms are practically always under the influence of an elevated temperature. The results of this condition can easily be seen in the continued production of nine generations a year for the entire four years since their introduction into the Islands.

Uniformity of hatching.—It would naturally be supposed that in changing from a monovoltine to a polyvoltine habit, a condition of uniformity of hatching would be almost impossible to secure, even after several scores of generations. Especially would we expect that in passing from seven to nine generations a year there would be many cases of retarded incubation in each batch of eggs and consequently a condition would obtain where continuous hatching, successive moltings, and hence continuous pupations, would take place, but this has not been our experience. The young silkworms begin their emergence from the egg early in the morning and by noon all are out.

LARVÆ AND MOLTS.

It has been the custom in the entomological laboratory of the Bureau of Science to allow each of the moths to lay her eggs upon a disk of filter paper. These disks are pasted to the hatching tray so that they will not be blown away or confused.

The larva (Pl. I, fig. 1) measures 2.5 millimeters in length when it emerges from the egg. It is then very dark gray, almost black, because of the dark brown head-case and the multitudinous spines which are dispersed regularly over the body.

The silkworms, as soon as hatched, wander a few millimeters away from the egg and remain in a quiescent condition for three to four hours. They then begin to show further signs of life and activity by lifting the

head and moving it from side to side. As soon as this occurs they should have their first food, as much, if not all of the silkworm's future vigor depends upon the first feeding. The tenderest, young, green leaves which have become nearly expanded and are still of a very pale hue and which are taken from the tips of the mulberry shoots should be given at this stage, but those which are not as yet unfolded should be avoided. The leaf is placed over the filter paper in such a way as to be within reach of the young larvæ.

The silkworm, in all stages of its growth, probably is one of the most helpless of domesticated animals, and it is especially dependent upon the person taking care of it while it is very young. It will hardly move twice its own length in search of food, and unless the leaf is placed directly upon it, the chances are that it will starve. Once the food is within reach, every young silkworm will soon climb up on it and begin feeding. When this transfer has taken place, the attendant removes the leaf to a paper tray, so placing it that the leaf will be beneath the silkworms. The effect of their feeding will be noted very quickly upon the leaf, as at first they only consume one epidermis and then feed through to the other. If the leaf is tender and succulent the entire substance, except the veins, will be consumed before it is necessary to change. However, if the leaves show any signs of being too dry for the larvæ, they should be replaced by fresh ones laid whole upon the old.

It is seldom necessary to transfer any silkworms from old to new leaf, as they readily go up themselves. If such a transfer must be made a small, clean camel's hair brush, or other similar instrument alone should be used for the purpose. The silkworms should never, on any pretext, be touched with the fingers, and it is seldom necessary to touch them with anything. In lieu of a camel's hair brush, a very delicate pair of fine-pointed pincers made from bamboo may be used, provided the attendant is expert enough to seize the larva without, in the least, pressing upon it.

Silkworms in the first stage require but little care other than to be well provided with the proper quality of leaf. The amount of excrement is small and very dry, so that the cleaning of the trays is extremely easy.

The silkworms remain in the first stage an average of from three to four days, during which the larvæ increase to 2.5 times their length at hatching. They prepare for the first molt at night and begin molting in the early forenoon. The signs are a cessation from feeding, a general appearance of fullness, an elevation of the forward third of the body, a drawing together of the forward three pairs of legs, the assuming of a sphinx-like attitude, and the extremely small size of the head as compared with the rest of the body. This latter is one of the most notice-

able features of a silkworm preparing to molt. The explanation is as follows:

The head is composed of a single segment of chitin, which hardens as soon as the insect emerges from the egg and is exposed to the light and air. The head covering does not stretch with the rest of the body covering and hence at the time of molting is comparatively very small. The skin of the body is more capable of expansion, but is not elastic enough to keep pace with the growth of the internal portions of the caterpillar. The necessity for molting at certain regular periods of the insect's growth is therefore apparent. (Pl. II, fig. 1.)

First molt.—In the act of molting, the old skin of the silkworm splits along the middle of the back, beginning at the head, and the insect slowly withdraws its six true and eight false or abdominal legs. The old skin is left just behind the larva, much crinkled and adhering to whatever the insect was resting upon. The head case is forced off gradually by inflation of the new head skin and by side to side motions of the insect itself. The newly emerged caterpillar is much paler than before its molt and the head covering is of a decidedly light buff color. Within two or three hours it becomes dark and very hard. The caterpillar then is in condition again to begin feeding.

Second stage.—The best time for transferring the young silkworms to the regular feeding trays (see page 34) is after the first molt and before feeding.

The new tray is placed over the one upon which the young silkworms are lying in such a manner that its meshes will touch them. Young leaves cut crosswise into strips 2 centimeters broad are then evenly sprinkled on the new tray over the parts below which the silkworms are. Within two minutes the silkworms will begin to come up through the meshes and commence feeding.[4]

The second stage lasts for from three to four days, during which time the silkworms eat an increasing amount of leaf, being fed regularly every three hours from 6 in the morning until 9 at night. In our laboratory work in Manila we have never practiced feeding silkworms during the hours from 9 in the evening to 6 in the morning, but in actual practice it would undoubtedly be better to do so in all stages.

The silkworms, when ready to molt the second time (Pl. II, fig. 3),

[4] It is one of the cardinal rules of silk culture that mulberry silkworms should always be fed in this manner. It is cleanly, all refuse is left behind; it is rapid, there is no necessity for taking the silkworms off a tray one by one, a process not only tedious, but sure to injure the delicate creatures; it is sanitary, the silkworms have the advantage of a tray in which there is always an abundant circulation of air and their excrement falls through to one provided for this purpose after the old tray is removed; and, finally it enables the attendant to discover quickly any silkworms which from debility can not come up and which, therefore, should be separated from the healthy individuals and watched for signs of illness.

measure 12 to 14 millimeters in length and have the characteristic markings of the species, although the pattern is small.[5]

Second molt.—The second molt, like the first and all succeeding ones, is heralded by a cessation of feeding and the comparatively small head case. Experience very soon teaches the careful attendant just how to proceed, and she makes a corresponding disposal of her leaf, giving directions to the leaf gatherer as to when to stop cutting and preparing a fresh supply, according to the appearance of the caterpillars. The second molt does not differ in any respect from the first. (Pl. II, fig. 4.)

After each molt the silkworms require a greater and greater amount of tray surface. Table II, page 17, shows the maximum number of silkworms to a given area at each stage, and it should be followed by the practical grower who must constantly bear in mind the danger of overcrowding, which is one of the most serious faults in sericiculture and invariably leads to losses which increase year after year. It has been the most fruitful source of the various diseases encountered by the silk growers of Europe and which, in some years, have annihilated whole crops of silkworms.

Third stage.—At the beginning of this stage the silkworms measure 2.5 centimeters in length; (Pl. III, fig. 1.) they are much paler than in the preceding and may safely be picked up with bamboo pincers without injury, provided a due amount of care is exercised. The length of time in this stage varies from 3 to 4 days, and the leaf fed to the insects need not be cut as finely as for those in the second, in fact many practical silk growers believe that silkworms in the third stage, if not even in the second, should be fed whole leaf.[6] Only fully opened, but tender leaf should be fed the silkworms during this stage. A safe rule is: "Age of leaf to age of silkworm."

Third molt.—The third molt occurs 4 to 5 days after the second and, so far as the life of the caterpillar is concerned, marks a point about half-way from egg to cocoon. The same signs of molting are evident and the same care should be taken not to disturb the insects while they are in their "sleep." Food offered to them is doubly injurious as it is a source of irritation to the silkworms and a waste of effort on the part of the attendant (Pl. III, fig. 1).

Fourth stage.—During this and the succeeding stage, the silkworms

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[5] That the caterpillar's head does not grow during a given stage is shown by placing a newly molted specimen in alcohol and comparing it with others of the same stage when they are ready for the succeeding molt. If this fact is borne in mind, and a study of the molted head cases made, the stage through which they are passing can readily be told by looking at a given tray of silkworms.

[6] It has been the experience in the Bureau of Science that they do not waste as much leaf when cut as when it is fed whole, and for experimental purposes it is much easier to calculate the amount required.

may safely be fed fully matured leaf; not hard, dry leaf which is on the verge of dropping from the plant, but fully expanded, dark-colored, glossy leaf of a rough feel, but which is free from sand, dust, and mold. As mature leaves are usually found near the base of the plant, they are also more likely to be sandy, due to rain spattering. All such should be cleaned thoroughly before being fed to the silkworms. Nothing will produce digestive disorders, especially diarrhœa, in silkworms, quicker than sandy or dusty food. (Pl. III, fig. 2.)

The silkworms in this stage require slightly more than double the space previously needed, but care should be taken not to feed them for two or three hours after they have passed the molt, in order that they may recover from its debilitating effects.

Fifth stage.—In this, the last stage previous to the chrysalis, the silkworms measure from 7 to 8 centimeters in length. Their bodies are plump, the skin having almost no folds and being buff-grayish white, turning to a translucent yellow a day or two before they begin to spin. They feed continuously and with great voracity, but the change of color indicates a previous cessation from feeding and, therefore, no more leaf should be given them.

Silkworms need 30,000 times their weight of food from hatching to cocoon. They consume two-thirds of this amount, the other third being waste, so that 35,000 to 40,000 larvæ, from 30 grams of eggs, require leaves as follows:

TABLE I.

Stage.	Kilograms.
First	5
Second	10- 15
Third	40- 60
Fourth	120-160
Fifth	700-800

The above table shows that of the total of 1,000 kilograms one-half is consumed during the latter days of the last stage.

The space required for 35,000 silkworms is as follows:

TABLE II.

Stage.	Space in square meters.
At hatching	1
After first molt	4- 8
After second molt	16
After third molt	32
After fourth molt	60

The more space allowed the silkworms the more silk will be produced. The same rule applies here as in fruit production. Careful pruning of trees or vines increases growing space and gives more and larger fruits. Careful spreading of the silkworms over sufficient space allows more room for development and consequently gives larger silkworms (Pl. IV, figs. 1 and 2) and larger and better cocoons.

Spinning.—The insect, apart from the periods of molting, is most susceptible to accident during spinning. There is great risk of losing many caterpillars if they are not properly cared for.

A silkworm first indicates that it is about to spin by ceasing to eat, protruding its head, and beginning to reach around as if looking for something. The body grows translucent, and careful examination shows that the caterpillar extrudes from the mouth a small, tongue-like organ from the tip of which a tiny thread of silk is attached here and there to the surface upon which it rests.

The instinct to mount, which is manifested when new trays of fresh leaves are placed over a tray of silkworms, is also shown when they are about to spin. In a short time after the first indications of this desire, the silkworms begin to crawl away from the tray and to climb up the sides of the racks. They must then be provided with a spinning place.

Various devices may be employed. Bundles of non-resinous twigs tied together and placed vertically over the trays in columns like the aisles of a Gothic church make excellent spinning places. Clean rice-straw, *cogon*, *talâhib*,[7] or other similar substances, may be put into bamboo baskets and the silkworms carefully picked from the trays and placed in these. Care should be taken to put them well down into the mass of the straw, so that they may spin with as little waste of silk as possible.

An excellent device used largely in Japan consists of a round, flat bamboo basket in which is placed, in spiral form, beginning at the center, a long strip of straw braid, the width of the braid and the spaces between the turns of the spiral being about the width of a cocoon when completed. Several hundred caterpillars can spin in such a tray and these are especially desirable for silkworms to be used for reproduction, as more perfect development of the chrysalis is possible. (See Pl. I, fig. 2.)

Various other arrangements for spinning (Pl. VIII, figs. 1 and 2) will suggest themselves to the alert silk grower and his chief object should be to get perfect cocoons with a minimum amount of web or floss.

The caterpillar, after finding a suitable spinning place, evacuates the alimentary canal and begins to throw out silken lines in various directions to serve as guys for building the actual cocoon. When these are

[7] *Cogon* and *talâhib* are species of large, coarse grasses growing wild in the Philippines.

completed and the dimensions of the cocoon thus laid out, it begins the real work of cocoon making. The motion of the head is in a path like the figure 8 and the thread is continuous until the cocoon is complete. One end of the latter is woven more loosely in order to enable the moth to emerge at the proper time.

Within three to five hours after beginning the cocoon, the caterpillar is hidden and within twenty-four hours the work is completed. The larva changes to a chrysalis on the first or second day thereafter and then the cocoon may be heated or other means of killing the inclosed insect employed, if the cocoon is to be used for silk.

ADULT OR MOTH.

The adult (Pl. V, fig. 2) emerges on the 11th or 12th day after spinning and about nine or ten days after the transformation to the pupa. The moth pushes aside the strands of silk in the weaker, more loosely woven end of the cocoon, by aid of a secretion which it exudes upon coming from the pupa-skin inside the cocoon (Pl. VI). The act of emergence is quite brief if the moth is healthy. It is moist upon coming out, the wings are yet small and folded, and the abdomen is long and distended with fluids. The digestive tract is soon evacuated, the wings expand and dry, and the insect, if a male, begins to search for the female. The latter remains quiet after becoming dry and perfect, but extrudes from the last abdominal segment a somewhat complicated apparatus which is slowly waved from side to side as a means of dispersing the alluring odor.

Copulation.—This act will usually be accomplished immediately upon emergence if the males are allowed access to females, but it is much better for the attendant to take measures to defer it until the moths are throughly dry. It should continue for about 2 hours in order to insure proper fertilization of all the eggs, and one copulation, if of proper length, is sufficient for a single female. A male may be used to fertilize 8 or 9 females, but it is decidedly better and more economical of time to have at least one male to every two females. If there be too few males, some of the females may begin egg-laying before being fertilized and of course such eggs are worthless.

Egg laying.—The females begin egg-laying very shortly after copulation. A healthy insect will deposit her eggs over a limited area, in a single layer carefully placed, the ova lying flat upon the surface.

The last eggs should be laid within 24 hours of the first, but a healthy, though slow, insect may take a slightly longer time. The egg papers are marked with the date and put away until the time of hatching, ten days thereafter.

THE CROSSING OF BENGAL-CEYLON AND JAPANESE SILKWORMS.

Bengal-Ceylon silkworms produce nine generations per annum in the Philippines. The cocoons are golden-yellow, large in the middle and rounded at both ends, one of which is always slightly more acute than the other. (Pl. V, fig. 1, row C.)

The Japanese white silkworms, with which we have experimented, produce a single generation a year. Their cocoons are constricted in the middle and bluntly round at each end. (Pl. V, fig. 1, row A.)

The crossed races produced at the Bureau of Science were at first of four classes; yellow, pale yellow, yellowish-white, and white, but after twenty-five generations they all are practically white and of the shape of the Bengal-Ceylon variety. (Pl. V, fig. 1, row B.)

It is not necessary to go into the details of our breeding experiments here as practically the same work was most admirably done by Toyama[8] who has discussed Mendel's law of heredity in this connection, in a highly interesting and scholarly paper.

The blend finally produced will be termed by us the "Philippine Race of Silkworms," and I am confident that it will continue, as it has now existed for more than twenty-five generations. We still have retained the pure Bengal-Ceylon variety, and have both kinds for distribution.

