Silk Culture in America

SILK CULTURE

IN

AMERICA

By

Walter Scott Roberts

Preface

This work is being offered to acquaint the individual who may have only a few feet of ground on which to plant mulberry trees, and to the farmer who has acres of ground and is prepared to put in an additional profitable acreage crop not heretofore enjoyed by the farmers of America, namely, sericulture (silk culture).

It is my intention in offering it to have it regarded as an educational and instruction feature for the American public, as well as the American farmer, and to bring faithfully before you a valuable industrial asset which has heretofore been overlooked and disregarded by Americans, who have depended upon Japan and other oriental countries to keep America supplied with raw silk, 90 percent of which came from Japan prior to Pearl Harbor.

This work describes in detail the practical side of sericulture (silk culture) and the simplicity with which it may be carried on by the individual hobbyist, the farmer, or commercial producer.

My purpose is to encourage raw silk production first *in every town and county in Texas,* and later throughout the United States of America in any town or community, with the immediate objective of supplying raw silk for the United States as quickly as possible. To make silk raising a patriotic and practical contribution from the State of Texas.

To initiate and guide educational training and research projects which will promulgate modern methods of sericulture for selected groups of farmers and individuals throughout the United States of America.

To establish silk growing and silk cloth and hosiery manufacture as post-war industries which will provide employment and utilize manufacturing facilities that will otherwise be idle after hostilities have ceased. And to supply a profitable business for our returning service men—even those who are physically handicapped by the horrors of war.

To work for immediate legislative measures, standards, testing, licensing, and various forms of protection, particularly to prevent exploitation and to safeguard an all-American silk industry from the speculative market features which had become the curse of this industry when under Japanese domination.

To encourage every possible cooperative enterprise which will put the rich profits accruing from silk production back into the pockets of the producers rather than in the pockets of a small controlling group of Japanese as in the past.

To serve as a clearing-house of general and technical information for farmers and others who may want to grow mulberry trees.

To bring about coordination and cooperation among private producers, manufacturers, research laboratories and governmental agencies; and to take all possible measures to strengthen our silk crop with all producers by establishing training schools and research projects in the United States which will be of mutual benefit to crop development in each productive community in America.

To provide an advisory service for all persons desirous of establishing silk projects, such service to be free or at the lowest cost possible.

To provide a cash market for all cocoons raised.

To investigate the reliability of all persons posing as qualified sericulturists and who may put forth "get-rich-quick" plans for prospective mulberry growers or silkworm producers, and generally to develop as an additional farmers' crop, the cultivation and growing of mulberry trees for silk cocoon production.

In our United States the Federal Government, being the common meeting ground of all interests and the final agency of the people, assumes a certain responsibility for the solution of economic problems. This is not a new role for the government, which has been engaged in since the earliest days of our history devising laws and machinery and techniques for promoting the well-being of the citizen, whether he were a soldier returning from a war, a new settler heading west to seek his fortune, a manufacturer looking for a market for his goods, or a farmer puzzled over a problem in farm husbandry.

The wealth exists in the earth, the power exists in the hills, men have tools and the training. What remains to be seen is whether they have the wit and the moral character to work together and develop America.

Fighting men coming back from the war will not be satisfied with a mere guarantee of dull security—they will expect to find useful work and a vigorous life.

Already moves are being made to meet this inescapable challenge.

The first step obviously will be to prevent the sort of slump which has usually followed a great war. War is tremendously costly in terms of money. Billions are being spent in order that we may win. The peace, too, will be costly, and nothing is gained by evading this fact. But a democracy which can organize itself to defeat one sort of enemy is capable of sustaining the efforts through the days that follow. Work, in vast quantity and in infinite variety, will be waiting to be done. We will have the capacity to produce the highest national income ever known and the jobs to keep men at work.

It is a people's own experiment and goes on through the cooperation of chemists, physicists, technicians and men of strong faith and unshakable resolve to build in America new enterprises and develop new agricultural crops to maintain our national income and provide new avenues of employment when the war has ended.

This important industrial crop, silk production, which is now available to the American people, has not heretofore been presented because of the Japanese and their propaganda in America prior to Pearl Harbor, always spreading the depressing news that American labor was too expensive and that it required the starvation wages of Japan and other Asiatic countries where the employees are paid in pennies instead of dollars. I am happy to say that this propaganda has been stopped through the invention of an American automatic silk cocoon reeling device. With the aid of this device, we have overcome the differential of oriental wages, and my research work discloses that the raising of cocoons by the American farmer is a profitable crop.

In northern states the mulberry tree leafing season begins during the latter part of April and ends in September. In Texas and southern United States and the Pacific coast, the leafing begins in March and ends in November. For this reason, and because of a longer leafing season for feeding purposes, Texas and the southern states are preferable for large production.

The Japanese government supervises all of the industries related to the production of raw silk in Japan by the Bureau of Sericulture, through its Ministry of Agriculture and Forestry.

No farmer nor anyone else in Japan is permitted to use silkworm eggs, grow mulberry trees for producing leaf to feed the silkworms, nor engage in any way in the production of raw silk, except with the permission of the Ministry of Agriculture. All trees, eggs, or other materials required are supplied and certified by the Japanese government.

WALTER SCOTT ROBERTS
Author

Biology

It is appropriate here to give the reader a brief outline of my work and study in Sericulture and in the over-all process of producing silk from the cocoon to the finished fabric.

Up to the year 1910 I had never seen a silkworm nor a piece of any kind of machinery used in the manufacture of silk thread, or cloth. I did know what a mulberry tree was, but I didn't know how important and necessary the right variety was to silk production. I was a broker and a dealer in investment securities in New York City. From time to time I was engaged by corporations to reorganize and refinance them, usually by banking institutions or bond holding committees. One afternoon in Autumn of 1910, I came home from a golf game and found a telegram from a friend of mine who was President of a life-insurance company in Hartford, Connecticut, asking me to come there for a conference. I thought the invitation was pertaining to some investment matter, since his company was a substantial customer of mine.

Upon my arrival in Hartford the following day I was told that he and his associates had invested in the underwriting of a Silk Manufacturing Corporation which represented the consolidation of some twenty-four of the principal silk throwing and weaving mills in America, with a capitalization of twenty-five million dollars ($25,000,000), underwritten by the Knickerbocker Trust Company of New York City, which had been placed in the hands of a Receiver. This Receiver notified the individual subscribers to the underwriting that he could not complete the underwriting work. It was apparent that if this were not done, the several individual underwriters stood to lose the money they had invested. I took the matter under advisement for a period of ten days, at the end of which time I accepted the task of completing the work, and in due course a new company was organized and financed. The stockholders then elected me President of the corporation.

In going to the various mill properties to familiarize myself with everything, I found at one of the mills a Frenchman in charge, and in his mill yard he had an imported mulberry grove of about 25 trees. I inquired about them and he told me that he had inside the mill complete equipment for producing raw silk from the cocoons produced by the silkworms that were fed upon the leaves of those trees. I also found that he had been employed, prior to becoming Superintendent of the mill, as a chemist on sericulture work in France by the celebrated Louis Pasteur of Paris, the greatest authority on sericulture the world has ever produced.

I was intrigued by what this Frenchman had at this mill and I told him I wanted him to continue the work and that I wanted to become a student and learn thoroughly the art and science of Sericulture under his direction, with the result that I gave much of my time and attention to the study of this work, since it was a part of the silk weaving and throwing business conducted at this mill.

During the period between 1910 and 1935, at which time I retired from the silk manufacturing business, I was constantly engaged in silk cloth manufacturing and sericultural development work, and in the designing of an automatic cocoon reeling device. During a considerable period of this time I was an important member of the Silk Association of America, an organization of silk manufacturers and raw silk dealers. This Association was closely allied with the United States Testing Company which maintained offices and Testing plants in New Jersey, Yokohama, Japan, and in China.

The United States Testing Company was the official organization for determining raw silk gradings for all manufacturers and dealers in America who imported raw silk from any country in the world. Their technicians located in China and Japan kept the members of the Silk Association informed as a special service on important matters; such as, mulberry farming, silkworm eggs, worm rearing, cocoon markets, silk reeling plant organization and management, reeling of cocoons, cost of production analysis, reeling girl wages, by-products of reeling, and every known important detail of the raw silk business.

Being the President of the third largest silk manufacturing establishment in the world, I had access to all this information in written report form besides much private information from these same foreign-located technicians, covering separate items that were mainly of interest to me in carrying on my Sericulture work.

In addition to this source of information, it was necessary for me to maintain in Paris, France, an agent who was contantly in touch with the fashion center, in order that I could be ahead of my competitors in producing fashionable fabrics. This required annual trips to Paris by me where I found time while there to study Sericulture in France and in Italy in a practical way.

This information offered here has been gathered entirely from actual operations and methods that have been employed on a large-scale production basis.

Introduction of Sericulture in Europe

As silk came from China by way of Persia, the Roman emperor, Justinian, who lived in the sixth century, A. D., found that due to a war with the latter country his supply of silk was cut off. As no one was allowed to export the silkworm eggs from China under penalty of death, and since the manufacturers who had been buying raw silk were in great distress, Justinian endeavored, through the Christian prince of Abyssinia, to divert the trade from the Persian route. In this he failed, but he did bribe two Nestorian monks who had formerly resided in China, and had learned the art and mystery of silk weaving, to go to that country and procure silkworm eggs. About 555 A. D., they returned, bringing the eggs with them concealed in the hollow of their bamboo pilgrim staves. From this source came all the varieties of silkworms which stocked and supplied the western world for more than one thousand years.

At a later period the conquering Saracens mastered the trade, and by their knowledge it was spread both East and West, through Greece and Syria into Spain in 711 A. D., and into Sicily and Italy in the twelfth century. In 1480, silk weaving was begun under Louis XI, at Tours, and in 1520, Francis I brought silkworm eggs from Milan and introduced sericulture in the Rhine valley. These industries were not firmly established until Colbert in the seventeenth century encouraged the planting of the mulberry trees by giving premiums and otherwise stimulated local efforts.

source of raw silk for American silk mills.

On these four steps depend the successful establishment of a commercial raw silk business in America.

The cocoons produced for the first and second years can be best utilized in making spun silk yarn by the existing spinning mills. For this purpose, pierced cocoons form the best type of raw material, in active demand at all times, which at the same time meets idealistically the requirements of the silk development program and a backlog egg supply for larger expansion for the United States, with some income to the raiser from pierced cocoons, and most valuable of all, necessary cocoon raising experience, and his future egg supply, while the mulberry grove is maturing, after which time the entire cocoon production will go to the reeling machine for silk for commerce.

In the sericultural work planned for the U. S. A. employees will be both male and female, at least 75 per cent of which will be unskilled. It is ideal work for the men for rehabilitation departments of the several states or from the Veterans' Administration where handicapped servicemen may find easy, light employment.

The reeling of a continuous filament of raw silk need not be considered here immediately, further than to state that this important development in producing raw silk in America has been taken care of. The delopment of mulberry groves to give this reeling equipment cocoons in quantity to be reeled into commercial raw silk is the essential thing now. The prospective grower must realize that a mulberry grove must first be created after which he must have experience in producing a good crop and if this preliminary work is carried on energetically, groves, cocoon raising, and experience can be learned during the first and second years.

The raising of silkworms to produce silk cocoons has always been a home or cottage type of industry in the orient where the work has been done largely by the women of the household. With our larger farms and rural electrification our rearing buildings can be equipped to produce cocoons on a large or mass production scale in addition to the oriental cottage type production.

During the first two years of grove development, a large percentage of the cocoons will be required for reproduction purposes, and to gain experience, that is, the moth will be allowed to pierce the cocoon and lay eggs. Eggs are produced by selecting the better quality of cocoons visually for reproduction purposes.

One hundred mother moths will lay about one ounce of eggs, producing when hatched about 30,000 to 40,000 baby silkworms called "ants." The moths that have emerged from one pound of pierced cocoons can produce about two ounces of eggs.

One ounce of eggs will produce about 180 pounds of fresh cocoons or about 40 pounds of pierced cocoons and require about 1,500 pounds of mulberry leaves. There are from 150 to 300 fresh cocoons to the pound, depending on the variety and care given in raising.

The pierced cocoons obtained will be a by-product of the sericultural development work and will be used by the spun silk mills for making silk yarns which in turn will be utilized in the manufacture of many articles requiring silk fiber.

Early History and Development of the Silk Industry in the Orient

The first use of silk as a fiber has been traced to China during the reign of Huang-Ti, a famous emperor. About the year 2640 B. C., his wife, the empress Si-Ling-Shi, is credited with being the first person to encourage the cultivation of the mulberry tree, the rearing of the worms, and the reeling of silk. It is claimed that she devoted herself personally to the care of silkworms, and the Chinese have attributed to her the invention of the silk cloth weaving loom, which to a modified extent, is still used today. Her name "Si" is the Chinese word for "silk," the English word probably being a derivative. Because of her discovery, she was deified and has ever since been known as "The Goddess of Silkworms."

The silk industry is believed to have originated in the valley of the Yellow River, and from there spread to different parts of China, the provinces of Chekiang, Kiagsu, Szechwen, Shatung, and Kwantug, and Manchuria being the best breeding and rearing sections.

China kept the method of producing silk a secret from other countries for nearly two thousand years, the penalty for its disclosure being death. Chinese silk manufacturers sold the finished cloth to the Persians, who for 1,000 years carried it in caravans over the plains of India and Syria to the western nations, without ever knowing how or from what it was made.

Many centuries passed before sericulture (silk culture) spread beyond China. During the early part of the Third Century this knowledge reached Japan through Korea. One of the most ancient books of Japanese history, the "Nihongi," states that towards 300 A. D., some Koreans were sent from Japan to China to engage competent people to teach the art of weaving and preparing silk goods. Four Chinese girls were brought back with them to instruct the court and the people in the art of plain and figured weaving. To the honor of these pioneer silk weavers, a temple was erected in the province of Settsu.

Knowledge of this industry then traveled westward, and the silkworm was established in India. Tradition has it that the eggs and mulberry seed were carried to India concealed in the head-dress of a Chinese princess. From the Ganges valley, the industry spread to Khotan, Persia, and the countries in central Asia.

