

After this operation, fresh water is poured on them, and they are transferred to a clean room, putting on the trays, where they are dried in air and then kept in conservation.

(3.) Precautions taken during the third period.

By this we mean the precautions necessary between the close of December and the period of the mulberries' budding. At the beginning of the winter, the eggs become dormant and breathe so feebly that the eggs, laid by a hundred moths (they weigh some 30 grams at the time when laid), are not injured for want of oxygen even in a sealed vessel, if only one litre of air is given to them during this period. The eggs in the dormant state are capable of beginning their growth at any time when they are kept at a temperature of over 50 degrees F., but they are so injured by their growth being stimulated out of the regular time, that the sound seed may often become weak and in the worst cases it may become of no use. Hence the precautions taken during this period are nothing but that the eggs in the dormant state are kept in stillness so as not to be exposed to any sudden warmth. The limit of the temperature in every month during this period is shown in the following list :—

The temperatures in the conservation of the eggs during the third period.	}	December	under 40 degrees Fahrenheit		
		January	„ 35	„	„
		February	„ 40	„	„
		March	„ 45	„	„
		April	„ 50	„	„

The keeping of the eggs at a constant temperature, notwithstanding the change of the external temperature, is carried out by one of the following methods :—

The first method: A double case is made for conservation. The space between the outer and the inner case is at least over 6 inches, which is filled up with non-conductor of heat, such as saw-dust, etc. The case may serve to conserve 200 egg-cards.

The second method: A store house is built for conservation, which consists of two buildings one over the another. The walls of both buildings are made thick to prevent them from being affected by the external heat.

The third method: The eggs are conserved in a cave or *Fūketsu*, or in a store house specially prepared for cooling, among which the latter is very convenient for storing on account of the operators being able to regulate the inner temperature as he wishes.

(4.) Precautions during the fourth period.

This is the precaution taken between the end of the third period and the hatching of the eggs. This period is about two weeks, and is often called the period of *incubation*. The purpose of the precaution in this period is to make the nucleus of the egg grow up regularly by a steady rising of the temperature.

The standard temperatures during the period of *incubation* are as follows:—

Day.	Standard temperature.	Day.	Standard temperature.
1st day	55 degrees F.	8th day	62 degrees F.
2nd „	56 „	9th „	64 „
3rd „	57 „	10th „	66 „
4th „	58 „	11th „	68 „
5th „	59 „	12th „	70 „
6th „	60 „	13th „	72 „
7th „	61 „	14th „	72 „

By the rising of the temperature as shown in the above table, the color of the eggs turns to a grayish white by the eleventh day, a few of them will hatch by the thirteenth day and a great many of them by the fourteenth day. The precaution taken during this period is to raise the temperature regularly, without making any mistake, to let a sufficient quantity of fresh air into the room for the respiration of the eggs and at the same time to keep the air sufficiently humid so as not to dry them too much.

#### IV. REARING OF THE SILKWORM.

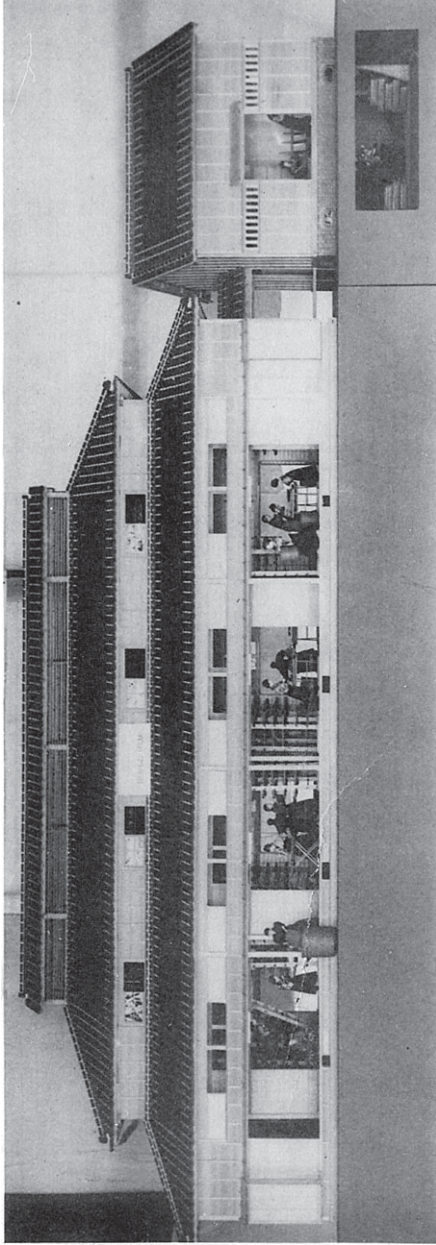
The time for *incubation* determines the time of "*brushing*"; and the time of *brushing* has very much to do with the crop of mulberry leaves and the quality of cocoons produced. In case *brushing* be carried on too early, the growth of the silkworms will be rapid, and the quality of the cocoons spun by such silkworms will prove excellent, while the crop of mulberry leaves will be considerably affected. If, on the contrary, *brushing* be undertaken too late, though we might expect a larger crop of mulberry leaves, they will lose some of their nutriment, and become too coarse as food for the young silkworms, spoiling the growth of the worms and the quality of the cocoons. Moreover, maggots are more apt to injure such late hatched silkworms, and high atmospheric temperature and humidity would give much trouble to the latter ages of their silkworms. So strict care must be taken to determine the proper time for *incubation* in consideration of the budding of mulberry leaves. It usually done and satisfactory in result to take out the egg-cards

from the preservation room at the budding of the first leaf of the early-budding variety, and keep it in the standard temperature mentioned before. This date of budding varies somewhat according to the place and year. In Tōkyō and its vicinities, in the experience of more than ten years, the earliest date was April 11th., and the latest April 23rd., the average date being 16th., or 17th., of April, which will, therefore, be the best time to commence the process of *incubation* in a usual year, but in case the budding takes place very much later, *incubation* must be commenced one or two days before the day of budding, and if the reverse is the case, *incubation* should be undertaken one or two days after the day of budding. This is so done, because in such a year that budding takes place too early, we may inevitably expect abnormally cold weather after the budding to retard the due development of mulberry leaves, while in the year of late-budding, a sudden warmth after the budding will cause the rapid growth of the mulberry foliage.

#### A. Brushing.

By *brushing* is meant the reception of newly-hatched silkworms into a feeding tray from the egg-card by *brushing* them off. Delicate treatment is required in *brushing* off the young silkworms, as they are extremely small and weak in body, and may be lost or wounded through the slightest carelessness. Various methods of *brushing* have been advocated, but the one most widely practiced at present is the *Uchiotoshi* method, a brief explanation of which is given below.





SILKWORM REARING.

Some silkworms hatch out usually one day after silkworm eggs have assumed a whitish gray color. These early hatched worms are called *Hashiri* (forerunners), and they must be brushed off and discarded, as they are not likely to spin good cocoons. The egg-card, after these early hatched silkworms have been brushed off, is wrapped up in a broad sheet of *Mino* paper, so that the young worms may not crawl off the card and be lost, and in this state it must be kept until the next morning, when under proper temperature and humidity the young silkworms begin to hatch out at five or six o'clock and the hatching for the day goes on until about ten o'clock in the morning. In ordinary cases, some 70 per cent. of the eggs on the card hatch out in one morning, but in some rare cases, the percentage may fall below 50. In such cases, the egg-card must be covered up again and kept untouched in a room with a temperature of 70 degrees F. until the following morning, when the process of *brushing* is to be taken up anew. This method must not be resorted to, when the natural atmospheric temperature is above 72 degrees F., as it may tire out the worms in the act of hatching.

*Brushing* should be carried out at about eleven o'clock in the morning. In the first place the egg-card is taken out of the wrapper and the young silkworms that may have crawled over to the back of the card are gently brushed off by means of a feather-broom. Then the card is turned over and held up tight with the egg-side downward, some five inches above a sheet of paper weighed beforehand, and a few succeeding taps are given the card on its back with the feather-broom or any other thing near at hand. Most of the worms are removed from the card in

this way, but the rest still clinging to the card have to be brushed off on the paper with a feather-broom, and then all the worms received are weighed together with the paper, and thus the net weight of the newly hatched silkworms is determined by reducing the weight of the paper.

Silkworms immediately after hatching are called *ants* and the weight of such young silkworms is technically termed "*ant weight*." As *ant weight* is very essential in determining the approximate number of silkworms, and a slight error in *ant weight* might bring an utter failure in all later plans, an accurate balance and strict care must be used in weighing such *ants*. As a rule, allowing 90 per cent. for hatching, the eggs laid by 100 moths will gain an *ant weight* of between  $4\frac{1}{2}$  and 5 *momme*, and one *momme* of *ants* usually contains from 9,500 to 10,000 *ants*.

After the weighing has been finished, millet or rice husk is sprinkled over the paper just to cover the *ants*, and mulberry leaves chopped fine are also scattered over just to equal the quantity of the *ants*. These mulberry leaves are not meant for food, but merely for the purpose of inviting the *ants* to come out over the husk. Some thirty minutes later when all the *ants* have crawled out of the husk, a fresh supply of husk is again scattered over them, and the *ants* and husk are then evenly mixed up by gently jumbling them with the feather-broom and the fingers. The usual quantity of husk required for this purpose is 2 *gō*\* per one *momme* of *ants*. After this, the *ants* and husk together are taken over into a bowl with a paper sheeting, over which they are to be scattered with proper

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\* 1 *gō* =  $\frac{1}{2}$  pint.

evenness, giving one square foot for one *momme* of *ants*. Some twenty minutes after this, almost all the *ants* come crawling out over the surface, upon which the mulberry leaves are then given as food for the first time. Here begins the most important yet intricate process of feeding, which shall be treated of under the next heading.

#### B. Feeding.

The growth of the silkworm varies a great deal according to the difference of temperature and humidity. Necessary variations must be given also to the methods of feeding, to the litter-clearing, and to the extent of the silkworm-bed in consideration of the temperature and humidity, under which the rearing is undertaken. Taking 70 degrees F. of temperature from and from 75 to 80 per cent. of humidity for our example, we shall describe here the methods required in the proper rearing of silkworms.

Young silkworms are observed to take food at more frequent intervals than the old ones, and the soft mulberry leaves required for the young worms dry up more readily than the coarser leaves that are fit for the older worms; therefore it is advisable to feed the younger silkworms with a smaller quantity of food at more frequent intervals, and according as the age of the silkworms advances, to increase the quantity of mulberry leaves for each feeding and decrease the number of feedings in a single day. Supposing that the temperature and humidity of the rearing room are as those before mentioned, the appropriate number of feedings in one day in each age of the silkworm is as follows:—

	No. of feedings in one day.	
1st age ... ..	From 7 to 8 times	
2nd ,, ... ..	6	7
3rd ,, ... ..	5	8
4th ,, ... ..	"	"
5th ,, ... ..	4	5

Some feed their silkworms less frequently in one day than is shown in the above table, for the mere purpose of saving the labour of feeding; it is, however, a bad practice, when the health of silkworms is taken into account, for, if too much food is given in one time, as is naturally the case, the silkworms may be led to take such leaves as are fouled by their own excrements, which would affect their health unfavorably and induce some contagious diseases. This is also unprofitable from an economical point of view, as many leaves may be left unconsumed. The quantity of the leaves to be given in one time, must be modified in accordance with the temperature, humidity and appetite of the silkworms. Generally speaking, in warm and dry weather, silkworms show evidences of a stronger appetite, so that they must be given more food, while on a wet and cold day, they seem dull and want but little food.

During two or three days after every moulting, the appetite of the silkworms decreases, so that the quantity of food must also be decreased, but as the time for the next moulting approaches, silkworms gradually regain their usual appetite, and they must be fed accordingly. After all, the secret of feeding is to make the silkworm eat as much as it pleases, and leave as little leaf as possible unconsumed. If much food is left unconsumed in the tray, it is not only uneconomical, but makes an

accumulation of litter, which is very objectionable for the health of silkworms. So in feeding silkworms, a delicate and sympathetic discretion must be exercised as to the quantity of food and the appetite of the silkworms as well as to the cleanliness of the tray. The quality of the mulberry leaf varies according to the variety and state of its development: some are coarse, and others soft; the younger leaves are invariably softer than the older ones. As the digestive power of the silkworm varies also according to its age, care must be taken in feeding silkworms with such leaves as are in the proper state of development. If young silkworms are fed with coarse leaves, they are likely to attain an irregular growth, and if very coarse leaves are given, they may fall victims to some kind of disease. If on the contrary, older silkworms are given only soft leaves, they may grow very fat, but become also subject to diseases.

The thickness of the mulberry leaf varies somewhat according to the variety; and the thick leaf is not suitable for young silkworms. So the early-budding variety that is used for young worms should be selected from among those varieties whose leaves are thin, and the late-budding variety with thicker leaves should be cultivated for the use of the older worms. The quantity of moisture contained in the mulberry leaf has very much to do with the health of the silkworm. If silkworms are fed with leaves with too much moisture, they may grow fat but become more subject to diseases, while the leaves with scanty moisture will cause the imperfect growth of the worms and good cocoons can not be expected to be produced by such silkworms. The appropriate degree of moisture can be attained when 100 *momme* of live leaves has been reduced to 95 or 90 *momme*.

For so doing ample care is required in the preservation of the mulberry leaves, and the temperature of the rearing room must always be properly regulated. In addition to these requirements, the regular distribution of mulberry leaves in the tray must be carefully observed.

As young silkworms seldom move about very far, the uneven distribution of mulberry leaves in the tray may cause an uneven feeding, which naturally leads to the irregular development of those silkworms. As their age advances, silkworms become more active in motion; nevertheless the uneven distribution of the mulberry leaves in every tray will cause some irregularities in their growth.

#### C. The Chopping of Mulberry Leaves.

Mulberry leaves are chopped so that they may be evenly distributed among the silkworms in the tray. Chopped mulberry leaves are used for the silkworms from the first age to the beginning of the fifth age. They must be cut square, their sizes corresponding to the age of the silkworm. Irregularly chopped leaves will be quite contrary to the object of chopping and end in the waste of labour.

#### D. The Preservation of Mulberry Leaves.

As previously mentioned, mulberry leaves wet with rain drops or with much moisture are liable to cause silkworm diseases. So prudent silkworm rearers will do well to keep some surplus mulberry leaves in store to prepare against rainy weather or to give chances for evaporation of the moisture in



the leaves. But a misguided method of preservation will often result in the withering or the fermentation of the leaves, making them quite worthless for practical purposes. There are two methods for the preservation of mulberry leaves; one is suited for the preservation of plucked-leaves, the other for leaves left on their twigs and branches. Plucked-leaves, are convenient for preservation, taking up a much smaller space, but they often become fermented, while in the case of leaves left on their twigs, though they are free from that danger, yet they have the defect of requiring a larger space. Mulberry leaves for young worms, wither fast, but as they are usually plucked from the branches, their volume is small, and if kept in a pail or an earthen pot in such a way as to prevent hard pressing, they may be preserved more than 24 hours without any injury. The silkworms in the fifth age consume a greater quantity of mulberry leaves, and their preservation requires more bulky equipments of the storage. The mulberry preservation room, must be kept at comparatively a low temperature, with but little light and ventilation. An underground room will make an ideal place of storage. Branch with their leaves left on kept vertical in loosed bundles can be preserved for two or three days without injury. Plucked leaves must be preserved in baskets (3½ft. long, 2½ft. wide, and 8 in. deep) and put on racks in the preservation room. Sometimes, roughly woven bamboo mattings are used, on which some five *kwan* of plucked-leaves are set in regular lines and rolled up and tied in two places. If this roll is kept in an underground room in a vertical position, the leaves may be safely preserved for two or three days.



E. The Extention of the "Silkworm-Bed."

In some five weeks that cover the period from the hatching of the silkworm to its maturity, the silkworm rapidly increases in its weight to the extent of about 10,000 times. Its growth is especially remarkable in the first age, at the end of which it attains the weight some 15 times its weight at the time of hatching. After from the second to the fifth age, the increase is from  $4\frac{1}{2}$  to over 5 times in each age. As the growth of the silkworm is thus wonderfully rapid, the dimensions of a bed allotted for each silkworm must also be widened, according as its age advances.

Different rearers follow different methods in extending the dimensions of the silkworm-bed, but here again moderation has much to do with the health of the silkworm and the economical interests of silkworm rearing. The narrow bed may somewhat save in the use of mulberry leaves and in the labour of feeding, but silkworms thus situated are apt to attain an abnormal development and, in consequence, a good crop can hardly be expected, while in case too wide a space be allowed for the silkworm-bed, though it may be very encouraging for the health of the silkworm, the labour of feeding and mulberry leaves will be wasted to some extent, so that this is also defective from an economical point of view. On the whole, narrow beds are preferable to wide ones for the younger silkworms, whereas in the case of the older worms the reverse is the case.

The dimensions of the silkworm-bed fit for the silkworm in each age is shown in the table below :—

	From the first to the middle day. sq. ft.	From the middle day and later. sq. ft.
1st age... ..	1- 3	5
2nd „ ... ..	3- 9	12
3rd „ ... ..	12-18	30
4th „ ... ..	18-30	60
5th „ ... ..	60-90	90

*N. B.* The table shows the dimensions required for the silkworms of one *momme* of original *ant weight*.

The process of extending the silkworm-bed is generally carried about just before the silkworm attains its full-growth in each age. In the first age, it is performed three times, in the first day, in the third day, and in the fifth day, after the hatching respectively. From the second up to the fourth age, it is convenient to perform this twice, each at the time of the first and the second litter-clearing, while in the fifth age, it is usually done once together with the first litter-clearing.