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[8] *Bull. Coll. Agr.*, Tokyo (1906), **7**, 262–386.

TABLE III.—*Showing the life histories of the Bengal-Ceylon and the Philippine races of silkworms since the beginning.*

I. BENGAL-CEYLON.[a]

Number of generation.	Eggs.			First stage.		Second stage.		Third stage.		Fourth stage.		Fifth stage.		As pupa.		Total of days.
	Laid.	Hatched.	Number of days.	First molt.	Number of days.	Second molt.	Number of days.	Third molt.	Number of days.	Fourth molt.	Number of days.	Pupated.	Number of days.	Emerged.	Number of days.	
	1907.	1907.		1907.		1907.		1907.		1907.		1907.		1907.		
1																
2																
3																
4																
5	Aug. 4	Aug. 14	10	Aug. 17	3	Aug. 20	3	Aug. 23	3	Aug. 25	2	Sept. 1	7			28
6	Sept. 17	Sept. 26	9	Sept. 29	3	Oct. 2	3	Oct. 5	3	Oct. 7	2	Oct. 13	6			26
7																
										1908.		1908.		1908.		
8	Dec. 7	Dec. 17	10	Dec. 20	3	Dec. 23	3	Dec. 27	4	Jan. 1	5	Jan. 8	7	Jan. 24	16	48
	1908.	1908.		1908.		1908.		1908.								
9	Jan. 25	Feb. 4	10	Feb. 7	3	Feb. 12	5	Feb. 16	4	Feb. 21	5	Feb. 29	8	Mar. 11	11	46
10	Mar. 12	Mar. 21	9	Mar. 24	3	Mar. 27	3	Mar. 31	4	Apr. 4	3	Apr. 11	7	Apr. 20	9	38
11	Apr. 21	Apr. 30	9	May 3	3	May 7	4	May 10	3	May 13	3	May 20	7	June 1	12	41
12	June 2	June 11	9	June 13	2	June 17	4	June 20	3	June 25	5	July 1	6	July 11	10	39
13	July 12	July 21	9	July 24	3	July 28	4	July 31	3	Aug. 3	2	Aug. 9	6	Aug. 20	11	38
14	Aug. 21	Aug. 29	8	Sept. 1	2	Sept. 4	3	Sept. 7	3	Sept. 11	4	Sept. 16	5	Sept. 31	15	40
15	Oct. 1	Oct. 10	9	Oct. 13	3	Oct. 16	3	Oct. 20	4	Oct. 22	2	Oct. 29	7	Nov. 10	11	39
	1909.	1909.		1909.		1909.		1909.		1909.		1909.		1909.		
[b]16																
[b]17																
[b]18																

[a] The blanks in the earlier generations of Bengal-Ceylon silkworms are due to the fact that in moving from the old Singalong station the records, kept on loose papers, were lost.

[b] Records lost.

TABLE III.—*Showing the life histories of the Bengal-Ceylon and the Philippine races of silkworms since the beginning*—Continued.

I. BENGAL-CEYLON—Continued.

Number of generation.	Eggs.			First stage.		Second stage.		Third stage.		Fourth stage.		Fifth stage.		As pupa.		Total of days.
	Laid.	Hatched.	Number of days.	First molt.	Number of days.	Second molt.	Number of days.	Third molt.	Number of days.	Fourth molt.	Number of days.	Pupated.	Number of days.	Emerged.	Number of days.	
	1909.	1909.		1909.		1909.		1909.		1909.		1909.		1909.		
19	Mar. 29	Apr. 7	9	Apr. 10	3	Apr. 13	3	Apr. 16	3	Apr. 20	4	Apr. 25	5	May 6	11	38
20	May 7	May 15	8	May 18	3	May 21	3	May 24	3	May 27	3	June 1	5	June 11	10	35
21	June 12	June 21	9	June 24	3	June 27	3	June 30	3	July 4	4	July 10	6	July 21	11	39
22	July 22	July 30	8	Aug. 2	3	Aug. 5	3	Aug. 8	3	Aug. 12	4	Aug. 19	7	Aug. 29	10	38
23	Aug. 30	Sept. 8	8	Sept. 11	3	Sept. 14	3	Sept. 17	3	Sept. 21	4	Sept. 28	7	Oct. 9	11	39
24	Oct. 10	Oct. 19	9	Oct. 22	3	Oct. 25	3	Oct. 28	3	Nov. 1	4	Nov. 6	5	Nov. 19	13	40
														1910.		
25	Nov. 20	Nov. 29	9	Dec. 2	3	Dec. 5	3	Dec. 8	3	Dec. 12	4	Dec. 20	8	Jan. 5	16	46
	1910.	1910.		1910.		1910.		1910.		1910.		1910.				
26	Jan. 6	Jan. 15	9	Jan. 18	3	Jan. 21	3	Jan. 24	3	Jan. 28	4	Feb. 4	7	Feb. 18	14	43
27	Feb. 19	Mar. 1	10	Mar. 4	3	Mar. 8	4	Mar. 11	3	Mar. 14	3	Mar. 21	7	Apr. 3	13	43
28	Apr. 4	Apr. 13	9	Apr. 16	3	Apr. 19	3	Apr. 22	3	Apr. 26	4	May 3	7	May 12	9	38
29	May 13	May 23	10	May 26	3	May 29	3	June 1	3	June 4	3	June 9	5	June 19	10	37
30	June 20	June 29	9	July 2	3	July 5	3	July 8	3	July 11	3	July 17	6	July 27	10	37
31	July 28	Aug. 6	9	Aug. 9	3	Aug. 12	3	Aug. 15	3	Aug. 18	3	Aug. 24	6	Sept. 5	12	39
32	Sept. 6	Sept. 14	8	Sept. 17	3	Sept. 20	3	Sept. 23	3	Sept. 26	3	Oct. 2	6	Oct. 15	13	39
33	Oct, 16	Oct. 26	10	Oct. 29	3	Nov. 1	3	Nov. 4	3	Nov. 7	3	Nov. 14	7	Nov. 27	13	42
34	Nov. 28	Dec. 8	10	Dec. 11	3	Dec. 14	3	Dec. 17	3	Dec. 21	4	Dec. 28	7	----------	------	30

II. PHILIPPINE RACE. (See page 20.)

	1908.	1908.		1908.		1908.		1908.		1908.		1908.		1908.		
1	Feb. 9	Feb. 19	10	Feb. 23	4	Feb. 26	3	Mar. 2	5	Mar. 8	6	Mar. 13	5	Mar. 24	11	44
2	Mar. 25	Apr. 3	9	Apr. 6	3	Apr. 11	5	Apr. 14	3	Apr. 19	5	Apr. 23	4	May 4	11	40
3	May 5	May 14	9	May 17	3	May 20	3	May 23	3	May 27	4	June 1	5	June 13	12	39
4	June 14	June 20	6	June 25	5	June 29	4	July 1	2	July 4	3	July 9	5	July 22	13	39
5	July 23	Aug. 1	9	Aug. 4	3	Aug. 8	4	Aug. 12	4	Aug. 16	4	Aug. 22	6	Sept. 2	11	41
6	Sept. 3	Sept. 11	8	Sept. 15	4	Sept. 18	3	Sept. 22	4	Sept. 26	4	Sept. 30	4	Oct. 12	12	39
7	Oct. 13	Oct. 22	9	Oct. 25	3	Oct. 28	3	Oct. 31	3	Nov. 4	4	Nov. 11	7	Nov. 24	13	42
														1909.		
8	Nov. 25	Dec. 4	9	Dec. 7	3	Dec. 10	3	Dec. 13	3	Dec. 16	3	Dec. 24	8	Jan. 6	13	42
	1909.	1909.		1909.		1909.		1909.		1909.		1909.				
9	Jan. 7	Jan. 17	10	Jan. 20	3	Jan. 23	3	Jan. 26	3	Jan. 29	3	Feb. 9	11	Feb. 23	14	47
10	Feb. 24	Mar. 5	9	Mar. 9	4	Mar. 12	3	Mar. 16	4	Mar. 20	4	Mar. 29	9	Apr. 9	11	44
11	Apr. 10	Apr. 18	8	Apr. 21	3	Apr. 25	4	Apr. 29	4	May 3	4	May 8	5	May 18	10	38
12	May 19	May 27	8	May 30	3	June 3	4	June 6	3	June 10	4	June 15	5	June 25	10	37
13	June 26	July 5	9	July 9	4	July 12	3	July 15	3	July 19	4	July 24	5	Aug. 7	14	42
14	Aug. 8	Aug. 15	7	Aug. 19	4	Aug. 22	3	Aug. 26	4	Aug. 29	3	Sept. 4	6	Sept. 15	11	38
15	Sept. 16	Sept. 25	9	Sept. 29	4	Oct. 2	3	Oct. 6	4	Oct. 10	4	Oct. 14	4	Oct. 25	11	39
16	Oct. 26	Nov. 4	9	Nov. 8	4	Nov. 11	3	Nov. 15	4	Nov. 19	4	Nov. 23	4	Dec. 6	13	41
										1910.		1910.		1910.		
17	Dec. 7	Dec. 17	10	Dec. 21	4	Dec. 24	3	Dec. 28	4	Jan. 1	4	Jan. 8	7	Jan. 24	16	48
	1910.	1910.		1910.		1910.		1910.								
18	Jan. 25	Feb. 4	10	Feb. 7	3	Feb. 11	4	Feb. 15	4	Feb. 18	3	Feb. 25	7	Mar. 9	12	43
19	Mar. 10	Mar. 19	9	Mar. 22	3	Mar. 25	3	Mar. 29	4	Apr. 2	4	Apr. 8	6	Apr. 18	10	39
20	Apr. 19	Apr. 28	9	May 1	3	May 5	4	May 8	3	May 12	4	May 18	6	May 27	9	38
21	May 28	June 5	8	June 8	3	June 12	4	June 15	3	June 19	4	June 24	5	July 4	10	37
22	July 5	July 13	8	July 16	3	July 20	4	July 23	3	July 27	4	July 31	4	Aug. 11	11	37
23	Aug. 12	Aug. 20	8	Aug. 23	3	Aug. 26	3	Aug. 29	3	Sept. 1	3	Sept. 8	7	Sept. 20	12	39
24	Sept. 21	Sept. 30	9	Oct. 3	3	Oct. 6	3	Oct. 9	3	Oct. 12	3	Oct. 20	8	Oct. 31	11	40
25	Nov. 1	Nov. 10	9	Nov. 13	3	Nov. 16	3	Nov. 20	4	Nov. 23	3	Dec. 1	8	Dec. 12	11	41
								1911.		1911.		1911.		1911.		
26	Dec. 13	Dec. 23	10	Dec. 26	3	Dec. 29	3	Jan. 2	4	Jan. 5	3	Jan. 13	8	----------	-------	31

TABLE IV.—*Showing the number of cocoons and amount of leaf fed. Bengal-Ceylon silkworms.*

No. of generation.	Total cocoons.	Seed cocoons.	Weight of leaf.	No. of generation.	Total cocoons.	Seed cocoons.	Weight of leaf.
			Kilos.				*Kilos.*
1	----------	----------	----------	18	----------	----------	----------
2	----------	----------	----------	19	1,149	145	28.9
3	1,670	----------	27.2	20	1,284	----------	26.1
4	5,570	----------	90.9	21	1,350	180	25
5	11,328	----------	118.1	22	5,135	180	110.2
6	8,290	----------	113.6	23	1,215	120	31.5
7	11,343	----------	118.1	24	2,425	150	40.9
8	9,533	----------	109.5	25	4,015	160	89.9
9	14,768	----------	126.5	26	3,438	100	34.8
10	4,659	----------	60.2	27	3,738	80	40
11	8,671	----------	97.5	28	2,090	80	30
12	10,493	----------	137.5	29	1,408	80	26.4
13	21,080	----------	230.9	30	2,570	100	59.6
14	4,782	----------	120.5	31	3,774	150	75.9
15	112,187	----------	1,354.9	32	2,538	148	56.3
16	----------	----------	----------	33	4,250	150	75.9
17	----------	----------	----------	34	40,379	1,723	789

TABLE V.—*Showing the number of cocoons and amount of leaf fed. Philippine race.*

Generation.	Total cocoons.	Seed cocoons.	Weight of leaf.	Generation.	Total cocoons.	Seed cocoons.	Weight of leaf.
			Kilos.				*Kilos.*
1	----------	----------	----------	14	3,400	200	68.6
2	----------	----------	----------	15	6,348	150	110.6
3	----------	----------	----------	16	4,322	200	71.7
4	----------	----------	----------	17	5,189	----------	85.9
5	----------	----------	----------	18	2,431	----------	45.2
6	415	----------	11.3	19	4,400	80	58.7
7	318	114	10.4	20	3,025	120	53.8
8	257	----------	9.0	21	1,600	80	43.4
9	103	----------	4.5	22	4,620	141	84.7
10	1,346	----------	26.8	23	4,925	140	92.2
11	766	----------	24.2	24	3,961	150	63.0
12	2,577	240	59.0	25	6,289	140	87.7
13	6,517	220	141.3	26	5,234	----------	----------

THE ERI OR CASTOR SILKWORM.

Attacus ricini Boisd.

This silkworm (Pls. IX–XII) is supposed to be a native of Assam, where the people cultivate it to a certain extent, producing little more than will satisfy their own requirements. The silk is fine, white, very soft and of great brilliance, and the fabrics woven from it are said to wear for twenty years. Unfortunately, the native weavers will never take the trouble to make any two pieces of silk of the same size, so no

export demand can satisfactorily be met.[9] After several unsuccessful attempts to introduce this silkworm from Ceylon, we were at last able to do so in the latter part of March, 1909, and, up to the present time, we have raised fourteen generations.

The moths (Pl. IX) must be allowed to emerge from the cocoons before the latter can be used; these can not be reeled as in the case of mulberry silk cocoons, but must be spun like cotton, wool, or other similar fiber and by means of a special apparatus.[10]

Aside from the character of the silk produced by the eri silkworm, the chief quality recommending it to the person who wishes to raise it in the Philippines is the great abundance of its food supply. The castor plant (*Ricinus communis* Linn.) grows as a weed in all portions of these Islands and produces a luxuriance of leaf, upon which the caterpillars thrive admirably. It is equally thrifty under cultivation and requires but 5 or 6 months from the seed to the time when it is suitable for feeding purposes. However the leaf wilts very quickly and, therefore, must be gathered only in the early morning or late afternoon. It may be packed in the same manner as mulberry leaf and taken out as needed by the silkworms.

CARE OF THE ERI SILKWORMS.

