

**SUPPLEMENT
TO THE
BULLETIN OF THE
THAI SERICULTURAL
RESEARCH AND TRAINING CENTRE NO. 8
1978**

**TECHNICAL GUIDES
IN THE
SERICULTURAL PRACTICES**

THE THAI SERICULTURAL RESEARCH AND TRAINING CENTRE
KORAT, THAILAND

Japan International Cooperation Agency, Tokyo, Japan

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国際協力事業団

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1. How to Grow and Harvest Mulberry Leaves for Young Silkworms, Reared 6 Times in a Year.

It is a very important technique to grow and harvest better mulberry leaves for young silkworms (1st to 3rd stage) and bring up strong silkworms thereafter, so that cocoon crops may be stabilized and result in a high yield. For the purpose, mulberry should have leaves with high nutritive value for young silkworm and ability to abundantly sprout new young shoots by cutting old shoots. The area of the exclusive field needs about 60 trees for rearing of 20,000 silkworms (1 sheet) during 1st – 3rd stage.

There are two methods to grow and harvest mulberry leaves for young silkworms: (1) We stop the growth of branch by cutting its top and let auxiliary buds sprout which are at the base of petiole by picking leaves, followed by harvesting young regenerated shootlets according to the respective stage of young silkworms, and (2) the branch is cut in the middle and let a few auxiliary buds near the cut part sprout, followed by harvesting the newly developed leaves according to the silkworm stage. And in the sericultural practices it is advisable that the two methods are well assorted in the exclusive field, divided into two parts of A and B. Needless to say, the field is to be properly manured (compost: 3,000 kg, N: 30 kg, P₂O₅: 15 kg, K₂O: 20 kg, per rai per annum) and maintained.

Operations to harvest leaves for young silkworms must be based on the scheduled date of HAKITATE. As a rule, this operation can be performed about 20 – 25 days in the rainy season and 30 – 35 days in the dry season, respectively, before the scheduled date of HAKITATE.

How to grow and harvest mulberry leaves for young silkworms are illustrated in Fig. 1.

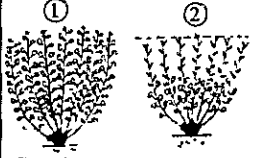
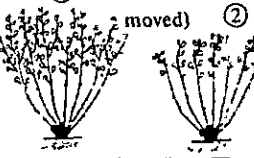
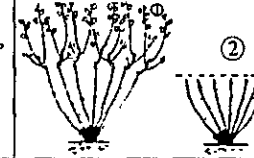
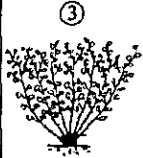



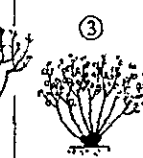

Plot to be set up	Base cutting	Rearing order					
		I		III			
		The Scheduled date of HAKITATE					
		Early in June		Early in September		Early in December	
A	Mid-March	1. Topping and leaf-picking		II. Topping on regenerated shoot		III. Intermediate cutting	
		<p>Before operation</p> <p>Operation 20 – 25 days prior to HAKITATE (about 15 cm of top of each branch is removed, and the leaves in the upper half are picked)</p> 	<p>Before operation</p> <p>Operation (25 – 30 days prior to HAKITATE, a young shoot is cut at about 20cm from the parting of branch, and the other young shoots are removed)</p> 	<p>Before operation</p> <p>Operation (30 – 35 days prior to HAKITATE, all branches are intermediately cut)</p> 			
	<p>Before harvest (1 – 3rd stage)</p> 	<p>After harvest (regenerated buds are plucked according to the stage)</p> 	<p>Before harvest (1 – 3rd stage)</p> 	<p>After harvest (Leaves are picked according to the stage)</p> 	<p>Before harvest (1 – 3rd stage)</p> 	<p>After harvest (Leaves are picked according to the stage)</p> 	
B	Early in May	Rearing order					
		II		IV		VI	
		The scheduled date of HAKITATE					
		Mid-July		Mid-October		Mid-January, next year	
		See I		See III		See V	

Fig. 1. Harvesting method of mulberry leaves for young silkworms, reared 6 times in a year.

2. How to Grow and Harvest Mulberry Leaves for Grown Silkworms, Reared 6 Times in a Year

There are many methods to harvest mulberry leaves for grown silkworms as follows: leaf picking, thinning, middle-cutting, and shoot-cutting etc. In order to produce good mulberry in abundance from a mulberry field, we should try hard to maintain the field in good condition by weeding, cultivation, and prevention of drought or moisture damage, followed by applying organic matter (compost: 1,500 kg per rai per annum) and chemical fertilizer (N: 30 kg, P₂O₅: 15 kg, K₂O; 20 kg per rai per annum) to make the soil suitable for a good growth of mulberry.