Aristotle, who lived in the fourth century, B. C., is believed to be the first European to learn the true origin of silk, such information being brought to him from Persia on the return from that country of Alexander's victorious army. The first notice of the silkworm in western literature occurs in his writing, when he describes "a great worm which has horns and so differs from others. At its first metamorphosis it produces a caterpillar, then a bombylius, and lastly a chrysalis—all these changes taking place within six months. From this animal women separate and reel off the cocoons and afterwards spin them. It is said that this was first spun in the Island of Cos by Pamphile, daughter of Plates." While his statement was not entirely correct, great weight was not given to it, for during the next 500 years, the common theory of the origin of silk among the Greeks and Romans was quite different, they believing that it was a form of processed cotton. At that time it was worth its weight in gold, and laws were passed restricting its use to the nobility and to women.

Introduction of Sericulture in Europe

As silk came from China by way of Persia, the Roman emperor, Justinian, who lived in the sixth century, A. D., found that due to a war with the latter country his supply of silk was cut off. As no one was allowed to export the silkworm eggs from China under penalty of death, and since the manufacturers who had been buying raw silk were in great distress, Justinian endeavored, through the Christian prince of Abyssinia, to divert the trade from the Persian route. In this he failed, but he did bribe two Nestorian monks who had formerly resided in China, and had learned the art and mystery of silk weaving, to go to that country and procure silkworm eggs. About 555 A. D., they returned, bringing the eggs with them concealed in the hollow of their bamboo pilgrim staves. From this source came all the varieties of silkworms which stocked and supplied the western world for more than one thousand years.

At a later period the conquering Saracens mastered the trade, and by their knowledge it was spread both East and West, through Greece and Syria into Spain in 711 A. D., and into Sicily and Italy in the twelfth century. In 1480, silk weaving was begun under Louis XI, at Tours, and in 1520, Francis I brought silkworm eggs from Milan and introduced sericulture in the Rhine valley. These industries were not firmly established until Colbert in the seventeenth century encouraged the planting of the mulberry trees by giving premiums and otherwise stimulated local efforts.

Silk manufacturing was started in England during the reign of Henry VI, but the first real impulse to manufacturers of that class was due to the immigration in 1585 of a large body of Flemish weavers who fled from the Low Countries in consequence of the struggle with Spain which was then devastating their lands. One hundred years later, religious troubles gave the most effective impetus to the English silk trade, at which time the revocation of the Edict of Nantes sent to Switzerland, Germany, and England a vast body of skilled artisans of France, who established silk-weaving colonies which are to this day the principal rivals of the French manufacturers.

A recent and important new area is also in England, where the initiative of a lady has, with Italian assistance, built up a notable industry. It is, of course, not the first time that silk has been raised and reeled in England. The English climate is not unlike that of Japan, but it possesses two features that are a great obstacle to the successful culture of the silkworm, namely the high humidity and its great and sudden variations. This is particularly detrimental when the worms are spinning their cocoons, because the fibroin, which is ejected as a fluid, does not harden swiftly enough to maintain the loops of the fibre distinct, so that the loops coalesce in knots, rendering the silk hard to reel.

During 1930 Lady Hart Dyke founded her silk farm in Kent, England, devoting a large part of her home, Lullingstone Castle, to the accommodation necessary for the feeding, rearing, and a hand-reeling plant.

Although the success achieved has been equally notable, there is an undoubted market in England for first-grade silk at a price that encourages schemes to produce it locally; but in spite of that admitted fact, there seemed little prospect of the actual attempt being made, until the initiative and energy of an English Lady brought English silk into being again, after a lapse of over half a century. When one compares the difficulties overcome in Kent, England, with those met with in parts of our America where half-hearted attempts have inevitably ended in failure, one is the more able to appreciate the industrial achievement of Her Ladyship and Americans should take due notice of her achievement.

Lady Hart Dyke has enjoyed the aid and advice of Italian experts and uses hand-operated reeling machines made in Italy.

Her Ladyship does not breed her own worms, but imports silkworm eggs from other countries. Those now used in England are mostly from France, Italy, Bulgaria, or Turkey. It has been decided that cross-bred Italian and French worms are best suited to English climate, or at least to that of Kent, England.

The worms are fed entirely upon the white mulberry (morus alba), plantations of which have been laid at Lullingstone.

To overcome the difficulty of excessive atmospheric humidity in England or elsewhere at spinning time, buckets of lime are placed about the rooms, and this method is found quite satisfactory, since the lime absorbs the moisture and reduces humidity.

The Lullingstone silk farm is run as a business: it is a commercial enterprise, not a hobby, and it deals only in wholesale trade. The income and expenditure has already been balanced.

All the silk produced at Lullingstone is purchased by the firm of Warner and Sons, Ltd., of Braintree, Essex, in England. This firm is of great antiquity, one of the earliest and most famous of English weavers. They are royal warrant holders, for many years have woven the coronation robes for English rulers. The robes worn at the coronation of King George the Sixth, by the Queen and the Duchesses of Gloucester and Kent were made of English silk produced at Lullingstone.

The creation of coronation robes is a difficult and highly skilled trade. The cocoons are hand reeled at Lullingstone, and the raw silk so produced is then transported to Essex, there it is thrown. It is then dyed by hand by the old sure methods, the exact shade of royal purple. The next process is the weaving.

Silk Production in Latin America

Brazil is the only American country which has produced silk on a commercial scale over a long period of years. Brazil's yearly cocoon production from 1939 to 1941, inclusive, has averaged about one and one-half million pounds. Since 1941 mulberry grove plantings in Brazil have been extended through the aid of the Brazilian government to approximately thirty million producing mulberry trees with the result in the increased production of cocoons which has reached approximately six and one-half million pounds in 1944.

However, the Latin American countries have to contend with tariff regulations in shipping their raw silk to America, which makes Latin American silk prohibitive in cost for American consumption. All Brazilian cocoon reeling is by hand, the same as in Japan.

Sericulture has been officially encouraged in Brazil. As a result of this with financial aid supplied for mulberry grove extension and increased filature equipment the production of raw silk in Brazil has taken on enormous proportions and is now about sufficient to meet the normal requirements of the Brazilian population. In spite of the tariff regulations, and the Oriental hand reeling of cocoons some of the fabrics manufactured in Brazil are now being offered for sale in America, but upon examination of these fabrics it has been found in the retail stores that the price per yard of about $3.00 compares in quality with silk cloth which should be sold, if made with United States silk, at $1.25 per yard.

Early Attempts at Sericulture in the United States

Attempts to establish sericulture were made in America, and in 1735 eight pounds of silk were exported from Georgia, 700 pounds in 1758, reaching a peak of over 10,000 pounds in 1759. Connecticut began to rear silkworms in 1760, and for 85 years that state led all others in the amount of silk produced. Soon after 1765, Pennsylvania, New Jersey, New York, Rhode Island, and Massachusetts became interested in this industry, and when the Revolutionary War broke out, Benjamin Franklin and others were engaged in establishing a silk filature at Philadelphia.

Practical investigation of silk culture by the United States Department of Agriculture was carried on under a specific appropriation by Congress from 1884 to 1891 and from 1902 to 1908.

Experiments were conducted on an extensive scale, the work being placed under the supervision of the Bureau of Entomology. It was demonstrated that an excellent quality of silk cocoons can be raised in any locality of the United States where the white mulberry tree will grow well. In the course of this work very many white mulberry trees were planted in different parts of the country. Imported silkworm eggs were placed out to many persons who had access to supplies of mulberry leaves, and the resulting cocoons were bought by the Department at European market rates.

These cocoons were reeled in Washington and for a time in New Orleans on hand-operated silk reels bought in Europe. This work was under the direct supervision of Mr. T. A. Keleher of the Department of Agriculture, who is now on the retired list, but who is still engaged in silkworm work on his private account.

During this experiment the Japanese propaganda entered the picture, and it is regrettable that our Department of Agriculture was completely sold on their argument that the United States should not interfere with the silk business of Japan since Japan was a major buyer of our cotton. The fact of the matter is that Japan would buy about $17,000,000 worth of our cotton annually and we would buy about $500,000,000 worth of their silk. It was a good racket for Japan while it lasted, and it kept the United States from developing this very important industrial crop, sericulture, and helped Japan to become an aggressor nation.

Mulberry Trees From Seed

To produce a true type of morus alba white mulberry tree directly from seed is very doubtful. The source of supply for mulberry seed has always been from foreign agents, who represent the seed to be white mulberry morus alba, but my experience discloses that these seeds are not true to type and that the result from planting them gives a conglomerated return, representing a great many types of the mulberry tree, of which there are some 273 varieties but only two suitable for silk production. My experience discloses that one cannot depend on mulberry seedlings for silk producing purposes. After the seedlings are raised from the seed, they must be budded to the proven developed type of a hybrid, known to be suitable for silk production. This holds true wherever a true morus alba white seed has produced the seedling, but generally speaking, when seeds are available—but none have been available since the war started—the result is, usually, the morus tartarica alba seedling, which at best is only a hardy root stock upon which to graft or bud a developed hybrid. Furthermore, a long space of time is necessary in raising mulberry trees from seed of any variety. To produce a mulberry tree from seed requires the following procedure:

1. Seeds are planted in beds usually after all danger of frost is over. They are allowed to grow in this seed bed until they become dormant in the Fall. Usually

about 75 per cent of the seed planted will produce a seedling. About this time the seedling should be 12 inches in height.

2. They are then dug and heeled in beds outdoors. They remain heeled in until about March first when they are dug and planted in grove formation. You will observe that one year has already been spent in bringing the seed to this development.

3. After the planting in grove formation and during the month of June when sap is high the seedlings are budded with the developed hybrid referred to elsewhere. The method of budding is the same method employed in budding most all fruits, such as peaches, etc. Buds inserted about 4″ above ground.

4. About August, the seedlings are topped (cut off just above the bud) and suckered below the bud. The seedling is then allowed to grow until the next summer. During this period the seedling has to be cultivated, fertilized, suckered, and about June following the seedlings are cut off at the height which you desire to create your permanent tree scaffold.

5. After this, the trees are allowed to grow for another year before they are fully usable as a source of mulberry leaf food for silkworms. In the meantime, the buds are subjected to any unexpected or late frosts or light freezes.

Mulberry Trees From Cuttings

Mulberry trees created or grown from cuttings give a shallow root plant without a tap root. Roots of a cutting have a tendency to keep at right angles with the cutting and near the surface, not going straight down as do roots from a seedling or a root graft. The tree or bush grown from a cutting does not have a long life nor any great resistance. It will require more water and cultivation than seedling trees or trees grown from grafted roots.

A tree from a cutting has an irregular growth and will not assume the true tree shape. No two are alike. The scrawny shape and lack of uniformity between the different trees will prevent the forming of the uniform scaffold on which to grow the leaves.

The replacement of cuttings planted in a field that do not root average from 25 to 50 per cent, although they may show a tendency to root at the time they are taken out of the sand. But experience shows that from 25 to 50 per cent of likely looking cuttings when transplanted to grove formation do not live. It is an item of considerable expense that must be considered in any large planting.

Mulberry Seedling Trees

A word of caution would not be amiss at this time to prospective planters of mulberry groves. A keen disappointment can be experienced if the planter does not choose the proper variety of mulberry trees for silkworm raising. There are many commercial nurseries throughout the United States who specialize in raising mulberry seedlings which they market under the trade name "Russian Tartarica Alba" or "Morus Tartarica Alba." Such varieties are suitable only for root stock for budding or grafting purposes. The leaf produced by tartarica alba is not satisfactory leaf for silkworm food. The leaf from this variety is small, thin and low in protein content. However, its root stock is the hardiest of all the mulberries and will withstand the severest climate anywhere that it has ever been planted. This tree or seedling should never be used for any purpose, except for root stock for budding, or grafting to other developed varieties for leaf value, or for windbreak purposes. Trees of this variety are raised in great numbers by commercial nurserymen throughout the United States.

Root Grafted Trees Recommended as the Best

If you plant by the method which I recommend, using the root-grafter hybrids which are available only between December 15 and February 28, you will get a considerable leaf production in the next summer after planting grafted root stock, and can cut enough leaf without tree injury to start your experimental work in cocoon raising the season following your planting, and accumulate an egg supply for the following season, at which time the tree will have developed sufficiently to start on a larger scale worm-raising production. Your graft is protected by the earth, not subjected to unexpected frosts or light freezes, and is usually free of suckers and permits development of a grove with a minimum of grove cost.

To get quick leaf and best results based upon scientific knowledge, and my own past experience, start your grove through the root grafted hybrid method. It costs less to make a grove by this method of planting.

Mulberry Farming

In order to supply the necessary food for silkworms to produce large crops of cocoons, it has been found that it is essential and most profitable to supply cultivation to mulberry plantations.

I suggest the harvesting of the leaves for feeding silkworms from the whole plantation by starting in on one side and going over the entire acreage during a period of probably 30 days and repeating this during the season, rather than the more or less total stripping of leaves from certain sections as the harvesting proceeds. Total stripping would be a shock to the tree or bush, depriving the pruned branches of shelter and upsetting the natural growth. A portion of the year's growth must always go through the dormant period when the winter pruning takes place.

In recent years, large amounts of fertilizer especially of the chemical type, are applied annually to the soil. This will produce every year luxuriant growth and succulent leaves, the ideal silkworm food.

The best method of cultivating mulberry trees is largely that of the "bush" plantation. According to this method, starting mulberry groves are planted with grafted root stock. The root being of an especial hardy stock, the graft being a developed hybrid which produces a very large and succulent leaf. These are planted in warm climates anytime during the dormant season up to February 1st, in northern climates where the ground becomes frozen, they are planted in November, March, and April. The planting is done by placing the grafts 2 to 4 feet apart in the drill and 8 feet apart in the row, and an acre will accommodate about 1500 grafts, provided they are well irrigated. Where irrigation is not to be had, trees should be planted 8 feet apart each way. In this formation, about 680 per acre can be planted. They are cut off level with the ground annually and in America this can be done with mechanical equipment. In the following year 6 to 12 shoots will grow from each plant which attains a height of from 4 to 6 feet. While I recommend cutting the trees off level with the ground for best results, it is not absolutely necessary. Good trees and fine leaves can be had without this method. I repeat, though, that cutting them back produces the best results. The accompanying photograph shows the result of this method of planting from grafts only 6 months old.

The advantages of this method of planting are: the plants grow quickly and yield a crop of leaves in a short period, the leaves are soft for a long time, the leaves may be gathered conveniently by machines, and these plants represent the most modern type of mulberry leaf production.

The average annual production of leaves by the bush type of mulberry planting at maturity is approximately 15,000 pounds per acre of superior quality, sufficient to feed 10 to 12 ounce egg hatch.