#### F. Litter-clearing.

The excrements of silkworms and the unconsumed mulberry leaves remaining in the tray are inclusively called *litter*. The accumulation of litter in a feeding tray should be strictly guarded against, as it is bound to give excessive moisture to the tray, and render the silkworms subject to various diseases. So it is absolutely necessary to keep the trays always clear of litter, but if the humidity of the rearing room be properly regulated and the methods of feeding be justly followed, litter-clearing will be sufficient, say, once or twice in each age from the second

to the fourth age of the silkworm. In the fifth age, however, the excretions of the silkworms become very lively, and the rainy weather makes the rearing rooms all the more damp, so that the litter should be cleared off once or twice every day. In the first age, silkworms are so small in size that they may be lost in the very act of litter-clearing; therefore, it is advisable to postpone this process until the time of moulting, unless an excessive amount of moisture is observed in the feeding tray.

The litter-clearing from the second up to the fourth age, is practiced three times in each age; the first clearing is to be performed when the silkworms have been fed three or four times after moulting; the second clearing is in the middle of each age, and the third clearing is just before moulting, when the silkworms show a dull appetite. The litter is usually cleared off by means of nettings, but it is as commonly done by sprinkling rice husk in the tray, upon which the silkworms crawl out, and then are carried over to other trays by means of a feather broom. The former method is applied to the silkworms in the fifth age, while the latter method is followed between the second and the fourth age.

#### G. The Protection of Silkworms after Moulting.

When silkworms have attained a certain state of development, they drop their appetite entirely and have a rest for some time. Silkworms in this state are said to be "*sleeping*." A new skin develops in the course of *sleeping*, and they awake casting off their old skins. This process is called *moulting*. The skins of the silkworms that have moulted are delicate and extremely sensitive to trivial changes of temperature and

humidity, so that special care is necessary for the protection of such worms. As *sleeping* silkworms are fond of airy and dry spots, they should be given a place as clean and dry as possible, and special care is required to prevent them from being left buried under the litter. In case some silkworms do not go to sleep even if fed four or five times after the last litter-clearing has been performed in that age, they must be transferred by means of netting into another tray to be fed therein, lest other silkworms that are *sleeping* should be covered up by the litter. During this period, the rearing room must be kept from any noise, and it is also desirable to keep the temperature one or two degrees lower than usual in the room. When any silkworms have finished moulting, draught and excessive light should be carefully kept from them, as those silkworms would crawl off from them and be crowded to one side. It is customary and better to resume feeding after all the silkworms have finished moulting. Should the silkworms that have moulted be observed as restless owing to an abnormal rising of the temperature, or a sudden attack of storm, they had better be given food, even though there be some one per cent. of the silkworms, still *sleeping* in the tray. Under ordinary conditions of weather and proper methods of protection, those silkworms that have finished moulting do not like moving about, and keep their beds for about 30 hours after moulting. But in case of a high temperature or a stormy day, or should they be affected by any bodily disorder, they will keep moving about in the tray incessantly. In such a case as this, if food is not given them, they may be compelled to succumb to some harm or other. In an ordinary case, twelve hours after moulting is considered the best time to

resume feeding. Mulberry leaves to be given to moulted worms should be of a somewhat softer quality, as their digestion has not yet regained its original activity. The quantity for one meal must also be moderated by one or two per cent., and some gradual increase should be made later.

#### H. The Temperature and Humidity of the Rearing Room.

The growth of the silkworm is very much affected by the difference of the temperature in the rearing room, and the method of rearing must be considerably modified by the humidity. So that temperature and humidity play an important part in the physical development and economical rearing of silkworms. We shall give here a resumé of the different number of days required from the hatching of silkworm eggs to the spinning of the cocoons in the different temperatures.

Average temperature.	No. of days required.
65 degrees F.	Some 40
70    "	" 35
75    "	" 30
80    "	" 24

As is shown above, the number of days required for the rearing of silkworms in one generation varies according to the different temperatures of the rearing room; nevertheless, if properly reared and protected, they may attain due development and spin cocoons in any case. We may, however, infer from this table a certain moderate degree of temperature, in which silkworms can be reared with the most satisfactory results.

Silkworms usually grow up properly and can be reared with little trouble in a temperature of between 65° F. and 75° F. In a lower temperature, their growth is slow and ununiform, while in a higher temperature, though their growth may be quick, they are more subject to various diseases. Silkworm rearers have, therefore, to be very careful in keeping the rearing rooms at the proper degree of temperature. In the first stage of the spring yield of silkworms, usually a low atmospheric temperature prevails, while in the summer and autumn yields, the temperature is mostly high. In the former case, such rooms are recommendable as are convenient to retain heat supplied by some heating apparatus. In the latter case, cool rooms should be selected, so that the effect of excessive light and heat may be averted and cool air may be let in to prevent the sudden rising of the temperature. In case the atmospheric temperature rises to 90° F., no matter whatever protection may be given, silkworms lose their appetite considerably, and in consequence, they spin cocoons of an inferior quality.

The influence of humidity on the growth of silkworms is not so remarkable as that of temperature; nevertheless, it affects a great deal the hatching of silkworms and the quantity of mulberry leaves consumed. If the air in the rearing room be too dry, mulberry leaves will dry up quickly and become wasted, and at the same time, the scanty moisture in the leaf will render the silkworms that should eat such leaves subject to incomplete development as well as to diseases, while, on the other hand, in case the air in the rearing room contains too much moisture, the mulberry leaves may not wither up so readily, and the waste may be smaller

accordingly, but it is quite as probable that the litter and silkworm-beds may become moistened, inducing the fall of the appetite of silkworms, and the steady development of micro-organisms, to which many silkworms would fall victims with wondrous rapidity. In fact, the moderation of the humidity, together with that of the temperature, is an indispensable condition in the rearing of silkworms. The humidity fitted for this purpose lies between 70° F. and 80° F. Should the air in the rearing room be observed over-dried, sprinkle water on the floor or sweep the floor with a wet cloth, or in case any fire be found in the room, get a kettle on it so that the water in the kettle may be evaporated and make the air in the room contain more moisture. If, on the contrary, the air should be observed to be saturated with moisture, throw open the windows and any other openings, and contrive to dry the room by means of fire-heating. In case the temperature of the room be so high that fire should not be used, parched rice husk, or lime must be sprinkled over the tray so as to hasten the drying of the litter. Some two *momme* of lime will be effective if it is sprinkled over a square foot of the feeding tray.

#### I. Application of Fire.

Fire is used in the rearing room for heating and drying purposes, as already referred to. There is another way of applying fire used with equal frequency and substantial benefit. In case there is no breeze in the air and the room is close and stifling, a fire is often made for causing the circulation of air-currents in the room. This great benefit of fire may, however, turn out as great a cause of destruction through its misguided

application. If the rearing room is not properly equipped for free ventilation, the room will naturally become filled with carbonic acid gas produced by the combustion of charcoal in the room, which will do great harm to the silkworms. The repeated failures of those who use fire in the rearing room lie in this point. Such men are strongly advised not to neglect to open the windows and doors as that the carbonic acid gas may escape and fresh air may come in through so as to keep the circulation of air-currents always active in the rearing room. In case fire is used as a mere contrivance of ventilation, not only should the windows be wide open, but the paper-shutters round the room should also be kept open for a proper duration of time.

#### J. The Mounting of the Silkworm.

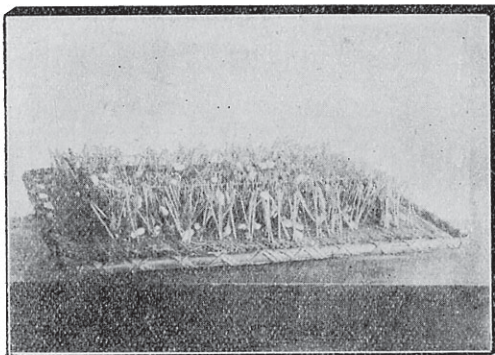
When the silkworm has attained its full-growth in the fifth age, its appetite fails all of a sudden and its body assumes an amber color and it throws out a fine thread from its mouth, restlessly moving about in search of a place fit for spinning a cocoon. A silkworm in this state is called *matured*. The process of transferring these matured silkworms into another tray fitted out for this special purpose is termed "*mounting*." The most important thing that requires special attention in this process is the determination of the proper state of maturity of the silkworm. Over-matured silkworms must needs have lost a great deal of its thread before *mounting*, which is in itself not a slight loss, and moreover, its body becomes shrivelled up and loses the activity of motion. Such a worm is most likely to spin a deformed cocoon, or a double cocoon. If, on the other



hand, those silkworms that have not yet fully matured, do not commence spinning at once, but crawl about the tray, spoiling other cocoons with their excrements. Such silkworms, as an inevitable result of their unfinished feeding, spin out a smaller quantity of silk, and so are of less value for reeling purposes, and are not either fit for reproductive purpose because of their imperfect growth.

Silkworms are said to be properly matured, when the first nine or ten segments of their bodies have become transparent and the last two or three segments remain not yet transparent.

Rearers must not lose a moment to pick up such silkworms that have attained this state of development.



FOLDED STRAW  
COCOONAGE.

The number of silkworms to be mounted in a certain area of the "*cocoonage*" varies according to both the kind and



CENTIPEDE COCOONAGE.

the construction of the *cocoonage*. In the case of the "*folded straw cocoonage*," fifty worms may be taken in a square foot,

while in the case of the "*centipede cocoonage*," the minimum is sixty. Silkworms packed in too densely are apt to spin deformed cocoons, stained cocoons, or double cocoons, spoiling the profit of the cocoon crop very much.

K. Protection of Silkworms after Mounting.

In a proper temperature silkworms finish spinning their cocoons in 48 hours after *mounting*, and in another 48 hours undergo the last moult and become pupae. The quality of the cocoon depends to a great extent on the protection given during this process. The defect in the luster and the reeling off of the cocoon is chiefly due to an imperfect protection in this stage. The items of protection required during the spinning of the cocoon are mainly as follows:—

- (1) The temperature of the room must be kept between 75° and 80° F.
- (2) The air in the room must be kept as dry as possible under 70° of humidity.
- (3) The room must be well ventilated.
- (4) The sun-rays must be evenly let into the room, and excessive rays should be kept off.

Should the temperature of the room fall below 70° F. in the course of the spinning, the silkworms often suspend their work until some higher degree of temperature is attained. In such cases, the layer of the cocoon-wall is likely to become doubled with an intervention between. If such suspension takes place twice, a threefold layer will be the result. Cocoons of such construction cannot usually be reeled off completely, but only

the outer layer is available. So any excessively low temperature of the room should be raised to a desirable degree by fire-heating. If, however, the temperature of the room be higher than 80° F. at the time of *mounting*, silkworms commence spinning at any random places without taking the trouble to find proper spots, and in most cases are apt to spin double cocoons, which cannot be used for the material of superior silk fabrics. Cocoons spun in a room with excessive moisture do not dry quickly and their filaments stick together too much, so that much difficulty is felt in reeling such cocoons, and this is especially the case with such cocoons that are spun in a high temperature in addition to a strong humidity. Prudent care should therefore be taken in having the room kept dry while the spinning is going on. In case the air in the room be of a high humidity, though moderate in temperature, the room must be dried by fire.

As spinning rooms are filled up with *cocoonages*, they are liable to become ill-ventilated and spoil the health of the silkworms. Bad ventilation usually prevents the proper drying of the room, so that all windows and doors have to be duly opened so as to have the room well kept under proper humidity and ventilation.

If excessively strong sun-rays should shine upon a certain side of a cocoon, the worm inside is apt to make the wall of the cocoon thicker specially on that side, thus forming a cocoon of uneven thickness in its wall. So in the course of spinning care must be taken to make the sunshine evenly over a cocoon.

As previously mentioned, silkworms finish spinning cocoons

in some 48 hours, so the regulation of humidity is important mostly during the first 48 hours after *mounting*.

After this, the room must be left open so as to induce the drying of the *cocoonaes* by leading in fresh currents of air.

#### L. The Gathering of the Cocoons.

Generally silkworms turn out pupae inside the cocoons within four days after *mounting*, but at the time of this transformation their bodies are very soft and assume a light yellowish tint. In this stage any rude treatment will readily hurt their bodies and spoil the layers of the cocoons with the blood that has been pushed out. Two days later, their bodies turn a deep brown and become hardened, and less subject to any harm from outside. This is, therefore, the best time for gathering cocoons.

Cocoons gathered are generally sorted into the following classes :—

- (1) Cocoons of a superior quality, that have the proper shape with a thick wall, fit for the material of the best raw silk.
- (2) Cocoons of a medium quality, that are deformed, stained with dead silkworms inside, with a wall of uneven thickness, or that are of imperfect construction.
- (3) Cocoons of an inferior quality, that have very thin walls.
- (4) Double cocoons, that have been spun by two or more silkworms.

Cocoons destined for reeling must be dried immediately after they have thus been sorted, while those intended for reproductive purposes have to pass an examination stated in a

preceding chapter, after which another strict selection must be made before they can be kept in preservation for their intended purpose.

#### V. DISEASES OF SILKWORMS.

Several diseases are found at present in our country during the breeding of silkworms. Among them those which cause great damage to sericulturists are Pébrine, Grasserie, Muscardine, Flacherie and the *Uji* disease. The damage sustained by our sericulturists due only to the latter is estimated at 15,000,000 *yen* every year, while that caused by the others is at least more than several ten millions of *yen*. It is not only in recent years that these diseases have been prevalent, but they seem to have been found from the most ancient times. One of them, described at the earliest time in our country is Muscardine just as it also prevailed in Europe. This disease was already described about a thousand years ago, then came Pébrine and Flacherie in 1712, Grasserie in 1817 and the *Uji* disease in 1814. But in the former times none of the proper ties of these diseases were thoroughly investigated. At the period, when sericulture was not so highly practiced as it is in these days, few of these silkworm diseases were prevalent and if they were so, the damage due to the diseases seems to have been insignificant. On the contrary, at present the sericulture of our country having been so much enlarged that it has penetrated and prevailed in every district and so much improved that silkworms are reared twice or thrice a year, the diseases have also grown to such an extent that they have ever threatend to destroy our sericulture. But

happily, they have been prevented according to the methods discovered by L. Pasteur and other authorities. Thus our sericulture has achieved to be such success as a safe enterprise which will not fall into any risk on account of those diseases.

Now we will describe briefly these various diseases in the following pages.

1. Pébrine.

Pébrine is a disease caused by the parasitic growth of a small ovoid organism, which is found to be *Nosema bombycis* Naegeli, a species of Sporozoa. The eggs of the diseased moth carry the germs of the disease and the worms which result from them are stricken down with it and it infects any healthy worms which come in contact with the germs which adhere to instruments or to the walls of the breeding chambers. The germ in the body of the silkworm develops into *Amaeba* which is distributed into every part of the body through the walls of the alimentary canal and grows up absorbing nutrient from the sick silkworm. Thus the micro-organism propagates by the direct division. After a while the primitive sphere appears in its interior in which spores are produced and finally it changes into a syst state. The spore is  $3\mu$  in length and  $2\mu$  in width, transparent and luminous. The ovoid micro-organism is found in quantities on every part of the worms, but especially in great many in the cells of the mucous membrane of the alimentary canal, the fatty tissues, the muscles, the cutaneous tissues, silk glands and reproductive organ and the cell attacked by the organism, being swollen and finally destroyed, we can clearly distinguish the injured parts in such simple tissues as

the muscles and silk glands. On account of the fact that the propagation of the *Nosema bombycis* is generally slow, although there are exception sometimes, the diseased silkworm is not caused a sudden death but it gradually presents the symptoms of decay. The silkworm may be attacked with Pébrine in all periods of its existence, when the worm is young or mature, or while it is moulting, or also after it becomes a moth. The worm attacked with Pébrine presents the following symptoms. The color of the diseased worms turns a grayish white and they appear to be rather shiny in their moulting and finally they are not capable of moulting or even if the worms can moult, they eat but little and remain small and fade in color. Even in their growing periods they remain small being retarded in their growth. One can discern a few black spots in their skin, but the spots are not so many, as in the diseased worms of the European species: when the worms are attacked with Pébrine at their maturity, they are not capable of spinning cocoons, they gradually shrivel up and finally die; those which contract the disease in the pupal stage, often produce black spots in the part of their rudimental wings and legs; finally the moths attacked with the disease show a black color on their tails, their scales on that part falling down and black spots appearing on the wings. The worms thus attacked with Pébrine may often accomplish all the phases of their existence, but their growth is always retarded.

That the eggs of the diseased moths carry themselves the germ of the disease is due to the parasitic growth of the micro-organism in the reproductive organs. The spore is often parasitic to the egg cell and is often enveloped by the shell

while the egg is growing on, otherwise, it attaches itself to the surface of the egg. In both cases the spore causes the disease to attack the worm which results from the egg. Hence the selection of the eggs free from the spore under a microscope is of great importance to prevent the disease, and this is the fact which has been discovered by E. Cornalia and L. Pasteur some 50 years ago.

In order to prevent the disease from spreading the following means are practiced :—

(1) The careful examination of the seed.

Seed is raised by the cellular system and the moths are examined under a microscope. If we find the spore in them, the eggs which the infected moth has laid, are not used for breeding purpose, recognising them as being also infected. The other method by which one part of the eggs is examined under a microscope, being troublesome in actual practice, the former is preferable for all practical purposes.

(2) The washing of the seed.

In order to get off the spores that have attached themselves to the surface of the eggs, the egg-card is dipped into fresh water in winter and washed carefully, both before and after brushing the surface softly.