In the sericultural practices, it is very important to adopt the method of harvesting good mulberry leaves with less labor besides the recovery of the vitality of tree. For the purpose, it is recommendable to harvest available shoots for grown silkworms throughout seasons, using a field divided into two plots of A and B.

The harvesting methods are illustrated in Fig. 2.




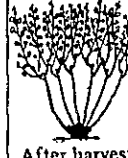
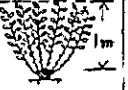



Plot to be set up	Base cutting	Rearing order					
		I	II	III	IV	V	VI
		Time to be harvested					
		Early in June	Early in August	Mid-September	Early in November	Mid-December	Early in next February
A	Mid-March 	Before harvest ① 		Before harvest ③ 		Before harvest ⑤ 	
		After harvest (Cut at 1 m from the base) 		After harvest (Cut above the parting of shoots, leaving 4-5 leaves) 		After harvest (Cut above the parting of regenerated shoots, leaving 4-5 leaves) 	
	The expected leaf yield per rai, 2,000kg	600 kg		1,000 kg		400 kg	
	Leaf yield ratio for each rearing season, %	30%		50%		20%	
B	Early in May 		Before harvest See ①		Before harvest See ③		Before harvest See ⑤
			After harvest See ②		After harvest See ④		After harvest See ⑥
	The expected leaf yield per rai, 2,000 kg		600 kg		1,000 kg		400 kg
	Leaf yield ratio for each rearing season, %		30%		50%		20%

Fig. 2. Harvesting method of mulberry shoots for grown silkworms, reared 6 times in a year.

3. A Method of Prevention of Mulberry Root Rot Disease by Usage of Grafting Method

The root rot is a very troublesome and destructive disease of mulberry in many of the sericultural regions in Thailand. A positive demonstration of the cause of the disease has not been worked out. And, the native good variety having power of high resistance to this disease in the sericultural practice is not available. At present, it may be said that we have nothing to do but to use grafted saplings upon current resistant variety, for convenience, as a stock, though mulberry is used to be directly planted by cutting and there has been no need for grafting in Thailand.

Among grafting methods, it is advisable to use bud-grafting, operated easily and efficiently with high rooting ratio.

Bud-grafting method (See Figs. 3 and 4)

1. Stock

Pai variety is used as a stock. Pai variety is considerably resistant to root rot disease, though it has many-lobed leaves, less amount of yield and low nutritious value.

2. Scion

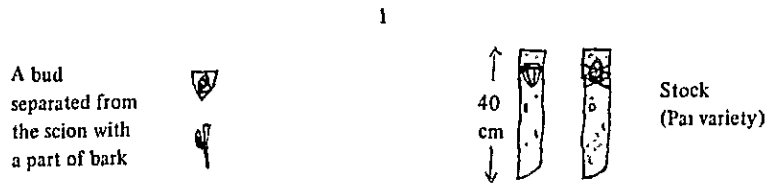
A good variety, for instance, Noi and Soi, though sensitive to root rot disease, is used as a scion. And, we can mitigate the damage by the disease.

3. Grafting method

There are two methods as follows:

- 1) Grafted saplings are planted out after operated and raised in the nursery.
- 2) Scions are grafted into the second year's Pai sapling after planting in the field.

These practices are illustrated in Figs. 3 and 4.



Part of the bark is cut open so as to have a bud insert the stock. After operation, bud and stock are tied with a string.

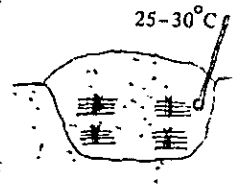
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Each 20 pieces of the grafted stocks are bundled.



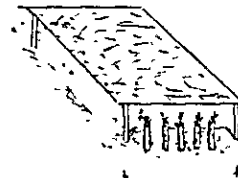
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Bundled grafted stocks are stored in a large basket filled with well moistened saw dust or burnt rice chaff for 7-10 days at 25°C-30°C or so.



4

Graftings are transplanted in the nursery. After insertion, water is timely and sufficiently sprinkled. A frame of 1 m high is set up over the bed, on which palm leaves or vinyl film are spread to serve as a sunchade.



5

Saplings, grown about 30-50 cm in height after 2 months raised in the nursery, are transplanted in the field.

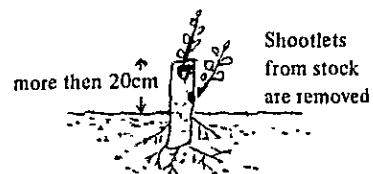


Fig. 3. How to raise bud-grafting sapling

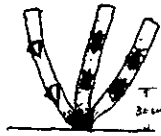
1

Grafting method (A)

A bud separated from the scion with a part of bark



The stock may have a T-shaped break to contain a bud in the stripped bark

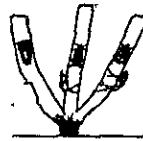


Grafting method (B)

A bud separated from the scion with a part of bark

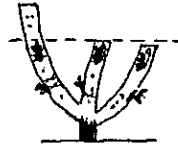


Operation is the same as in case of Fig. 3.