In feeding silkworms, it requires about 1500 pounds of leaf to raise 180 pounds of green cocoons, the hatch from one ounce silkworm eggs.

The best soil for the bush type morus alba white mulberry plant is clay loam, stiff clay, or sandy soil. Annual cultivation is necessary. Irrigation and fertilizers will increase the leaf poundage.

There is a great scarcity of suitable mulberry stock for silkworm raising. This condition exists because no recent attempt has been made to establish a silk business in America. Particular attention is being given to tree development of the root-grafted variety at Mineral Wells, Texas. Because of tree scarcity and the labor situation it is necessary for the planter to contract ahead now or at an early date for early planting.

Climate

The best climate for silk-rearing is a dry, moderate one (varying between 50° and 90° F.) where the humidity can be kept between 65 and 85 per cent. England might be highly satisfactory were it not for the uncertainty and sudden abnormal variations of its climate, which is otherwise somewhat similar to that of Japan. It must be remembered that England is warmer than its latitude and position would suggest, whilst Japan is colder, because of streams from the Arctic. There are, however, no rigid rules as to climate, except that it must not be exceedingly dry, exceedingly wet, exceedingly hot, or exceedingly cold:

whilst the permissable limits of altitude also vary widely. Silk is reared at great heights and almost at sea-level, but generally speaking, it thrives best at medium elevations.

The mulberry tree will thrive almost anywhere that silkworms can be reared.

Characteristics of the Silk Filament

The average diameter of a duplex silk filament is between 0.02 and 0.025 mm. (approximately 20 microns), but wild silks attain more than double this dimension.

All silks become swollen in the processes of dyeing, sometimes to the extent of 100 per cent increase in diameter. On the other hand, fierce and destructive degumming preparatory to dyeing separates the duplex elements, thus halving each filament, both in size and weight. Silk, in its natural duplex form, is used mainly for lace and gauze, and for use in some machines and instruments.

Silk is hygroscopic—that is, it contains water as an integral constituent, absorbing it from the atmosphere. At about 120° c. it loses 10-15 per cent of moisture and the loss, which commences at 100° C., is degrading to the silk and commences the breakdown of its microcrystalline structure—a matter to which I shall refer later.

The filament is a non-conductor of electricity, but like most hard non-conductors, it becomes highly electrified by friction. High-tension static charges accumulate on the surface, and this causes difficulties in spinning and weaving, necessitating the use of glycerol or soap solutions to dissipate and prevent the electrification.

The density of raw silk is about 1.33; falling to 1.25 on degumming. When heavily weighted and dyed it may again increase to 5.00.

The constitution by weight of a normal duplex silk filament after reeling is about 72 per cent centre (fibroin), 25 per cent enveloping tube (sericin), plus wax (1 per cent), colouring matter and traces of minerals. The central backbone is insoluble in water and organic solvents, and weak acids do not affect it. Weak alkalis have a slightly corrosive action. In strong mineral acids and alkalis, however, it dissolves completely.

The enveloping sericin dissolves readily in scalding water and olive oil, and at lower temperatures in weak acid and caustic baths, and in the presence of organic ferments. It is highly gelatinous and a 1 per cent solution in water forms a jelly on cooling. The addition of alcohol to a solution of sericin precipitates it as a white powder.

The behavior of silk in the presence of the various agents mentioned above is of interest in the study of the processes it has to undergo in the course of its process from the cocoon to the throwing mills.

The tensile strength (breaking strength under a stretching force), of the finest reeled silk is greater at low temperatures than that of tempered steel of low carbon content. Under test it has shown a tensile strength equal to 29 tons per square inch of cross-section rupturing capacity. That of steel rods varies between 23 and 60 tons per square inch of cross-section; a usual value for locomotive connecting-rods being 42 tons—only one-third greater than silk. But it requires about one million filaments to provide one square inch of cross-section, so that a load of 29 tons is half an ounce per filament, or quarter of a pound per four-fiber thread, doubled.

The above comparison is on a basis of equal area. But it is very difficult to compare textile fibres on this basis, because the area of cross-section of threads is so indeterminate and that of fibers is so microscopical. Threads are therefore compared on a basis of a unit derived from a comparison of length and weight—a unit of density of cross-section. We may also compare steel and silk on such a basis—that is, compare a steel rod and a silk thread of equal length and weight. If the rupturing capacity of the steel is 42 tons, that of silk will now be 126 tons, or 200 per cent greater at normal temperature.

Reflecting on this, the reader may wonder whether fine metal wires could not be produced as soft and flexible as silk. Indeed, they can! Metal wires have been made as slender as a silk filament; much finer than rayon. Gold was spun four thousand years ago. But we are never likely to have metallic textile fibres. Their immense weight and the fact that they are conductors of heat and electricity, and, moreover, cannot be dyed, are insurmountable obstacles to any such experiments. The nearest approach is "weighted" silk—silk impregnated with metallic solutions. Its tensile strength is thereby impaired—certainly not increased—although its weight becomes more than quadrupled—hence the name.

First-class silk has a tensile strength twice to four times that of the best rayon, though wild silk has a strength only about one-third that of cultivated silk.

It is very difficult to realize the properties of resistance resident in a filament of silk that is almost invisible to the eye. Even if the actual chemical nature of silk could be reproduced, no imaginable mechanism could ever mould it into a form as fine and strong as that produced by the wonderful organs of the silkworm. A filament or fibre, the long continuous portion of a silk cocoon, may attain 1000 yards since its average diameter is only a few microns, yet it narrows or tapers towards the inner cocoon. In cross-section a filament is of definite shape—ovular, having a major and a minor axis.

Stranger still, every filament from the same brood is of identical cross-section, but every brood differs from every other; indeed, considering a brood as an individual, the cross-section characteristics are almost as powerful a clue in fixing the identity of a filament as are finger-prints in the identification of humans. Every kind of worm, every community of the same worm in different localities, and even two broods of the same worm in the same place at different times of the year, all yield differing characteristics of cross-section.

The dimensions which are studied are the ratios of the major and minor diameter, and the value of the mean diameter. This has new importance in dyeing, where differences of tone have been proved to be due, in 65 per cent of the cases reviewed, to the use together of silks differing in their cross-section characteristics. A difference of 0.03 per cent in diameter ratio, or 0.7 microns in mean diameter will cause two-tone dyeing. Generally speaking, the diameter ratio is greater in yellow fibres than in white, and is affected by seasonal and climatic conditions.

A filament, in absorbing moisture to saturation, expands laterally 18 per cent and longitudinally about 1 per cent. This fact seems related to the elasticity, since that of the tubular walls of sericin is considerably greater than that of the core of fibrin. A filament can be stretched from 1 - 2 per cent with immediate elastic recovery—that is, a 1000-yard fibre can be stretched some 10 to 20 yards longer without damage, but greater stretch produces permanent elongation.

We may explain this scientifically as follows. A filament may be crudely represented by a bundle of steel wires encased in a rubber sheath. The tensile strength resides in the core, which is not really a bundle of wires, but has an ultramicroscopic crystalling structure similar to steel, the crystals being arranged in long lines or strings, having stupendous adhesion in a longitudinal direction, but a lesser one laterally, so that silk filaments can sometimes split along their length (this does not refer to the mere separation of the two elements of the duplex fibre). This submicroscopic crystalline structure has been found to be broken down by exposure to steam for ten hours at a temperature of 100° C. Above 100° C. the destructive degradation increases very rapidly. In consequence of these results of recent research the age-old use of steam in silk processes is being superseded by other methods as far as practicable.

It should be clearly understood that the foregoing all relates to the filaments, not to a silk thread, since the reeling and twisting confers on the latter properties varying greatly from those of the individual components, the fibres. Moreover, the bundle of wires in a sheath is a very crude illustration, since silk is not an electric conductor when dry and the tubular walls have no resemblance to rubber save in their great elasticity, which confers upon them their marvellous flexibility and protective quality towards the contained fibroin.

When silk is stretched beyond the elastic limit, so that the elongation becomes permanent, the crystals slide over one another into new positions. The maximum elongation of real silk under tension, before breaking, is some 30 per cent as contrasted with vegetable and animal fibres, and with rayon, all of which elongate more than 100 per cent. This resistance to deformation is one of the more valuable properties peculiar to cocoon silk.

Hatching Silkworm Eggs

1. When the leaves on your mulberry trees start to sprout, it is time to expose the silkworm eggs to the air for hatching. The eggs will come to you straight from refrigeration. Don't make the mistake of putting the eggs in a heated room. Unnatural heat will spoil the eggs when they are in the first stage of development. Sericulturists call this first stage "seasoning the eggs." In reality, you are acclimatizing them. Therefore, put the eggs into an unheated room.

Then take an empty box or one of the feeding trays, stretch a sheer cloth over it, or a piece of muslin, or if neither of these is available, punch tiny holes in a piece of paper, and stretch it across the top of the box or tray, fasten it to sides of box or tray to keep it tight and so it won't sag. The eggs must have complete circulation of air, and it is for this reason that you are preparing the proper nesting place for them. Draw the muslin or sheer cloth, or perforated paper tightly across the top of the box or tray, and glue the sides which protrude over to the sides of the box or tray. You now have a nesting place for the eggs.

Take the silkworm eggs and gently place them on top of the cloth or perforated paper. Spread them gently over the nesting place with a feather if they are loose eggs so that the eggs are next to each other, but not on top of each other. If they are on paper attached, the use of a feather is not necessary, but allow air passage under the paper. Keep them in this condition for three days, without heat, in cool, natural temperature of a room without heat.

On the fourth day, if the room temperature is below 55 degrees try to bring it up to that degree by opening the radiator slightly or by an oil, gas, or electric heater. Again for two days keep them in that temperature. On the sixth day, increase the temperature of the room to 60 degrees. After two more days, increase the temperature another five degrees, if possible. The temperature is now 65 degrees. Use a reliable thermometer with temperature and humidity register on it.

Take a feather once a day and move the silkworm eggs slightly if they are loose eggs so that they may ripen all over at the same time. At this time, try to keep the *humidity* even with the *temperature*. This you can always do by keeping a bowl or bucket of hot water in the open where the silkworm eggs are hatching. On rainy days you won't need the use of water because the natural humidity will be sufficient. *Watch your thermometer.*

After two days more, raise the temperature of the room to 70 degrees and humidity to 90 degrees. (Just have more open bowls or buckets of water in the room). On the twelfth day, you will see a change in the color of the eggs. They will turn from dark grey to very light grey, and you will see that they are swollen in size.

On the fourteenth or fifteenth day the "scouts" will show up. That means a few of the worms will hatch, warning you that next morning is mass-hatching day. The usual hatching period is three days, and usually about six to nine o'clock A. M., but don't wait until they are all hatched to begin feeding them. The usual procedure is to disregard the scouts because they will not be of sufficient number to transfer.

Transferring the Worms From Hatching

2. When the first scouts appear, place a piece of fine netting or a fine mesh veil gently over the eggs. If veil is used, mesh must be large enough for worms to crawl through. The next morning, slice some mulberry leaves lengthwise in one-eighth-inch strips. Use sharp knife for this purpose. Put these strips of mulberry leaves gently over the netting on the part where the silkworms are hatching. The strips should be about one-quarter inch apart from each other. The hatching worms will immediately smell the mulberry leaves and will crawl through the netting and over the strips of leaves. As soon as you see these strips half covered with worms, pick the mulberry leaves up with the aid of a small tweezer, and gently place them in the center

of the bottom of another box or tray. Keep them together in the center of the box or tray, else some of the worms will wander into corners of the box or tray where there is no food, and may starve to death. Use a feather to brush the worms back to their proper place.

Keep on transferring until that day's hatching stops. This might last until about 10:30 A. M. Put the hatching of the first day all together in one box or tray and date the box or tray to keep a record of exact day of birth. Also transfer the birth day card to each change of trays during the life cycle to enable you to follow accurately the moult periods.

Rearing and Feeding the Silkworms

3. Get some mulberry leaves and cut off the stems, and chop them with a sharp knife, just like you chop parsley, until the pieces are about a quarter of an inch in size. Don't squeeze the leaves in your hands while chopping, or crush them under pressure of the knife, and be sure your hands are clean and not smelling of tobacco. No tobacco or other smoke is allowed where silkworms are reared.

After airing the chopped leaves for five or six minutes in order to dry the juice that comes from them while chopping, sprinkle the chopped leaves gently and evenly over the worms from a height or not more than two inches. This two inch height will not hurt or frighten them.

Be sure to cover the strips which the worms are on, and the empty spaces between them, in order that the worms will find food in any direction they may crawl. Don't pile the leaves over these tiny worms, but spread them evenly, and gently, like you would put together a jig-saw puzzle. This operation is called feeding. Don't forget to air the room every time you feed the worms. Feed them every four hours beginning at 6 A. M. until you go to bed. Be sure to give them plenty of food for their last night feeding, about 10 P. M.

The Second Day

4. The second day more worms will hatch. Repeat what you did the first day, but with this exception. Don't put the second day's hatchings in the same box or tray with the first day's worms, because the first day's worms are one day older, and their life cycles are different. Mark birth date on each tray. Transfer birth date each time the worms are transferred to another tray. Both sets of hatchings get their food every four hours.

The Third Day

5. Repeat the same operations for the balance of the hatchings. If there are any eggs remaining unhatched, discard them because after three days usually the delayed eggs produce inferior worms. From now on feed them all every four hours. Begin feeding at 6 A. M. each and every day, Transfer birth card to each changed tray.

Fourth and Fifth Days

6. The fourth day, continue as directed. On the fifth day, if the worms are fed properly and the temperature of the room kept at 70 degrees to 75 degrees Fahrenheit, the worms will moult.

Moulting is commonly called sleeping. Moulting worms become motionless, the heads raised high, while their feet grip the subject they are lying on. Their color becomes glassy and glossy, and their nostrils pointed and sharp. Don't disturb the moulting worms, and don't try to brush the worms back to their bed in case some might move to moult along the edges of the box.

Nature has provided the worms with a little silk from the day they hatch from their eggs. They use this silk to fasten their feet to the subject on which they are going to moult. This fastening enables the worm to crack the old skin and walk out of it. The disturbed worm can't get rid of the old skin and is helpless. The reason for the worms moulting is that after eating for four or five days, they have grown five times larger than they were at birth. This makes their skin too tight on them and they must shed it. During the moulting or coma, the worm forms a new skin under the old skin, and walks out of the old skin. This takes about twenty-six hours in normal temperatures.