(3) The disinfection of instruments and breeding chambers.

In order to destroy the spores on instruments and in breeding chambers, they are disinfected. For the disinfection of breeding chambers, the formalin solution is sprinkled upon them and for that of instruments the solution is also used or sometimes steaming is recommended.



(4) Precautions during the breeding of silkworms.

The diseased worms are picked out as soon as possible, the litter is often removed to clean the bed; the inner temperature and moisture are so regulated as to avoid sudden changes and mulberry leaves are given to the worms in such proportions as to breed them vigorously.

2. Grasserie.

This disease is said to be caused by the parasitic growth of a kind of protozoa or some other organism. The cause which produces Grasserie is not well known at present time, however it has been known to be one kind of a contagious silkworm disease, because if the healthy worms are fed with mulberry leaves stained with the liquids that ooze from the diseased worm or they are injected with the liquid, they are always diseased. If we examine the liquid of the diseased worm closely under a microscope we find in any case an innumerable quantity of luminous corpuscles of a polyhedrous or spherical shape. The corpuscles peculiar to the disease are found not only in the blood but in the cells of various tissues in the silkworm body among which we find a great many of them in the fatty tissues and the tracheal membrane. The size of the polyhedrous golbules is variable, but the largest one is  $5-6\mu$  in diameter. Some recognize them to be the spores of the injurious organism but others attribute them to the accessory products of the same organism and do not regard them as being the very cause of the disease. The blood of the diseased worms, revealing the presence of an enormous quantity of polyhedrous globules, as we have described above, becomes milky. On this account,

the skin of the worm changes into a milky white, losing its proper color and presents an appearance approaching transparency. The body is distended as if it were suffering from a form of dropsy and its segments are especially swollen up. The skin, being feeble, the milky blood oozes through it out of the body of the insect.

The diseased worm does not moult at the proper period, its body swells up, its skin becomes gradually a grayish white and finally the worm dies changing into a milky white color. If worms are attacked with the disease a short time before maturity, they never ripen but swell up and die without spinning their cocoons. Even if they make a cocoon, they die in it before their pupation, sometimes a few of them may change into moths but very rarely.

For the prevention of the disease the following methods are applied :—

(1) The disinfection of breeding chambers and instruments.

On account of the fact that the liquid of the diseased worms disinfected with steam or the formalin solution, loses its contagious qualities, the disinfection of the breeding chambers and instruments is necessary as a preventive.

(2) Precautions during breeding.

The accidentally diseased worms should be taken out and the removal of the litter is of course necessary. Grasserie being caused by the bad breeding, the inner temperature and moisture are well regulated, the ventilation is kept well in hand, and the mulberry leaves are given at proper times and proportions.

3. Muscardine.

Muscardine is caused by the parasitic growth of a fungus called *Botrytis bassiana* Bals. . This injurious fungus propagates by the spore and often causes great damage to the feeding of silkworms. When the spore attaches itself the skin of worms, it begins to vegetate under the proper temperature and moisture, and gives out a filament called mycelium which develops through the skin into the interior of the body and absorbs its nutrients from the worm. The mycelium thus prolonged for a certain time and then branch, and produces an oval bulb called a conidium at its end. These conidia fall into the blood and develop for a little while to form secondary conidia. At this period all the tissues of the insect have been devoured by the formidable parasite and it can not escape from death. The time between the beginning of the parasitic life and the death of the diseased worm varies according to the age of the worm and the temperature during breeding, but as a rule young worms will die in shorter time than full grown ones and when the temperature is high, the diseased worm will die sooner than when it is low. The shortest of the periods is three days and the longest is two weeks. The conidia and the secondary conidia again give out mycelium which will branch soon after. By this time the dead worm takes on a petrified aspect and always bends a little. The dead body presents often a reddish violet color, owing to the propagation of the *Bacillus prodigiosus* Flügge in it. The myceliums which occupy the dead body produce special branches called conidiophores which exude from the skin and extend over the body fruitfully. After two days,

these conidiophores are so numerous that the body seems to be covered with white fleece. On the conidiophore the conical sterigma are produced on which spores are formed. When the spore is produced innumerable, the body presents an aspect as if covered with white powder. The spore is spherical and its size is  $2\mu$  to  $3\mu$  in diameter and buds on one side or sometimes two.

The worm stricken with this disease does not show any remarkable symptoms at the beginning and has every appearance of good health, but it begins to cease taking leaves, to be in agony and to show an intense impulse of its dorsal vessel a few hours before its death; moreover irregular brownish black spots often appear in the skin of the ventral or the lateral part of the body. In short it is always impossible to be aware of the presence of the disease until the first few worms have been suddenly stricken and die. The disease is specially characterized by the fact that the dead body becomes hardened after some days, and sometimes presents a reddish violet color which afterwards changes into white. Muscardine attacks not only the larvae but also both pupae and moths.

Beside Muscardine we find several kinds of silkworms diseases caused by parasitic fungi. Those which have been known up to the present time are as follows: *Nomuraea pricina* Delacroix, *Oospora destructor* Delacroix, *Isaria densa* Link (A. Giard.), *Isaria farinosa* Fr., *Isaria funosorosea* Cashimir Wze., and a variety of *Aspergillus* species, etc. These injurious fungi cause sometimes great damage, but they are not so serious as in the case of the Muscardine.

In order to prevent the diseases caused by *Botrytis bassiana* and other fungi the following articles should be noticed :—

(1) The disinfection of breeding chamber and instruments.

By disinfecting the breeding chambers and instruments, the surviving spores of the injurious fungi which have developed in the previous breeding are destroyed.

(2) Precaution during breeding.

The worms attacked accidentally with the fungi are distinguished from healthy ones and are so far as possible taken out previous to their forming spores and the litter is often removed to clean the silkworms tray. Since a damp atmosphere greatly assists the growing of the fungus, we should avoid too much wetness in the breeding chambers so far as possible.

4. Flacherie.

Flacherie is a disease caused by parastic microbes. Although the silkworms in every stage are attacked by this disease, it especially happens at the end of the fifth age and the following days up to the time of moulting, causing serious damage to the sericulturists. Various bacteria are injurious to the silkworms among which *Bacillus sotto Ishiwata*, and *Streptococcus bombycis* Cohn. are important. The former is a bacillus with a rod like shape. The length is  $2,6-6\mu$  and the width is  $1,5-2\mu$ . The body is covered with a fruitful crop of fine cilia with which the bacillus moves violently. It forms an endospore in the middle or one side of the body. This endospore is oval and  $1,6\mu$  in the longer diameter. The bacillus produces a kind of toxin in this endospore and its pathogenic action is due to

the production of the toxin. So the bacillus which has been swallowed by a silkworm causes its sudden death after from thirty minutes to an hour. As we have described above the subjects attacked by the disease during suddenly in many cases, we can not perceive clearly the particular symptoms of the malady. The form and color of the body of an affected worm are not distinguished from those of a healthy worm, but in looking at the body carefully, we will find the following symptoms: The two or three segments near the head are somewhat transparent at the beginning of the disease and the silkworm raises its head, shaking it right and left. The posterior part has always a wrinkled skin; the legs losing the power to hold the body, the worm easily falls down if only touched, it becomes soft and flabby to the touch. The bacillus attacks not only worms but larvae and moths, lurking for a while in the body after contagion.

The second microbe is a streptococcus which is round and has a diameter of  $0,9\mu$ . It exists in the connection of two or several individual with each other. These bacteria do not cause such a severe malady as the ones just mentioned. The diseased worm presents the first disorder after the great many multiplications of the microbes in the mucous membrane of the alimentary canal. It injures vigorous worms but little, but on account of its causing a formidable malady to the weak ones, often a great many of them are suddenly condemned to death.

The symptoms of the disease vary according to the period attacked, worms stricken with this disease after their moulting remain small and lose their vital aspect; those attacked with it during the active period of feeding also remain small and finally

die or the fore part of the body is swollen up and becomes transparent and the end part shrinks into a remarkably small compass. The streptococcus attacks worms at any stage but it especially injures them before moulting.

By the following directions the rearer can prevent the disease :—

- (1) By the disinfection of the silkworm chambers and instruments.

By disinfecting of the silkworm chambers and instruments any bacteria left are destroyed.

- (2) By the selection of healthy seed.

On account of the fact that vigorous silkworms are little attacked by the disease, healthy seed is selected and protected completely.

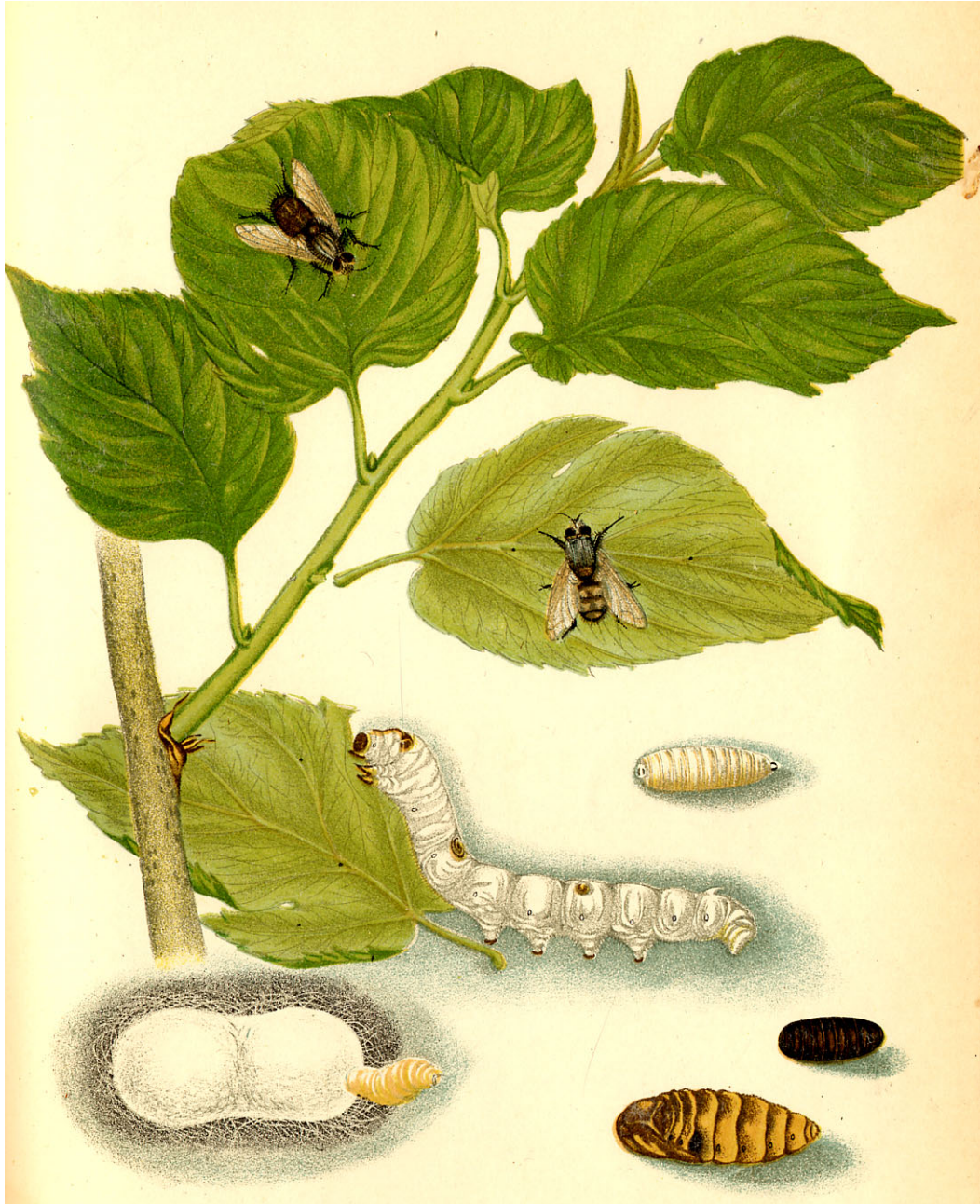
- (3) Precautions during breeding.

A proper temperature and moisture are kept, good ventilation is indispensable in the nurseries; that a proper quantity of food be given to the worms; of course the affected or attacked silkworms are taken out and the removal of the litter is often practiced.

##### 5. The "Uji" disease.

This disease is caused by the parasitic growth of a insect called Ugimiya (*Crossocosmia*) sericaria Rondani. This parasitic maggot caused great damage to our sericulturists. The cause of the disease is due to the worm's swallowing the eggs of the fly which are laid on mulberry leaves. The fly lays eggs between the middle and the later of May on mulberry leaves





*Ugimiya (Crossocosmia) Sericariae* ROND.



which are given to the worms after the third age. The female and the male imago of the maggot are different in size; the male is 15 mm. in length and its wings are 30 mm. in length and female 14 mm. in length and its wings 28 mm.. The body is blackish brown and covered with coarse hairs. We always find some seven or eight thousand eggs in the female body among which several thousand eggs are actually laid. The female flies do not lay their eggs in any one place but in so many places that the number of eggs laid on one mulberry leaf being only one or two, at most seven or eight, thousand of the leaves receive the eggs of only a single female fly. The egg is black and shiny and has the marks of a regular hexagonal shape, like the meshes of a net. The form of the egg is an elongated oval, its length is 0,33 mm. and its width is 0,2 mm.. As soon as the egg is laid, its nucleus begins to develop and finally hatches into a tiny larva soon after it is swallowed by the poor worm. The larva or maggot escapes into the body space through the wall of the alimentary canal and finally invades a ganglion. The time from the hatching until it reaches this stage, is only one hour. Thus the maggot lives on the ganglion and after one or two weeks it comes out again into the body space and remains in the inside of a stigma, turning its hind end to the stigma and stretching its mouth into the interior of the body. In this position, the maggot grows adsorbing the nutrient from the diseased worm. After the maggot continues one to three weeks in this state, it matures and leaves the patient, that is ten to fourteen days after the worms has spun a cocoon. Either when the worm is attacked with the disease while it is young or when it is injured by several maggots, the worm is killed before it spins a

cocoon. The mature maggot is of a cylindrical form whose one end is round and the other pointed, it is yellowish white, 20 mm. in length, 6 mm. in width and consists of 12 segments. It moves very actively and lies low in the ground escaping out of the nurseries through a narrow space. The maggot that has thus buried itself in the ground, changes into a chrysalis whose puparium is a blackish brown and elongated oval. Passing the winter in earth, the maggot re-appears as an imago or fly in the middle of April, of the next spring. Many of the flies swarm about mulberries and lay eggs on the leaves which repeat the same cycle.

The worm attacked with the disease presents different symptoms. In the case of an attack by a single maggot, the silkworm has every appearance of good health and accomplishes all the stages but after pupation, the stigma of the pupa is always black and it can never change into a moth. On account of this fact, the parasite causes a serious damage to our egg producing. Either when the worm is stricken with this disease while it is young, or when the worm is attacked by several maggots, it presents such symptoms as *Tareko* (the hanging worm) that means the worm which hangs down on the edge of the tray and dies, *Kubimagari* (the worm bending its anterior parts) or sometimes *Hadaka-sanagi* (the naked pupa) that is the pupa which does not imprison itself in a cocoon.

In order to prevent this disease the rearer should take the following measures:—

- (1) The maggots which come from cocoons should be killed.

- (2) The rearer should sweep and dust under the floors of the mulberries after the breeding is finished and destroyed the puparium of the maggot which lies low in the ground to pass the winter.
- (3) Mulberry leaves which are suspected of carrying the eggs of the fly should not be given to silkworms and especially the leaves should be carefully selected to feed the worms of the fifth age.



## CHAPTER VII.

### MANUFACTURE OF RAW SILK.

#### I. REELING METHODS.

There are three principal methods of reeling cocoons here, at present, "*hand-reeling*" (*Te-guri*), "*sedentary reeling*" (*Za-guri*), and "*machine-reeling*."

There was the "*flapping method*" (*Tata-ki-dori* or *Dōtori*), which is the most primitive one for reeling and now out of use. The method of *hand-reeling* is its improved form which is used in some remote districts; then comes the *sedentary reeling* which prevails in many parts of Japan; the most improved method is that of *machine-reeling*; the method called "*foot-reeling*" (*Ashi-bumi*) is a combined form of the *sedentary* and *machine-reeling* methods. The *hand-reeling* and the *sedentary reeling* methods have come down to us from ancient times, but *machine-reeling* was introduced from Italy and France about forty years ago.

Details of these methods are as follows:—

##### I. Hand-reeling (*Te-guri*).

In *hand-reeling*, there is a reel which is revolved by a rod with the right hand of the reeler, and a pan is used for both the boiling and the reeling of cocoons. The index-finger and the middle-finger of the left hand serve for twisting the silk threads; of course we can get only two or three twists in this

way. The reeler, in this case, has to stop the work as soon as the filaments are broken and she can reel only one thread at a time. The raw silk produced by this method is coarse and does not have the uniform denier.

2. Sedentary reeling (*Za-guri*).

In this method only one pan is used for the boiling and the reeling of the cocoons, as in the case of *hand-reeling*. The reeler can, generally reel only one thread at a time, but some can reel two threads at a time, though this is rarely the case. The reeler must determine the number of filaments which she will attach to a single thread; the number varies according to denier of the silk thread. The cocoons are first boiled, then the true uniform filaments are found out. The required number of them is passed towards the angular point of a brass wire which is kept just over the pan, then it comes into contact with folded hairs which are fixed to a short wooden post, both for the purpose of uniting the filaments and also for getting rid of the water from the raw silk. Then the thread passes through a bamboo stick which moves to and fro and thereby prevents the thread from accumulating on a part of the reel, and at last it passes to the reel. Sometimes the Kennel system is adopted in this method for twisting and uniting the filaments.