2

In some 2 weeks after grafting, the swollen buds of scion will be seen, united perfectly with the stock. And the tied strings and the upper part of stock are thrown away.



3

Development of young shoots



Shootlets from stock are removed

Fig. 4. How to apply bud-grafting on the tree in the field.

4. A Standard Table for 20,000 Young Silkworms (a Sheet) Rearing

4-1. June – October rearing season

Stage	Order of day	Feeding time	Works	Area of rearing bed	Amount of leaves supplied			Remarks	
					Arrangement	A time g	A day g		
I	1	9 00	HAKITATE Disinfection of newly hatched larval body	30x30cm	Finely chopped, Tender chopped leaves, 0.5x0.5 cm	40	380	5% Ceresan lime, 2 10g/m ²	
		+80							
		100							
		11 00		Spacing 60x60cm		160			
	2	6 00				160	640		
		11 00		Spacing 80x100cm		200			
		16.00			280				
	3	6 00	Disinfection Net setting before feed- ing			280	860	5% Ceresan lime, 2 10g/m ²	
		11:00			280				
		16:00			300				
	4	6 00	Molting, spacing rearing bed		Cut leaves into small pieces	200	200	Be in dry condition	
		11 00				-			
		16 00				-			
					Total	2,080			
II	5	6 00	After all get up, disinfec- tion Net set- ting before first feeding Bed cleaning	Spacing 90x180cm		400	1,700	5% Ceresan lime, 2 20g/m ²	
		11.00				500			
		16 00				800			
	6	6 00		Spacing 90x180cm		700	2,500		
		11:00				800			
		16 00				1,000			
	7	6 00	Disinfection Net setting before feed- ing Bed cleaning		Cut leaves into pieces	800	1,400	5% Ceresan lime, 2 20g/m ²	
		11.00				600			
		16 00				-			
					Total	5,600		Be in dry condition	
III	8	6 00	After all get up disinfec- tion Net setting be- fore feeding Enlarge two trays	Spacing 2(90x180)		1,200	2,600	5% Ceresan lime, 2 30g/m ²	
		11.00							
		16 00				1,400			
	9	6.00				1,200	5,400		
		11:00				1,800			
		16:00				2,400			
	10	6 00	Disinfection Net setting before feed- ing Bed cleaning		Cut leaves into pieces	1,800	2,800	5% Ceresan lime, 2 30g/m ²	
		11:00				1,000			
		16.00							
	11	6 00				-			
		11:00				-			
					Total	10,800			
Grand total							18,480		

4. The Standard Table for 20,000 Young Silkworms (a Sheet) Rearing

4-2. December – January rearing season

Stage	Order of day	Feeding time	Works	Area of rearing bed	Amount of leaves supplied			Remarks
					Arrangement	A time g	A day g	
I	1	9 00 11 00 16 00	HAKITATE Disinfection of newly hatched larval body	30x30cm Spacing 60x60cm	Finely chopped tender leaves Tender chopped leaves, 0.5x0.5 cm	40	380	
						+80		
	2	6 00 11 00 16 00		Spacing 80x100cm		160	640	
						200 280		
	3	6 00 11 00 16 00	Disinfection Net setting before feed- ing			300	1,080	5% Ceresan lime, 2 10g/m ²
4	6 00 11 00 16 00	Bed cleaning		Cut leaves into small pieces (0.5cm)	300 480 200			
5	6 00 11 00 16 00		Spacing		- -		Be in dry condition	
						Total	3,080	
II	6	6 00 11 00 16 00	After all get up, disinfec- tion and net setting be- fore first feeding Bed cleaning			400	1,700	
						500 800		
	7	6 00 11 00 16 00		Spacing 90x180cm		700	2,500	
						800 1,000		
8	6 00 11 00 16 00	Disinfection, Net setting before feed- ing Bed cleaning			800 600	1,800		
9	6 00 11 00 16 00				- -		Be in dry condition	
						Total	6,000	
III	10	6 00 11 00 16 00	After all get up, disinfec- tion and net setting before first feeding Bed cleaning Enlarge to 2 trays	Spacing 2(90x180cm)		800	2,600	
						800 1,000		
	11	6 00 11 00 16 00				1,000 1,800 2,400	5,200	
12	6 00 11 00 16 00	Disinfection Net setting before feed- ing Bed cleaning			1,800 1,500	3,900	5% Ceresan lime, 2 30g/m ²	
13					- -		Be in dry condition	
						Total	11,700	
Grand total							20,780	