Moulting worms do not eat, nor do they walk. Examine the worms on the tray carefully and see that they all bear the same description. The worms of a good sericulturist will moult all at the same time because they are fed evenly. If they have all moulted, you will find that the worms have not eaten the previous meal because the moulted worms stop eating four or five hours before they go into their coma. If some have moulted and some are still walking, keep feeding these unmoulted worms very lightly on the four-hour rule and keep the feeding up as long as there are walking worms on the tray. Don't pile mulberry leaves on the moulting worms while you are feeding the others because you will deprive the moulting worms of fresh air that they need.

As soon as you see that some of the worms have already finished moulting, stop feeding and wait until you see if 80 per cent of worms on the tray are through moulting. You can easily recognize a worm which has finished moulting from one which has not because it has a brownish color. In this case, some sericulturists wait until all the worms are through moulting before they start feeding them again, but it is my opinion that the ones which finished moulting earlier than the others are weakened by being deprived of food too long. My system is to transfer to another box or tray the 80 per cent which have already moulted by placing an open mesh cloth with mesh large enough for the moulted worm to pass through, sprinkle leaf on it and they will crawl up and away from the worms which have not moulted.

Second Transfer

7. Or you may do this, put some mulberry leaves cut lengthwise in one-half-inch strips on top of the worms. The worms will immediately crawl to the top of the strips and start eating. As soon as these leaves are half covered with worms, with the aid of a tweezer move them to another box or tray. Do this operation very gently, without disturbing the moulting worms, and with speed. The speed is required because some of the worms will satisfy their hunger and go back to their old bedding which they have made from the uneaten portion of their food. It is necessary that they be removed to clean quarters, so you must do it quickly while they are on the strips of leaves. Continue this operation until the 80 per cent have been transferred to their new quarters. The other 20 per cent

which are still moulting must be kept separated from the 80 per cent, and so all you do is leave them where they are for another eight or ten hours. At the end of the eight or ten hours, you will find they all have finished moulting. Put these new moulters into a second box or tray, apart from the 80 per cent, using the same method of transferring as you did with the 80 per cent. After all the worms have moulted and have been removed to their new quarters, continue the practice of feeding them every four hours, but they are now able to eat more food.

Second Stage

8. When the worms are through moulting, they enter the second stage of their life cycle. This phase lasts four days if they are fed every four hours and are kept in a temperature of 70 degrees to 75 degrees. After four days they will moult again. This moulting will last twenty-four hours. Transfer them as you did before. Your worms are now larger and have lost their dark hue. They are becoming lighter in color every day.

Third Stage

9. The worms are now more lively and eat much more. when you chop the leaves, chop them in half-inch to one-inch squares, always remembering to re-

move the stems. In case of continued rain and heavy humidity, the worms will not eat so much. The food which remains becomes damp and soggy. If this happens, transfer the worms to a fresh tray. A rotted bed is also unhealthful for the worms. It is always advisable to keep the bedding of the worms clean, and if you can take the time to change the trays every other day you will always have healthy worms.

While these instructions are given during the third phase, it is well to remember them throughout the life cycle of the silkworm.

The third phase lasts five to six days under ordinary circumstances. Even under the best of circumstances of weather, because of the length of time between the moulting periods at this stage of the life cycle, it is advisable to transfer the worms to new trays after the third day. At the end of this period, the worms go through a third moulting.

Fourth Stage

10. When they are through with the third moulting they enter the fourth stage. The worms are cared for as you have been instructed, with this exception: the transfer must now be made by means of a complete mulberry leaf instead of the strip method or mesh cloth used heretofore. They must also be fed on the full leaf because they are now big and healthy. This phase lasts approximately six days. Then comes the fourth or last moulting.

Fifth Stage

11. The moulting period is now from thirty to thirty-six hours, and the transfer is made as previously instructed. You can feed the worms on small green shoots from the mulberry tree now. They like the shoots from now on because they can climb over the shoots and walk and exercise and eat more. Don't feed them unless they finish all of their previous feeding. At this stage of their lives they eat almost continuously. Keep feeding them every time their food disappears, instead of waiting for certain hours. In the evening give them a very heavy feeding so it will last all night. In this stage, if they are fed properly, they will eat for eight days, at the end of which time they reach maturity. Fed improperly, this stage might last up to eleven days. *Avoid* the *humidity* which has been necessary up to this point. Be sure the worms are in *dry air*. Remember that the more you feed them at this stage, the better cocoons you will get.

The life cycle of the silkworm is now complete and it is ready to spin its cocoon. You will notice that the worm now stops eating and becomes very active. From ten to fifteen hours after it stops eating it becomes a clear, light amber color. If you hold it against the light, it looks transparent. The worm raises its head and looks from side to side searching for a place to start spinning the cocoon. It is at this time that the worm will leave its bed if necessary to search for a space in which to spin its cocoon.

You can help now by preparing the mounting for the cocoon which must be set on the bed immediately as soon as these signs are seen in the worms and before the worms waste their silk or spin their cocoons in the bed between the dried branches or leaves that have accumulated.

Mounting for the Cocoon and How to Prepare It

12. There are several different weeds and tree leaves suitable for cocoon spinning, and in every country the sericulturist or silk expert adopts one or two of them. I have found that broom weeds, wild mustard weeds or dried oak branches are best. You can use any of them.

If you are going to use the weeds, form them in the shape of a loose bouquet with enough space between the branches to house individual cocoons.

No matter whether you use weeds or oak branches, they must be bone dry. You can start preparing them six or seven days before you expect to use them so that they will be ready when they are needed.

If you are using weeds, put two or three bouquets in each *end* of the box or tray in which you have worms. *Allow space in the middle of the box or tray in which to feed the worms which have not yet matured.* Never touch the box or tray or move it once the weeds have been put in it. It must not even be slightly jarred, because if a worm starts to spin its cocoon, the first thing she must spin is the anchorage and if the anchorage is broken, she will never be able to finish spinning her cocoon.

If oak branches are used, dry them until they are bone dry. Be sure the leaves and the branch itself are dry. Then place them (as many as needed) in both ends of the box or tray, and the worms will spin their cocoons in the curled leaves. In this case too, leave a space in the middle of the box to feed the immature worms and don't allow the box or tray to be touched or moved.

A draft or a hard blow of wind will spoil the anchorage or half-spun cocoon. Therefore, allow free ventilation but avoid drafts or gusts of wind.

It will take from three to four days for a worm to finish its cocoon. During the spinning, no worm or mounting should be touched or disturbed.

After all the worms have spun their cocoons, the cocoons themselves should not be touched for five days after the last worm has started its cocoon.

13. Don't smoke or allow smoke in the silkworm's rearing rooms.

Don'ts

Don't feed the silkworms wet, dusty, damp, muddy, bird refuse, yellowish or dried or shriveled leaves.

Don't pile the reserved leaves one on top of each other. Keep them in the icebox or refrigerator or cool cellar.

Don't handle the worms with the hands. Let them crawl on a leaf and move leaf with your hands.

Don't feed the leaves to the worms immediately after you cut them. Allow them half an hour to cool.

Don't allow the beds to rot.

Don't allow sunshine on the worms.

Don't have a draft or direct blow of wind on the worms.

Don't have spotted or dirty papers on the trays. Change as often as necessary.

Don't forget to transfer birth date of each batch of worms when worms are transferred to fresh trays from time to time.

Don't forget to transfer worms every third day to a fresh tray.

The Silkworm and Cocoon

The wonderful insect that makes the silk is the larva of a small moth called *Sericaria Mori*. This moth is classed with the *Lepidoptera,* or scaly winged insects, family *Bombycidae,* or spinners, or *Bombix Mori*. This species of caterpillar is commonly called the Mulberry Silkworm. First reared in China, it is now extensively cultivated in China, Japan, Italy, France, Spain, the United States and other countries.

The silkworm has become domesticated since, during the long centuries in which it has been cultivated, it has acquired many useful peculiarities. Man has striven to increase its silk producing power, and in this he has succeeded, for, by comparing the cocoon of the silkworm of today with its wild relations, the American cocoon is found to be much larger, even in proportion to the size of the worm that makes it or the moth that issues from it. The moth's loss of the power of flight and the white color of the species are probably the results of domestication.

The silk moth exists in four stages—egg, larva, chrysalis, and adult. The egg of the moth is nearly round, slightly flattened, and closely resembles a turnip seed. When first laid it is yellow, soon turning a gray or slate color if impregnated. It has a small spot on one end called the micropyle. When the worm hatches, it gnaws a hole through this spot. Black in color, scarcely an eighth of an inch in length, covered with long hair, with a shiny nose, and sixteen small legs, the baby worm is born leaving the shell of the egg white and transparent.

Small and tender mulberry leaves are fed the young worm. They simply pierce them and suck the sap. Soon the worm becomes large enough to eat the tender portions between the veins of the leaf. In eating they hold the leaves by the six forward feet, and then cut off semi-circular slices from the leaf's edge by the sharp upper portion of the mouth. The aws make a noise like falling rain.

The American worms are kept on trays made of wood with window screen wire bottoms. The trays are placed on racks for convenience in handling. The leaves are placed between the worms when fed. The worms breathe through spiracles, small holes which look like black spots, one row of nine down each side of the body. They have no eyes, but are quite sensitive to a jar, and if you hit the rack they stop eating and throw their heads to one side. They are velvety, smooth, and cold to the touch, and the flesh is firm, almost hard. The pulsation of the blood may be traced on the back of the worm, running towards the head.

The worm has four moulting seasons, at each of which it sheds its old skin for a new one, since in the very rapid growth of the worm the old skin cannot keep pace with the growth of the body. The periods between these different molts are called "ages," there being five, the first extending from the time of hatching to the end of the first molt, and the last from the end of the fourth molt to the transformation of the insect into the chrysalis. The time between the four "molts" will be found to vary, depending upon the species of worm.

When the worm molts it ceases eating, grows slightly lighter in color, fastens itself firmly by ten prolegs, and especially by the last two, to some object, and holding up its head and the fore part of its body remains in a torpid state for nearly two days. For a day or two previous to molting a dark spot is noticed just above the nose of the worm, from which the head emerges apparently renewed. In molting the old skin breaks at the nose, the head is pushed out, and the worm by struggling and twisting gradually frees itself of the old skin. Weak and feeble, it gains strength by resting, and then, freshened, supple, and hungry, goes to work eating again with renewed vigor and apparently determined to make up for lost time.

By each successive molt the worm grows lighter, finally becoming a slate or cream white color, and the hair, which was long at first gradually disappears. Two days after the third molt, when the worm is fifteen days old, it is three quarters of an inch long, and just after the last molt it is one and a fourth inches long. If its growth seemed rapid before, it is as nothing compared to its growth now. In six days it grows from one and a fourth to two inches in length, and in three days more becomes fully three inches in length. It is an interesting fact that nearly three-fourths of the silk the worm spins is made or secreted in these last two or three days. However, at all ages and times the worm secretes silk with which to protect itself from injury, for when in danger of falling it instantly fastens a silken thread to whatever it may be standing upon. In case of accident, the worm uses this thread, which is strong enough to sustain its weight, as a ladder to go either up or down. In ascending the thread is wound around its forelegs to shorten it. When the worm is young the thread is so fine as to be almost invisible, yet it is always strong enough to sustain the worm.

Having attained full growth, the worm is ready to spin its cocoon. It loses its appetite, shrinks nearly an inch in length, grows nearly transparent, often acquiring a pinkish hue, becomes restless, seeks a quiet place or corner, and moves its head from side to side in an effort to find objects on which to attach its guy lines within which to build its cocoon. The silk is elaborated in a semifluid condition in two long, convoluted vessels or glands between the prolegs and head, one upon each side of the alimentary canal. As these vessels approach the head they grow more slender, and finally unite within the spinnaret, a small double orifice below the mouth, from which the silk issues in a glutinous state and apparently in a single thread. The gummy liquid which combines the two strands hardens immediately on exposure to the air.

Hatching Table Temperatures

1st	day	FAHRENHEIT	60	degrees
2nd	"	"	60	"
3rd	"	"	60	"
4th	"	"	60	"
5th	"	"	60	"
6th	"	"	60	"
7th	"	"	61	"
8th	"	"	63	"
9th	"	"	64	"
10th	"	"	65	"
11th	"	"	68	"
12th	"	"	69	"
13th	"	"	71	"

Cocoon Completed in Three Days

The worm works incessantly, forcing the silk out by the contraction of its body. The thin, gauze-like net-work which soon surrounds it gradually thickens, until, twenty-four hours after beginning to spin, the worm is nearly hidden from view. However, the cocoon is not completed for about three days, and in some cases, four days.

The cocoon is tough, strong, and compact, composed of a firm, continuous thread, which is, however, not wound in concentric circles, but irregularly in short figure eight loops, first in one place and then in another. The motion of the worm's head when starting the co-coon is very rapid, and nine to twelve inches of silk flow from the spinnaret in a minute, but later the average would be about half this amount per minute.

The silk secretion, on account of its transparency, is sometimes used for snells, the tough, sinew-like cords by which fish-hooks are attached to longer lines, and in foreign countries large numbers of worms are annually used for this purpose. When the worm is ready to spin, after being steeped in strong chemicals, the silk glands are taken from its body and are dexterously drawn out to the desired length. One gland is usually suffiicient for two and sometimes three fishhooks.

The color of the worm's prolegs before spinning indicates the color the cocoon will be. This varies in different species, and may be a silvery white, cream, or yellow.

When the worm has finished spinning, it is one and a quarter inches long. Two days later, by a final molt, its dried-up skin breaks at the nose and is crowded back off the body, revealing the chrysalis, an oval cone one inch in length. It is a light yellow in color, and immediately after molting is soft to the touch. The ten prolegs of the worm have disappeared, the four wings of the future moth are folded over the breast, together with the six legs and two feelers, or antennae. It soon turns brown, and the skin hardens into a tough shell. Nature provides the cocoon to protect the worm from the elements while it is being transformed into a chrysalis, and thence into the moth.

With no jaws, and confined within the narrow space of the cocoon, the moth has some difficulty in escaping. After two or three weeks the shell of the chrysalis bursts, and the moth ejects against the end of the cocoon a strongly alkaline liquid which moistens and dissolves the hard, gummy lining. Pushing aside some of the silken threads and breaking others, with crimped and damp wings the moth emerges; and the exit once effected, the wings soon expand and dry.

Moth Has Eyes But No Mouth

The escape of the moth, however, breaks so many threads that the cocoons are ruined for reeling, and consequently when ten days old, all those not intended for seed are placed in a steam heater to stifle the chrysalis, and the silk may then be reeled at any future time.