These insects, having been in a state of domestication for comparatively few years, are much more robust than the mulberry silkworms and do not require the delicate manipulation which is indispensable in the care of that caterpillar. Their life cycle in the Philippines corresponds very closely with that of the Bengal-Ceylon and the Philippine silkworms, and the methods of feeding and general care are much the same. The leaves of the castor plant do not need to be cut up when used for their food, but it is necessary to feed the very youngest eri caterpillars on the youngest leaves of the castor plant. The older ones may be fed with impunity after the second molt of the caterpillars if the leaves are large and succulent. Braine even recommends that this be done after the first molt, provided the leaf is taken from plants not more than four months old. The same trays may be used for the eri and the mulberry silkworms, but as the former are much larger at maturity than the latter, not more than 100 worms should be allowed to each tray. They may be transferred from tray to tray by being covered with a fresh leaf, which is lifted off after a sufficient number have crawled over to it and begun feeding.[11]

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[9] Braine, The Cultivation of the Silkworm, 33.

[10] It has been found recently that the native Philippine apparatus used for spinning cotton in Iloilo Province produces an excellent thread from eri silk. It can be spun on this machine to a very remarkable degree of fineness.

[11] Braine calculates the following as the number of trays for 5,000 eri caterpillars: First day 2; second 4; third 6; after first molt 10; after second 20; after third 35; after fourth 50.

These caterpillars are at no time as inert as the mulberry silkworms and at the time of spinning are extremely prone to wander over everything around them in search of a place to spin. At one time in the laboratory in Manila, owing to carelessness on the part of the attendant who failed to provide suitable spinning quarters, several thousand caterpillars wandered over racks, trays, tables, chairs, walls, and screening, and many were drowned in the water under the legs of the racks.

The most satisfactory substance on which to allow this variety to spin consists of finely shredded, dry, banana leaves, or dried *cogon* (*Imperata exaltata* Brongn.) or *talíhib* (*Saccharum indicum* Linn.) leaves arranged in a basket about 15 centimeters in depth and as large as a tray. In preparing any material of this nature for silkworm nests, care should be taken to see that it is clean and free from ants, mice, and such vermin, otherwise havoc may result.

As the cocoons can not be used until the moths have emerged from them, all cocoons of this species should be carefully placed in trays until after that time. They can then be dried and packed or otherwise disposed of. Before the moths have emerged, the cocoons should be laid in rows with spaces between each two rows of, say 5 centimeters, so as to allow of proper room for emerging without injury. It is best to remove moths to other trays or to breeding cages made of wire or mosquito netting, where they can hang by their feet and properly develop their wings, after which they are in condition for mating.

The mature insects of this species lay their eggs in a lunate mass, row upon row, projecting from the surface upon which they rest, but the eggs are placed side by side so that the young caterpillars can easily hatch from them.

Moths, after egg laying, may be fed to poultry, or else killed and burned, or buried. They should under no circumstances be allowed to lie around near the silk house where they would attrack ants or other vermin, and decaying, give rise to danger of disease among the silkworms.

Eri cocoons will keep indefinitely if they are dried thoroughly in the sun after the moths have emerged. They should be kept dry, and in the rainy season should be watched to prevent the attack of molds or mites. The ideal course would be to spin the material into yarn as quickly as sufficient quantities accumulate.

The Bureau of Science recently has acquired two machines, one for reversing the eri cocoons and throwing out the chrysalids and caterpillar skins, the other for spinning the silk. The object of reversing the cocoon is to obtain a silk free from the debris left by the moth and thus cleaned and of better quality. These machines were in operation at the Carnival of 1911, together with samples of the work done with them.

Even after learning the theory of eri silk spinning, good results or even fair ones are only obtained by months of practice in the effort to spin fine threads of a uniform size and free from waste particles and knots.

In India the silk from this insect is woven into cloth by the natives. It is called eri or eria[12] and lasts practically a lifetime. It is probable that, once started in the Philippines, its cultivation and use for fabrics would be popular not only among the Christian Filipinos, but also with the mountain tribes and the Moros, all of whom use large quantities of cotton in making the fundamental articles of dress as distinguished from mere ornaments.

Eri silk, because of its lustrous appearance and durability, would find a ready sale among Americans and Europeans for hangings, upholstery, and even for heavy dress goods, as it can be dyed any color. If dyed to resemble pongee, which is produced from the wild tusser, *Antheræa paphia* Linn., of China and India, there would be a decided local demand for it, but it is doubtful if for many years to come there would be a sufficient amount produced for export.

Sample weaves of this silk are shown in Plate XVII.

WILD SILKWORMS.

There are several wild species of silk-producing moths found in these Islands.

Among these in order of abundance are: *Attacus atlas* Linn., which feeds on the ylang-ylang (*Cananga odorata* H. & Th.); *Attacus ricini* Boisd., a wild variety of the eri which feeds on ylang-ylang; the Philippine tusser, *Antheræa semperi* Feld., which feeds on *amaga* or *mabolo* (*Diospyros discolor* Willd.), and *Cricula trifenestrata* Helfer, which lives only in high altitudes feeding on *Melastoma* sp., and producing a beautiful, golden cocoon of an open basketwork design, but thus far not known to have value as a silk producer.

A small unidentified species of the genus *Bombyx* has been captured in Mindanao and it may be that something might be expected of the silk produced by it. No cocoons have been found and only a single adult specimen was taken, but the matter merits investigation as soon as opportunity permits.

All of these wild species have possibilities and it may be that when silk culture is once established, those who are interested in experimenting along this line will secure results.

The silk of both *Attacus atlas* and the wild *Attacus ricini* could be obtained in considerable quantities and easily prepared; it might find a use as a packing or padding material. However, with the true silkworm and the eri now well established in this Archipelago, it will not be necessary for some time to look further for silk producers.

Braine[13] in his book gives an interesting chapter on wild silkworms, and the reader is referred to it for more detailed information as to what has been done in Ceylon, India, and elsewhere.

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[12] Native Assamese terms.

[13] *Loc. cit.*, chapter IX, p. 39.

ENEMIES AND DISEASES OF SILKWORMS.

Thus far, very few enemies of the silkworm have appeared in these Islands. The most serious are: The little red ant, *Monomorium floricola* Jerd.; the large red ant, *Solenopsis geminata* Forel; and rats and mice. Owing to the great care exercised in the only three buildings where silkworms have been raised, no serious damage has resulted, nor have gekkos (*Gecco* spp.,) or other lizards, spiders, flies, wasps, hornets, or ichneumon flies, pests which are common in Ceylon, ever been found around the silkworms here. They can all easily be kept out with the exercise of a little care.

After four years of breeding the Bengal-Ceylon silkworms in the Philippines, no disease has ever manifested itself except at one period during the third generation, when, through neglect of the attendant in charge there was a slight indication of diarrhœa on the part of about two dozen silkworms in the third stage. It was impossible at the time to determine whether this disease was a true "grasserie" or not. All the affected silkworms were killed immediately, and no further trouble was experienced.

The five ordinary infections of silkworms are described below.

Pebrine.[14]—This disease, in silk-producing countries, has been the most serious of all infections. In thirty years, from 1833 to 1865 this malady reduced the silk production of France from 57,200,000 pounds to 8,800,000 pounds a year. It has appeared in all the European and Asiatic silk countries. There is no remedy for silkworms affected by it, but it can be prevented in succeeding generations by inspection and selection of eggs free from its micro-organisms. It need not be feared in the Philippines as long as the importation of eggs is under government control.

Larvæ affected with pebrine develop slowly, irregularly and very unequally. Black spots are the most marked outward characteristics of the disease; the internal signs are oval spores, only visible through the microscope.

Larvæ born healthy may contract pebrine during life, but this may not prevent their spinning, as the disease does not reach its climax before the chrysalid or moth stage, and in its incipiency the larvæ is strong enough to spin, although the moth will produce diseased eggs. It is therefore necessary to repeat the microscopic examination for each generation.

Pebrine is not always visible, and when latent induces a predisposition to other diseases. When only one crop of cocoons is made annually, it is comparatively easy to resist pebrine, as its germ when in contact with the outside of a silkworm egg does not retain its vitality longer than seven months. The disease has an incubation period of thirty days; therefore, if larvæ from pebrinized eggs can be made to spin within twenty-five days after hatching, they may yield a fair harvest of cocoons. However, in any case, the only safe course is to use unaffected eggs, as pebrine, even in undeveloped stages, weakens the caterpillar and renders it liable to contract all other diseases.

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[14] Remarks on this and succeeding diseases are in part abstracted from *Farm. Bull. U. S. Dept. Agr.* (1903), 165.

Flacherie, or flaccidity.—This is now the most dreaded disease among European silk growers. In general, the caterpillars manifest it after their fourth molt, when they are mature, or even while spinning.

Without any apparent cause, they begin to languish, then remain completely still, and soon die. They blacken after death and have a disagreeable odor. Often entire chambers perish in a day. Again, the progress of the disease may be slow, the larvæ even spinning their cocoons, but, as they die in the chrysalis state they putrefy within the cocoon and thus soil it, greatly diminishing the value of the harvest. *Flacherie* is enteritis. Pasteur and many other scientists assert that the disease is due to ferments and vibrios developing in the intestinal canal of the larvæ; other authorities maintain that it may exist independently of these. However, as these micro-organisms, in the majority of cases, play a prominent part in the development of *flacherie*, it is well to guard against them.

The principal conditions favoring the development of this disease are: (1) Eggs being spoiled through careless preservation; (2) hereditary tendency; (3) overfeeding of larvæ; (4) wet, sweating, dewy, and fermented leaf; (5) leaf submerged in water or full of mud; (6) leaf from a new plantation or from a shaded spot, coarse leaf, or change of leaf; (7) lack of ventilation; (8) excessive heat; (9) dust; (10) keeping too many larvæ on the trays; (11) accidental deaths of larvæ from injuries, the putrefying insects forming a medium for micro-organisms and infesting the others; (12) general debility.

If these causes are avoided, *flacherie* is not likely to invade a rearing. To prevent contagion, the silkworm eggs should be dipped in a solution of sulphate of copper before being incubated; and in cleaning shelves and nets, powdered sulphate of lime or copper should be applied wherever a dead larva is seen.

Unlike the germs of *pebrine*, the micro-organisms which are probably the immediate cause of *flacherie*, remain alive from one year to another, and the dust of a rearing room may contain them in considerable quantities and become the means of infection. Hence, if the infection starts, the walls, shelves, and all the implements should be washed in a solution of chloride of lime or some other germicide immediately after the rearing, and the room should be fumigated with sulphur.

Gattine.—The external signs of *gattine* are indifference to food, torpor, dysentery, and emaciation. It attacks the silkworm in the first stages, and is especially manifest after a molt. Sometimes it is associated with *flacherie*, and, in its incipient stage, is confounded with this disease. Later, the silkworm becomes extraordinarily emaciated and sufficiently transparent to be mistaken for a mature larva. The hooks of the pro-legs are lengthened and strongly attach the larva to whatever it touches. Meanwhile, torpor creeps on and soon ends its life.

Silkworms having *flacherie* or *gattine* do not always die before mounting into the brush, and if the disease has not completely incapacitated them they may even arrive at the spinning stage, but instead of mounting with the promptness and rapidity of healthy larvæ, they stop and hesitate at the base of the brush, then begin slowly to mount, remaining on the first little twigs and assuming an attitude similar to that taken when asleep, sometimes with the head turned toward the tail. Again, especially in case of *gattine*, the larva wanders restlessly here and there, apparently seeking sufficient power to eject the silky matter, but too impotent to do more than throw out a scanty thread, to weave a web or the veil of a cocoon, in which it generally falls and dies.

Eggs free from disease and capable of resistance to disease are the prime requisite in guarding against *flacherie* and *gattine*. The moment dead insects are

noticed, the following procedure should be adopted: (1) The beds should immediately be changed, briskly shaking the silkworms; (2) the silkworms must be placed on disinfected shelves; (3) the diseased and suspected individuals that do not mount to fresh beds must be burned; (4) if possible, the whole rearing must be removed to another room which has previously been aired and disinfected, and also aired after disinfection; (5) the caterpillars must not be fed during the three or four hours in which the change is being made; (6) a little wood smoke should be maintained in the room; (7) a few scanty meals of light leaf should be given; and (8) the temperature slightly diminished, if possible.

Calcino, or muscardine.—This disease, at first, gives no visible evidence of its presence, but by degrees the vitality of the insect is impaired, and it eats and moves slowly. The body turns rose-color or red, beginning with the stigmata, and then contracts and loses its elasticity, after which the silkworm stands still as though paralyzed and finally dies 20 to 30 hours from the appearance of the first symptoms. After death the body dries and is covered with a white efflorescence, causing it to appear like a piece of chalk; hence the name of the disease.

Calcino is caused by a fungus. There are two varieties of this fungus: *Botrytis bassiana*, and *B. tenella*. They both attack the silkworm in the same way. The spores of the mold by chance get on the body of the insect when it is in a molting condition, and there take root, penetrating below the skin. The thread-like mycelium ramifies until it fills the entire body. Later, some of the branches fructify on the surface, and the fruit, bursting, envelops the larva with innumerable spores resembling a white powder.

Each spore is capable of settling on a molting larva and giving it *calcino*. *Calcino* is more contagious than other diseases of the silkworm. Darkness, stagnant air, dirt, excessive warmth and moisture are the five things that favor mold.

The chief cause of the disease is the neglect to change the beds and the keeping of litter in and around the room. If even one or two silkworms have died from *calcino* all the shelves should at once be cleaned and divested of dead insects. The floor racks and trays should be sprinkled with a solution of sulphate of copper (1 to 2,000 by weight) care being taken not to get it on the caterpillars, and if the silk house is so constructed that it can be tightly closed, sufficient sulphur should be burned strongly to fumigate or a dense wood smoke created in the room, which should then be shut up for five or six hours, after which the silkworms should be fed. Should any silkworms die on the next day, the beds should again be changed and the house again fumigated with sulphur. The quantity of sulphur fumes that would kill rats, bats, and lizards and even human beings does no harm to silkworms. Therefore, no hesitation need be felt in fumigating the rearing room with sulphur; but eggs and thread nets must not be subjected to sulphur fumes. Silkworms affected with *calcino* die before the moth stage; therefore, the disease is not hereditary, but loose spores of the mold creating the disease may settle on healthy eggs. These may be washed off by a good bath of fresh water. Some recommend a bath with a solution of one-half per cent sulphate of copper. In cases of *calcino* the room should be disinfected immediately after the cocoons are gathered, the paper and brush used should be burned and all trays disinfected.

Grasserie.—Silkworms having this disease become restless, bloated, and yellow. If punctured they exude a purulent matter full of minute polyhedral, granular crystals.

Grasserie is not hereditary and does little harm to silkworms in Europe, but in warm countries, such as Bengal, it sometimes assumes an epidemic form.

Silkworms first fed on mature leaf, and afterwards on young leaf, are liable to take *grasserie*. The propagation of large trees is the best means of keeping free from the disease by enabling the silk grower to have always at hand leaf of the age adapted to that of the silkworm. The main cause of the sporadic appearance of grasserie is mismanagement of the silkworms at the molting periods. Feeding should not be stopped before all the insects have begun to molt, and should not be recommenced until all are well out of the molt; otherwise they are likely to contract *grasserie*.