By this method, the reeler can work without stopping operations for the reason that she can add a new filament by means of her right hand when one filament is broken, while her left hand is engaged in revolving the reel by the handle which is fixed to the wheel. Of course, by this method, the production and quantity of the raw silk are better than in that of *hand-*

*reeling*, but it is by far inferior to those varieties of raw silk produced by the *machine-reeling* method.

3. Foot-reeling (*Ashi-bumi*).

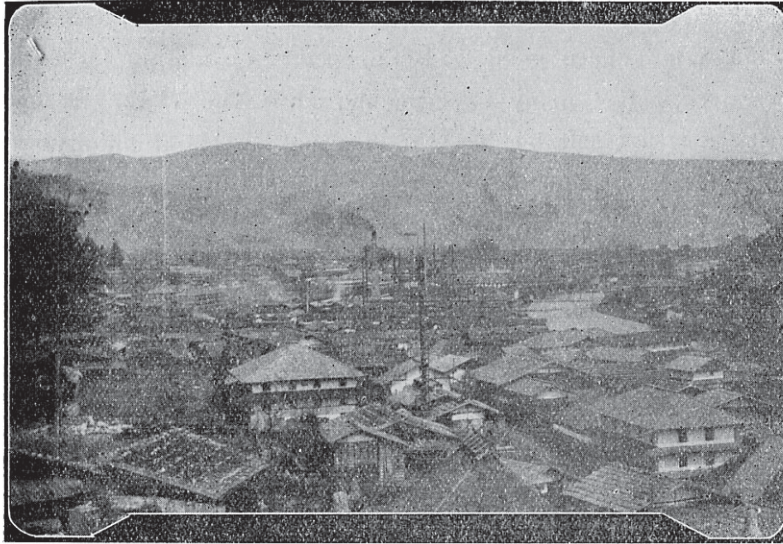
In this method, there is only one pan for the boiling and the reeling of cocoons, and not two as in the case of *machine-reeling*. The water is heated by a charcoal fire. The operation of reeling by this method is similar to that of the *machine-reeling*, except that the reel is revolved by the feet of the reeler.

4. Machine-reeling.

The *machine-reeling* method is quite different from that of *hand-reeling*, and the *sedentary reeling*. There are prepared two pans, one is for the boiling of the cocoons and the other is for the reeling, and the reels are revolved by mechanical energy. By this method, we can produce a superior grade of raw silk, as the cocoon filaments are well united by complete twisting, and both the hands of the reeler can be devoted to the throwing of filaments to maintain the continuous uniform denier of the raw silk.

The energy used is of several kinds, human labor, water power, steam power, and electricity. The human labor is used in very rare cases and it will be gradually decreased. At present, most of the filature works use steam power; electric power is not used so much but it will be introduced into the filature works in the near future on account of its cheapness.

There are two systems of reeling by machines, one is the Kennel system and the other is the Chambon system. The former was introduced from Italian filature factories and latter



FILATURES AT SUWA, NAGANO PREFECTURE.

from France. And there is another form of twisting apparatus which is modified from the Kennel system and it is called the *Inazuma system*. Most of the filature factories of Japan have adopted the Kennel system, and the Chambon system has been adopted in a few filature factories in which a very fine or superior raw silk is produced, but it is more difficult to reel by this system than in the case of the Kennel system. Well united superior raw silk can not be produced by the *Inazuma system* and most of the factories have been converted to the use of the Kennel system, so we can see it but rarely now.

There are two kinds of reels in the *machine-reeling* system, one is for “*double reeling*” (or reeling with small reels) and the other is for “*direct reeling*” (or reeling with large reels). All the filatures adopted the *direct reeling system*, when the



*machine-reeling method* was introduced from Europe, but the result was not so good. The managers of filature factories perceived, after many experiments, that the *direct reeling* method is not suitable here, on account of the humidity of the Japanese climate. So, they changed it to the *double reeling system*, though it required much more expense for changing the system.

There are many defects in the raw silk produced by the *direct system*. As the climate of Japan differs from the Continental climatic conditions, the raw silk round on the large reels does not dry well, and it does not unwind freely again, as its different parts stick to one another when they come into contact with the frame of the reel and harden when they become dry. Besides, it is difficult to keep the uniform denier of the raw silk in all its parts, because we examine the denier of the raw silk only at the time of reeling and the worker becomes careless for the maintenance of an uniform denier. These defects can be avoided to some extent by the *double reeling system*.

The number of the silk threads which are reeled by a reeler at a time is not the same in all cases. In the Chambon system a reeler can reel two threads only, but in the Kennel system she can reel two, three, or four threads according to the silkfulness of the worker. Generally, many filatures adopt the *two-thread-system* at the Kennel method.

Also, there are several methods of reeling cocoons. Generally, cocoons float on the water while being reeled, but there is another method in which they are forced to sink in the reeling water, and then reeled. The cocoons are boiled and reeled by the same reeler though rarely different persons are

employed for the two purposes. When the European reeling method was introduced into Japan, the latter method was adopted in all filatures as in the case of European filatures, but the result was not good because quarrels arose between the reelers and those who boiled the cocoons.

There are two methods of arranging the cocoon filaments in the reeling pan; in the one method, in the first place, the true uniform filaments are found out and kept in the reeling pan and then thrown up at the time of reeling, but in the other method, only the ends of the filaments are gathered, not arranged uniformly, and in the course of the reeling itself the reeler finds out the uniform filaments and throws them up without stopping the revolution of the reels.

The raw silk produced in the former method is superior in quality, but much more silk can be reeled in a certain time by reeling by the latter method, but the silk so produced shows some inferiority in its quality. Most of the filatures prefer the latter method, reeling silk of medium quality.

## II. MACHINES AND INSTRUMENTS.

Reeling machines can be divided into two kinds, i.e., reeling and re-reeling machines.

Reeling machines include *flapping reeling* (*Dō-tori*), *hand-reeling* (*Te-guri*), *sedentary reeling* (*Za-guri*), *foot-reeling* (*Ashi-bumi*), and *machine-reeling* (*Kikai-dori*).

There are three ways of re-reeling, (1) by pulling (*Sha-kuri*), (2) by turning with the hand (*Temawashi*), and (3) by the use of a machine.

Different kinds of energy can be applied to these various kinds of machines. The implements for the *Dō-tori* method, *hand-work* method, and the *sedentary reeling* method, are turned by hand and that of the *foot-reeling* method is revolved by the reeler's feet. These implements serve to assist in the home industry of our country, but in all filatures, machines are used for reeling silk, whose motive powers are produced by water, steam, or electricity.

The working and mechanism of each of these instruments and machines is as follows :

#### A. Reeling Machines and Instruments.

##### 1. The Frapping reeling instrument (*Dōtori-kikai*).

This instrument was prevalent from the most ancient times in Japan, but at present, there is no example of the use of it. The construction is very simple ; it consists of a cylindrical piece of wood, which serves for the purpose of the reel, and a support, and an axis which is fixed to the cylinder. The cylinder is made of light wood and supported by the axis on the support and revolves round the axis.

The diameter and the length of the cylinder are about 5 inches and 2 feet respectively. The height of the stand is about 6 inches. The worker can not reel continuously with this instrument. At first, she must gather five or six filaments and twist them with her palms, then she turns the cylinder by frapping with her hand, and winds the silk on the cylinder, After reeling off the twisted part of the silk, she must stop frapping the cylinder and twist the filaments again, and so on.

2. The Hand-reeling instrument (*Te-guri-kikai*).

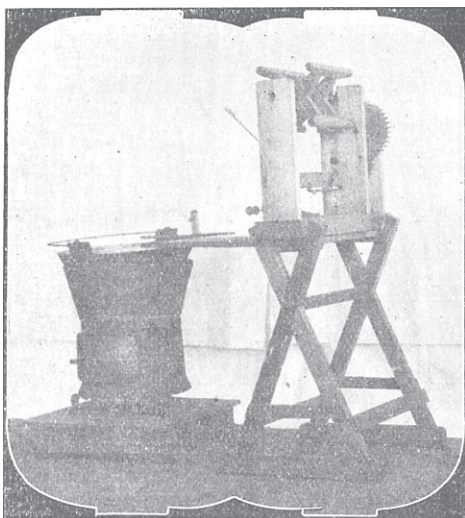
This is a little more improved instrument than that of the *frapping reeling*. About forty years ago, it was prevalent mostly in the mountainous and remote localities, but more improved instruments took the place of it, by and by, and it is used there only in rare cases at present.

The construction of the instrument is very simple and it consists of a rectangular reel and its stand. The circumference of the reel is nearly  $2\frac{1}{2}$  feet. The reel revolves round on axis which is on the stand; the cross section of the stand is  $1\frac{1}{2}$  inches square; the length of the stand is fitted according to the height of the reeler who reels while sitting down and the length and the breadth of the base or support of the stand are 8 inches and 1 foot respectively.

The reeler turns the reel by putting in a bamboo stick, whose length is about 1 foot, between the frames of the reel by means of her right hand, while the left hand is engaged for the purpose of twising the cocoon filaments.

3. The Sedentary reeling instrument (*Za-guri-kikai*).

This instrument is more improved than that of the *hand-reeling* and it is used in many parts of Japan as an important instrument of house-industry. There are two kinds, one is the *Zyo-shiū-za-guri* (which means the one that prevails mainly in the *Zyo-shiū* district), and the other is the *Ōshiū-za-guri* (which means the one that is prevalent chiefly in the *Ōshiū* district). In the former, the reel is revolved by means of toothed wheels and in the latter two wheels and a belt are used. In both of



THE SEDENTARY REELING MACHINE (*Za-guri.*)

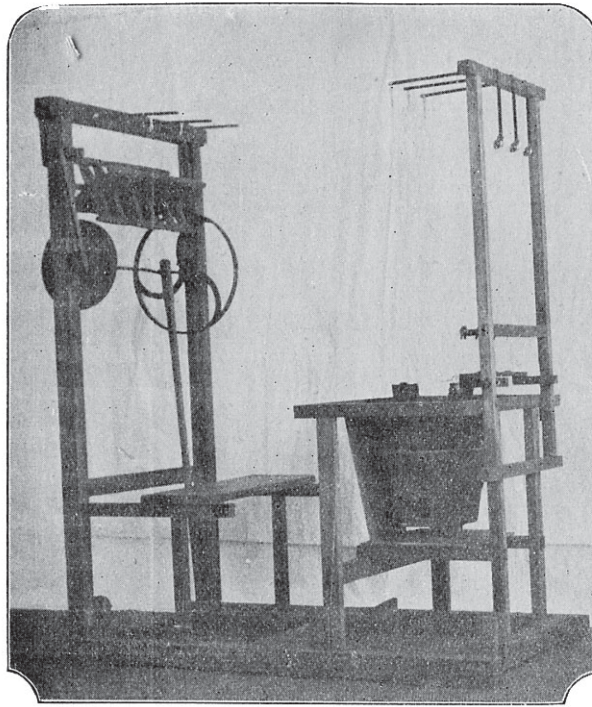
them, several kinds of apparatus for reeling silk are prepared as follows; (1) A bamboo stick which moves to and fro and over which the silk is made to pass, and then wound uniformly round the reel; (2) Folded hairs which are fixed to a small wooden post and serve to unite the filaments; (3) The brass wire which has

the form of a V at whose angular point filaments are to be projected; (4) The rectangular reel whose circumference is 1 foot and 9 inches.

The reeler turns the reel by the handle which is fixed to the large wheel with her left hand and she uses the right hand to adjust the filaments, so as to maintain the denier of the raw silk.

#### 4. The Foot-reeling machine (*Ashi-bumi-kikai*).

This is a simple machine which is a combined adoption of the reeling machine with the *sedentary* instrument. It consists of a reeling table, a reeling holder, and several utensils for reeling silk. The table and the reel holder are connected. On the reeling table, a detachable iron pan is placed which serves to



THE FOOT-REELING MACHINE (*Ashi-bumi*.)

boil and reel the cocoons; two or three porcelain bottoms which have very small holes, are fixed in the twisting apparatus in one horizontal line upward a few inches from the pan, and they are used for the purpose of avoiding nobs of the silk,

getting rid of water from the filaments, and collecting the filaments which go to form a silk thread. Besides, there is a twisting device which is an aboptation of the Kennel system.

In a part of the holder, there are; (1) Two wheels, one is very large and the other very small whose diameter is about one tenth of the former; (2) The axis of the reels; and (3) *Aya-furi* which are small pieces of wooden or iron posts fixed on the top of the reel holder, but which move to and fro, and which have glass or enameled iron round hooks in their ends. The *Aya-furi* has to prevent the silk thread from accumulating too much on

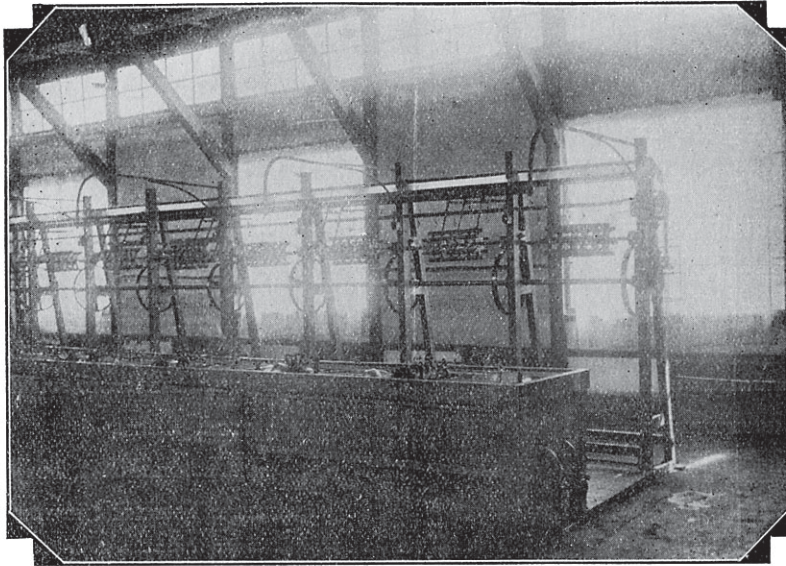
any one part of the reel. The small wheel revolves round the wooden rod which is the axis of the reels also, and the axis of the large wheel is connected by wooden rod to the wooden plate which is to be moved by the feet of the person reeling the silk. The small wheel is in close contact with the large wheel just above it, and when the large wheel turns by the wooden rod which is set in motion by the foot of the reeler, the reels revolve as the small wheel also is turned, because it is in close contact with the larger as has been already stated.

By using this machine, both the hands of the worker are at full liberty to throw up the cocoon filaments, and at the same time her feet serve to assist in the turning of the reels. The filaments which go to form a silk thread, first, pass through the hole of a porcelain bottom and are twisted by the twisting apparatus, then pass through a hook of the *Aya-furi* and go to the reel.

##### 5. The Reeling machine.

This is one that modified from the European silk reeling machine. It consists of two parts; a reeling table; a reel holder. On the reeling table, there are two basins and two pots for each worker, one of these basins serves for boiling the cocoons and the other for reeling. To both the two pans, water and steam are conducted by means of pipes. The pots are used to hold water and to contain the waste silk or chrysalis after they have been reeled off their filaments. Besides there are the porcelain bottoms and the twisting apparatus which are of three kinds, namely the Kennel system, the Chambon system, and the *Inazuma* system.





FILATURE.

In a part of the reel holder, there are the large and the small wheels which are in close contact with each other; the axis of the reels being fixed to the smaller one, and the shaft to which the large wheel is attached; the contrivance to stop the revolution of the reel; and a iron or wooden rod which moves to and fro, and to which three or four glass or enameled hooks are attached (*Aya-furi-ki*).

There are two kinds of reels in this machine, one of which is small and the other large. The former serves for the *double reeling method* and the latter for the *direct method*. The number of the reels for a reeler varies according to the number of the silk threads to be reeled by the reeler at a time. Generally it is two, three, or four, but sometimes there are

six, eight or even twenty for a reeler according to the construction of the machine.

In the construction of the reeling machines, different kinds of materials are employed in various ways, wood entirely; iron; and partly iron and partly wood, etc.

#### B. Re-reeling Machines and Instruments.

##### 1. The re-reeling instrument by pulling (*Sha-kuri*).

This was prevalent from earliest years in Japan, but it was very incompletely constructed, as the apparatus to wind the silk on the reel uniformly was not yet prepared.

The construction is very primitive. It consists of a long reel and its support. The length and circumference of the reel are nearly 6 feet and 4 feet respectively. The height of the support is about 4 feet. At one end of the reel axis, a small handle is fixed and on the handle a rope is tied, its length being 3 or 4 feet. The reel is revolved by pulling the rope by the hand of the worker and the manner of pulling is said as *Sha-ku-ru* in Japanese, so this instrument is called *Sha-ku-ri*.

##### 2. The Hand-re-reeling machine (*Ti-mawashi*).

This is a more improved one than the first, and it is used much by sericulturists who manufacture silk in their houses.

The machine consists of a reel and the holder of the reel. In the holder, there are several apparatus; they are (1) wheels, (2) contrivances to stop the revolution of the reel, and (3) the *Aya-furi-ki*. At the end of the large wheel, a handle is attached by means of which the reel is turred with the hand of the person operating it.

The form of the reel is rectangular or hexagonal, and its length and circumference are  $1\frac{1}{2}$  feet and 5 feet respectively. Generally, there is only one reel but sometimes two or three reels are used in one machine and that rather rarely.