The moths are cream white in color. They have no mouths, but do have eyes, which is just the reverse of the case of the worm. From the time it begins to spin until the moth dies, the insect takes no nourishment. The six forward legs of the worm become the legs of the moth. Soon after mating the eggs are laid.

The male has broader feelers than the female, is smaller in size, and quite active. The female lays half her eggs, rests a few hours, and then lays the remainder. Her two or three days' life is spent within a space occupying less than six inches in diameter.

Moth Lays 300 to 400 Eggs

One moth lays from three hundred to four hundred eggs, depositing them over an even surface. In some species a gummy liquid sticks the eggs to the object upon which they are laid. In the large cocoon varieties there are full thirty thousand eggs in a single ounce avoirdupois.

The worms are never fed wet leaves, nor very dry ones. In rainy weather the leaves are first dried by spreading on a place suitable away from dust, never on the floor, usually a large table or platform preparatory to feeding. Worms get diarrhea from eating wet leaves, and may die; in any case their strength is impaired. The leaves should not be dried in an oven, or the worms will not eat them unless very hungry, which they should never be. After dusty winds the leaves are washed and dried before feeding.

TABLE OF SPACE AND LEAF REQUIRED
BY ONE OUNCE OF EGGS
(About 30,000 Worms)
Initial space required by eggs—2 square feet

Moult	Age	Days	No. of Trays	Theoretical Space Required by American Raisers (Sq. Ft.)	Weight of Clean Leaves Consumed (Lb.)
After hatching and before 1st moult	First	5	2	10	6
Between 1st and 2nd moult	Second	4	4	24	22
Between 2nd and 3rd moult	Third	6	8	60	65
Between 3rd and 4th moult	Fourth	7	16	120	200
After 4th moult and until ready to spin	Fifth	8	32	206	1200
	Total	30			1493

If the trays are all of equal size, then the theoretical area can only be loosely approximated, but with the trays of two or more sizes it can be very closely attained. For instance, with trays of 6 sq. ft. and 7½ sq. ft. we can follow the theory that the first is 2 x 6 sq. ft.; the second 4 x 6 sq. ft.; the third 8 x 7½ sq. ft.; the fourth 16 x 7½ sq. ft.; the fifth 32 x 6 sq. ft.

Suitable trays can be built locally or at home out of ordinary dressed lumber ¾″ x 2″, the bottom covered with metal fly screen. The racks for holding these are constructed with posts 2″ x 2″; the cross pieces are of the same as the material used in the trays. See cut of rack suitable elsewhere in this book.

Reeling Cocoons

In the Orient, the filature operation (unwinding the cocoons so as to produce continuous filament raw silks, starts with boiling a definite measure of cocoons from six to eight minutes to soften the natural gum, so the cocoon will unwind easily. A measure of cocoons is taken to each reeling basin where the reeler finds the end of the cocoon filament by brushing. These are picked up in large groups of fifty or more and fastened to an anchor post located on the reeling device for ready use in reeling. The average Oriental reeling girl reels five threads, each thread being made up of five cocoon filaments or each reeler must watch 25 cocoons. When the filament is completely unwound, a new cocoon is added to the group by hand to replace the spent one, without stopping the reeling equipment. The raw silk thread passes through the following operations:

1. Reeling from cocoons to small swifts.
2. Re-reeling from small swifts onto larger swifts for commercial sized skeins.
3. Lacing skeins with the hands to hold thread crossing formation.
4. Twisting skeins.
5. Forming 30 skeins into books or bundles wrapped in thin paper with tie bands.
6. Baling of 28 books of raw silk into bales of 132.273 pounds each and shipping to export centers.
7. Testing and weighing for quality and quantity of raw silk at export centers.
8. Shipment of bales to U. S. A.

You will observe that there are 8 handling and labor operations to Oriental reeling—but this is not all. When the Oriental silk is received by the American manufacturer, he has the following labor operations to perform before the Oriental silk is usable:

1. Opening bales which contain 28 books or bundles of 30 skeins each—the whole bale weighing 132.273 pounds avoir.
2. Cut tie bands on books and skeins.
3. Untwist skeins.

4 Soak skeins in an expensive, hot solution of silk oil, olive oil soap and water for several hours to degum silk and make it workable.

5. Remove skeins to an expensive electric whiz run at high speed to remove excess silk oil, soap and water, and partly dry it.
6. Hang skeins out to completely dry.

7. Wind dry skeins to bobbins and double two or more threads laid parallel with each other.

8. Transfer these bobbins to first-time spinner bobbins.

The methods used in reeling silk cocoons on the American automatic reeling device are radically different from those used in the Orient where the spent cocoon has to be replaced by hand. The American device eliminates all of the operations referred to above in the following manner.

The gum in the cocoons is softened and brushed and the ends of the cocoon found exactly as it is done in the Orient. The cocoons are then lifted into a basin in front of the reeling operator on the machine, and the ends anchored at a point near a device operated electrically which may be called an electric eye.

The number of cocoon filaments required to build a complete commercial thread are selected, usually five. The eye is threaded with these required number of cocoon filaments, run through an electric gauge, and attached to a first-time spinner bobbin. The machine is then started and no further hand operation is required. The speed of the machine is up to 300 yards per minute per spindle. When one of the cocoon filaments has been spent, the electronic device on the machine automatically throws in and ties on another fresh cocoon. On the reeling machines there are 20 of these spindles with 20 of the basins. As each thread passes through the eye onto the bobbin, it passes through a solution which soaks and softens the natural gum on the silk making it workable; thus eliminating the expensive soaking thread in soap and oil and water solution. When the bobbin has been filled it is exactly at the point of fabrication requirement that the Oriental silk has to arrive at with the Oriental cocoon reeling and American mill operations eliminated. Each spindle has its separate stop motion so that a full bobbin may be removed and replaced without any stoppage of other spindles on the machine.

The uniformity of silk reeling as produced by the automatic reeling machine surpasses anything which could be done by hand. One operator reeling by hand in Japan can handle only 5 reeling basins of 5 cocoons each slow speed or 25 cocoon threads producing only 5 completed threads of commercial silk at a time, and in order to accomplish this result a long and tedious period of apprenticeship is required of the operator before such hand work is able to produce commercially salable thread.

The operator on the American automatic reeling machine can learn how to operate it and make a perfect commercial thread with 24 hours of preliminary instruction, after which time she is capable of handling 20 basins of 5 cocoons each producing 100 cocoon threads or 20 commercial threads of 5 filaments each and at a rate of speed that the hand reeler cannot attain.

Any suggestion, heretofore, about producing raw silk in America has always been met with the reeling operation requiring worker dexterity as well as cheap labor. It can now be said that both these objectives have been met by the use of this machine perfected in this country and that commercial raw silk is now being produced in American on this machine, grading of 90 per cent in evenness and cleanness.

To return to the life cycle of the silkworm, besides those which have only one life cycle, there are some races which repeat the cycle twice, or oftener, within a year. These are called mono-, bi-, or poli-voltine races, according to the number of life cycles. Moreover, it is possible to change a one-voltine worm into another kind, artificially, by immersing the eggs in some chemical solution. And also, at the start of the life cycle it is easy to regulate—to either hasten or retard—the time of hatching. This is the reason why Japan can raise cocoons, not only in the Spring as in other countries, but also in the Summer and Fall while the mulberry leaves are available, and accordingly, increase the total production of cocoons to meet the increasing annual demand. The total production of cocoons in Japan during 1939 was approximately 360,000,000 kilograms. More than 2,000,000 farmhouses (about one-half of the farmers in Japan) cooperated in producing that amount of cocoons.

As can be seen from the above, the mulberry leaves are indispensable in raising cocoons. The farmers tend to their mulberry fields in order to get the greatest yield of mulberry leaves, and this is as important as all the other combined farming in Japan. The total acreage of mulberry fields in Japan is 273,000,000. The eggs are supplied by professional egg producers who are licensed by the Government. There are more than 6,000 licensed egg producers (whose total capacity of production amounts to more than 200,000,000 grams of eggs). The silkworm egg is a small sphere often compared to a mustard seed. About 4,000 eggs weigh one gram. The farmers buy the eggs from the egg producers and the average amount of eggs bred by one farmer is 80 grams; and 175,000,000 grams in total were bred by all the farmers in 1939.

During 1931-1940

(Report of Dept. of Agriculture and Forestry) Annual Silk Worm Egg Production in Japan Unit, Gram

		Quantity of Egg Cards Incubated (Unit, Gram)		
Year	Number of Cocoon Raisers	Spring	Summer and Autumn	Total
1931	2,119,908	80,490,932	89,515.593	170,006,525
1932	2,064,639	77,898,238	88,913,344	166,811,582
1933	2,092,187	81,198,451	100,002,480	181,200,931
1934	1,995,492	77,463,070	83,366,263	160,829,333
1935	1,894,647	69,389,203	81,787,423	151,176,726
1936	1,856,551	65,052,710	80,598,920	145,651,630
1937	1,815,443	66,295,746	77,141,740	143,437,486
1938	1,696,931	58,653,695	69,448,310	128,102,275
1939	1,650,684	58,654,235	74,014,612	132,668,847
1940		55,450,615		

30 Grams equal 1 ounce Avoir. As annual production in Japan has been 767,000,000 pounds of cocoons during the last ten years, representing 175,000,000 grams of eggs that have reached healthy cocoon maturity, and since there are about 4,000 eggs in a gram, the number of eggs produced each year in Japan is at least 700,000,000,000.

Cocoon Statistics—Unit Kamme
(Unit-Kamme equivalent to Pound 8.2672 or Kilos 3.75)

Year	Spring White & Yellow Cocoons	Summer and Autumn White & Yellow Cocoons	Grand Total
1927	46,228,627	44,633,932	90,862,559
1928	49,561,743	44,287,347	93,849,090
1929	50,594,540	51,498,890	102,093,430
1930	56,103,136	50,360,380	106,463,516
1931	52,667,225	44,405,230	97,972,455
1932	46,391,478	43,158,859	89,550,337
1933	50,019,027	51,144,539	101,163,566
1934	48,390,465	38,740,883	87,131,348
1935	44,175,526	37,890,527	82,066,053
1936	41,392,474	41,510,522	82,902,996
1937	45,503,933	40,468,030	85,971,963
1938	40,863,284	34,380,363	75,243,647
1939	44,741,162	46,071,893	90,813,055
1940	43,867,981		

Figures on this page and the following pages of statistics are published to show the reader the magnitude of the silk business as it was conducted by Japan up to the time of the Pearl Harbor attack, and to demonstrate a basis for the American, who wants to raise silk cocoons, that there is a market.

About 90 per cent of all the silk imports shown in these statistics was consumed by America.

MONTHLY SHIPMENT OF RAW SILK FROM JAPAN TO U. S. A.
(Unit Bale)
(132.275 Lbs. Avoir.)

1939/40 Month	Kobe	Total Exported Yokohama	Total
JULY	5,720	23,395	29,115
AUGUST	6,570	28,925	35,495
SEPTEMBER	8,760	29,485	38,245
OCTOBER	5,625	27,726	33,351
NOVEMBER	6,765	20,595	27,360
DECEMBER	7,100	20,955	28,055
JANUARY	2,645	7,195	9,840
FEBRUARY	2,690	7,575	10,265
MARCH	3,940	11,266	15,206
APRIL	2,650	8,545	11,195
MAY	3,460	10,231	13,691
JUNE	6,170	17,720	23,890
TOTAL	62,095	213,613	275,708

1940/41			
JULY	4,936	16,715	21,851
AUGUST	5,045	17,735	22,780
SEPTEMBER			
OCTOBER			
NOVEMBER			
DECEMBER			
JANUARY			
FEBRUARY			
MARCH			
APRIL			
MAY			
JUNE			

MONTHLY TOTAL SHIPMENT FROM JAPAN TO VARIOUS COUNTRIES
(Unit Bale)
(132.275 Lbs. Avoir.)

Month	To U. S. A.	To Europe	To Australia	To Other Countries	Total
1939/40					
July	29,115	3,177	850	27	33,169
August	35,495	5,140	930	92	41,657
September	38,245	2,503	1,100	29	41,877
October	33,351	3,815	440	138	37,744
November	27,360	4,640	545	125	32,670
December	28,055	5,105	640	60	33,860
January	9,840	4,340	330	25	14,535
February	10,265	3,850	433	45	14,593
March	15,206	6,181	431	70	21,888
April	11,195	5,206	427	40	16,868
May	13,691	4,212	532	55	18,490
June	23,890	1,046	515	26	25,477
Total	275,708	49,215	7,173	732	332,828
1940/41					
July	21,851	346	813	58	23,068
August	22,780	50	595	114	23,539
September					
October					
November					
December					
January					
February					
March					
April					
May					
June					
Total					
1941					
July					
August					
September					
October					
November					
December					

STATISTICS OF RAW SILK IN JAPAN
During 1936-1941
(Unit Bale)
(132.275 Lbs. Avoir.)

TOTAL OF KOBE AND YOKOHAMA

Year	Arrivals from the Interior	Deliveries to Exporters	Returned to the Interior	Stock at the End of June
1935/36	524,076½	475,745	46,398	16,175
1936/37	545,350½	511,762	39,151	10,612½
1937/38	529,883½	478,309	40,477½	*11,899½
1938/39	461,661½	407,107½	57,462	8,991½
1939/40	467,762½	360,562½	99,930½	197,458

*Government Stock 9920 B/s excluded.

KOBE

Year	Arrivals from the Interior	Deliveries to Exporters	Returned to the Interior	Stock at the End of June
1935/36	153,409½	137,580	14,990½	6,389
1936/37	147,431½	135,118	15,571½	3,131
1937/38	139,192½	123,376½	12,703½	*3,763½
1938/39	461,661½	407,107½	57,462	8,991½
1939/40	140,473	109,467½	26,590½	60,045

*Government Stock 2480 B/s excluded.

YOKOHAMA

Year	Arrivals from the Interior	Deliveries to Exporters	Returned to the Interior	Stock at the End of June
1935/36	370,667	338,165	31,407½	9,786
1936/37	397,919	376,644	23,579½	7,481½
1937/38	390,801	354,932½	27,774	*8,136
1938/39	341,118	305,570	37,266	6,418
1939/40	327,289½	250,915	73,340	137,413

*Government Stock 7740 B/s excluded.