As has been stated, little fear need arise that any of the above-described diseases will break out in these Islands as long as all eggs are inspected at the entomological laboratory of the Bureau of Science and proper measures taken by growers to avoid dirty, crowded, or ill-ventilated silk houses. Of course, in a community where eight to nine generations are raised in a year and where the process of silk culture is therefore practically continuous, a much greater degree of vigilance is necessary in order to detect the slightest tendency toward disease, than when monovoltine varieties alone are grown.[15]

It is natural to suppose that in handling large numbers of silkworms some of them will be injured. These should be killed at once and burned to prevent fungi from developing in their dead bodies. Dead larvæ are always a menace to the living ones. Healthy silkworms require little handling and when it is necessary to remove slow or lazy ones from tray to tray, this should be done, if they are very small, by means of a small camel's hair or feather brush; when larger they may be handled by means of a pair of pincers made of bamboo. In the last stage, before spinning their cocoons, they may safely be picked up with the clean fingers. The silk grower is again cautioned against overcrowding as this is the most prolific source of disease among silkworms.

If silkworms can be raised through 36 generations without the appearance of disease, they can, by proper care, be raised through 360 or any other number with the same assurance. As the Philippines are isolated from countries in which silkworm diseases are prevalent, it should be possible to prevent their introduction into the Islands.

THE SILK HOUSE.

Once the question of the amount of land which the silk grower wishes to devote to the enterprise is settled, the kind and size of silk house must be determined.

The silkworm must be protected from sun, wind, and rain during its entire existence, but an elaborate silk house is by no means essential.

[15] If diseased silkworms are detected, three or four of them should be put into a small vial of 70 per cent alcohol and sent by mail to the Bureau of Science, Manila, and the remainder should be killed and burned, or buried deep in the ground away from the silk-house.

The simplest construction, with the ordinary materials available in any given district, fully answers all requirements and these factors enter largely into the problem when considered from a commercial standpoint.

A silk house of bamboo, with grass or *nipa* [16] roof, and with the walls of *sinamay,*[17] for a portion of their height, and bamboo wainscoting, would probably last for a period of from 5 to 7 years and give as satisfactory results as one of wood or concrete with wire screening, where initial expense is a vital consideration.

In Ceylon, where a very favorable impetus has been given to silk culture during the past 10 to 15 years, several types of permanent silk houses have been recommended.[18]

The plans shown on Plate XIX contemplate the use of *nipa,* bamboo, wood, and *sinamay,* the wood being used only for the heavy framework, with woven bamboo, called *sawali,* for wainscoting.

The three great essentials in a silk house, aside from cost, are: (1) Protection from pests such as ants, flies, rats, and lizards; (2) protection from winds and excessive sunlight; (3) adaptability to the growing of a maximum number of cocoons within a given cubic space; (4) ease with which the house may be cleaned.

Site.—Dust is dangerous to silkworms as it is to many other living organisms. Therefore the house should be so placed as to be remote from dusty roads or frequently plowed land, and should be located, if possible in the center of a grass plot. The prevailing wind should be considered in this respect.

The direction of the long axis in this latitude would be of small consequence except that in a region where typhoons are prevalent the broadside of the house should not be placed across the usual track of the storms. The general effects of sunlight will probably be the same whether it is placed east and west or north and south.

Ground free from termites (white ants) should be selected and, if necessary, treated with either crude petroleum or ordinary illuminating petroleum, if crude is not available, before building, so as to insure against this pest.

Shade.—If the house can be so built that shade trees can be used both as a wind break and a protection from excessive sunlight, the grower will have a decided advantage. However, too much shade is worse than not enough, because of dampness. As the roof of the house can be constructed as an important factor in shading the interior, it is better to have too few trees than too many near the silk house.

Shape and construction.—In the Philippines the best form is long

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[16] *Nipa;* a wall and roof material made from leaves of the nipa palm.

[17] A cloth woven from Manila hemp.

[18] Braine, *loc. cit.,* 17, pls. IV and V.

and narrow, giving space inside for two rows of racks. In the silk laboratory at the Bureau of Science three rows of racks are used, but for a house in the field two are to be recommended. There should be sufficient room to allow passage around the racks in all directions.

A house 5 by 30 to 35 meters or 6 by 35 to 40 meters inside measure would probably be the best proportioned, provided there is a covered passage way along each side and at the back 1.75 to 2.5 meters in width and the eaves of the roof come down to within 1.5 meters of the ground on all sides. The low eaves and covered passage serve two purposes, to keep out an excess of sunlight and to guard against the full force of strong winds which would prove detrimental to the silkworms.

The best kind of roof is made of *cogon*, *talíhib*, or *nipa*, as it keeps the silk house much cooler than any other material—for this reason corrugated iron is not to be recommended. If well made, the roof may have a pitch of 30°, in fact a low-pitched roof would be better than a high one, because there would be less space to become heated during the day and still sufficient space to produce good ventilation of the upper parts of the building.

The lower part of the walls should be 1 to 1.25 meters high and may be made of *sawali*, wood, or other light material. The upper portion should be of an ordinary grade of *sinamay* of sufficiently close weave to keep out flies and other insects. Wire gauze, either of iron or brass, may be substituted, but would increase the cost very much without affording special advantage except as a protection against rats and mice. These can be kept down by poisons judiciously used or by traps. The ceiling should be made of white cotton cloth, or of *sawali* or boards, painted to prevent accumulation and subsequent falling of dust upon the silkworm trays.

One end of the silk house should be reserved for tables upon which the leaves are prepared and the trays containing the silkworms are changed and arranged for cleaning; the latter operation being conducted best outside the house.

The floor may be of concrete, in which case provision should be made when the floor is put in, for troughs to hold the legs of the racks, or if concrete is too expensive, a simple dirt floor packed hard and raised 30 to 45 centimeters above the surrounding ground will be found equally good. In case a dirt floor is used, earthen or metal pans must be provided for the legs of the racks, so that these may be kept filled with water and kerosene as a deterent for ants, which quickly destroy both silkworms and cocoons if they once get among them.

The racks require for their construction 5 by 10 centimeter scantlings for the base and feet, 5 by 5 centimeter pieces for the uprights and 2.5 by 5 centimeter pieces for the cross battens to hold the silkworm trays. When made of materials of this size they are very stable. As they can not be supported from above, because of ants and mice finding their way over these supports, it is quite necessary that they be of firm construction, and not likely to be tipped over easily.

They are so made that trays 50 by 100 centimeters may be put in from either side and the battens may be placed so as to allow 15 centimeters space between the several trays. This will give ample light and ventilation for the silkworms. The lowest trays should be 45 centimeters from the floor and the highest 2.15 to 2.45 meters, but it is better not to have them so high that they can not easily be removed by the caretakers. Cocoons, empty trays and other apparatus may be stored on top of the racks, although it would be better to have a separate room for these.

A large table, about 1 by 2 meters, and a long, deep, wooden trough for storing leaf in order to keep it fresh, complete the absolutely necessary furniture of the silk house.

Racks may be built in the outer covered passage at the back of the silk house for the storage of baskets, trays, and frames, but care should be exercised in the construction and use of such places to avoid making harboring places for rats and mice. It is very essential that there should be no places around a silk house where dust may collect. While painting would undoubtedly add much to its preservation and appearance it is not necessary so to treat the building.

In a region of strong winds or frequent typhoons the silk house should be provided with movable screens of *sawali* to be put up outside as a protection, but it is very inadvisable to attempt silk culture in places much subject to high winds, as nothing is more disastrous to these insects.

As little sweeping as is possible should be done in the silk house while the worms are developing and to this end it would be better to do all cleaning of trays outside; but if sweeping must be done it should be after the floor is sprinkled lightly. In the case of a dirt floor this must be done sparingly. General cleaning of the silk house should only be done during the periods between successive generations, but a daily cleanliness of house, persons, utensils, and apparatus should be insisted upon by any owner as the surest means of keeping disease away from his silkworms.

Silkworm trays.—The most convenient size of tray is 50 by 100 centimeters. Heretofore we have employed trays of coarse-meshed *sinamay* for the smallest silkworms and of wire netting of 6-millimeter mesh and 12-millimeter mesh for half-grown and full-grown silkworms.

At the Batac School Farm in Ilocos Norte, a very suitable tray has been constructed of bamboo for the large silkworms. It is in every way as serviceable as the wire ones and has this advantage, that the material for its construction can be obtained anywhere in the Islands. The cost is practically nothing, as it may be made by the workers at odd times.

The tray with intermediate mesh can be discarded, as the large meshed one will always hold the leaf if the latter is cut properly, that is, not too fine. The bamboo tray has the outer rim nailed but if the ends of the woven portion were turned back and woven in to form a selvage, the rim could easily be attached by rattan.

A small step-ladder will be found serviceable in a silk house to enable the attendants to remove and replace the upper trays on the racks.

For the transfer of silkworms and for certain other work where the trays must be taken from the racks, a small, two-legged table made of the size of a tray, will be found very convenient, if set with the legless end resting on the rack.

The silk house, if possible, should have two doors and a small vestibule so as to keep out flies when attendants enter or leave the building. Then too, with two doors one of them is almost always likely to be kept closed and all kinds of vermin are more easily excluded. It must be remembered that chickens are extremely fond of silkworms and when once they locate a place where these insects are kept, they are difficult to keep away. It would be well in constructing the silk house to place it far away from poultry haunts.

A silk house 5 by 30 meters inside in which a space 5 meters long is left at one end for working, would provide for 134,000 silkworms if the racks were 24 meters long and 2.15 meters high, the first tray being placed 45 centimeters from the ground, and 125 silkworms allowed to each tray, 50 by 100 centimeters.

If, instead of being continuous, the racks are divided by 1-meter cross-passages, a deduction in capacity of 3,000 silkworms for each such passage, is to be made.

Overcrowding is one of the tendencies against which the silk grower will have to fight with the greatest energy. When he knows how many cocoons he wishes to raise he should provide house capacity for fully that number and not think that he will get as large cocoons by putting in just a few thousands of silkworms more than the number indicated. Just as overcrowding of persons in dwellings and of plants in field rows, tends to produce inferior individuals predisposed to disease, so will a like procedure have its results in the silk house, and in the crop produced there, both in cocoons for spinning and in those to be used for reproduction.

A well-kept silk house is one of the pleasantest places in which a person can work. There are no odors, no noises, no dirt, grease, dust, nor smoke; clean clothes and hands can be maintained and the sericiculturist can emerge in the evening looking as fresh as when he entered in the morning. On the other hand, an ill-kept silk house can be made extremely repulsive.

THE MULBERRY.

Morus alba Linnæus.

This tree, supposed to be a native of China but now widely dispersed and growing wild as well as cultivated in both temperate and torrid zones, is the only food upon which the true silkworm can thrive, so far as both experiment and practice have shown.

It is a shrub-like tree attaining, if left to its own mode of growth, a height of 5 meters, and being of a broad oval shape—but young trees, by constant pruning, may, like the willow, be trained to any desired form and may produce an exceedingly large number of very small-lobed leaves together with few or many fruits, or by cutting back to the main stem may be caused to send forth long, healthy branches or whips bearing large, whole leaves which in their various degrees or ages are perfectly adapted as food for the different stages of the silkworm.

The mulberry in the Philippines thrives upon almost any kind of soil having proper drainage. It seems to prefer a habitat which for most other plants of economic value, would be termed sterile; thus vast areas of rocky or stony ground in these Islands, unfit for the raising of any other corps, could be planted with this tree with every assurance that it would produce abundantly.

I have seen mulberries growing at sea level and in the region of Baguio at an elevation of 1,500 meters, and I must say that the former,

where there is a mean annual temperature of 28 to 30°C. (82° F.) give a better yield of larger leaves than those grown where the annual mean is 17°C. (63° F.).

VARIETIES OR KINDS OF MULBERRY.

Mr. E. D. Merrill, botanist of the Bureau of Science, states that the several apparent varieties of mulberry found here are all true *Morus alba.*

This would seem highly probable for several reasons. When the early Spanish priests anticipated the introduction of silkworms into the Philippines, they started the movement by bringing mulberry plants from China. José Montero Vidal's remarks on this subject have already been quoted.

Had there existed at the time any species of mulberry in the Philippines, it is almost certain that the learned Church fathers, many of them no mean students of botany, would have discovered them and some record would have been left of attempts to cultivate the trees for the purpose of silkworm feeding.

The great adaptability of this plant being known, there is no doubt that the trees which are now often found growing wild in scattered parts of the Islands are the progeny of those early importations.

No effort has been made in recent years to determine specific localities for the mulberry in the Islands, but as has been indicated above, scattered old trees are known both in Luzon and in the Visayas, while reports state that as late as 1868, silkworms were being raised in the region of Aparri, at Pamplona, from eggs evidently brought over either from Japan or Formosa by Japanese traders.

It is quite obvious that before any serious attempts at commercial silk culture are undertaken in this Archipelago a very general distribution of cuttings must be made and large, healthy plantations started and kept under cultivation for periods of 2 to 3 years or more.

This work of distribution is already under way and no fewer than 75,000 cuttings have been distributed by the Bureaus of Agriculture and of Science during the past four years. In most cases these cuttings have been given to industrial and agricultural schools, but many thousands have been put into the hands of private individuals some of whom were in earnest regarding the undertaking of sericiculture, and a few of whom have merely taken cuttings because it was the fashion to ask for them.

In every case these distributions were made gratis and instructions were given as to the best methods to be used in planting and caring for the trees. While a record has been kept of the persons to whom cuttings have been sent, no reports have yet been requested as to results, but these data will be collected in the near future.

METHODS OF PROPAGATION.

While the mulberry produces a considerable quantity of edible fruit from which fertile seeds could be secured, the best way to propagate it is by means of cuttings which are obtainable readily from trees of the proper age and size.

It is recommended that for this purpose a number of trees be set aside and allowed to grow after their natural bent for two or three years, care being taken to keep down weeds and to loosen the soil for a distance of half a meter around the tree three or four times during the year. During this time the tree should be pruned only to the extent of removing defective or dead branches. A tree thus cultivated should, at the end of three years, produce 200 to 300 healthy cuttings and thereafter an average of 75 cuttings every six months.

If proper care is taken in planting the cuttings, every slip should produce a perfect tree. The best way to proceed is to prepare a bed such as is made for rice seed. This should be elevated sufficiently above the surrounding ground to insure against an excess of water around the inserted ends of the planted slips and at the same time keep them damp. For this reason a sandy soil is best for a seed bed, as it insures both moisture and drainage. The evil results of excessive moisture can not too strongly be urged, as experiments have shown that as high as 80 per cent of cuttings planted under conditions of excessive humidity of soil, rot and die, while practically 98 per cent of cuttings made in the right way will bud and grow if the bed is constructed properly before planting. Mulberry plants may be permanently set out when the shoots have attained a height of 20 centimeters and the same precautions as to preservation of roots and rootlets and of proper moisture should be taken as in transplanting of other plants.