### 3. The Re-reeling machine.


This is the most improved one for re-reeling silk, and several mechanical powers are used as its motive power, that is to say, water, steam, or electricity. It is constructed on a large scale in filature works, and in one machine from twelve to twenty-five, or even fifty reels are placed continuously in one line or double lines. The steam pipe is laid in front and under or behind and above the reels. The diameter of the steam pipe is from 2 to 4 inches and it serves to dry the silk on the reels while in the process of re-reeling. The materials used in the construction of the machine are of various kinds; (1) wholly wood, (2) wholly iron, (3) partly wood and partly iron. The *Aya-furi-ki* is of the same sort as that used with the reeling machine, and usually one *Aya-furi-ki* is prepared for each reel, but sometimes for the whole line of the reels, one *Aya-furi-ki* only is constructed.

### C. Cocoon Drying Chambers.

Cocoon drying chambers are generally of two sorts: one is used for drying cocoons by heat and the other by steam. The former is called the cocoon desiccator by means of heat and the latter the cocoon desiccator by steam.

Now we will explain the principal parts of the construction of the cocoon desiccator which is popularly used now-a-days.

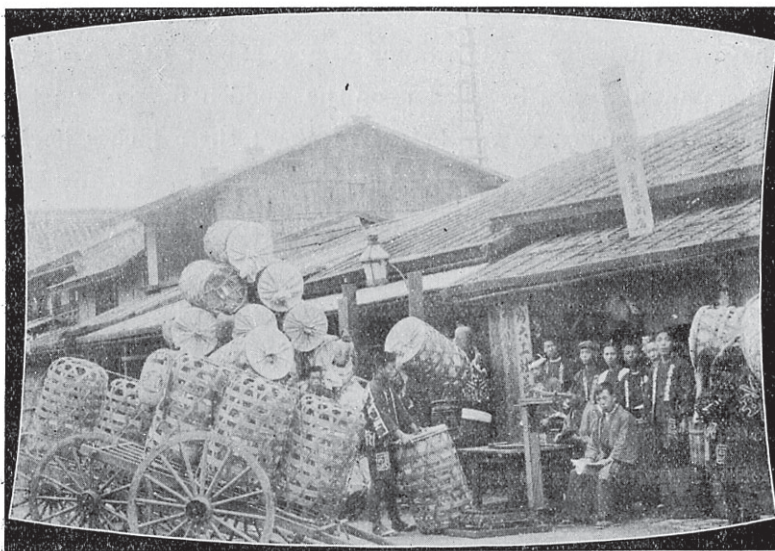
Among desiccators of the first kind we find *Nishigahara*, *Taniguchi* and *Nakahara* systems. The *Nishigahara* system is the most widely used among all of them, so that we will describe its principal parts below.

This system was designed in 1898 in the Tōkyō Sericultural Institute. The desiccating chamber is of brick work. The inner side is seven feet in height, an entrance is made on one side and a fire grate is opened on the front side which is connected with iron pipes of a  shape under the floor of the chamber. The ends of the iron pipes are connected with each other and open into a chimney above the fire grate. The external air is circulated into the chamber through the holes opened in the wall. The air thus passed in is warmed by the heated iron pipes. The floor of the chamber is made of an iron plate which we call the “*obstructing heat plate*.” On the iron plate, clean sand is placed one and half inches deep. On the wall that touches the behind part of the iron plate, innumerable small holes are opened which we call the “*radiation-hole*.” In the chamber a frame work is made for the reception of cocoon trays which are made as deep as the thickness of one and half cocoon. In the front part of the chamber, another plate is prepared to lead out the waste hot air, which is circulated in the chamber, through “*ejecting hole*” in the upper part of the wall to the chimney where the air leaves the chamber.

Among the second sort, *Ito*, *Minorigawa* and *American* systems are best known. The last one is most widely applied for operators upon a large scale.

### III. THE COCOONS.

It is hardly necessary to say that the utmost care must be taken in selecting the best cocoons, as the quality of the raw silk greatly depends upon them. Their handling, however, is



BUYING OF COCOONS.

not less important in obtaining a good grade of raw silk, as even the best cocoons are very often spoiled by improper handling. The method named below is considered to be a good practice.

#### A. Handling.

The live cocoons and the dry cocoons are handled in different ways, of which here we explain how to handle the live ones.

As soon as the live cocoons are taken in hand, they are classified, according to their quality and stored in proper places. Should they need stifling and drying, they must be placed in the drying room at once or, if necessary, forwarded to other places without delay.

When the live cocoons are to be left without treatment, they must be put in the cocoon trays, placed one over the other; or they must be piled upon the wooden floor or on the waterproof papers, to the height of about three inches in the former case and about one foot in the latter.

When a considerable amount of cocoons are to be stored for a comparatively long time, the room must be provided with shelves, on which the cocoon trays may be so placed that the air passes freely between the cocoons and prevents them from getting roasted.

The cocoons with dead worms inside, or discolored cocoons very often spoil the other good ones near them so that the bad must be picked out carefully and must at once undergo the process of stifling and reeling.

The live cocoons are to be classified, according to their quality: the lustre, the size, the thickness of the layers and the difference in their moulting periods being taken into consideration. Usually they are classified into two or three groups.

The cocoon crop comes in at a season very limited in its duration, so that when cocoons are wanted in any quantity, they must be purchased very quickly and stored with the greatest care possible. Very often the best kind of cocoons are handled improperly and the result is that they are invariably attacked



by maggots, or mould and the best grade of good silk will never be unwound from them.

When a large quantity of live cocoons are purchased, it is better to stifle and dry them first and then store them. But as quickness is essential in handling the live cocoons, they should preferably be stifled and dried at the same time and stored immediately afterwards.

Here we are going to explain how to stifle, dry and store the cocoons in which the drying machines, etc. will be touched upon at the same time.

#### B. Stifling.

The object of stifling consists of killing the pupae inside the cocoons before they appear as moths and at the same time, the killing of the maggots that are parasites in the silkworms.

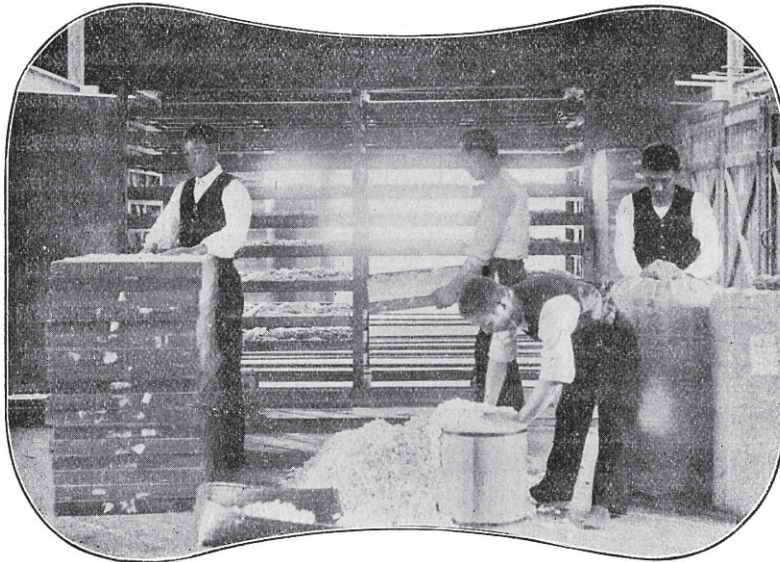
The proper time for stifling and the methods are as follows:

Stifling must be done immediately after the silkworm has spun the cocoon, that is, within seven days after the *mounting* in the case of the *spring* breed and five days in that of the *autumn* breed. If stifling is too early, it may kill the silkworm before he has finished spinning or even if it has already changed into a pupa by that time, its skin may be so delicate that it may easily break open during the treatment and spoil the inside of the cocoon. The damage from this cause is the greatest when the worms are just changing into pupae.

The methods of stifling are different but the essential thing is to keep the cocoon layers in a perfect condition and to get through with it as quickly and as economically as possible.



Three methods are generally used, i.e., “*steam-stifling*,” “*dry stifling*” and “*steam and dry stifling*.” In a wet country like Japan, the *dry stifling* is preferred to the others.



COCOON DRYING.

### C. Drying.

The object of drying is to drive out the moisture from the body of the pupa after stifling and to keep the characteristic nature of the cocoons for an unlimited period. Below are explained some methods of drying and also the care to be taken during the treatment.

There are two ways of drying, i.e., the natural and the artificial methods of drying. In the natural drying the cocoons are dried by the circulation of the air only, while in the artificial method they are dried by heat and consequently this saves a great deal of time.

Although the natural drying is very simple, it takes a longer time, a considerable amount of room, and more hands to do it, thus making the expense of drying much higher, and moreover it spoils the lustre of the thread and makes the reeling a good deal harder, moreover the cocoons are apt to be attacked by mould, not to speak of rats and mice and certain insects. To put an end to these difficulties, the system of artificial drying was devised.

The most essential part in drying is the circulation of the air in the drying chamber. When the air is saturated with the evaporations from the body of the pupa, it needs frequent changing, otherwise, the drying will never be done successfully. Although the time needed in drying greatly depends upon the temperature, it is not less affected by the humidity which in its turn is lessened greatly by the circulation of the air. So during the drying the air must be changed as much as the necessary temperature of the chamber permits.

#### D. Storing.

The object of storing is the keeping of the cocoons from getting wet again after drying and to keep them from the attacks of vermin such as rats, mice, insects, bacteria and vegetable mould.

The process and care necessary in storing are explained belows.

There are three ways of storing; by bagging, by canning and by storing in a warehouse.

- (a) Bagging: About one *koku*\* of the cocoons is put in a bag made of thick paper and then sealed and the bags are stored in piles in an ordinary storehouse. These bags are to be treated with *Shibu-kami* or waterproof paper to keep the moisture out.
- (b) Canning: About five *to*† of the cocoons are put into a tin or zinc can and the cover is put on tight and the cans are hermetically sealed. They are also stored in piles in a storehouse or in any kind of room.
- (c) Storing in a warehouse: The entire storehouse is divided into compartments of about one hundred forty-four or one hundred eighty square feet each. The four sides and the top and bottom are protected by zinc plates, the joints being soldered tightly and the bags are piled in good shape. The cocoons are put in paper or cotton bags and placed in the sections.

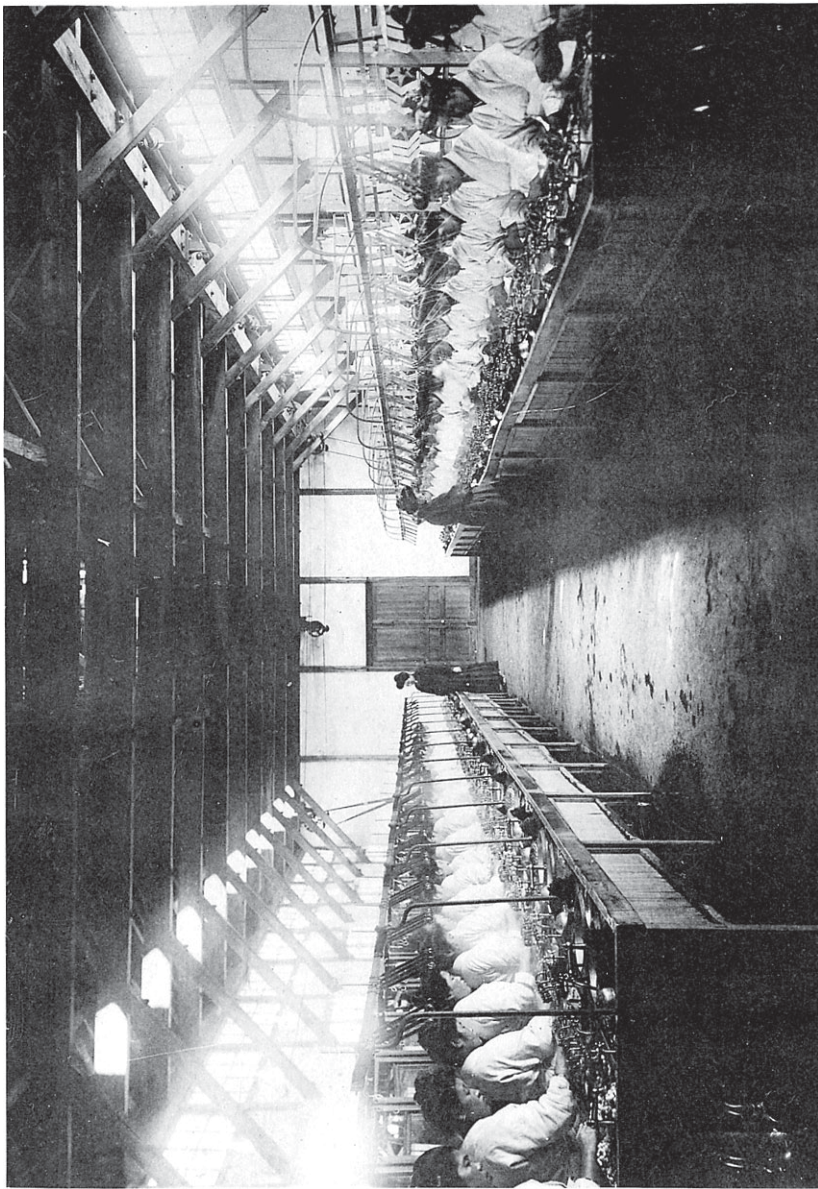
Special attention must be paid to the location of the storehouse, which must be built on dry soil and its construction must be tight enough to keep out the moisture. If possible the house should be built on a high place, otherwise it may be necessary to raise the ground by filling in so as to get rid of the dampness.

Cocoons must not be put in a storehouse before the final drying. When they are brought in, they must be dried until they reach the weight which perfectly dried cocoons ought to have.

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\* one *koku* of live cocoons weighs about 375 kilograms.

† one *to* of live cocoons weighs 3.75 kilograms.



RAW SILK REELING.



#### IV. REELING.

The process of drawing silk thread from the cocoons is called reeling. The amount of silk thread drawn differs more or less according to the quality of the cocoons, but usually we get about ten *momme* of silk thread from one *sho*\* of cocoons (about 270 to 280 cocoons) and a reeler reels about eighty *momme* of silk thread in a day of ten working hours.

##### A. Cooking.

With the object of softening and dissolving the gelatinous substance, *sericin*, in the outside layers of the silk thread, which makes them stick to each other, the cocoons are cooked.

The cocoons are so placed in a basin, filled with water to about eight-tenths of its depth, that they cover the surface of the water. The cooking is done by raising the temperature of water gradually, first wetting the surface of every cocoon in the basin by stirring. Care must be taken not to actually boil the water while cooking. The boiling of the water causes some of the cocoons to sink to the bottom and makes the reeling work somewhat difficult. Nor should the cocoons be stirred more than what is absolutely needed. Too much stirring is apt to cause much precipitation and also to waste much silk. If the cooking is over done, the thread obtained will be less in quantity and of a poor quality, although it makes the reeling easy, while under-cooking makes it hard to reel and the thread obtained will lack uniformity in titre and will be full of knots. The proper degree of cooking is

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\* one *sho* of live cocoons weighs 375 grams.

the most important thing to consider. Of course, it depends upon the quality and the conditions of the cocoons, but, as a general rule, the best time to stop cooking is when the cocoons begin to be a little gray and they give a smooth and agreeably elastic feeling to the fingers, and the filaments are easily drawn from the cocoons.

#### B. Discovering the Filaments.

In order to draw out the silk threads from the cocoons without getting them tangled up, it is necessary first to seek the ends of the threads. There are two ways of doing this, according to the conditions of the cocoons at the time. The first method is applied to the new cocoons, that is, the cocoons from which no thread has yet been drawn. The cooked cocoons are stirred by a dipper handle or a stick and the thread-ends that float out from the cocoons are picked up by contact with it. The second method is applied to the "*lost thread cocoons*," the thread-end of which has been lost by its breaking off, while the reeling process was going on. For this purpose we use a kind of broom, made of rice ears, whose upper ends spread apart while the lower ends are tied together, thus making a broom shape. The cocoon surface is swept over slowly with this broom and the filaments are thus picked up by contact with it. In this second method, the basin must be filled with water and after boiling the water the *lost thread cocoons* are put in the basin and as soon as the cocoons start to rise up to the surface of the water, the boiling should be stopped and that will be the time to begin discovering the lost threads.

When the thread-ends are found by the above methods, the next thing is to find the true thread-ends. To do this, take the filaments thus sought in the left hand and shake them up about seven or eight inches above the surface of the water and after two or three trials of a general character, make the final search very carefully. And then after the waste silk in the hand has been put aside, the true thread-ends are put together and hooked to the hanger.

#### C. Reeling.

The reeling is to be done immediately after the cooking and discovering the true thread-ends is over. The cocoons are thrown into the basin filled with water at a temperature of about 160° F..