Statistics of Raw Silk in New York During 1930-1941 (Unit Bale) (132.275 Lbs. Avoir.)

Total of Japanese, European and All Other Silks

Year	Imports During the year	Approx. Deliveries to American Mills*	Stocks at the End of June
1930/31	615,052	606,150	37,352
1931/32	574,091	558,395	53,048
1932/33	537,563	556,678	33,933
1933/34	467,295	442,180	59,048
1934/35	456,800	473,830	42,018
1935/36	450,302	456,911	35,409
1936/37	493,889	483,742	45,556
1937/38	379,381	380,480	44,457
1938/39	389,233	414,481	19,209
1939/40	345,658	323,045	41,822
1940/41			

Japanese Raw Silk

Year	Imports During the Year	Approx. Deliveries to American Mills*	Stocks at the End of June
1930/31	517,796	506,418	29,824
1931/32	524,304	505,428	48,700
1932/33	494,302	511,922	31,080
1933/34	438,965	418,745	51,300
1934/35	446,651	458,285	39,666
1935/36	417,093	427,805	29,354
1936/37	453,930	444,134	39,150
1937/38	358,749	357,600	40,299
1938/39	361,405	385,164	16,540
1939/40	282,173	268,693	30,020
1940/41			

*Includes re-exports.

Monthly Statistics of Raw Silk in Japan During 1939-41 (Unit Bale) (132.275 Lbs. Avoir.)

Month	Arrivals from the Interior	Deliveries to Exporters	Returned to the Interior	Stocks at the end of Month
1939/40				
July	45,992½	36,279	3,715	14,920
August	46,934½	43,745	3,411	14,698½
September	46,379	43,391½	3,909	13,777
October	47,013½	39,777	3,976½	17,037
November	44,211½	34,507½	9,750	16,928
December	45,557	29,437	19,135	13,913
January	18,202	14,076	7,774½	10,264½
February	32,066½	19,749½	7,715	14,866½
March	39,518	24,020	10,150½	20,214
April	37,506	23,470	10,361½	23,881½
May	36,771	29,065	10,904½	20,690
June	27,681	22,982	9,128	16,161
Total	467,762½	360,562½	99,930½	
1940/41				
July	49,102½	*21,008½	2,850½	23,474½
August	58,046½	†24,775	1,711	22,985
September	50,013½	‡38,432½	3,598½	27,097½
October				
November				
December				
January				
February				
March				
April				
May				
June				
Total				
1941				
July				
August				
September				
October				
November				
December				

*Government purchase 18,030 B/s excluded.
†Government purchase 32,050 B/s excluded.
‡Teisan purchase 3,960 B/s excluded.

Monthly Statistics of Raw Silk in New York
(Unit Bale)
(132.275 Lbs. Avoir.)

Total of Japanese, European and All Other Silks			
Month	Imports During the Month	Approx. Deliveries to American Mills*	Stocks at the end of Month
1939/40			
July	32,673	26,134	25,748
August	32,407	33,095	26,060
September	39,569	36,869	27,760
October	50,003	41,858	35,935
November	38,233	32,241	41,927
December	34,811	21,128	55,610
January	33,121	29,506	59,225
February	13,566	22,485	50,306
March	17,266	21,685	45,887
April	18,551	21,740	42,698
May	19,584	18,997	43,285
June	15,844	17,307	41,822
Total	345,658	323,045	
1940/41			
July	24,155	22,766	43,211
August	33,876	30,189	46,989
September	26,384	28,828	44,454
October	43,720	39,877	48,297
November			
December			
January			
February			
March			
April			
May			
June			
Total			
1941			
July			
August			
September			
October			
November			
December			

*Includes re-exports

MONTHLY STATISTICS OF RAW SILK IN NEW YORK
(Unit Bale)
(132.275 Lbs. Avoir.)

JAPANESE RAW SILK			
Month	Imports During the Month	Approx. Deliveries to American Mills*	Stocks at the End of Month
1939/40			
July	29,055	22,968	22,627
August	28,175	30,059	20,743
September	34,800	32,292	23,251
October	44,546	36,897	30,900
November	29,635	27,105	33,430
December	26,265	16,598	43,097
January	27,020	24,243	45,874
February	9,095	18,113	36,856
March	13,945	17,720	33,081
April	13,741	16,939	29,883
May	13,135	13,583	28,435
June	12,761	12,176	30,020
Total	282,173	268,693	
1940/41			
July	21,255	17,497	33,778
August	27,022	23,463	37,337
September	20,165	23,106	34,396
October	37,350	32,966	38,780
November			
December			
January			
February			
March			
April			
May			
June			
Total			
1941			
July			
August			
September			
October			
November			
December			

*Includes re-exports.

Raw Silk Consumption by Hosiery Industry
(Unit Bale) (132.273 Lbs. Avoir.)

Year	Total Deliveries to American Mills*	Consumption by U. S. Hosiery Mills	Percentage Hosiery to Total
1935/36	456,911	251,152	55.0
1936/37	483,742	291,588	60.3
1937/38	380,480	279,994	73.6
1938/39	341,118	305,570 37,266	6,418
1939/40			
July	26,134	19,407	74.3
August	33,095	27,135	82.0
September	36,869	25,007	67.8
October	41,858	27,814	66.4
November	32,241	26,057	80.8
December	21,128	19,633	92.9
January	29,506	21,680	73.5
February	22,485	22,024	97.9
March	21,685	22,113	100.2
April	21,740	21,184	97.4
May	18,997	19,895	100.5
June	17,307	16,338	94.4
Total	323,045	268,287	83.4
1940/41			
July	22,766	15,562	68.4
August	30,189	21,033	70.0
September	28,828	20,249	70.3
October	39,877		
November			
December			
January			
February			
March			
April			
May			
June			
Total			
1941			
July			
August			
September			
October			
November			
December			

*These figures include re-exports.

The Japanese industrialists, of which there are about 20 leaders, own and control the silk producing business of Japan; also dictate the Japanese governmental war policies of that country. These same industrialists are now in the cabinet of the government and are directing and managing the war against America, which bought their silk from which their war machine was erected. You will see in the daily papers that Mr. Suzuki of Tokyo who is the Premier of Japan in active charge of the war effort against us owns or controls nearly 100 silk reeling plants in Japan. Mitsui of Tokyo controls 49 silk producing centers in the Orient. Hara of Yokahama has a number of plants. Katakura of Tokyo has 75 reeling plants. Mitsubishi who is now engaged in building airplanes, some of which are named after him, is a large producer of silk. Morimura Arai and Mogi are silk merchants in peace time. Toda, Sakichi, Yoshiba, Hatsujiro, are silk operators and members of the war cabinets in Japan. Wakimato, Tokuichi, Sigiyami, Satoshi and others a total of about 20, all silk operators, are now engaged in killing Americans.

Are we going to do business with these men again? Will America wake up or shall we help Japan again in supplying to us the silk we need? Or shall we pass this profitable agricultural crop on to the American farmer while we have the opportunity?

There can be no denial that Japan has deliberately and systematically robbed the United States of its silk manufacturing industry—once an extensive and lucrative business. Nothing could have demonstrated this more clearly than the outbreak of this present war when the supply of commercial new silk was cut off. That we should resume that trade with Japan after this war is over—and thus assist her to rise against us again—is unthinkable. Yet we must have silk—and its culture, production and manufacture are necessary—and profitable.

Again, this cutting off of the largest available source of raw and spun silk has left idle tremendous investments in machinery in America, or made costly conversions necessary. That again has demonstrated the urgent necessity for creating within the continental United States a source of raw silk.

Certainly we must never again let Japan gain a throttle hold on this essential industry. So, not only is silk culture profitable and necessary—but patriotic.

QUESTIONS AND ANSWERS

Q. How extensively can silkworm cocoons be produced in the United States?

A. This, under experienced and systematic guidance, can be developed into one of our major industries.

Q. Does the silk grower, in order to market his product, have to unwind the silk of the cocoon or do any reeling?

A. No. The grower's work in this industry is finished when he gathers the cocoon from its anchorage. He ships his crop to the market which pays him the prevailing market price. The unwinding or any further operations are solely factory processes with which he has nothing to do.

Q. In what localities of the United States can silkworm cocoons be produced?

A. Silkworm cocoons can be produced in every State of the Union, yielding a silk of super-fine quality.

Q. What are the first requirements if one desires to enter the business of raising silk cocoons for the market?

A. One must possess land upon which to plant the hybrid mulberry root graft stock which is a developed hybrid mulberry non-fruit-bearing type developed for quick growth and high protein food value. The leaves of this bush, the finest of all known food for silkworms, make for the best results, both as to quality and quantity of silk thread. These bushes will grow luxuriantly anywhere in this country.

Q. How does one begin the producing of silkworms —with eggs or with worms?

A. The silk grower always raises the silkworms from eggs. It is absolutely necessary that he procure certified eggs, thus eliminating the danger of disease.

Q. Where can one procure the root graft of the developed hybrid variety?

A. There are many nurseries throughout the United States where ordinary mulberry trees may be purchased. However, the Texas Mulberry Nursery, Inc., of Mineral Wells, Texas, specializes in the developed hybrid variety of the bush type, referred to throughout this book.

Q. Is any special farming experience required in the planting and care of mulberry bushes.

A. No. The developed hybrid referred to is extremely hardy and requires but little attention. Even the Japanese beetle does not attack its foliage, and if grafted root stock is planted the annual grove work is greatly reduced.

Q. What type of root has this bush.

A. It has what is commonly known as a long "tap root" and a few top surface "feed roots."

Q. When may one begin to plant the mulberry bushes and how are they spaced?

A. Just as soon as the frost has left the ground. They should be spaced eight (8) feet apart in each direction in non-irrigated locations. Where irrigation is available they are planted two to four feet apart with rows eight feet apart.

Q. Why eight feet apart?

A. When thus spaced it produces larger leaves and at the same times facilitates the gathering of same. It also saves much labor. The result is a healthy, thickly leafed bush with ample room for mechanical equipment cultivation.

Q. You refer to planting on irrigated locations two to four feet apart in rows eight feet apart?

A. The advantages of this method of planting are: the plants grow quickly and yield a crop of leaves in a short period of time, due to ample moisture when required.

Q. At what age can the leaves be used to feed the worms?

A. This depends to some extent upon the section of the country. The average by root graft method is 6 to 12 months.

Q. Should any fertilizer be used for these bushes: if so, what kind?

A. Yes, a fertilizer is advised. Any of those used by nurseries and gardeners will produce excellent results.

Q. How many bushes can be planted on an acre?

A. Six hundred and eighty spaced eight feet apart each way in the drill and row. If on irrigated land, up to 1500 bushes.

Q. Has climate anything to do with the growing of silkworms?

A. Contrary to popular belief, the silkworm is not a tropical insect. Where mulberry trees will thrive silkworms can be raised.

Q. Are silkworms grown in or out of doors?

A. Silkworms are raised indoors in a suitable room or rooms on a tray. They are thus protected against rodents, birds, and storms.

Q. What constitutes a "suitable room" for silk-worm raising, and how much space is required if the grower is cultivating one acre of mulberry trees?

A. The worms require good ventilation but must be kept out of drafts. The windows should be opened on one side of the room only, and that side away from the wind. Any good clean room will suffice, or an old barn protected against rodents, or even an attic. As to space, where the grower is operating on the basis of one acre, of two- or three-year-old bushes, the indoor space must be great enough to house 24 racks. The dimensions of each rack may be 9 feet long by 2 feet wide by 5 feet high. These racks can be multi-tiered.

Q. What equipment is necessary for the raising of silkworms?

A. First, racks as described elsewhere in this book. Removable trays with wire screen mesh bottoms. These are removable so as to facilitate cleaning and disinfecting. (For other equipment see hatching and feeding table.)

Q. Do the worms ever wander away from their beds?

A. No. Occasionally one will fall to the floor but this does not occur very often.

Q. Is it true that silkworms are sightless from egg to moth?

A. Yes. They do possess what is known as a "false eye" but as far as known it is useless for sight. Yet they have marvelous instinct.

Q. Do the worms crowd each other as they grow?

A. Yes. As they increase in size they must be thinned out by removing them to other trays. This is done by placing netting over them and scattering a few fresh leaves threon just before meal time in the same manner in which the beds are cleared for cleaning. Watch them carefully and when about half of the worms have ascended take them, netting and all, and place on another tray. After third age, allow about 250 worms to each tray of 28" x 30".

Q. How do the worms go about spinning and how do they find a suitable spot whereon to make their cocoons?

A. Some growers place very dry oak branches with the dead leaves still attached around the edges of the racks. Some use wild broom weeds or wild mustard weeds, form them in the shape of a loose bouquet with enough space between the branches for the worm to climb, form its anchorage and spin its individual cocoon. The worms seem to like to climb into any of these for spinning their cocoons.

Q. What takes place within the cocoon and what becomes of the worm after it spins the cocoon about itself?

A. A great transformation takes place, the worm changing to a chrysalis (pupa). After about twelve days this becomes a moth (butterfly) which, piercing the cocoon, emerges therefrom to lay silkworm eggs. *We now have what is known as a "pierced cocoon."*

Q. What commercial value has the *pierced cocoon?*

A. There is a market at all times for the *pierced cocoon*. In fact, assuming that the reader has had no practical experience in silk raising, he is advised at first to produce *pierced cocoons* only. At the spun silk factory they are treated in a manner similar to cotton, producing what is known as spun silk.

Q. What is done with the cocoon so as to prevent the moth emerging?

A. The cocoon, if to be reeled into silk thread, is "steamed," or refrigerated by the reeling company who buys your cocoon crop.

Q. Just how is a cocoon steamed and what is the object of this procedure?

A. The steaming process kills the chrysalis in the cocoon and therefore it does not pierce the cocoon and emerge as a moth. By preventing the emerging of the moth the continuity of the thread is preserved. Each cocoon contains approximately 1400 yards. The cocoon is preserved intact by steaming. *These are the ones required for unwinding to produce silk thread!* This is a *factory job* and has nothing to do with the grower whose sole job is to produce the cocoon.

Q. How is steaming accomplished if a grower should decide to try home reeling of his cocoon crop?

A. The new cocoons may be placed within any steaming apparatus. An excellent home-made one consists of a wooden frame of four narrow strips of wood, resembling a window screen with a piece of cheese cloth fastened securely to all four sides. The cloth should be large enough to form a sort of bag. In this the cocoons are placed. They are then subjected to a very hot steam bath for about 30 minutes. If some sort of cover is put over the top, the hot vapor will work through the cocoons throughly. Some growers in other countries simply dip the cocoons into boiling water for a few minutes and this effectively kills all life within. However, this method is not generally advocated. When the grower becomes sufficiently experienced he can steam his cocoons for the market if he desires.