Cuttings.—Cuttings should always be made from healthy stock and should invariably consist of well-made wood of at least six months' growth from 2- or 3-year-old stock. It is preferable to make the cuttings when the tiny new bud shows within the leaf axil, as the tree is then in a condition of semiquiescence previous to sending out new leaves. The entire portion destined to be cut up is removed from the stock plant by means of a sharp pruning knife, shears, or saw, and if a clean cut is made no further treatment of the stock will be necessary. The leaves upon the shoot thus cut should be clipped off with shears, leaving one or two centimeters of the petiole for protection to the new bud. In some instances, shoots have been seized by the tip and the leaves stripped off toward the base of the shoot, but this method is not to be recommended.

The shoot should then be cut into pieces not less than 15 centimeters in length, each containing at least three buds. Where the supply of cuttings is unlimited, they would be better if made 20 centimeters long.

When properly prepared and packed without an undue amount of moisture, mulberry cuttings or shoots may be shipped considerable distances. If allowed to dry out the chances of their reviving and budding are decidedly unfavorable.

After planting in the seed bed, mulberry cuttings should be protected from the direct effects of the sun by a canopy of banana or other leaves. Excellent results have been attained in Manila by making the seed bed beneath the shade of full-grown rain trees. (Pl. XV, fig. 1.) These, having high branches, admit light, air, and sunshine, the last in moderate quantities only.

Planting and cultivation.—Several distinct methods of planting and training mulberry trees are in vogue in the various countries where silk is grown.

In China, the custom is to plant the cuttings in rows and when the shoots attain a length of some 2 meters, to cut them down as fodder corn is cut and new shoots are cut in successive crops as they spring up from the stumps. In

most places in Japan the trees are grown in bush form, while in northern Italy the custom is to plant healthy young trees in orchards with a distance of some two meters between the trees. They are allowed to grow a main stem which is then cut off at a meter and a half from the ground. Each spring these trunks produce dense crowns of shoots with abundance of leaves, and these shoots are cut off for feeding purposes.

Several methods have been employed in the Philippines by way of experiment. One is to let the young tree take its natural bush or oval form, removing only the young shoots for feeding, but the most successful method from the standpoint of leaf-production, is to allow a main stem of say 75 centimeters to 1 meter, to attain a diameter of about 10 centimeters and then so to prune it as to permit of a crown of shoots forming at the top. (Pl. XV, fig. 2.) Trees thus cultivated can be depended upon for a fresh output of leaves every 4 months, provided irrigation is practiced, otherwise but two good crops a year can be secured.

While it has been impossible to carry on thus far any experiments in regular irrigation of mulberry trees in the Philippines, a limited observation of the small patch on the grounds at the Bureau of Science and the trees formerly used at the Singalong Experiment Station in Manila, would point to the avoidance of an excess of irrigation in the dry season. The reasons of this are two-fold: Mulberry trees respond very quickly and efficiently to water. There is a period of their growth in the latter half of the dry season when they do not naturally produce new leaves. This corresponds to the quiescent stage or wintering of trees in temperate climates and undoubtedly serves as Nature's means of recuperation. Naturally, if this fact is overlooked and irrigation kept up for a long period, as would be the tendency among those who entered the field of silk culture from the commercial standpoint, a material degeneration of the plant would result and while continuing to cause the production of an inferior quality of leaf, this method would eventually result in the necessity of abandoning the trees and replanting the ground with new stock. Trees provided with a constant excess of moisture produce leaves of too great succulence. The proportion of solids, especially minerals, to that of water being low, the effect upon the silk produced is decidedly deleterious.

THE LEAF.

Sericiculturists in general agree that the leaf used as food for silkworms should have certain physical characters easily recognized after the grower has had some experience with the care of the insects and has noted the effects of different qualities of leaf upon them.

The large, well-developed, dark green, glossy, yet somewhat rough leaf is the best for silkworms from the beginning of the third stage on

to maturity. For the newly hatched silkworm, the very youngest leaf on the stem, tender, pale, nonfriable, alone should be used. For those of intermediate growth leaves should be selected between these two extremes and in accordance with the insect's growth.

No greater mistake in sericiculture can be made than that of feeding too young caterpillars on too old leaves or vice versa. Young silkworms in the Philippines, when provided with old leaves simply starve, shrivel, and die, while the giving of young leaves to nearly nature ones (those from the third stage on) is sure to produce a fatal diarrhœa. This, while not a contagious disease nor to be classed with those which devastate silkworm colonies in Japan and Europe, is not a desirable thing in a country where, up to the present, no form or illness has attacked the silkworms grown under expert supervision.

Gathering the leaf.—Leaf should be gathered in the early morning before the sun has had its wilting effects. The importance of securing clean leaf which is as free as possible from sand and dust can not be too strongly emphasized. If dirty when taken from the tree, it should be washed and then dried by wiping with a cloth. Leaf should be stored in tight trays, covered with damp cloths and kept in cool, shady places. Care should be taken to gather only the amount needed for the day, as the leaves are liable to ferment if kept over from day to day. The best method of taking the leaf, as the work at the Bureau of Science demonstrates, is to cut off entire shoots and then strip the leaves therefrom into a sack or basket. These, when taken to the silk house, are quickly inspected, cleaned and packed as are betel leaves when being prepared for market.

THE SELECTION OF COCOONS FOR REPRODUCTION.

It is obvious that the ideal silk-raising establishment would be the one in which no diseases occur and where sufficient knowledge of the general rules of breeding, both as applied to plants and to animals, would keep the owner always on the alert for signs of degeneracy and especially for robust individuals of good cocoon quality which could be bred with other good individuals remote from them in degree of relationship.

Remoteness in relationship may be acquired by carrying a series of parallel breeds in which the offspring of a certain pair have been mated for a given number of generations, after which crossings are made to either parallel member by male to female and vice versa. As an example, the offspring of A and B being interbred for say five or six generations would be mated with those of C and D of a like number of generations. A variation of this would be to mate inbred offspring of a fifth or sixth generation with inbred offspring of a seventh or eighth or a second or third generation.

Another means of invigorating the strain would be by the crossing of silkworms bred in different localities, or at different altitudes. The question of further crossing by stock imported from other countries is one which comes exclusively within the province of the Government, owing to the prohibition of importation of silkworms by private persons.

In selecting cocoons for moths, care should be taken to obtain those of silkworms which have been the most prompt in coming up to spin. The points to be taken into consideration in picking these cocoons are: Color, shape, texture, body,[19] and amount of external floss.[20]

Large cocoons usually contain females and small ones males, but a considerable percentage of small cocoons will produce female moths, so that size is no real criterion to distinguish between sexes. Small cocoons weighing more than others of equal size, almost invariably contain female chrysalids, but in order to determine this fact delicate scales and a trained operator are necessary. A safe rule would be to select twice as many large cocoons as are desired for females and the same proportion of small and medium sized ones in order to get a fairly large number of males.

These cocoons, stripped of the outer floss, are glued or pasted to a tray made of heavy Manila paper and protected by a cover until the moths emerge. Upon leaving the cocoon the insects should immediately be isolated in order that copulation may be controlled, and they should be allowed to evacuate their bowels upon a piece of absorbent paper before being placed within the bamboo ring for copulation and egg laying.

Only the most vigorous females and those having the largest abdomens should be selected for egg laying. Those males which are the most energetic and which are perfect in body and wing formation, make the best for brood purposes. In this laboratory copulation is usually allowed to continue for two hours, but the time may be shortened to an hour if the moths can be separated without danger of mechanical injury. This must be judged by the experienced attendant.

Toyama[21] has had excellent results after pairing a single male with as many as 8 females, but where males are plentiful it would be better to confine a single male to one or two females.

After copulation the females are placed singly upon small disks of filter or other absorbent paper 9 or 10 centimeters in diameter, and a ring of bamboo 2 to 3 centimeters high and of a diameter slightly

[19] The regularity with which the silk thread has been disposed in constructing the cocoon.

[20] The amount of silk used by the silkworm in the preliminary work of building a support for the cocoons proper. This should be very small on healthy cocoons spun in proper quarters.

[21] *Bull. Coll. Agr.*, Tokyo (1906), **7**, 125.

less than that of the paper is placed over them. This is simply in order to confine the eggs within a certain area and to protect the moth while laying.

A healthy insect lays her eggs evenly over the surface, close together, not in scattered bunches and not piled up two or three deep. Papers having eggs not evenly distributed in a single layer should be rejected as indicating debility. There should be 300 to 400 eggs on a paper, but fewer eggs, if they are large and healthy and evenly laid, should not be discarded.

The date of laying should be indicated upon each paper and those of a given date should be lightly pasted, by one side, to a paper tray and covered to prevent injury or accumulation of dust.

The eggs hatch, in this region, most frequently in 9 days, less so in 10, rarely in 8, and steps should be taken for caring for the young caterpillars in accordance with this fact.

The moth, in laying her eggs, sometimes discards a considerable quantity of hairs or scales from her body and these should be brushed away by means of a small camel's hair brush.

The eggs are of a clear yellow when laid. Within five days they turn to a uniform gray. If there are a large number of reddish or blotched eggs, or if shrivelled ones are noted, they should be discarded as indicating disease or debility.

SHIPPING EGGS.

It is very difficult to ship silkworm eggs or cocoons in the Philippines unless they are packed in tight tin boxes, as the small red ant is sure to attack them in the post-office or in transit on the boat or train. It is not safe to ship eggs to points more than six days removed by direct communication from the point of departure, as incidental delays will mean the hatching and subsequent death of the silkworms. For points remote from the source of supply, a sufficient number of carefully selected cocoons should be "threaded" and packed in a tight, capacious box, carefully lined with blotting or other suitable paper. The moths will, upon emerging, copulate and lay their eggs on this paper and there is a better chance of these eggs reaching their destination before hatching.

In threading, a needle with a stout linen or cotton sewing thread is passed through one side of the cocoon, care being taken not to pierce the live chrysalis inside. The ends of the thread are secured in notches in the extremity of a stick tightly fastened inside the shipping box, or by any other means that will insure their being kept in a fixed position while traveling. Eggs should never be sent in letters as they are invariably destroyed by ants or else are crushed.

Braine has used ventilated shipping boxes for cocoons in Ceylon. He makes these by boring holes in tight boxes and protecting these openings with large wads of raw cotton, but it is doubtful if this ventilation is necessary or even desirable, especially where the cocoons are sent by post, as in the latter case the package is placed in a practically air-tight bag with other objects which may prove deleterious to the moths.

SILK ELABORATION.

In the Philippine Islands, as in other countries of the East, the success of an enterprise often depends more upon the aggregation of a considerable amount of raw material from isolated growers, than from attempts to produce large amounts in a few localities or under a limited number of owners. The silk industry is one eminently fitted to the means of the small grower, who will either reel his own silk for the local market or else send his cocoons to a central reeling factory where power is used. Inasmuch as the latter scheme is not likely to find development on a large scale for some years, I will indicate what has already been done experimentally in the production of hand-reeled silk in these Islands.

At the time of the production of our first cocoons, in casting about for some means of reeling we secured a Japanese woman under whose direction a primitive hand reel was constructed. (See Pl. XVI, fig. 1.) This apparatus produces one thread at a time and as few as four cocoons may be reeled with it.

The chief points to be borne in mind in using this machine are: (1) To learn to keep the water at such a temperature that it will not dissolve too much of the natural gum of the cocoon after the first boiling for loosening the fibers; (2) to keep the wheels running at a uniform rate of speed in order to avoid differences of tension among the several fibers composing a given thread; and (3) to add cocoons in such a manner as to produce a thread of equal size throughout.

In order to become familiar with the mode of operating this apparatus, it is quite necessary to see the work being done and therefore it would be useless to attempt a description of the process. In the hands of our experimenters it has given a grade of silk of rather irregular fiber, but in those of an expert it should give a material of very good quality, uniform in size and at least as good as that from China imported for the making of *jusi* which is a fabric woven from unscoured silk just as it comes from the reel. The machine can be constructed for about 5 pesos [22] and should be able to turn out about 500 grams of silk per day, after the operator has become proficient in its manipulation.

The machine may be seen in operation at the Bureau of Science, Manila, and at the Batac School Farm, Batac, Ilocos Norte, at the present time.

POWER REELING.

A Berthaud 4-pan silk-reeling machine loaned by the United States Department of Agriculture, was in operation for some time at the Bureau of Science, but it has now been installed at the College of Agriculture at Los Baños, La Laguna Province. A similar machine was operated at the 1910 Carnival in Manila. (See Pl. XVI, fig. 2.)

However, it is considered beyond the scope of this work to go into detail with reference to the disposition of the cocoon after it has left the silk house, as the writer feels that recommendations and instruction of this character should come rather from the textile expert than from the entomologist.

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[22] One peso Philippine currency is equal to 50 cents United States currency.

QUALITY OF THE SILK.

The quality of silk so far produced in the Philippines, according to reports from France, Switzerland, and the United States is equal to that of the best Italian or Japanese varieties when reeled in conformity with silk standards and in proper skeins.

The Bengal-Ceylon variety gives the golden-yellow, the Philippine variety a pure white, but the quality is in no wise affected by the color and, in fact, the golden-yellow silk would find as great a demand in this country as the fine white for the making of *jusi.*

Many very excellent fabrics have already been made of Philippine silk, including *jusi,* handkerchiefs, and plain and fancy woven silk, and silk and cotton fabrics. (Pl. XVIII.) The last named, made in Batac have a peculiarly pleasing texture and appearance.

SILK SCOURING.

In order to give raw silk the luster characteristic of silk as we usually know it, the thread must be scoured or boiled in a solution containing soap and sodium or potassium carbonate. The two formulas used in the Bureau of Science are:

No. 1.	Water (rain or distilled)	liter	1
	Good quality non-resinous soap	grams	6
	Sodium carbonate	do	10
No. 2.	Water (rain or distilled)	liter	1
	Good quality non-resinous soap	grams	7
	Potassium carbonate	do	5

The silk is boiled in either of these solutions for about 20 minutes, after which it is soaked in soapy water and then thoroughly rinsed several times in clear water and hung to dry without wringing.

This should only be done to twisted threads as others become irretrievably tangled if so treated. Fabrics woven of unscoured silk may be scoured afterwards by the same process.

JUSI.

Jusi is a gossamer fabric woven in the Philippines entirely of silk, imported, practically *in toto,* from China. Into its fabrication two kinds of silk enter, the one forming the body, unscoured, lusterless, and stiff, the other to give the figures, stripes, plaids, etc., scoured, lustrous, soft, and flossy, and having the appearance of silk as we usually know it in the European and American markets.

It has erroneously been supposed for many years that *jusi* was made of vegetable fibers mixed with silk, but this is never the case as far as I have been able to ascertain. It is true that the body of *jusi* cloth, owing to the natural glue present on the fibers, has the dull appearance of cloth woven from vegetable fibers, but there are many simple tests for proving it to be silk.

THE SILK TRADE OF THE PHILIPPINES.

The silk trade of the Philippine Islands has never been one in which figures appear on the credit side of the ledger. In other words all the silk used in or exported from the Philippines has had its origin in other countries, principally in China.

In 1907 the statement was made[23] that the Philippines receive annually about 300,000 pesos worth of raw silk, of which one-half comes from China. It is very probable that instead of one-half, nine-tenths would better have expressed the ratio as will be seen by the figures given below.