A number of thread-ends drawn from the cocoons (the number being different according to the titre) are passed through a porcelain ring. After that, in the Kennel method, these threads are twisted after passing over the upper and lower rollers or, in the Chambon method, they are twisted first and then fastened to the reeling frame after passing through the guide rings and the hooks of the counter cranks. The thread is reeled up by revolving the frame. The speed of revolution must not be too fast, or the undoing of the cocoons can not keep up with the motion of the frame, which causes the thread to break off often, during the reeling and much time is wasted in fixing it, and moreover, this method gives the thread too many knots. But if the speed is too slow, a much less amount of thread is obtained, making the reeling more expensive and the thread drawn is slow in



drying which not only spoils its lustre, but causes the filaments to stick together. The number of the revolutions depends upon the size of the reeling frames, the number of thread-ends put together, the skill of the reelers, the quality of the cocoons, the titre of the thread, etc., but usually when an ordinary reeler is given ordinary cocoons and wants to reel the thread of the quality of fourteen denier with a *quadruple machine*, the proper revolutions per minute are believed to be 250 for small frames, and 100 for larger ones. The water must be changed from time to time during the reeling as dirty water spoils the lustre of the thread. In order to maintain the uniform titre of the thread, a new filament must be added every time the old one is about to end. To do this, pick up the cocoon to be added with the right hand, take hold of its thread-end with the left hand, drop the cocoon in question near the other cocoons from which the thread is being drawn, grasp the new thread-end with the right hand with its face down, hang the thread-end on the middle part of the first finger, and push it against the trunk thread with the first finger of the left hand, which is now placed outside of that of the right hand, cut the end of the new filament between the thumb of the left hand and the first finger of the right hand and at the same instant, turn the right hand face up, throw the cut end of the new filament against the trunk, about one inch below the porcelain ring and thus the addition of a new filament will be affected.

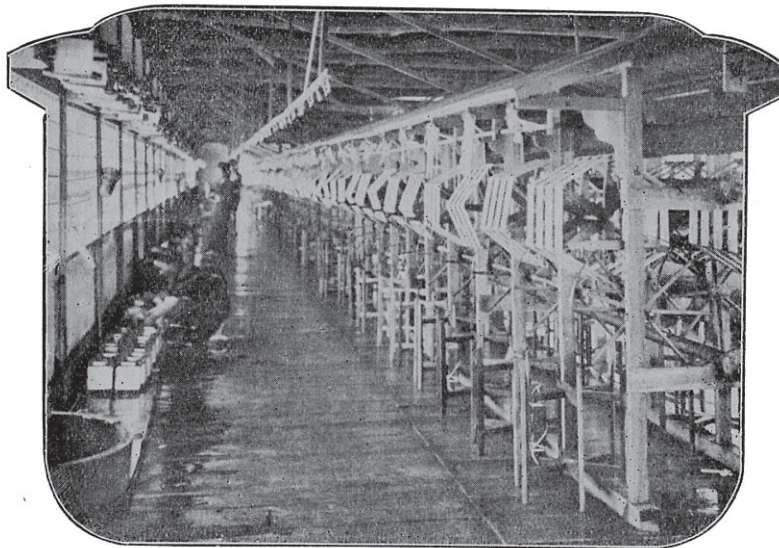
The number of twists taken gives not a little effect to the lustre and the sticking of the thread as well as to the working expenses. Too many twists make the work difficult

and lessen the strength of the thread, on the contrary, too few twists make the thread hard to dry, thus spoiling both the lustre and the adhesion of the filaments to each other. As a general rule, the proper number of twists for the thread of fourteen denier is about 300 in the Chambon method, and about 250 in the Kennel method, the length of a twist being about nine inches in the former and eight inches in the latter.

## V. FINISHING AND PACKING.

### A. Re-reeling.

The reeling machine usually used in Japan is what is called the *double reeling system*. So after the reeling has been done, it is necessary to re-reel it into the skeins of the standard length.



RE-REELING.

The way to do this is to moisten a pretty well dried frame with water and place it vertically on the table in front of the re-reeling machine, and then hang the thread-end on the glass hook of the counter crank, after passing it through the guide ring and reel up the thread on the new frame. Or, in another method, the frame is hung horizontally on the supports, placed about from six to nine feet in front of the re-reeling machine and about five feet above the floor. The former is called the "*vertical method*" and the latter the "*horizontal method*."

As the frame revolves, the thread is reeled up in a slanting direction on the frame by the action of the counter crank. Care is to be taken not to wet the entire frame before re-reeling, but just the corners. The revolution should be about 120 to 130 per minute and must be kept uniform during the re-reeling. Reel about ten *monme* of the thread on one frame. Usually a reeling frame of about five feet in the entire outside measure used, so that four skeins of silk thread are reeled on one is frame.

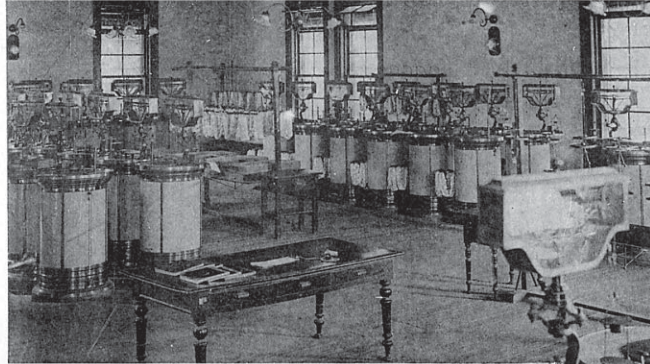
#### B. Drying.

When the thread is re-reeled, it is not easily taken off the frame, on account of too much moisture being contained in it. The threads are usually put in a special drying room before being taken off the frame, so as to dry them to contain just the amount of moisture, that is officially approved.

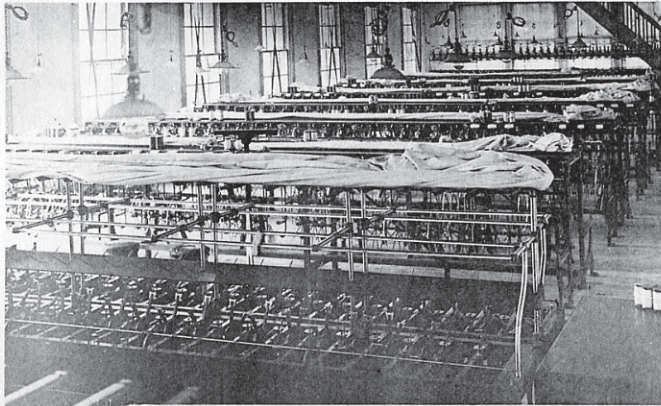
#### C. Inspection.

The quality of the raw silk (lustre, knots, strength, etc.) is affected by many causes, among which the principal ones

1.



2.



3.



### CONDITIONING OF RAW SILK.

1. CONDITIONING OVENS.
2. MACHINES FOR TESTING THE SIZES AND THE WINDING.
3. MACHINES FOR TESTING THE CLEANLINESS.

are the quality and selection of the cocoons, the method of stiffing and storing, the quality of the water used in cooking, etc.

The uniformity in titre depends greatly upon the skill of the reelers, the number of the revolutions of the reeling machine and the kind of machine used.

The lustre is inspected in a dark room specially made for this purpose, to which the light is admitted from the north window only, the other three sides being painted black to prevent the dimming of the reflection. Different manufacturers give different numbers of classes, but usually silk threads are classified into four or five grades according to their lustre. The silk of the fourth or fifth class is usually consumed by the local customers and is not exported abroad.

To inspect the titre, take about two hundred winds of the silk thread of the ten *momme* grade on a standard frame and after drying measure it with a special scale for measuring the titre. If it is detected that it differs by over three denier from what is wanted it is rejected for export purposes.

The inspection of knots is made at the same time with the thread reeled for measuring the titre, by looking over the thread on the frame. If it contains too many knots, rejection must follow.

The strength is tested by the serimetre, every time the silk thread is taken from the different kinds of cocoons. If the test falls short of the required strength, the silk thread must be rejected.



D. Dressing.

To make the handling and shipping easy the raw silk must be properly dressed. The first thing is to mark both ends of the thread on the skein, so as to make it easy to find them when re-reeling is needed. For this purpose, there are three ways in common use.



FINISHING OF RAW SILK.

- (a) *Sukui-dome*. Only the outside end is fastened at the middle of the skein with a few threads. The objection to this method is that it is pretty hard to find the thread-end and especially when the first end is lost, it is impossible to find the other end.
- (b) *Wa-dome*. Both ends are folded together four or five times and wound round the skein. In this method the

thread-ends thus fixed are apt to be broken while handling.

- (c) *Wari-dome*. Both ends are folded together four or five times, twisted and pushed into the skein and fastened at one end of the skein after winding it around. This method seems to be most convenient for finding the thread-ends and they will not be easily broken while handling. The proper position for fastening the thread ends is between the corner and the middle part of the frame.

Two pieces of cotton yarn are used to keep the form of the skein. They are usually No. 42 *Sarashi-futako* threads and are sewed with five stitches across the skein and with five more in the opposite direction, i.e., about an half from the fastened thread-ends.

After the thread-ends are fastened, the skein is ready to be dried and dressed.

There are several ways of dressing up the raw silk skeins.

- (a) *Teppō-zukuri* and *Sage-zukuri*. These two are very awkward to handle and the threads are easily tangled up, so they are not used at present.
- (b) *Shimada-zukuri*. It has the same trouble as the above mentioned, so it is seldom used.
- (c) *Orikaeshi-zukuri*. This method of dressing is used in Miyagi and Fukushima prefectures, and some of the export silk is dressed in this style. In this, a stick is passed through the ends of two skeins and supported by a pair of columns of about one-eighth of an inch



square and three inches high, standing on a board. The skeins are stretched out beyond another pair of columns on the same board and another stick is placed on the skein and the skein is folded on the stick. Then the stick at the other end of the skein is pushed into the first end and turned so to give a twist to the skein. After five skeins were dressed in this way, they are tied together with cotton threads. Even in this method, the threads are very often tangled up while they are being handled.

(d) *Nezi-zukuri*. This is the one in common use and the greater part of the export silk is dressed in this style.

Two iron needles are bent like fish hooks and fastened to a column by first attaching them to a thick board. Two skeins of the raw silk are placed side by side and a pair of bamboo sticks are passed through both ends of the skeins. The stick at one end is rested on the hooks on the column and the skeins are given some five twists by turning the stick at the other end. Then they are folded once and twisted again. Then the end held by the hand is forced into the other end. Care must be taken to give the proper twists. Usually in a skein of eighteen to nineteen *momme* the first twists are five and the last ones number three. After being thus dressed up, a brass needle is passed through the ends of six of these bundles, placed side by side. And the five of these are placed one over the other. Covers are put on and the whole mass is placed under a screw press and pressed down to a height of about four inches. After that the package is fastened by

threads at three places and put in a tough and smooth paper cover.

#### E. Packing for Shipment.

To pack the raw silk for the purpose protecting it from damage and making the handling easy, we usually wrap it in *Shibu-kami*, a sort of water-proof paper and then put it in oil paper covers. Fifteen or sixteen of these packages are placed in a box and the cover is put on tightly so as to keep out the moisture and insects. After the marks, numbers, and the address of both parties, etc., have been put on, ropes are put round the whole to prevent damage and then a straw mat is placed over it, and it is tied with some more strong ropes. The boxes used for this purpose are usually made of the three-quarters of an inch board of Japanese cedar or Japanese cypress. To prevent damages from friction, the inside is planed smoothly and one part of the outside of the box is planed to unite upon it the necessary formations. The board of the box must be fitted tightly and kept from breaking by the use of cross pieces on the outside.

The above is the way the local manufacturers ship their raw silk to Yokohama. For export, a little different way of packing is used. Twenty eight to thirty two packages of raw silk are put in a cloth bag and tied with ropes at two places. After the *Shibu-kami*, toughened paper and oiled papers have been used, they are again wrapped in two sheets of mats. The mats are sewed together and strong ropes are tied round them in every direction. And then the marks, numbers, addresses are written on the cover.

VI. WASTE SILK.

A. Chappy Silk.

While searching for the true thread-ends, we get the thread from the coarse, loose outside layers surrounding the cocoon. This unreelable part is dried up and used as the raw material for silk spinning.

B. Floss.

This substance we get by stretching the unreelable part above mentioned before drying. Usually it is two and a half feet long. When it is about six feet long, we call it especially the "*long floss*." To make this, stretch we take the wet chappy silk and tie it round two pillars of about a half inch square standing on a board. About twenty *momme* are taken off at one time, and dried in the sunshine. Twenty to thirty of these are put into a bundle and thirty of these bundles are made into a package. This floss is one of the best raw materials for silk spinning.

C. "Dohyō."

The innermost layers of the cocoons are not fit for reeling. These are dried and separated from the body of the pupa and used as a raw material for silk spinning.

D. "Furi."

To produce this take the innermost layers of the cocoons and dip them in water and separate the cocoon layer from the body of the pupa by stirring them with a bamboo brush. The

cocoon layers are washed in water several times and dried in the sun and thus we get what we call *Furi*. This also gives a good raw material for silk spinning.

E. The Snapped Unreelable Part of the Cocoons.

When we take the unreelable parts from the inner layers of the cocoons and boil them in water with the addition of some soda and treat them as mentioned in the previous article, then we get cocoon layers softened like silk cotton. This is also a good raw material for silk spinning.



## CHAPTER VIII.

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### SALES OF RAW SILK.

#### I. "DZIYARI."

The sale of raw silk for home consumption is termed *Dziyari*. This is carried on either by direct dealing with silk producers, or through the medium of brokers. The raw silk used for home consumption is usually of an inferior quality or such silk as is suitable for the export trade owing to the amount produced being too insignificant, though it is of good quality. It may, however, be noted that the recent increase of the export of *Habutae* has caused a greater demand for raw silk for home consumption.

#### II. "HAMA-URI."

The raw silk destined for export is forwarded to Yokohama, the export market for silk, where it is sold off to the export merchants through the medium of the raw silk dealer. This kind of sale is termed *Hama-uri*, as it is effected at Yokohama. The greater part of the raw silk produced in Japan is sold off by this process.

##### A. The Process of Consignment.

The consignment of raw silk from the local silk raisers to the raw silk dealers at Yokohama is performed in two different ways; one is by the method of unlimited consignment, the other

that of limited consignment. In the former method no restrictive condition is put on the consignee as to the mode of sale, quotation, or the time of such sale, while in the latter case, the quotation, time, and mode of sale must be strictly followed according to the instructions of the consignor. In this case, it is customary for the consignor to take from the raw silk dealer a note of consent to the conditions agreed upon, so that the consignor may be assured that the sale shall be executed in accordance with his desires. This method, however, has its defects in this point that the consignee can not exercise his own discretion, as in the case of unlimited consignment, as to the situation of the market and the most suitable time for effecting a sale, and naturally lacks the activity which is the most important factor in all business transactions.

#### B. The Process of Forwarding Raw Silk.

When any local silk producer wishes to send his silk to Yokohama for sale, he must first have his silk packed properly in cases, each containing some nine *kwan*, and have it forwarded by the transporter to any trustworthy raw silk dealer at Yokohama. In case the producer desires to get the money for the silk paid at once, he can do so by negotiating a documentary bill to the bank in his locality, to which he has to present the bill of lading together with the insurance policy on his goods. Though the value allowed for the documentary bill varies somewhat according to the credit the producer enjoys, the usual rate is 70 per cent. of the price of the goods to be forwarded. This having been done, the producer must send to the raw silk dealer the whole set of the documents, while the bank notifies its

correspondent bank at Yokohama of the completion of this process. Upon this, the raw silk dealer goes to the latter bank and receives the goods that have arrived there against the bill of lading and the documentary bill, after paying the sum of money stated in the documentary bill and its interest. When the goods have been identified with those stated in the bill of lading, the raw silk dealer notifies the owner of the goods of the arrival of the goods, and then commences the process of selling the same at once. In case the goods received should prove defective or damaged, he must notify his consignor to that effect without any unnecessary delay.

#### C. The Process of Executing a Sale.

In selling raw silk to the exporter, the raw silk dealer sends his clerk to the exporter's or the exporter himself may come to the raw silk dealer's house, and make up some agreement there. When such an agreement has been arrived at, the raw silk dealer takes a few books of the silk to the exporter's as specimens, which are accordingly put under examination, and if they prove satisfactory, the exporter makes a provisional contract of purchase, fixing the price and quantity required. Upon this, both parties clap their hands by way of swearing to keep the contract. This is termed *Te-awase* (clapping hands). This done, the raw silk dealer sends the whole of the goods to the exporter's warehouse against the warrant. Then the exporter examines the goods comparing the same with the specimens offered. After the goods have passed this examination, the real contract is made, and then after weighing the whole of the goods, the exporter pays out the



price. Should the goods, however, prove inferior or defective upon examination, the contract may be cancelled and the goods be set back to the raw silk dealer, or be bought with some deduction on the price settled in the provisional contract, or in some cases, as is often done, the sale may be executed after discarding the defective portion.

#### D. The Examination of Raw Silk.

The examination of raw silk is chiefly carried on macroscopically, but mechanical examinations are often practiced such as the following operations :—

- (1) Two twisted skeins are taken out of each case for each test.
- (2) Twenty filaments out of each skein are put in test for size.
- (3) The amount of silk wound and the number of breaks made in an hour should be examined.
- (4) Tenacity and elasticity are put in test.
- (5) The number of knots and knobs are examined.

In order to aim at accuracy in the examination and quickness in the transaction, the mechanical examination is generally requested to the Silk Conditioning House, and the raw silk dealer presents the certificate of such examination received beforehand from the Conditioning House in dealing with the exporter, or asks the Conditioning House for the examination of the raw silk after the provisional contract has been made.

#### E. Customs and Usages in Dealing.

Raw silk is usually sold by its net weight, but should it be observed to contain too much moisture, one half of the whole of

the goods is selected in the presence of both the exporter and the dealer, and sent over to the Conditioning House for examination. If the difference between the net and the conditioned weight be over 2 per cent., the dealing weight of the silk is determined by deducting the difference. The weighing at the actual delivery of the goods is termed *Kwan-kwan* (weighing). All the tare (basket, calico bag, wrapper, etc.) must be deducted from the gross weight according to their materials, and in the case of the cord used for making a book a deduction of 0.75 *kin* shall be made, any fraction below a quarter *kin* being cut off. A weighing charge of fifty *sen* per case is due to the weigher.