Q. Why refrigerate the cocoon?

A. This method of refrigeration at a constant temperature between 20° - 30° F. does not kill the chrysalis but keeps it from developing. The reeling girl can reel more silk in a given time and produce better silk and less waste. The raw silk thread maintains a better luster, greater strength, elasticity, and elongation by this system. If the cocoon is stifled by heat, elsewhere referred to, some of the life is taken out of the silk in order to kill the chrysalis. It is for this reason we recommend refrigeration.

Q. What quantity of leaves will one ounce of eggs require?

A. As one ounce of eggs will produce about 40,000 silkworms, these will require about 1,500 pounds of leaves for their life cycle.

Q. How many fresh cocoons will one ounce of eggs produce?

A. About 180 pounds of fresh cocoons.

Q. How many worms will the leaves from one acre of trees feed?

A. From 400,000 to 500,000 for the entire season. This is the hatching from ten to twelve ounces of eggs.

Q. How many fresh or pierced cocoons will the above described bush cultivation and egg hatching yield *per crop* per acre?

A. About 1500 to 1900 pounds of fresh cocoons, or about 400 to 500 pounds of pierced cocoons. One hundred pounds of refrigerated cocoons will yield approximately 14 pounds of "reeled" silk. Attached to each cocoon is a small quantity of silk used for the anchorage. From every 100 pounds of fresh cocoons about 10 pounds of this waste can be gathered.

Q. How many crops of cocoons can be grown in one year?

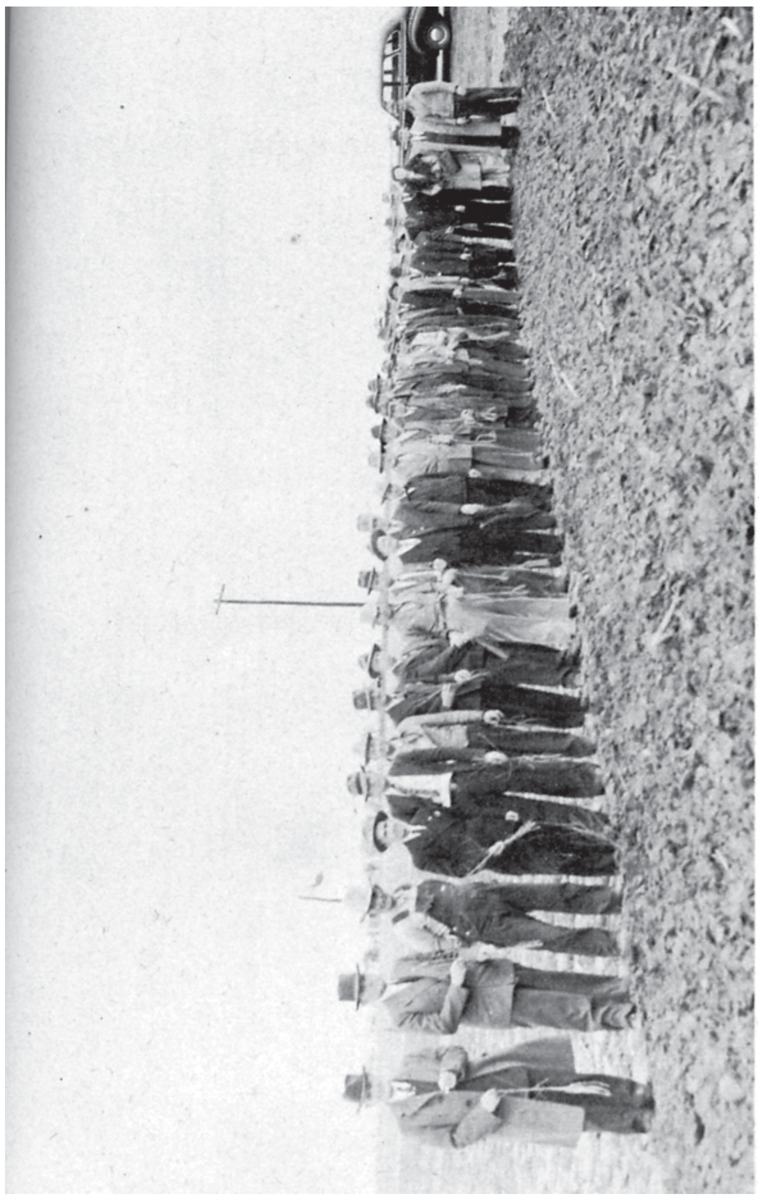
A. It takes about six weeks in which to complete the entire cycle from egg to cocoon, which constitutes the saleable crop. However, several concurrent hatchings can be timed, after the grower acquires some experience, so that the following results can be realized. In Texas, Florida, and other southern states—as well as in California—seven (7) crops per year can be produced. In northern states the number of crops would be three (3).

Q. How often should the silkworm trays be changed?

A. Every third day. This is very important as it helps to prevent disease and makes better cocoons.

Q. How does one go about changing the beds?

A. Netting is placed over the worms on the tray at feeding time. The worms, in their anxiety to reach the fresh leaves which have been thinly sprinkled on the clean netting, will make their way upward through the openings to the top. The netting, with leaves thereon, is now carefully lifted and transferred to a clean tray. After the worms reach their fourth stage the transfer is made from trays as shown in hatching instructions. The used tray may now be cleaned and sterilized, with a five per cent solution of chloride of lime.

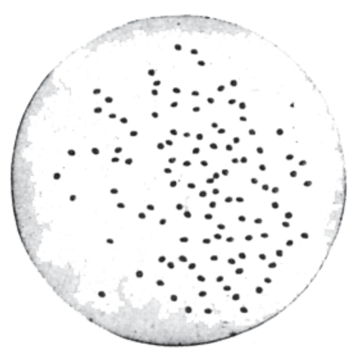


Local Citizens of Mineral Wells, Texas, who own the Mineral Wells mulberry grove.

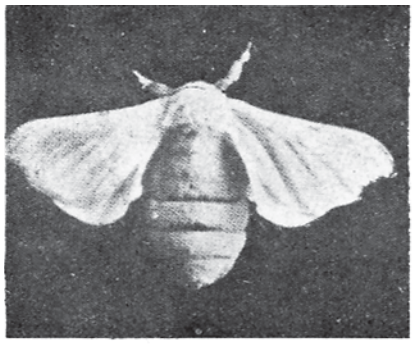
U. S. Signal Corps Aerial View, Mulberry Grove, Mineral Wells, Texas.

Male Moth

Female Moth



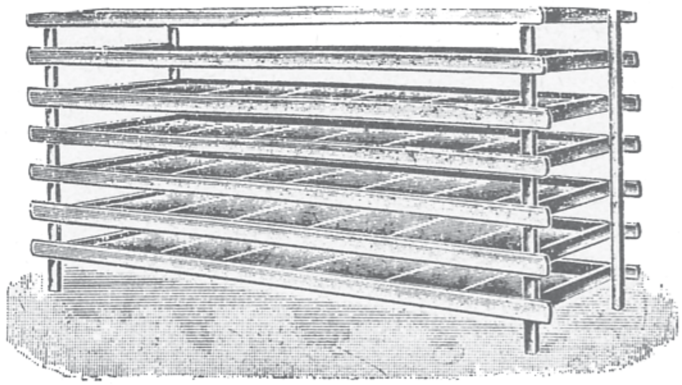
Eggs of the Silkworm Moth



Female Butterfly (moth)

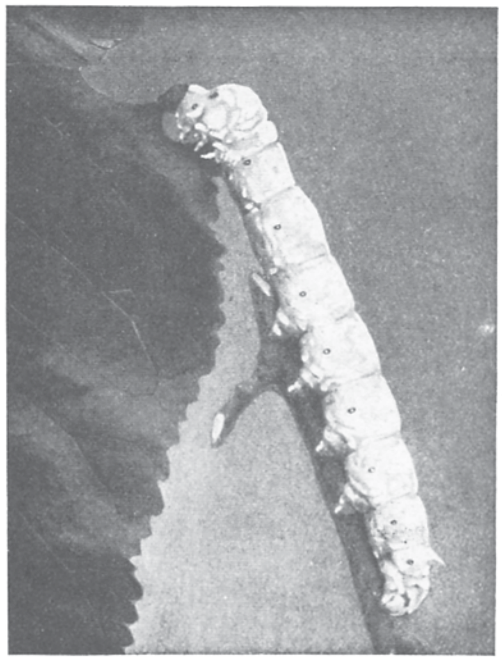
Moths Mating—Male Below

Female Laying Eggs

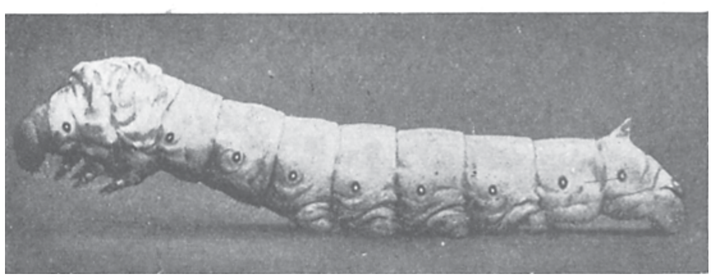


Silkworm Rack, 9 ft. x 2 ft.
Shelves 15 inches apart

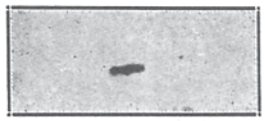
Silkworms—Six and Ten Days Old



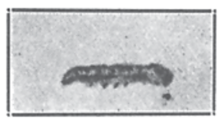
Silkworm Eating



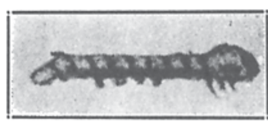
Full Grown Silkworm, Showing Position in Molting