The customs reports for the years 1903 to 1905 showed importations of 1,098,322 pesos worth of raw silk and silk in hanks and as thread, on which a duty of 256,574 pesos was paid.

For the fiscal year ending June 30, 1910, under schedule 277 of the Philippines Tariff, raw silk to the value of 6 pesos was imported, but under Schedule 278, yarns and thread, which includes paragraphs 142, 143, and 144 of the New Customs Tariff, the following imports are indicated:

Schedule No. 278.—Yarns and thread.

Country.	Weight.	Value.	Duty.
	Kilos.	*Pesos.*	*Pesos.*
United States	880	6,302	254
England	47	324	108
France	36	638	220
Germany	27	210	98
Italy		2	
Spain	1	24	8
Switzerland	2	20	6
China	36,410	314,644	119,696
British East India	48	284	118
Japan	409	3,594	1,288
Total	37,860	326,042	111,796

It will be seen that China, Japan, and the United States sent the greatest amount under this schedule, but as the United States is not a silk-producing country the amount imported from there can be classified, as under paragraph 144, "floss and twisted silks" or probably as "manufactured" or "partially manufactured," including sewing and embroidery silks. The amount from Japan is even less, not one-half as much as from the United States.

From information gained at the custom-house, the duty of which it is to rate fibers and textiles, it is quite certain that practically all of the true raw silk or that which is used in the manufacture of fabrics such as *jusi*, and other native cloths and which is classified under paragraph 143, "Spun silks, not twisted," comes from China as will be seen by the tables given herewith.

[23] *Manila Daily Bull.* (1907) **16**, 32.

Importations of raw silk and manufactures of silk into the Philippine Islands.

	Country of origin.	Weight.	Value.	Duty.
Raw silk:		*Kilos.*	*Pesos.*	*Pesos.*
July, 1908, to June, 1909 (par. 169, old tariff).	China	28,033	232,360	84,090
July, 1909, to October, 1909 (par. 169, old tariff).	do	5,288	44,500	15,848
	Japan	188	1,516	564
	Total	5,476	46,016	15,412
October, 1909, to June, 1910 (par. 143, new tariff).	China	24,789	214,668	74,362
	Japan	128	1,038	368
	Total	24,912	215,706	74,730
July, 1908, to June, 1910— Total under old and new tariffs		58,421	492,562	174,668
Yearly average		29,210	246,281	87,334
Yarns and threads, July, 1909, to June, 1910: Total yarns and thread		37,860	326,042	111,796
Under paragraph 143, for weaving in Philippine Islands.		30,388	261,722	90,142
Thread other than for weaving		7,472	64,320	21,654
Plain silk fabrics, fiscal year 1910 (Schedule 282).	China	14,325	118,274	51,038
	Japan	18,088	255,742	120,612
	Total	32,423	374,016	171,650
Velvets, plushes, tulles, laces, and knit fabrics, fiscal year 1910 (Schedules 279 to 281).	All countries	33,136	180,366	77,482
All other silk, fiscal year 1910 (Schedules 279 to 281).	From countries excluding China and Japan.	37,850	620,766	159,331
	Total	70,986	801,132	236,813

Silk thread valued at 326,042 pesos was imported into the Philippines during the year 1910. Of this silk, 261,722 pesos worth or an increase of 15,441 pesos over the general average for these years, was used here exclusively for weaving purposes and this can be apportioned about as follows: 49,152 pesos for Iloilo and the southern Islands and 212,570 pesos for Manila and the remainder of the Philippines by direct importation. It is undoubtedly true that much of the silk for weaving imported to Manila, finds its way to Iloilo, but these figures are taken from data at these two ports of entry.

Therefore we sent at least 261,722 pesos to China during the last year, for raw material on which a duty of 90,142 pesos was paid, or a total cost to the manufacturer here of 351,864 pesos, all of which could be kept in the Philippines were the cultivation of the silkworm an established and flourishing industry here.

Were we to do no more than supply the local demand, we could safely count upon an eventual trade of at least 897,528 pesos or the value of plain woven goods from China and Japan and of fiber imported for weaving.

COMMERCIAL SILK CULTURE.

In a region like the Philippines, where an industrial problem of this kind has been tried only from the standpoint of scientific experiment to prove its adaptability, it is very difficult to give accurate figures

as to initial outlay, cost of production, and profits. So many factors must be taken into consideration and these factors vary so decidedly among themselves that it is difficult to determine what to take as a standard.

LAND.

As in all agricultural undertakings, the question of land is the first to enter into the consideration. Inasmuch as land suitable for mulberries may be found in almost any portion of these Islands, it is not necessary to select certain regions as would be the case for crops like sugar, tobacco, or rice. In fact, land which will not produce any of these crops seems most desirable for mulberry cultivation. If it can be irrigated so much the more advantageous, as this would assure a yield of leaf the year round. If irrigation is impossible, the grower would be able during the dry season to obtain sufficient leaf to carry over seed to the next wet season or he could obtain seed (eggs) from Manila.

The question of labor is of paramount importance as upon the cost of this commodity will depend the profits in silk culture. In Ilocos Norte the daily wage is 30 centavos for men, 20 to 25 centavos for women, and 20 centavos for girls and boys. This is probably slightly lower than in many other parts of the Philippines, but it is safe to calculate on a basis of a wage of 40 centavos for men, 30 for women, and 20 for children in almost any of the strictly rural regions.

SILK HOUSE.

The silk house required is of the simplest construction, the most expensive part being the *sinamay* gauze for walls and the white cotton cloth for ceiling. The other paraphernalia, aside from the racks of sawn lumber, need hardly be counted in the cost, as they are made of material ready at hand and easily worked up during spare hours by the laborers. The reeling apparatus is very cheap, and fuel is a negligible quantity.

It is very difficult to calculate the average yield of leaf per tree. It is estimated that in India a full-grown tree will produce about 70 kilos per annum, which is sufficient to feed 2,500 silkworms. "But these figures include in each case the weight of branches and twigs, and as regards the yield, may probably be halved." One hectare of land can support about 1,100 trees planted 3 meters apart each way. This has been found quite feasible in the Philippines, the trees not showing signs of crowding and producing an abundance of leaf. It must be remembered that there are few plantations of mulberries here in which the trees are more than four years old, so that they have not their full growth. Braine recommends the planting of 300 trees to the acre (750 to the hectare) but there is no danger of overcrowding with 1,100,

and if the tract were overcrowded and the trees not doing well, they could be easily thinned out.

On a basis of say 50 kilos of leaves per tree per annum, we have on each hectare leaf production to the extent of 55,000 kilos. This is given as a minimum under ordinary processes of cultivation. Allowing 66 silkworms for each kilo of leaves, one hectare will support during a year 3,630,000 silkworms.

One thousand cocoons weigh one kilo; 3,630,000 silkworms produce 3,630 kilos of cocoons in a year. On this weight, an average of 12 per cent or 435.6 kilos of reeled silk can be calculated. As pure reeled or "spun" silk has a wholesale market value of 11 to 14 pesos per kilo in the Philippines local markets, a gross total of 4,791 to 6,098 pesos per hectare could safely be assumed. This is based upon the following figures:

1 picul (62.5 kilos) of raw silk, unscoured, costs in Hongkong 675 to 735 Hongkong dollars, making a kilo worth about 8.80 to 10.23 pesos upon importation, duty free, but such silk pays a duty of 3 pesos per kilo in the Philippines. Hence its market value here is:

675 Hongkong dollars at 0.875=550.62 pesos plus 189 pesos duty=739.62 pesos,

735 Hongkong dollars at 0.875=643.12 pesos plus 189 pesos duty=832.12.

One picul (62.5 kilos) of scoured silk costs in Hongkong 800 Hongkong dollars, making a kilo worth 14.59 pesos in Manila including duty. This sells in the local *tiendas*, or small Chinese stores, at from 0.60 peso to 0.80 peso per 20 grams or from 30 to 40 pesos per kilo, a neat profit on an industry which has, at present, a wholesale value of 300,000 pesos.

In this connection it is well to quote here portions of a letter from the Philippine Products Company, of New York, dated September 16, 1907:

"*Filipino silk.*—We have now received replies from the bulk of the manufacturers in this country and they all ask for 5 to 10 pound samples. On receipt of same, after working up, they would be able to give us very accurate value on this particular quality. Judging from their replies, however, we are satisfied they would pay the full market price 4 to 5 dollars. * * * For Canton and Bengal silk 3 to 4 dollars per pound, for European, "Japanese" 5 to 6 dollars per pound.

"We would say 5 dollars per pound would be full value until the grade and quality were better known.

"*Duty.*—As reeled from the cocoon, raw silk is free, but it must not be doubled or twisted or advanced in manufacture in any way."

Reports from samples sent to Switzerland indicate a ready acceptance of this silk in European markets if properly reeled and in skeins of official length.

This will give the prospective grower an idea of what he may expect for his silk if properly reeled and sent to American markets.

From the gross income of 4,700 to 6,000 pesos per hectare must be deducted the cost of cultivation, manufacture and marketing, together with interest on the investment, but even then there must be an unusually large profit per hectare to the man who goes into the work with a thorough knowledge of conditions, methods of work, and results expected and who oversees the work of silk culture himself.

The small grower will receive his proportionate profits and if he does not reckon the cost of labor, depending upon the members of his family for this, he can materially add to his income.

SUMMARY AND CONCLUSIONS.

We have now carried on a sufficient number of experiments with both mulberry and eri silkworms in the Philippines to warrant the statement that this industry can be carried on here under conditions as favorable as those which obtain in the best silk producing countries of the world and with the added advantage that no disease has appeared among the insects, or upon the trees used for feeding them.

Certainly with such decided advantages in our favor, it but remains for the people thoroughly to inform themselves by attendance at the places where silk culture is being carried on, and then to advance the industry by planting large numbers of mulberry trees, and when the trees are sufficiently old (two years from planting) endeavoring to establish silk raising in their communities under competent instructors from some center of instruction. The Batac School will soon be in a position to furnish young women who have had a thorough course in this work. The Bureau of Science has already had several Filipino teachers from different parts of the Islands under instruction and is ready to receive others when communities desire to send them.

The greatest mistake will be made if persons or communities undertake the culture of the silkworm without having a person in charge who has had competent instruction. In fact it will be the policy of the Bureau of Science *not* to send silkworm eggs in the future to any person or locality where it can not first be assured that a properly trained person is to have charge of them.

Such a procedure will mean greater security against disease, greater possibility of getting as much out of the industry as possible, and a stronger likelihood that the mass of the people will begin right, which means half the battle.

The market for silk produced in this country is assured for years to come. Local demands will not be met in the next two or three decades and the person who goes into silk culture with determination and knowledge of the requirements must make a success of it in the Philippine Islands.

Information along any line pertaining to silk culture is always to be obtained from the entomologist of the Bureau of Science and it is particularly desirable that silkworms which appear diseased or debilitated be sent in for examination. If they are sent from the immediate vicinity of Manila, they can be kept alive in tight boxes containing an ample supply of food. If the place is distant, the silkworms should be placed in small vials containing 70 per cent alcohol, carefully packed and sent by mail or by some one coming to Manila.

APPENDIX.

No. 1684.—An Act prohibiting the importation by private persons of silkworms, their eggs or cocoons.

Whereas the Bureau of Science has succeeded in importing silkworms into the Philippine Islands without the introduction of any of the diseases which have caused serious injury to the silk industry in other countries; and

Whereas said Bureau of Science is prepared to furnish, without charge, eggs or unhatched cocoons of silkworms in reasonable numbers to the people of these Islands; and

Whereas the importation of silkworms, their eggs or cocoons, by private persons would ultimately result in the introduction of disease: Now, therefore,

By authority of the United States, be it enacted by the Philippine Commission, that:

SECTION 1. The importation, except by the Bureau of Science, into the Philippine Islands of silkworms, their eggs or cocoons, or of the moths which produce silkworm eggs, is hereby prohibited, and any of the aforementioned objects which are imported, or of which the importation is attempted, shall be liable to forfeiture under due process of law. The provisions of this section shall be enforced by the Insular Collector of Customs, in accordance with the provisions of Act Numbered Three hundred and fifty-five, as amended by Act Numbered Eight hundred and sixty-four, as amended.

SEC. 2. The public good requiring the speedy enactment of this bill, the passage of the same is hereby expedited in accordance with section two of "An Act prescribing the order of procedure by the Commission in the enactment of laws," passed September twenty-sixth, nineteen hundred.

SEC. 3. This Act shall take effect on its passage.

Enacted, August 14, 1907.

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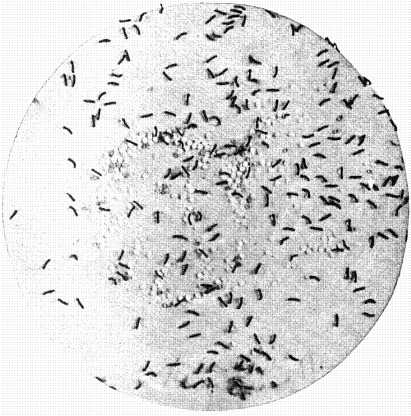

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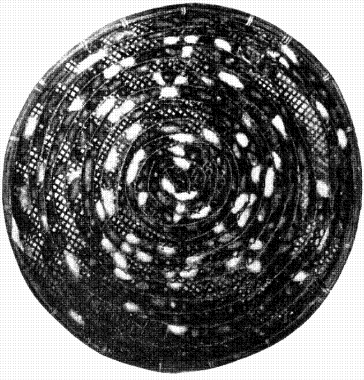

Fig. 2.

PLATE I.

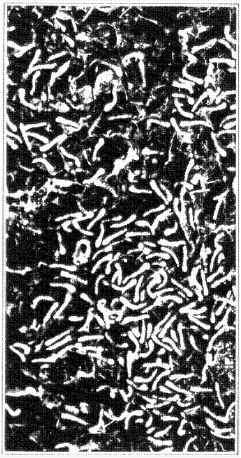

Fig. 1

Fig. 2

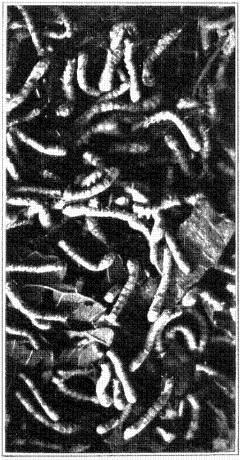

Fig. 3

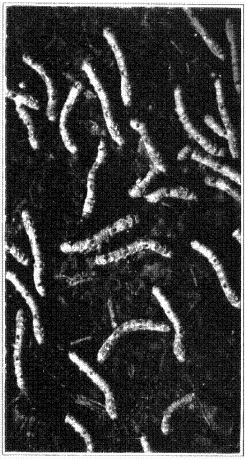

Fig. 4

PLATE II.