In the dealings of raw silk, no credit is allowed, and the goods are always delivered against cash. There is another mode of buying raw silk called the "*preliminary contract*," in which the exporter makes a *preliminary contract* of purchase with local silk producers through the medium of the raw silk dealers. The quality of raw silk, its price, and the date of delivery are all specified in this contract, and the contractors are bound to follow the terms without any variation whatever on account of the current price of the goods at the time of delivery.

#### F. Charges for Effecting a Sale.

The sale of raw silk for export at Yokohama requires these charges:—

raw silk	{	1. 1. 5% of the selling price	for selling commission.
		2. 0.03 % „ „	for daily interest on documentary bill.
		3. ¥0.12 per bale	for carriage.
		4. ¥0.50 per bale	for weighing charges.

}	refuse silk	1. 3.5% of the selling price	for selling commission.
		2. ¥0.15 per bale	for carriage.
		3. ¥0.275 per bale	for weighing charges.
		4. ¥0.075 per bale a month	for storage.

## G. Exporters and Dealers of Raw Silk.

Dealers of raw silk at Yokohama are as follows:—

Name of Company.	Trade mark.	Dealer.
Hara Gōmei Kaisha.	正	Tomitarō Hara.
Gōmei Kaisha Mogi & Co.	免	Yasuhei Mogi.
Ono & Co.	合	Mitsukage Ono.
Shibusawa & Co.	⊕	Sakutarō Shibusawa.
Yokohama Branch of the Shinyei Kabushiki Kaisha.	⊖	Katarō Okumura, the Ciefe of the Branch.
Gōmei Kaisha Tanaka & Co.	⊗	Shinshichi Tanaka.
Watanabe & Co.	⊘	Bunshichi Watanabe.
Ogawa & Co.	尔	Katsusaburō Ogawa.
Imai & Co.	三	Dirosaburō Imai.
Kimura & Co.	区	Riuyemon Kimura.
Kaneko & Co.	命	Masakichi Kaneko.
Itō & Co.	①	Kinbei Itō.
Gōmei Kaisha Kojima & Co.	⊙	Genzaburō Kojima.
Yajima & Co.	⊚	Zenshichi Yajima.
Ōtani & Co.	⊛	Kahei Ōtani.
Wakao & Co.	命	Ikuzō Wakao.
Yamada & Co.	⊜	Komakichi Yamada.
Inouye & Co.	命	Sadakichi Inouye.
Nakazawa & Co.	今	Gosaburō Nakazawa.
Sasamoto & Co.	全	Toyojirō Sasamoto.
Okada & Co.	欠	Shinbei Okada.

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Name of Company.	Trade mark.	Dealer.
Abe Gōmei Kaisha	卍	Taichi Abe.
Kakuwa & Co.	⊗	Zensuke Kakuwa.
Anzai Gōmei Kaisha	Ⓛ	Tokubei Anzai.
Iwakura & Co.	卍	Minoru Iwakura.
Ichihara & Co.	⊕	Matashichi Ichihara.

Exporters at Yokohama are as follows :—

Vivanti Bros.  
Siber Wolff & Co.  
Sulzer Rudolph & Co.  
F. Strähler & Co.  
L. Mottet.  
Jardine Matheson & Co.  
Jewett & Bent.  
Siber & Co.  
Pila & Co.  
Henri Pernardin & Co.  
Vavier & Co.  
Cornes & Co.  
Otto Streuli.  
Varenne & Co.  
Carlowitz & Co.  
Boyer Mazet Guilliee & Co.  
C. Eymard & Co.  
Nabholz & Co.  
P. Dourille.  
Herbert Dent & Co.  
Montel & Co.

R. Schmidt Scharf & Co.  
Langin & Co.  
Yokohama Branch of Mitsui Bussan Gōmei Kaisha.  
Yokohama Kiito Gōmei Kaisha.  
Dōshin Kabushiki Kaisha.  
Hara Gōmei Kaisha.

### III. DIRECT EXPORT.

The raw silk raised by local silk producers is sometimes exported through the medium of direct exporters at Yokohama.

#### A. The Modes of Direct Export.

The direct export of raw silk is executed by means of (1) consignment and (2) exportation to fill orders. In the former case, the producer entrusts the sale of his silk to the direct exporter fixing the destination of such export. In the latter, the producer sends abroad through the direct exporter his silk reeled in accordance with the order placed previously in his hand.

#### B. The Process of Shipping.

In the direct export of raw silk, the silk producer must first of all send his silk packed properly to the direct exporter at Yokohama stating its destination, who will accordingly examine the goods received against the invoice, and if he finds the goods in proper condition, he will notify the producer of their arrival. A close examination is then carried into operation on the quality of the silk, and an invoice is drawn up stating the

quality, quantity, and cost price, which is to be sent over with the goods to the branch offices of the direct exporter in America or France, and a duplicate of the invoice should also be sent to the producer for reference. The silk is so packed as to weigh some 150 pounds per case, classified according to its quality. In case the silk is to be exported to America, from one to four books together with each invoice, must be sent in a separate bale as samples. The branch offices in America or France receive these goods and execute the sale properly.

#### C. Documentary Bills and Exporting Charges.

In drawing a documentary bill, the amount usually allowed for the silk intended for direct export is 80% of the current price of the silk plus the exporting charges. The silk that is sent abroad as samples is not included in the documentary bill. The branch office abroad is notified of this amount after it has been converted into American or French currency according to the current rate of exchange of the bill four or six months after sight. At the completion of the sale, the branch office settles the accounts after deducting the value of the bill.

The charges for exporting silk to America and France are roughly estimated as follows:—

to America.	{	Packing and Shipping charges	¥2.00 per bale.
		Freight	\$ 6.00 per 100 lbs. gross.
		Charge for consular certificate	¥5.02 per lot.
		Marine Insurance premium	¥0.50 per ¥100.

to France.	{	Packing and Shipping charges	¥2.00	per bale.
		Fregiht	¥8.00—9.00	per 112 lbs. gross.
		Marine Insurance premium	¥0.75	per ¥100.

#### D. Collection of Prices and Selling Charges.

As sale on credit is customary in the markets of America and France, the branch office of the direct exporter executes the immediate collection of drafts drawn at such sale, since the direct exporter will be held responsible for all losses that may be caused by the bankruptcy of the purchaser, or by unforeseen and unavoidable accidents. After collection has been finished, the account sale is mailed over to the head office, which will accordingly settle the account with his consignor.

The selling charges in America are as follows:—

Charges <i>Ad varolem</i>	5%	of the selling price.
Direct exporter's commission	3%	„ „
Insurance against purchaser's bankruptcy		
	1.5%	„ „
Marine insurance premium	0.5%	„ „

Charges according to weight      3 cents per pound.  
(storage, carriage, storing charges,  
fire insurance premium, etc.)

The selling charges in France are as follows:—

Direct exporter's commission	3 %	of the selling price.
Broker's commission premium	0.5%	„ „
Fire Insurance premium	0.1%	„ „



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Marine insurance premium	0.5% on <i>insured</i> value.
Storage, carriage, storing charges, wires, postage, and testing	Fcs. 15 per bale.

E. Direct Exporters at Yokohama.

- (1) Yokohama Branch of the Mitsui Bussan Kaisha.
- (2) Yokohama Kiito Gōmei Kaisha.
- (3) Yokohama Dōshin Kabushiki Kaisha.
- (4) Hara Gōmei Kaisha.

F. Amount of our Exported Raw Silk and its Destination.

The destination of our exported raw silk and refuse silk,  
and its amount and value are shown below:—

## Amount of Exported Raw Silk.

Year.	For United States of America. Kg.	For France. Kg.	For Italy. Kg.	For Great Britain. Kg.	For Canada. Kg.	For Others. Kg.	Total. Kg.
1903	2,751,016	992,417	582,787	2,011	2,596	58,492	4,389,319
1904	3,937,508	1,138,489	701,909	14,913	1,061	1,270	5,795,150
1905	3,242,751	676,427	415,450	121	4,944	5,447	4,345,140
1906	4,407,023	1,260,814	514,861	1,914	44,294	1,258	6,230,164
1907	3,804,661	1,219,670	562,396	260	1,523	24,082	5,612,592
Average	3,628,592	1,057,563	565,485	3,844	10,883	18,110	5,284,477

## Value of Exported Raw Silk.

Year.	For United States of America. Yen.	For France. Yen.	For Italy. Yen.	For Great Britain. Yen.	For Canada. Yen.	For Others. Yen.	Total. Yen.
1903	47,018,559	16,691,055	9,678,010	34,491	41,663	965,129	74,428,907
1904	60,747,832	17,090,337	10,639,184	227,096	17,127	19,126	88,740,762
1905	53,825,893	10,999,503	6,843,846	1,267	80,746	92,500	71,843,755
1906	78,392,085	22,085,916	9,094,696	34,032	813,031	23,040	110,442,800
1907	79,759,893	25,243,007	11,378,827	5,650	30,756	470,494	116,888,627
Average	63,948,852	18,421,964	9,526,913	60,507	196,665	314,058	92,468,958

**Amount of Exported Waste Silk.**

Year.	For United States of America.	For France.	For Italy.	For Great Britain.	For Switzerland.	For Austro-Hungary.	For Hong-kong.	For British India.	For Others.	Total.
	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
1903	70 665	2,549,520	230,743	358,278	78,981	177,943	95,040	3	937	3,562,120
1904	77,212	1,940,302	358,946	325,055	300,670	111,422	42,103	15,503	1,398	3,172,611
1905	42,217	3,050,042	273,446	314,883	322	56,199	131,728	33,824	60	3,902,721
1906	66,337	2,262,953	469,694	242,770	724	107,746	161,635	42,712	21,900	3,376,471
1907	54,532	2,510,310	572,371	58,298	21,408	139,455	—	25,960	7,738	3,390,672
Average	62,192	2,462,626	381,040	195,367	80,428	118,553	86,101	23,600	64,662	3,474,769

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**Value of Exported Waste Silk.**

Year.	For United States of America.	For France.	For Italy.	For Great Britain.	For Switzerland.	For Austro-Hungary.	For Hong-kong.	For British India.	For Others.	Total.
	Yen.	Yen.	Yen.	Yen.	Yen.	Yen.	Yen.	Yen.	Yen.	Yen.
1903	200,047	5,372,044	594,529	79,963	255,844	387,215	65,905	3	1,771	6,957,321
1904	219,308	3,176,960	737,552	628,497	566,186	153,953	72,062	33,290	2,921	5,590,729
1905	130,759	4,923,729	463,591	455,271	600	81,656	118,847	58,726	75	6,233,164
1906	177,289	3,869,051	841,423	458,340	3,307	183,656	153,321	83,858	44,904	5,815,149
1907	209,627	4,623,056	877,178	137,966	43,699	290,339	—	53,211	7,329	6,243,305
Average	187,406	4,393,148	702,837	352,007	173,927	219,364	82,027	45,818	11,400	6,167,934

## CHAPTER IX.

### WILD SILKWORMS.

In Japan we rear not only the domestic silkworm (*Bombyx mori* L.) but two species of wild ones. There are several known species of silkworms found wild in our country. The *Kuwako* (*Bombyx mandarina* Moore) which has the same ancestor with the *Bombyx mori*, *Yamamai* (*Antherea yamamai* Guér-Mén) *Sakusan* (*Antherea pernyi* Guér-Mén), *Shōtzu* (*Caligula japonica* Moore), and *Chosan* (*Attacus cynthia* Drury). Among which we will sketch in the following pages about those which have practical use.

#### 1. *Antherea yamamai* Guér-Mén.

*Antherea yamamai* is an indigenous silkworm in our country. Over one thousand years ago the silkworm was already described, from which it is thought that the silkworm has been known from the most ancient times. At the present time silkworms may be found in the forests of every district.

Their feeding was undertaken for the first time about ninety years ago in the prefecture of Nagano. Afterwards they were introduced into the neighboring districts. About forty years ago, their rearing was encouraged by the Financial Department, and along with the general rising of various other industries among the people, the rearing became widely practiced in every district spreading over the boundary of the prefecture of Nagano. Especially at Kita-azumi-gōri, Nagano,

a guild called the Matsukawa-gumi has been organized to carry on the enterprise energetically. But the attempt ended in failure owing to the difficulties of the work of rearing silkworms and people became fully aware of the disadvantages of the undertaking, according to the circumstances of the districts. At present the limit of the feeding sphere has become narrower, and the wild silkworms seem to be almost the special product of Minami-azumi-gōri and Kita-azumi-gōri, in Nagano prefecture. Although they are reared to some extent in other prefectures, such as Ibaragi and Chiba, yet the business is practiced by all the farming people of Nagano.

According to the latest investigations, the number of the breeding houses in the prefecture of Nagano, is 216 and in the others about forty. The yield of the cocoons varies greatly year by year and the number collected in 1907 was some 8,435,800; their price also varies yearly and in the same year that of the superior class of 1,000 cocoons was about five *yen*.

The bush of *Quercus serrata* Thumb. is the best of all as a feeding bush. Some of the other trees and shrubs on which the worms may feed are the *Quercus glandulifera* Bl., oak (*Quercus dentata*), chestnut (*Castanea vulgaris*) and others of the *Quercus* species, but the cocoons of the worms which are reared with the leaves of these plants have thin and weak layers.

For the plantation of the *Quercus serrata*, a coarse sandy place along a stream or a hill side facing towards the south east, is preferable. The sprouts should be prepared beforehand by the seedling process. The seeds gathered in the autumn, are

immersed in water for one or two days, then, they are sown either soon or at the close of March in the next spring after having been preserved in the earth, mixed with fine sand. Thus they germinate in May. The young plants, thus grown, are dug out in the following spring and transplanted. In the second year the beds are changed and the young plants are cultivated as vigorously as possible. They are transplanted in the third year to the farms for permanent plantation, and are planted in the ground in the proportion of one in five or six square feet. Afterwards they are so managed that the height of the stems as well as the branches will be six feet and that they may produce as many lateral branches as possible and if over grown, they should be cut off properly. Then weeding is practiced from time to time. Thus when after about ten years, the vigour of the trees may be impaired, then, they are cut down from their bases and new shoots are made to come out from their stumps.

The moths come forth from the latter part of August to the former part of September and lay eggs. For the preparing of seed, the cocoons which have a healthy pupa and thick layers, are selected and placed in layers with a silky pedicel upward in a shallow box. The moths usually emerge at the end of thirty or forty days after they have entered into the pupal condition. Their wings are a bright yellow, a brown transverse line runs through them and a large transparent eye spot lies on both the fore and hind wings. Their length is 30 mm. (male) and 37 mm. (female). One or two pairs of female and male moths are transferred in a small bamboo basket within which they are allowed to couple and lay eggs. The baskets have a





*Antheraea yamamai* GUÉR-MÉN.



bell shape, a diameter of about eight inches, a height of about ten inches and the width of the mesh is about one inch. After a while, the female moths will deposit their eggs on the outside of the basket, by putting their posterior parts out of the meshes. When the egg-laying process is finished, the moths are removed, and the baskets bearing the eggs, are hung down by means of string in a cool place, protected from sunshine, rain and dew. In January of the next year, the eggs are scratched off from the basket with the fingers and washed with clean water, then, they are spread over a wooden frame with a bottom made of hemp-cloth and are kept hanging down in an airy place. The eggs are nearly round and are of a dark grayish brown color. Before they are hatched out, the eggs are pasted on the middle of a long piece of paper in the proportion of ten to fifteen grains per each piece, in order to bind them around the branches of the food producing trees. This operation is practiced when the first worms are hatched. A tree which spreads its branches about six feet square, receives some five pieces of the papers. Hatched larva distribute themselves over every part of the food trees and grow by eating the leaves. The newly hatched larva has a dull ochre brown head and light yellow body but after being full grown, the color of the body changes into green and the subdorsal part of each segment is covered very coarsely with yellow hairs.

The number of the days during each age of development is as follows :—

The first age	...	...	...	...	...	...	15 days
The second age	..	...	...	...	...	...	10 „
The third age	...	...	...	...	...	...	10 „

The fourth age ... ..	10 days
The fifth age ... ..	15 „
Total ... ..	60 „

On account of the fact that the worms are fed in the open fields, the climate has so great an influence upon them that in the rainy years, many of them will die and moreover their cocoons have thin layers; in the years of drought the cocoons have small sizes. Although these climatical influences are not capable of being avoided, the rearers should notice the following points, while they are feeding the worms; whether they are in want of food, owing to the incomplete growth of the leaves or the worms have eaten them all up, by gathering together in one place, as it sometimes happens. The rearers should endeavour to keep the worms and the leaves in the proper proportion, looking after the food plants from time to time.

There are several enemies to attack the worms: sparrows, Manchuria great tits, cuckoos, field mice, squirrels, tree frogs, spiders, wasps, ants, etc. For the protection against these enemies a kind of scarecows is made here and there, a gun with a blank cartridge is fired off occasionally, trenches are dug out round the food trees, or the weeds under the trees are got rid of.

The mature worms finish spinning their cocoons in one or two days, then, after three or four days the cocoons are collected. On account of the fact that they are colored so green and are so wrapped up with leaves, that they are often overlooked, it is difficult to gather them. In general, a skilful gatherer may collect five hundred cocoons in one day. Seventy per cent. of the total amount of worms distributed, is usually lost during the feeding season, so that about seventy thousand

seed-grains are distributed among the food bushes in one *cho*\*, but the crop is only about twenty thousand cocoons.