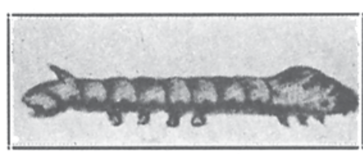
First Age



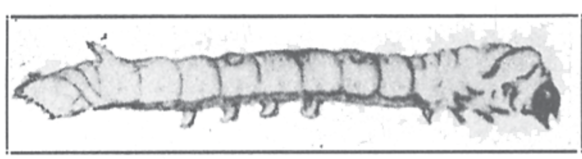
Second Age



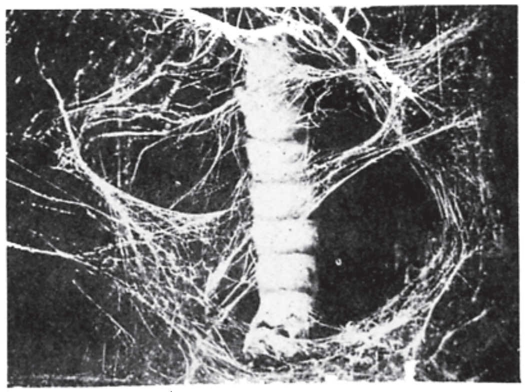
Third Age



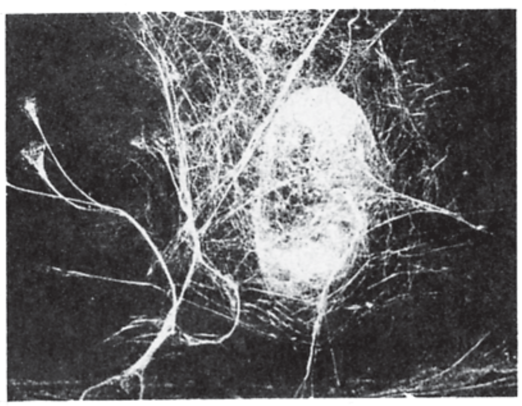
Fourth Age



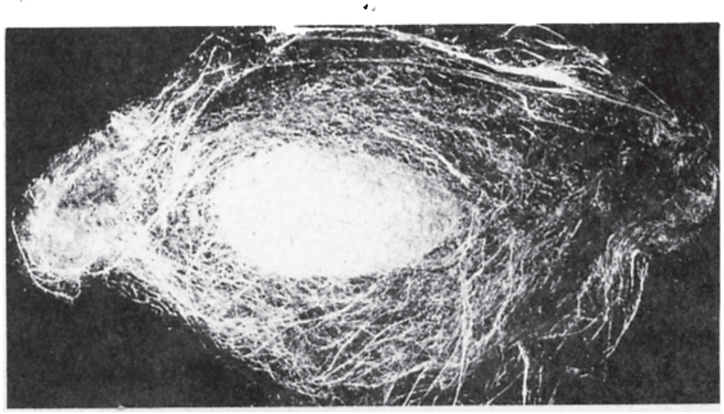
Fifth Age



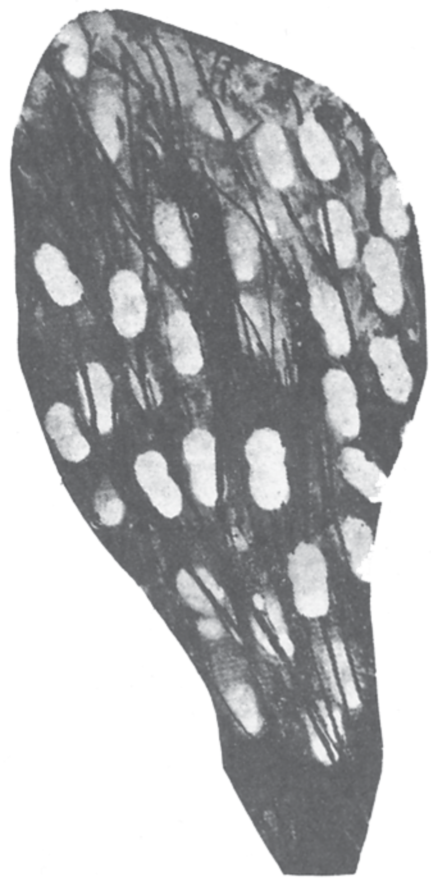
Silkworm Preparing to Form Its Cocoon



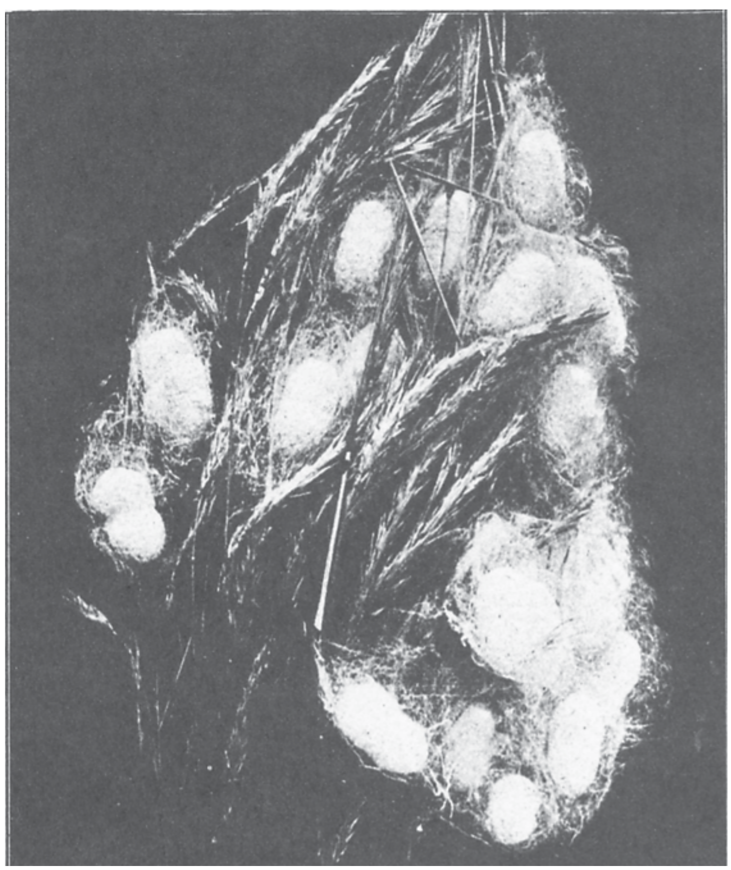
Cocoon Begun—Silkworm Can Still Be Seen



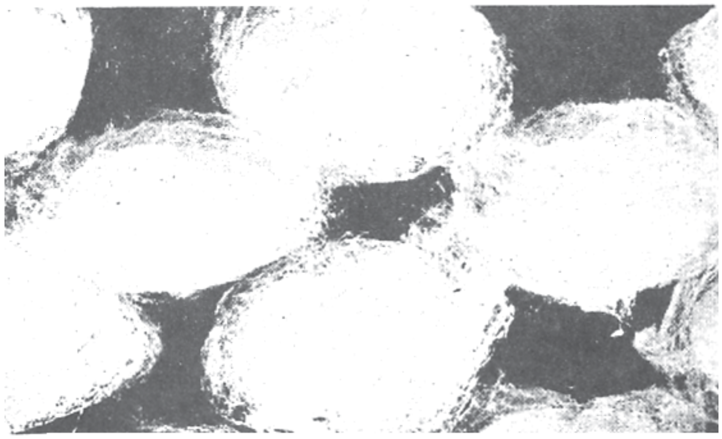
Completed Cocoon



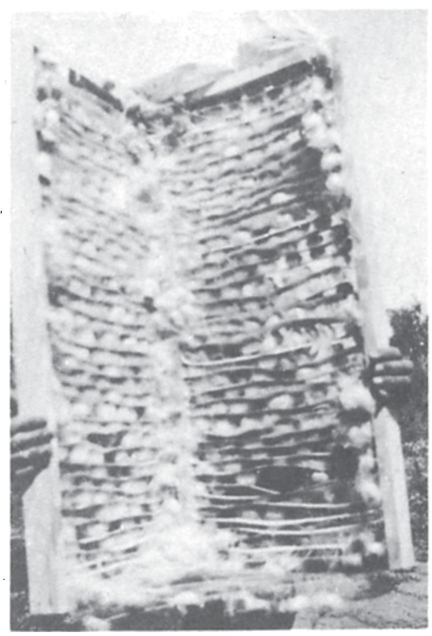
Complete Cocoons on Oak Branches



Cocoons as Spun by Silkworms in a Bundle of Straw



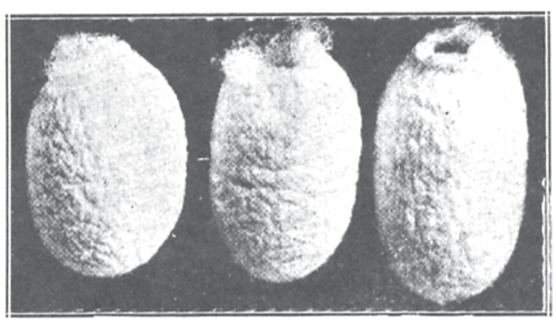
Cocoons Picked From the Oak Branches with "Anchors" Still Attached



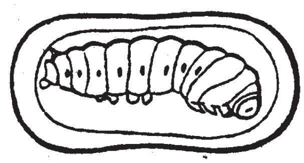
Cocoon Spinning Rack

An improvement over oak branches, broom weed, and mustard weed. This rack is laid over the worm tray when spinning seems imminent. The worms crawl in the slats, spin their cocoons, and by this method the anchor silk is kept clean and easily recovered.

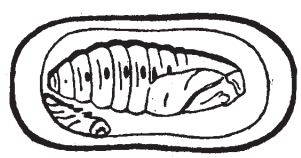
Perfect Cocoons
("Anchor" Removed)
Steamed and Ready for Reeling



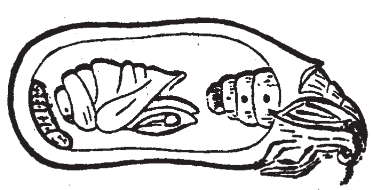
Pierced Cocoons
(Moth Emerged)
Ready for Spinning (Carding)



Completed Cocoon Showing Chrysalis Within



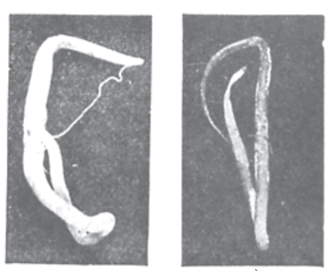
Formation of Chrysalis



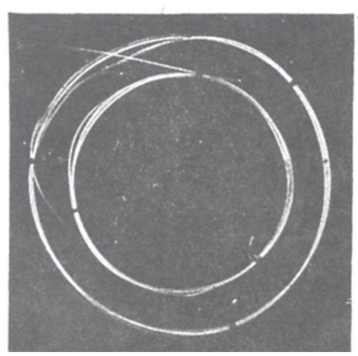
Moth Emerging From Cocoon Leaving Chrysalis Within

Cocoons from Which the Moths Have Emerged

Moths Emerging from Cocoons



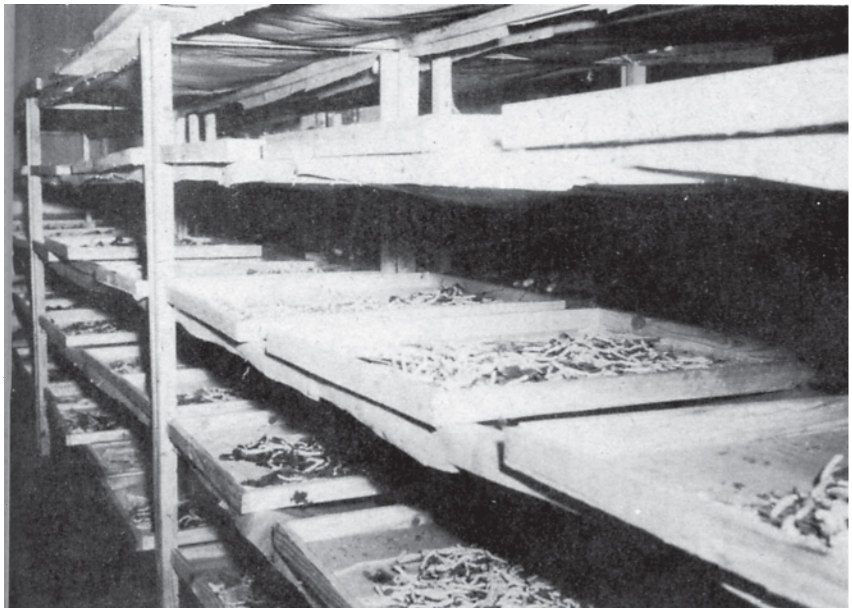
Two Silk Glands Taken to Make Snell



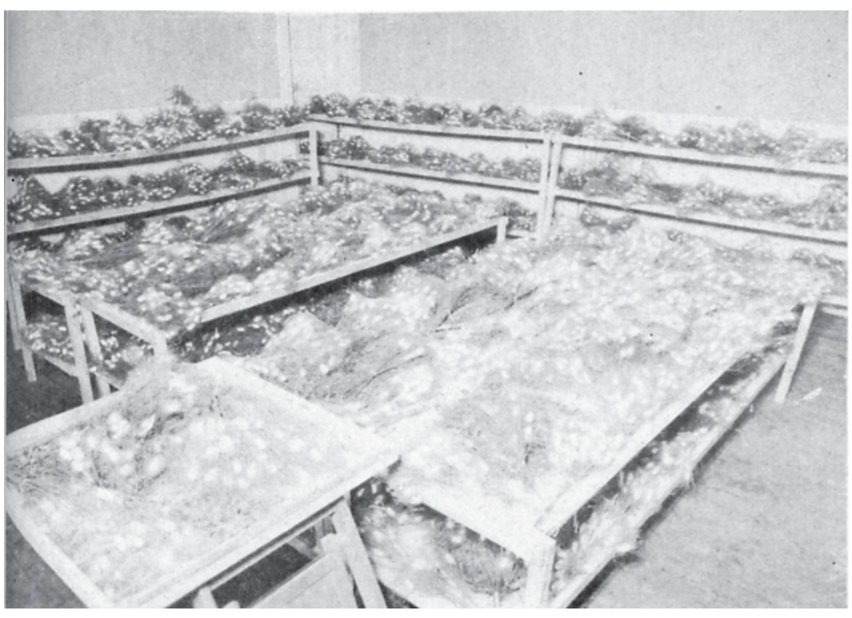
Silk Snells

Table matured silkworms, Mineral Wells, Texas, hatchery, ready to spin cocoons.

One section of changing silkworm beds at hatchery, Mineral Wells, Texas.



ne section worms feeding on racks, Mineral Wells hatchery. There were 648 of these trays.



Partial view silkworms with completed cocoons at hatchery, Mineral Wells,

Operator examining silk reeled at Mineral Wells, Texas. Silk grown in Texas.

Full grown silkworm just before preparing to spin cocoon.

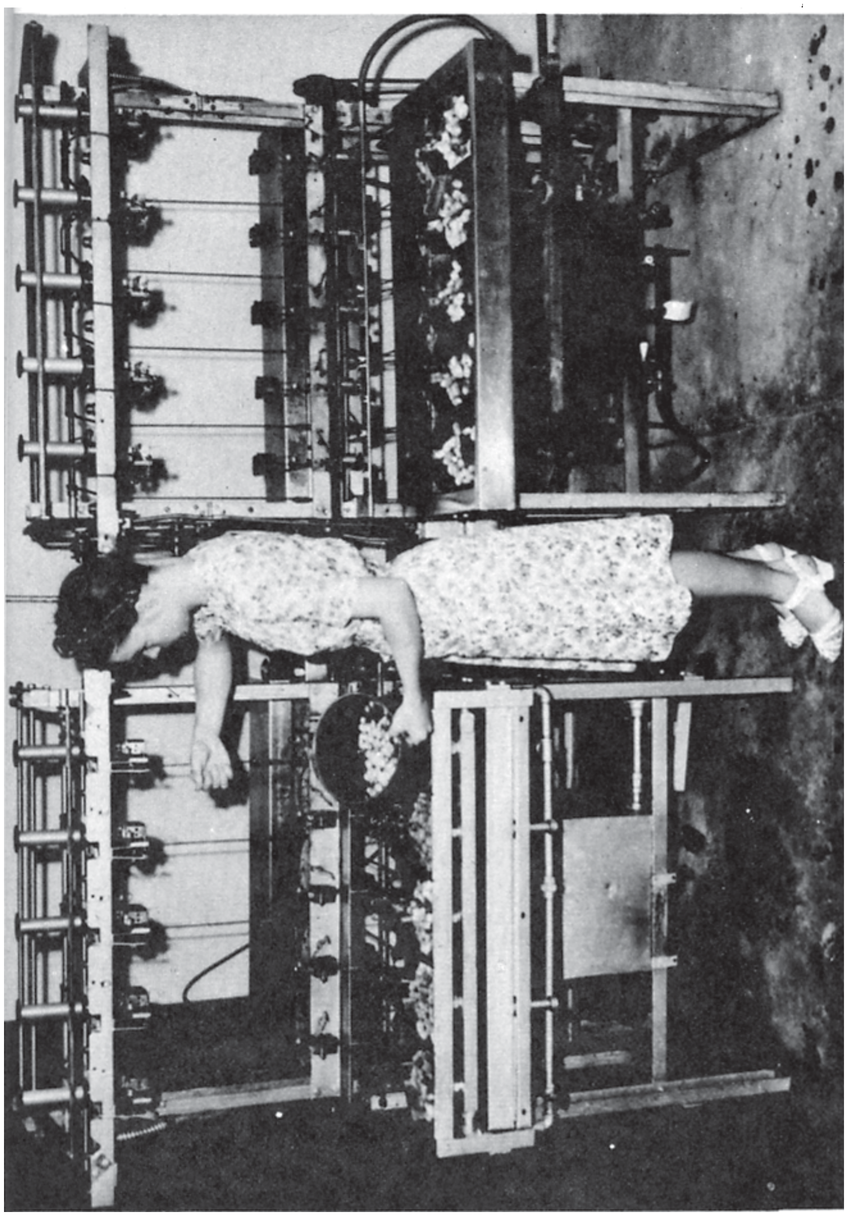
Row of *Hybrid* mulberry bushes planted March, 1945, photographed August 1, 1945.

Farmer's son, Mineral Wells, 13 years old, who has a mulberry grove, feeding his silkworms.

Section of cocoon house where the cocoons have been piled. They have been finished by the silkworms. ***Mineral Wells, Texas.***

Storing finished cocoons in cold storage plant to stifle chrysalis and prevent moth emerging. These cocoons are to be converted into commercial raw silk.

Cocoons brushed filament ends found ready for transfer to cocoon reeling machine.



Operator on cocoon reeling machines.

One pair of ladies' full-fashioned all silk hose, showing the average number of cocoons required to make one pair.