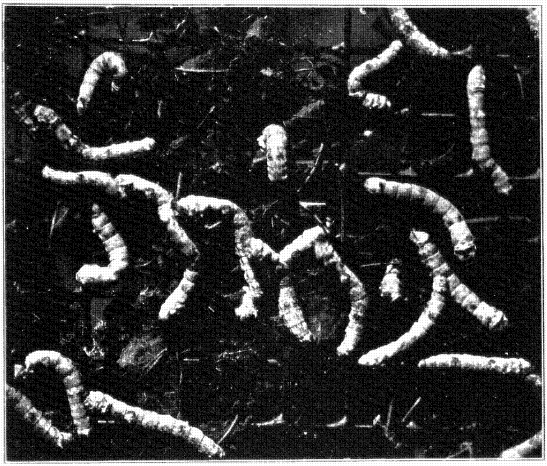

FIG. 1

FIG. 2

PLATE III.

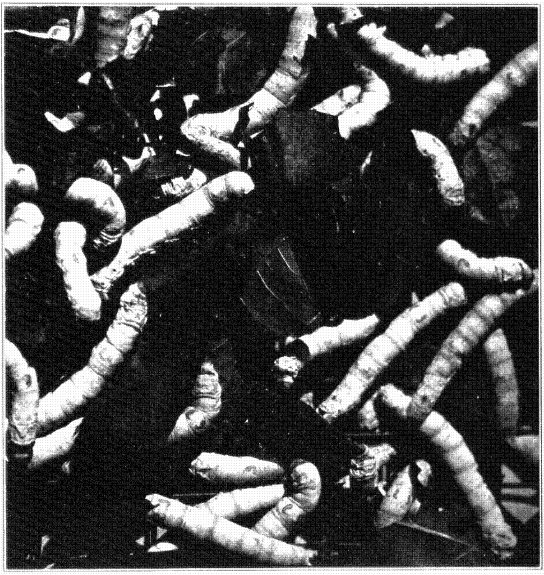

Fig. 1

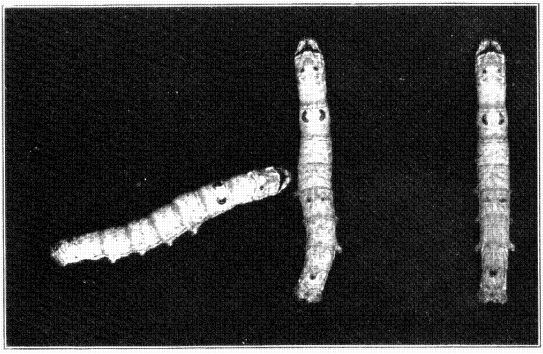

Fig. 2

PLATE IV

Japanese. A | Philippine. B | Bengal-Ceylon. C

Fig. 1.

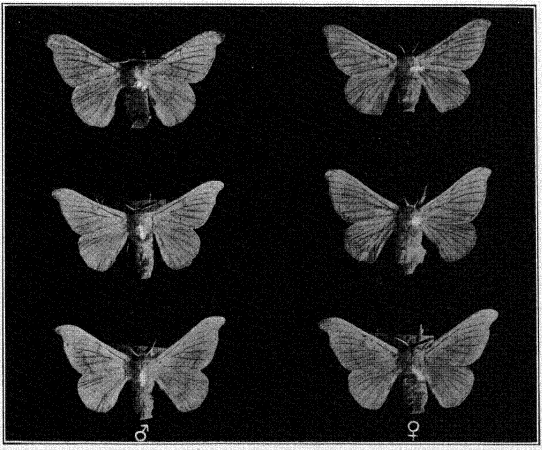

Fig. 2.

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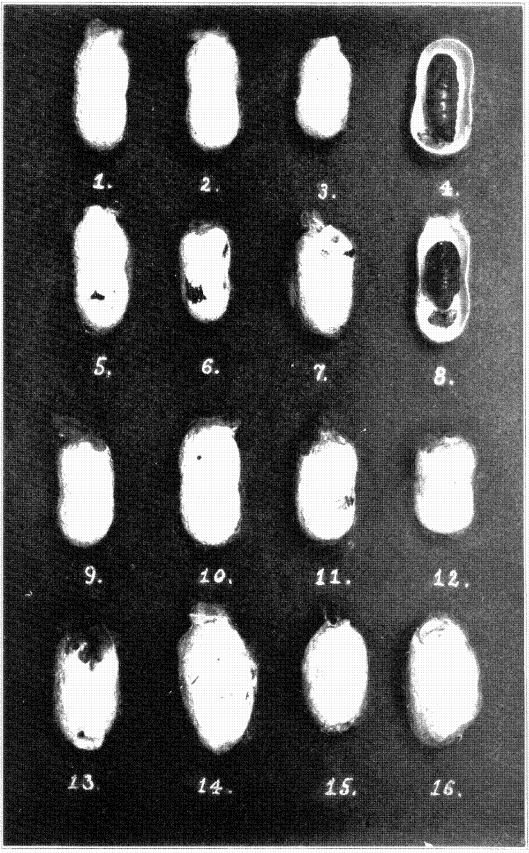

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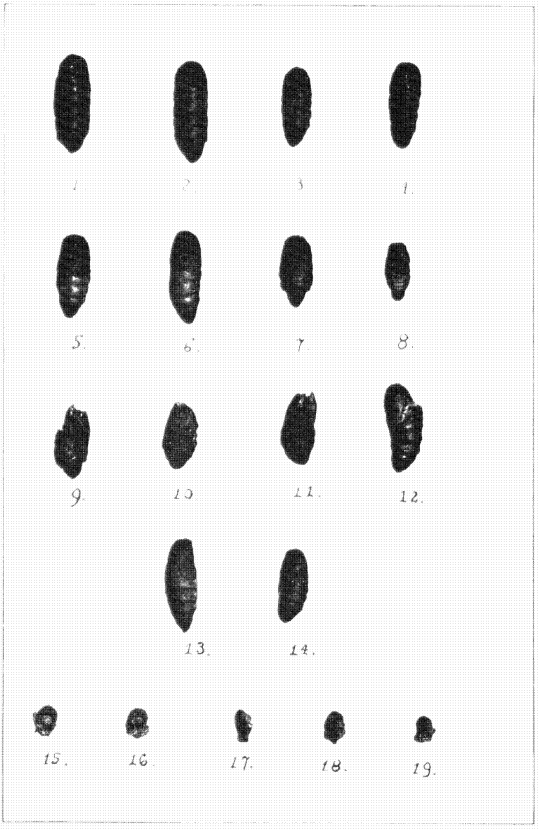

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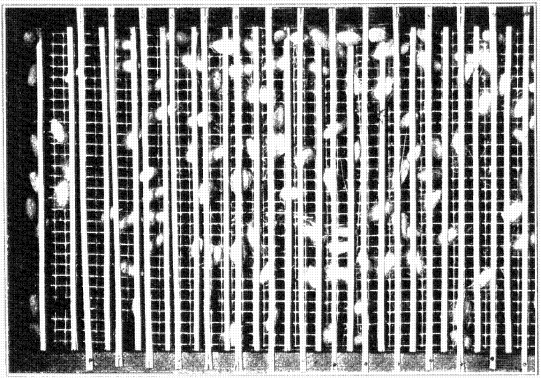

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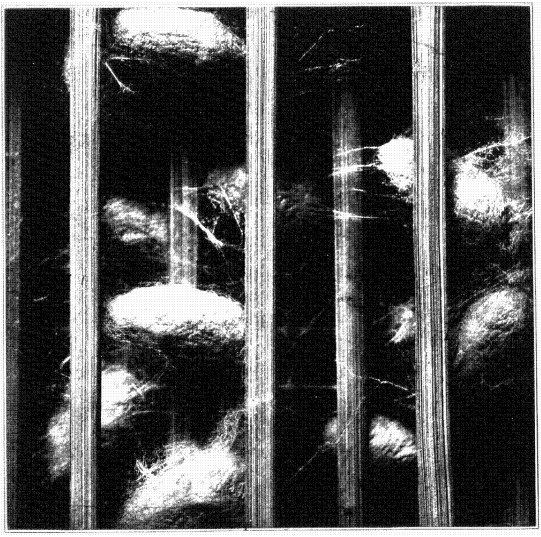

Fig. 2.

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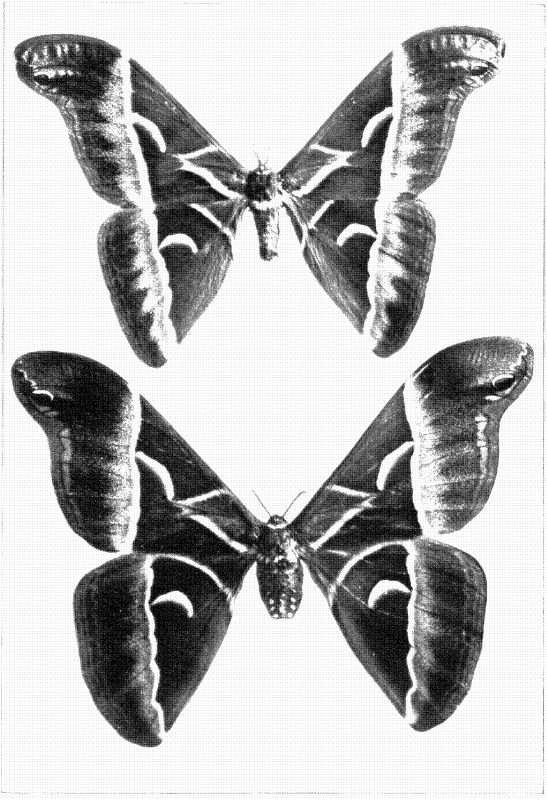


PLATE IX

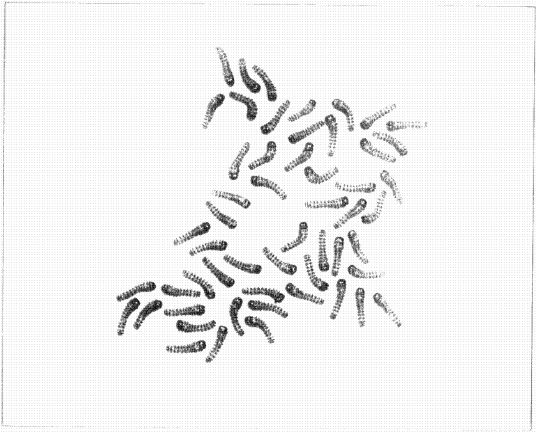


Fig. 1

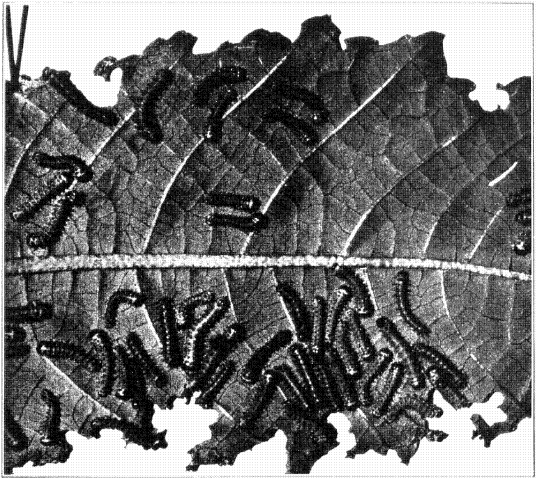


Fig. 2

PLATE X.

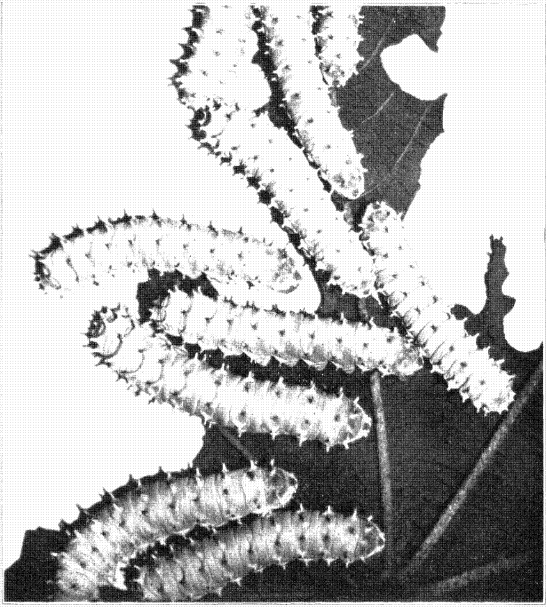
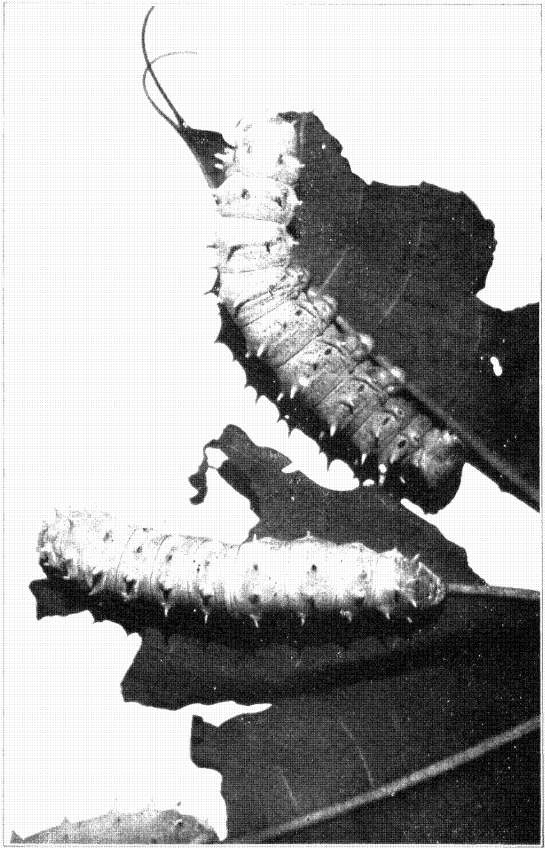


FIG. 2

PLATE XI



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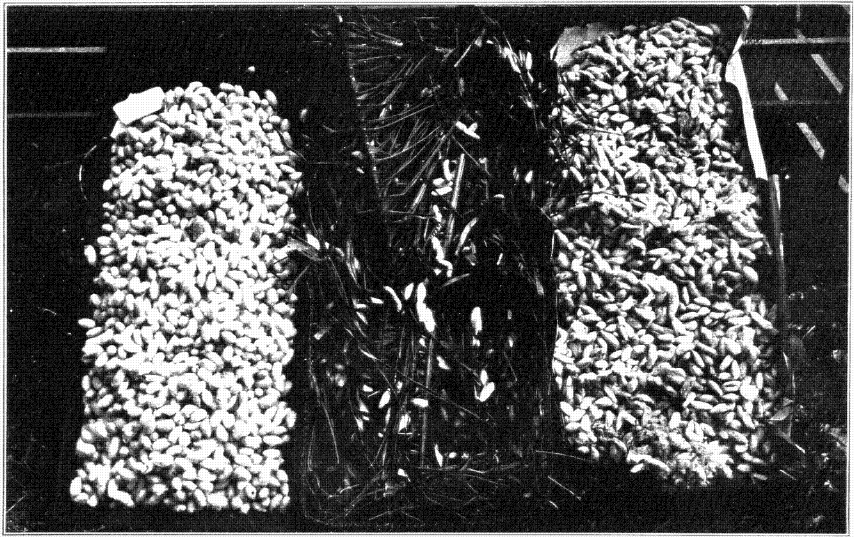