The cocoons are of a bright green color and oval. Their length is 46 mm., their breadth 23 mm. on the average. The average length of the filaments taken out by unwinding a single cocoon is 520 metres and the average titre 5.41 denier. The thickness of the filaments of the cocoons is greatest in the outside layer and is gradually reduced in the innermost layers.

For reeling the cocoons have been stifled beforehand by steam or heat, and then have been boiled. After these operations, they are reeled in the same way as we do in the case of the cocoons of the domestic silkworms. On account of the imperfect unwinding of the filaments, owing to their sticking to each other by means of a gummy substance, to the cooking and reeling water should be added small pieces of Marseilles soap. About eight *momme* of raw silk may be reeled on the average from a hundred cocoons. The produced raw silk is light green and strong, its luster is fine.

The product is partly made into cloth in the district that has produced it, and is partly used to comply with the demands from other parts. In 1907, 1090 kilograms of raw silk was sent into Gifu, Tochigi, Niigata, and Aichi prefectures from the Minami-azumi districts of Nagano. Its market price varies sometimes, but at present one *kwan* of it costs about 65 *yen*.

## 2. *Antherea pernyi* Guér-Mén.

A. *pernyi* originated in China, where it seems to have been reared in the north part from the most ancient times, and

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\* one *cho* = 245 acres.



*Anthrea pernyi* GUÉR-MÉN.



was imported into Japan at first in 1875. At that time the worms were experimentally reared at Sapporo in the Hokkaidō, and in Tōkyō. They excited the curiosity of the people and were gradually propagated into every district, but many of the rearers had no experience in the matter and reared them only for their own amusement. For these reasons, almost all of the rearers failed and were compelled to stop the work of feeding silkworms. The districts of the feeding of the worms became narrower and narrower.

The rearing of the worms began in 1880 in the prefecture of Nagano, where the people fed them in the same way as had been used in the rearing of *A. yamamai*, and now Minami-azumi-gōri and Kita-azumi-gōri in the same prefecture are the most important among all the districts for the feeding of these worms. Besides these districts, the rearing is practiced to some limited extent in various places in the prefectures of Ibaragi, Tochigi and the Hokkaidō.

According to the investigations carried on in, 1907, the number of the houses of the rearers of the *spring* breed is 170, the crop amounts to 5,495,600 cocoons and these of the *autumn* breed to 97, the crop being some 745,000 cocoons. The yield of the other districts is so small that it is not necessary to describe it here.

As food plants of the worms, *Q. serrata* Thumb. is preferable. They may be fed with other plants, *Q. glandulifera* Bl., *Q. dentata*, *Q. glanca* Thumb., *Forma serica*, *Q. glabara*, *Castanea vulgaris*, etc., but they produce inferior cocoons, when they are reared with these leaves. The food plants are similarly managed and cultivated as in the former case.

*A. pernyi* appears twice a year. The spring breed comes forth in the latter part of May, matures after about 50 days and spins a cocoon. The *autumn* breed emerges in the middle of August and spins a cocoon after about 40 days.

The cycle is shown as follows :—

The spring breed.

The number of the days of the first age	6	days.
„ „	the second age	7 „
„ „	the third age	9 „
„ „	the fourth age	13 „
„ „	the fifth age	15 „
	Total	50 „

The moths appear at the end of 25 days after they have become pupae, couple and lay eggs which will hatch after about two weeks.

The autumn breed.

The number of the days of the first age	4	days.
„ „	the second age	5 „
„ „	the third age	6 „
„ „	the fourth age	10 „
„ „	the fifth age	14 „
	Total	39 „

The worms pass the winter in the pupal state and the moths appear in the early part of May of the next year and deposit eggs after coupling. The wings of the moths are a yellowish brown and each of them have a transparent, circular

spot surrounding which is a border of red and black lines. The body-length of the male is 32 mm., that of the female some 40 mm..

For the selection of the breeding stock, cocoons should be thoroughly differentiated after they are gathered. The cocoons for the *spring* breed are placed side by side in a basket which is put away during the winter and the early spring in a well ventilated and rather warm place, kept away from the direct sunshine. When the moths appear, each one or two pairs of them are then transferred into such a bamboo basket as that we use in case of *A. yamamai*, within which each pair is allowed to couple and lay eggs. The latter are scratched off from the basket with the fingers after two weeks. The *autumn* breed deposits eggs in the same way which are scratched off after one week. The eggs are oval, their diameter 3 mm. For the rearing of the worms, about twenty eggs are pasted on each piece of paper and before hatching, they are distributed among the food shrubs in such a way that each piece is bound up and around the branches, with the eggs turned down, avoiding the direct sunshine. About 130,000 eggs are scattered in every *chō*. Thus after hatching, the rearers should endeavor to keep the uniform distribution of the worms, looking about the feeding bushes from time to time, and also take care to protect them from their enemies. *A. pernyi* is more vigorous and less attacked by diseases than *A. yamamai*. On this account, it is less necessary to select carefully the feeding places. Even in the most unfavorable conditions for *A. yamamai*, such as the luxuriance of foliage and too much rain, the former may grow up healthy and vigorous. The cocoons are gathered



several days after the worms finish spinning and being brown and just like the withered leaves, their collection is a troublesome work to any one without skill and experience.

The yield in every one *chō* is from 20,000 to 25,000 cocoons. The cocoons of the *spring* breed have somewhat different qualities from those of the *autumn* breed; namely, the latter unwind with more difficulty than the former, so the *spring* cocoons are chiefly used for filature, while the *autumn* ones are used for breeding purposes. Their length is two inches, and their breadth on the average one inch.

The average length of the filaments of a single cocoon is 650 metres and the average titre is 4.86 denier. Their titre varies so that small in the outer layer, gradually becomes great in the middle and then again small in the *innermost*.

For reeling the cocoons, a special method is adopted owing to the difficulty of unwinding them. A method which has been hitherto practiced in the prefecture of Nagano, is to steam the cocoons a long while with some soda before reeling them, but the improved method is to treat them with hydrochloric acid, then, to boil them several hours with bicarbonate of soda and soap, and afterwards to reel them on a plate. From seven to eight *momme* of the raw silk may be reeled from 100 cocoons on the average. The raw silk is a light brown color and similar to that of the Indian Tussah. It is partly woven in its own habitat and partly in compliance with the demands of the weaving factories in the prefectures of Gifu, Tochigi, Niigata, Aichi, Kyōto and Saitama.

In 1907, 812 kilograms of the raw silk were produced at Minami-azumi-gōri, Nagano. The market price varies from

year to year, but on the average the price of yamamai raw silk of a superior quality is about 35 *yen* per *kwan*.

3. *Caligula japonica* Moore.

Cocoons of the *Shōsan* or *Caligula japonica* are found wild in the forests of every district in our country. There are none who rear the worms, but only their cocoons are gathered. The districts, where the cocoons are found, are different sometimes, but at present they are collected in Iwate, Fukushima, Tochigi, Nagano, Gumma, Yamagata and Miyagi prefectures in the north eastern part of Japan and in Hiroshima, Okayama, in both of which they are found in large numbers, and in some districts of Kyushū and Shikoku in the south western part.

The worms appear once a year. In the vicinity of Tōkyō, the eggs hatch from the latter part of April to the early part of May. The larvae feed themselves on the leaves of camphor trees (*Cinnamomun camphor*), Chestnuts (*Castanea vulgaris*), *Rhus vernicifera*, Walnuts (*Juglans* species), etc.. They mature from fifty to sixty days after hatching, moulting four times, they then come down from the trees to spin cocoons on the twigs of shrubs, three or four feet high above the surface of the ground. The cocoons are an elongated oval in shap, composed of net-work layers and one end is open. The moths come forth about August or September, couple soon after and lay eggs on the twigs at the lower part of the trees that produce leaves for their food. The eggs will hatch during the next spring.

The moths have grayish brown colorations, with green lines on their wings. On each of their hinder wings lies an eye

spot whose inner side is bordered successively by concentric rings, differently colored and their fore wings also have a grayish spot in shape like a boat. The mature larvae are green and provided with long white hairs. The cocoons of the worms, not being fit to reel, are developed into floss silk which is then either spun into threads or used for various purposes without being spun.

The cocoons may be gathered from July to May of the next spring. On account of fact that when they are left in a field for a long while, their qualities become vitiated, the superior ones may be collected at any time until the autumn. They are boiled with a little soda at first, thus softened, and washed with water, they are pressed with a machine, and then stretched into floss silk, after the pieces of leaves and the cast-off-matter of the worms on them has been picked away. The floss silk, made into a moderate size, is hung down in a room. After drying, we will have a yellowish brown silk which has a fine lustre and feels soft.

The amount of the cocoons produced, varies every year, according to the climate, but on the whole, the annual production is about 188,800 kilograms, that is to say, 50,000,000 cocoons.

Although floss silk is more or less in demand in the interior, the greater part is exported chiefly into France and Germany and next into England and Hong-kong.

According to the relation between demand and supply, the market price of the floss silk varies so greatly as to be some 350 *yen* per 100 *kin*, when dear, while it costs the half of that price, when cheap.

## CHAPTER X.

### CONCLUSION.

The progress and the present state of the sericultural industry of Japan has, we presume, been clearly and fully treated of in the preceding chapters. Here we shall conclude by giving another review of the state of this industry in the past and the present so that we may form some opinion as to the future development of this industry.

#### I. THE SERICULTURAL INDUSTRY OF JAPAN HAS A LONG HISTORY AND A FIRM STANDING.

The origin of the sericultural industry of Japan is very old, but the first stage of its development was in the reign of the emperors Chiū-ai and Ō-jin. The warm encouragements given by the successive emperors and empresses had indeed very much to do with the rapid progress it attained after that time.

Another important cause in the growth of this industry was the adoption of silk fabrics for the payment of taxes as well as for wearing purposes. By this time, silk-raising attained such an importance that it was considered one of the most lucrative branches of industry. Thus aided by the Imperial encouragements, the foundation of this industry had been so strongly laid in the hearts of the people that even the long series of political as well as economical vicissitudes that this industry passed through, could not entirely destroy it, until towards the close of the Tokugawa Régime it began to show signs of a new life. At

this juncture, the port of Yokohama was fortunately opened for foreign trade and the exportation of our silk was practiced there for the first time, which led to the sudden activity of this long-suppressed industry.

Since the Restoration in 1867, the newly established government, in sympathy with the desire of the Imperial Household, turned its utmost attention towards the improvement of the industry by bringing in many equipments in the way of protection and encouragement with the same enthusiasm that was shown by the Imperial Courts in ancient times. These governmental enterprises combined with the individual efforts of the people have an ample share in the development and prosperity the sericultural industry of Japan enjoys at present.

## II. THE PRESENT DEVELOPMENT OF THE INDUSTRY OF JAPAN IS SOUND AND WHOLESOME.

As the silkworm rearing in Japan is managed mostly as a subsidiary work of farmers, being practiced at less busy times of farming, it is naturally safe from any serious fluctuations in its work and management, such as might be caused by a single failure of a crop or sudden falls in the prices of cocoons. The work of filature, on the contrary, being carried on as a special industry, is subject to the fluctuations of the prices of raw silk and various other economical circumstances, far more than silkworm rearing. But many years' experience of those concerned in this industry have succeeded in discovering effective measures to overcome these difficulties, so that practical management has become much easier and safer, being less subject to serious apprehensions. Moreover, as has often been

referred to, the recent perfection of the equipments for sericultural education, the encouragement, and protection as well as for the prevention of silkworm diseases, have caused a remarkable advancement in the knowledge and practical art of silkworm rearers and raw silk reelers, giving safety and steadiness to the management of this industry.

### III. THE PROGRESS OF THE SERICULTURAL INDUSTRY OF JAPAN HAS REASONABLE CAUSES.

We have already seen that the recent striking progress of the sericultural industry in Japan is due to a great extent both to the Imperial encouragements and to the dauntless endeavors of the people, but at the same time we must take into consideration another important factor, the presence of the various conditions necessary for the practical management of this industry.

As the climate of Japan is generally mild, the cultivation of mulberry trees and the rearing of silkworms are carried on quite extensively from Formosa to Hokkaidō, and the geographical feature of the country being mountainous, the level land fit for the cultivation of rice and wheat is rather scarce, while we can meet with everywhere tracts of sloping land, which are favorable for mulberry plantation. The green hills and deep forests that can be found everywhere throughout the country are natural reservoirs of water, so that water power is freely applied to mechanical purposes, thus giving a strong facility to the improvement of the reeling industry.

As silkworm rearing is rather a tedious process of handling the delicate insects, it naturally admits of little or no room for the application of mechanical force, depending very much on

manual labor. Filature, on the other hand, has adopted the factory-system introducing highly improved reeling machines. Nevertheless, manual art has much to do with the reeling work, which is the most important process of filature. The natural artistic skill and the hereditary customs of the Japanese are very favorable for the mastery of the delicate process of reeling work.

Most Japanese farmers are engaged in the cultivation of the land only, and stock-breeding is not yet widely practiced, as a result of which, some waste of the time of laborers cannot be avoided between sowing, weeding, and harvest, even though enough care is taken for the regular distribution of labor in the cultivation of rice, wheat, vegetables, and other products. Silk-worm rearing is indeed practiced by taking advantage of such surplus of labor, without requiring any heavy expense for its special purposes. Moreover, this work can be easily managed by women and girls, who would be less productive in other lines of work. This is indeed another great economical merit of this industry. In short, Japan is gifted with every favorable condition natural, geographical, and economical, for the progress of sericulture, which she has attained throughout the long course of her eventful history.

IV. THE PRODUCTION OF JAPANESE SILK OCCUPIES  
THIRTY FIVE PER CENT OF THAT OF THE WHOLE  
WORLD, AND ITS GREATER PART IS EXPORTED  
TO THE WORLD'S MARKETS.

The silk-producing countries throughout the world are fully twenty. But those countries that produce so much silk as to be



able to meet the demand of the world's markets are only three or four. According to the report published by the silk-dealers' guild in Lyons, the total output of silk throughout the world in 1907, amounted to 24,500,000 kilograms (the figures for the four Eastern Asiatic countries being those for exported silk). The silk exported from Japan in the same year was 6,350,000 kilograms, while the total output of Japanese silk reached 8,760,000 kilograms. So Japan produced 35 per cent. and exported 25 per cent. of the total output of silk throughout the world in that year. The comparison of the figures with the statistics of 1897 will give some idea of the increase of our silk production during the last ten years:—

Year.	World's product. Kg.	Japan's product. Kg.	Japan's export. Kg.
1897	17,000,000	5,760,000	3,500,000
1907	24,500,000	8,760,000	6,350,000

Thus it may be seen that the quantity of raw silk supplied to the world's markets by Japan ten years ago was 3,500,000 kilograms, making 20 per cent. of the total output of the world, while at present, the rate has increased to 26.5 per cent.

These considerations led to the conclusion that it would be more profitable for Japan to increase the export of raw silk than to attempt the furtherance of silk weaving industry, and in accordance with this view, efforts are being made now both by the government and the people with an unanimous intention for the further increase and betterment of our raw silk. The filature instruction in the Tōkyō Sericultural Institute and the silk conditioning work at Yokohama described in the preceding chapters are intended with this special object in view.

V. THE SERICULTURAL INDUSTRY OF JAPAN  
PROMISES A FURTHER DEVELOPMENT.

The development of the sericultural industry of Japan in the past has already been dwelt upon at length. In conclusion, we shall try to make some observations and remarks as to the possibility of its future development.

The area of land used for the annual production of 8,000,000 kilograms of Japanese silk covers 400,000 *chō*, and the labor required for the purpose is supplied by the farmers at less busy times of farming. The total area of uncultivated land fit for agricultural purposes extends over some 4,500,000 *chō* throughout the Empire with the exclusion of Formosa, and this vast area of land is more fitted for the cultivation of mulberries in every respect. It goes almost without saying that the national expansion of Japan will not long leave such land uncultivated, the necessary sequel to which will be the utility of the same chiefly for sericultural purposes.

As already alluded to, silkworm rearing depends chiefly on manual labor with little chance for the application of machinery. The supply of labor, therefore, constitutes a problem worthy of much deliberation in the management of this industry. In Japan, however, the vast population together with the favorable economical circumstances has been effective in preventing the want of labor-supply, and the annual increase of population by half-a-million furnishes us with a strong reason to hope that we may make use of the surplus population for the cultivation of such valuable yet untouched land as well as general sericultural management.

It has been an old custom in Japan that women should not partake in any labor but those pertaining to their household duties, depending upon their husbands for subsistence. In fact, it is not rare cases to be met with that girls born in the heart of a large city should grow up to womanhood without the least idea about the refreshing verdure of rice fields so common in Japan. Happily, however, this sedentary habit is gradually giving way to the present pressure and those women are increasing in number who propose to be engaged in some sort of lucrative industry. And it is much to be gratified that this tendency is also given encouragement by more sensible classes of the community. Under such a state of things, there is little or no fear that sericulture, which is an industry best fitted for the delicate character of woman, should be neglected by the prudent house-wives and daughters of Japan. In fact, it is to our great satisfaction that the female education in sericulture is making a steady progress.

To sum up, the present state of land and labor-supply is thus favorable, and other various conditions are as satisfactory, while the customary modes of life of the people are, as above mentioned, perfectly fitted for the economical management of sericulture. Moreover, the government and the people are unanimous in giving efforts for the furtherance of the industry, and above all, the Imperial Household, the leading force of all national activities, in all times has condescended to set an example to the people by personally being engaged in the work of silkworm rearing. It may, therefore, safely be predicted that the expansion and development of the sericultural industry

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of Japan in the future will be far greater than what it has been heretofore.

[ END. ]

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