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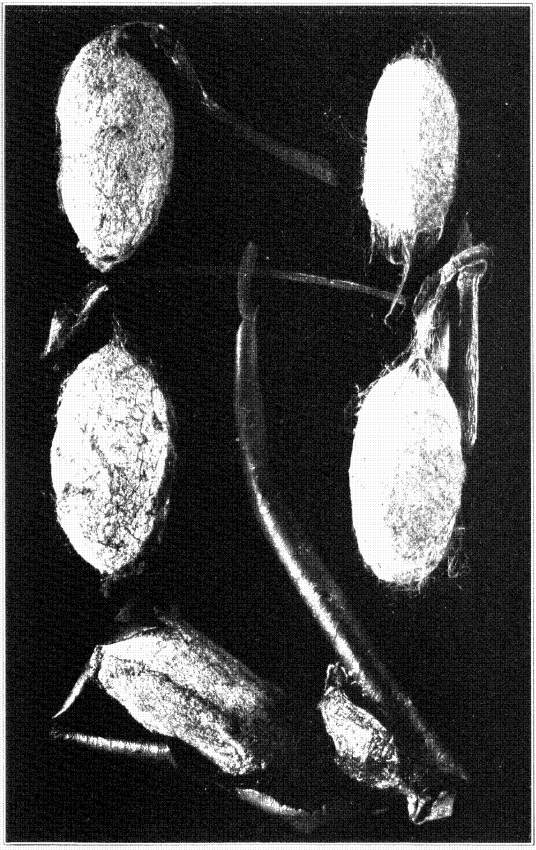

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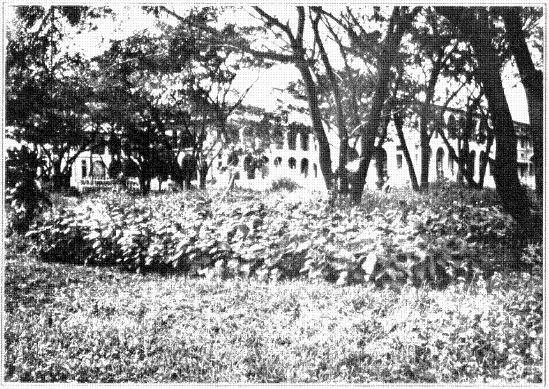


Fig. 1

Fig. 2

PLATE XV.

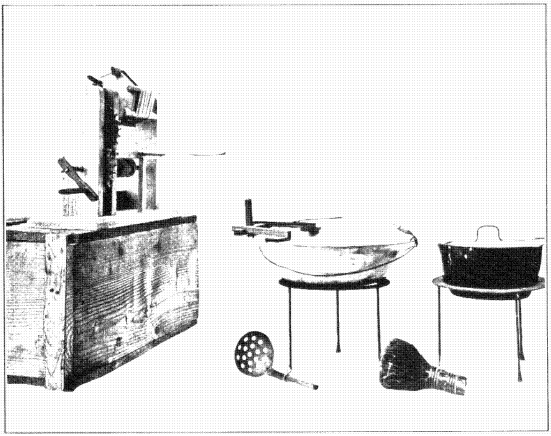


Fig. 1.

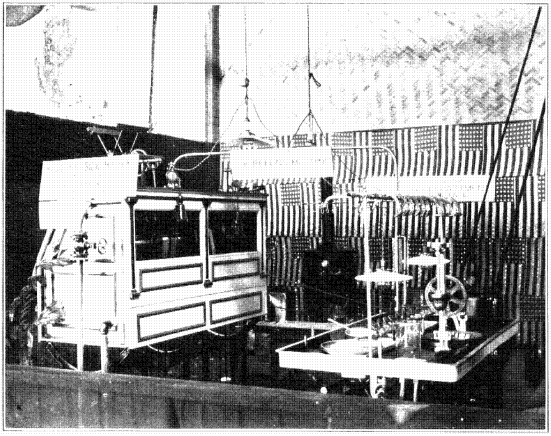


Fig. 2.

PLATE XVI.

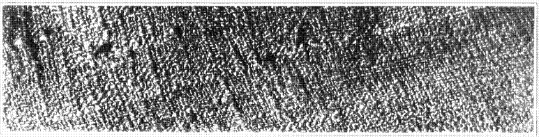
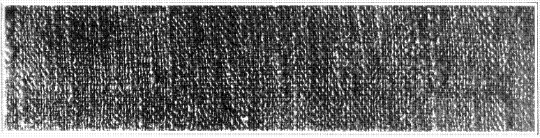


FIG. 1.



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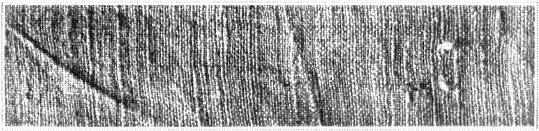

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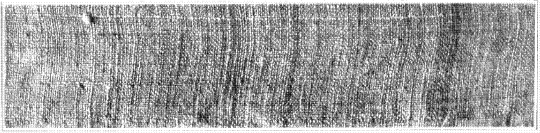

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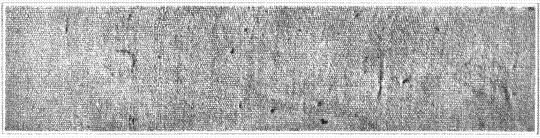

FIG. 5.

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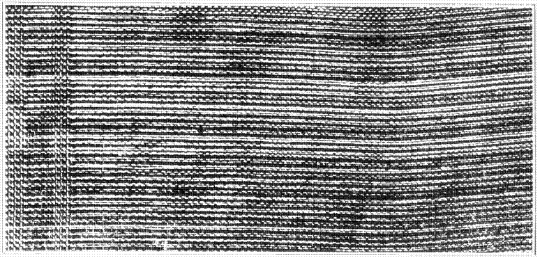

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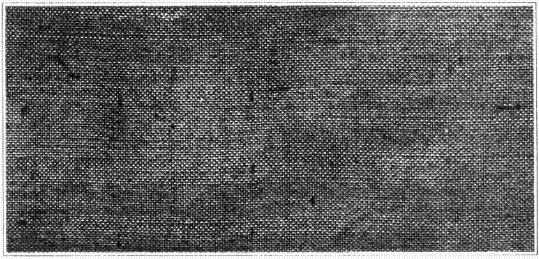

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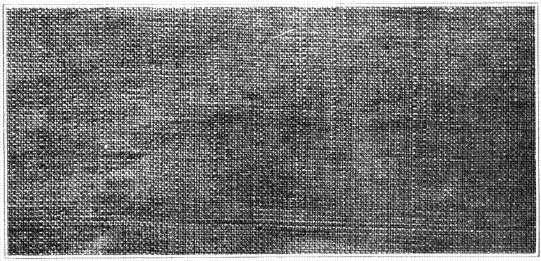

Fig. 3.

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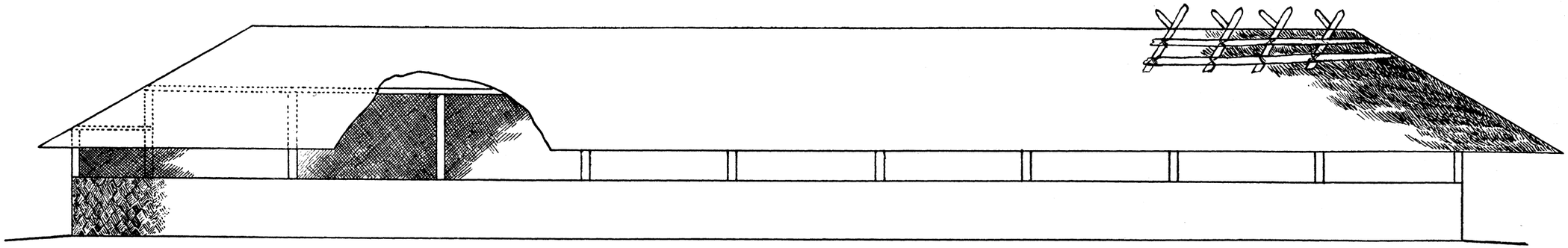
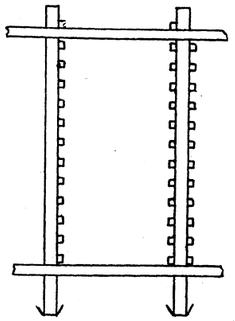
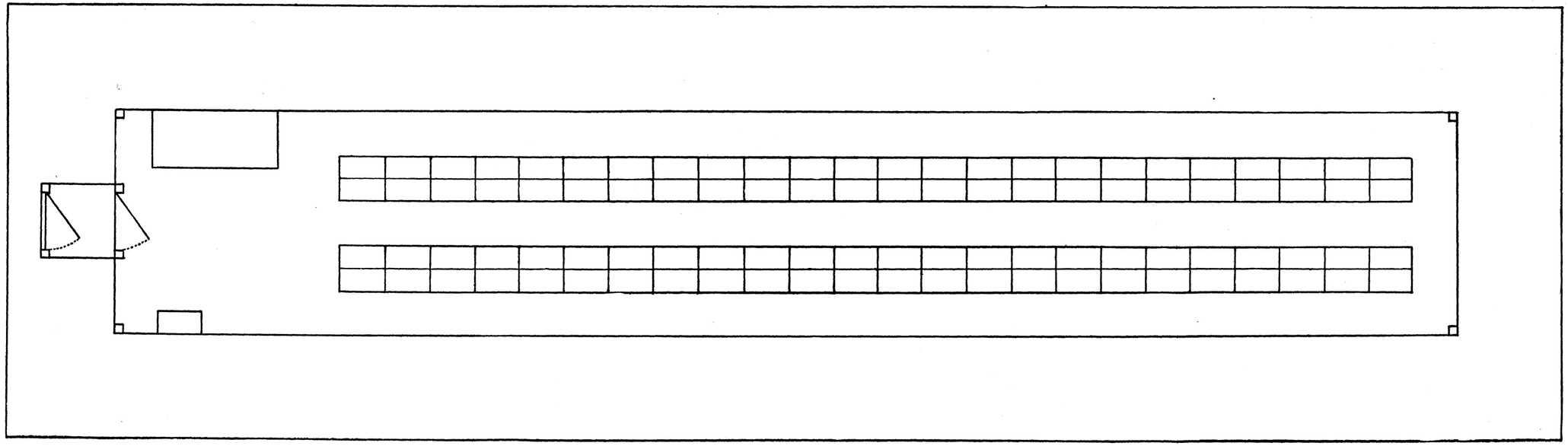
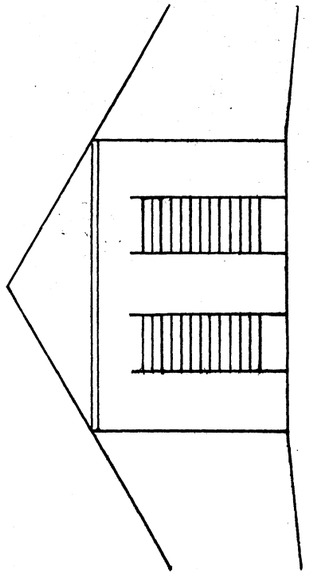




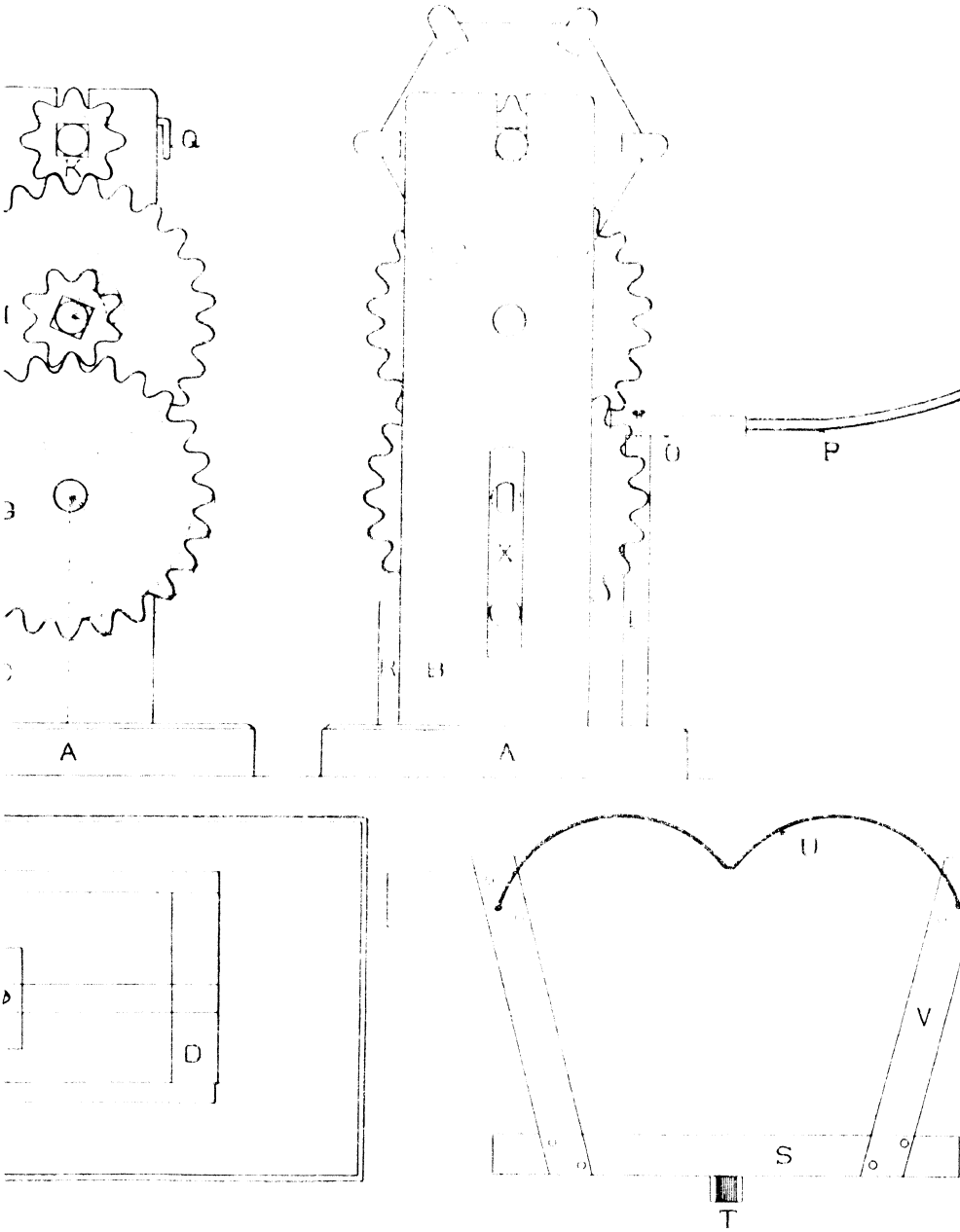




SCALE

1CM = 1M

PLATE XIX.



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