5. A Standard Table for 20,000 Old Silkworms Rearing

5.1. June – July rearing season

(Leaf percent: 50% of shoot)

Stage	Order of day	Feeding time	Amount of shoots		Rearing area	Remarks
			Per time kg	Per day kg		
IV	1	6:00	6	27	8.0m ²	After all get up, Cerean lime (40g/m ²) Extend rearing bed to 5 trays of 0.9x1.0m area.
		11:00	6			
		18:00	15			
	2	6:00	13	42		Ceresan lime (40g/m ²), Net setting Bed cleaning
11:00		8				
18:00		21				
3	6:00	22	44		Net Setting Bed cleaning	
	11:00	10				
	18:00	12				
4	6:00	–			Keep bed in dry condition	
	11:00	–				
	18:00	–				
V	5	6:00	15	60	16.0m ²	After all get up, Ceresan lime (50g/m ²) Extend rearing bed to 60 trays of 0.9x1.8m area.
		11:00	15			
		18:00	30			
	6	6:00	29	95		Net setting Bed cleaning
		11:00	19			
		18:00	47			
	7	6:00	42	140		Ceresan lime (50g/m ²), Net setting Bed cleaning
		11:00	28			
		18:00	70			
	8	6:00	42	140		Net setting Bed cleaning
		11:00	28			
18:00		70				
9	6:00	45	150		Net setting Bed cleaning	
	11:00	30				
	18:00	75				
10	6:00	20	45		Net setting Bed cleaning	
	11:00	10				
	18:00	15				
11	6:00	5	5		Mounting	
	11:00	–				
	18:00	–				
				Total 635		

Grand total 748 kg.

5.2. August – September rearing season

(Leaf percent: 50% of shoot)

Stage	Order of day	Feeding time	Amount of shoots		Rearing area	Remarks
			Per time kg	Per day kg		
IV	1	6:00	5	17	8.0m ²	After all get up, Ceresan lime (40g/m ²) Extend rearing bed to 5 trays of 0.9x1.8m area.
		11:00	5			
		18:00	7			
	2	6:00	9	30		Ceresan lime (40g/m ²), net setting Bed cleaning
11:00		6				
3	6:00	20	48 Total 95		Net setting Bed cleaning	
	11:00	14				
	18:00	14				
4	6:00	–			Keep bed in dry condition	
	11:00	–				
5	6:00	–	50	16.0m ²	After all get up, Ceresan (50g/m ²) Extend rearing bed to 10 trays of 0.9x1.8m area.	
	11:00	20				
	18:00	30				
6	6:00	30	100		Net setting Bed cleaning	
	11:00	20				
7	6:00	42	140		Ceresan lime (50g/m ²), Net setting Bed cleaning	
	11:00	28				
	18:00	70				
8	6:00	45	150		Net setting Bed cleaning	
	11:00	30				
9	6:00	48	160		Net setting Bed cleaning	
	11:00	32				
	18:00	80				
10	6:00	45	95		Net setting Bed cleaning	
	11:00	20				
	18:00	30				
11	6:00	5	5 Total 700		Mounting	
	11:00	–				
	18:00	–				

Grand total 795 kg.

5-3. October – November rearing season

(Leaf percent: 50% of shoot)

Stage	Order of day	Feeding time	Amount of shoots		Rearing area	Remarks
			Per time kg	Per day kg		
IV	1	6:00	6	27	8.0m ²	After all get up, Ceresan lime (40g/m ²) Extend rearing bed to 5 trays of 0.9x1.8m area.
		11:00	6			
		18:00	15			
	2	6:00	13	45		Ceresan lime (40g/m ²), Net setting Bed cleaning
11:00		9				
3	18:00	23	40		Net setting Bed cleaning	
	6:00	20				
4	11:00	15	Total 112			
	18:00	5				
5	6:00	–	45	16.0m ²	After all get up, Ceresan lime (50g/m ²) Extend rearing bed to 10 trays of 0.9x1.8m area.	
	11:00	15				
6	18:00	30	95		Net setting Bed cleaning	
	6:00	28				
7	11:00	19	140		Ceresan lime (50g/m ²), Net setting Bed cleaning	
	18:00	48				
8	6:00	42	150		Net setting Bed cleaning	
	11:00	28				
9	18:00	70	150		Net setting Bed cleaning	
	6:00	45				
10	11:00	30	80		Net setting Bed cleaning	
	18:00	75				
11	6:00	45	5		Mounting	
	11:00	30				
	18:00	75	Total 665			

Grand total 777 kg.

5.4. January – February rearing season

(Leaf percent: 50% of shoot)

Stage	Order of day	Feeding time	Amount of shoots		Rearing area	Remarks
			Per time kg	Per day kg		
IV	1	6:00	6	22	8.0m ²	After all get up, Ceresan lime (40g/m ²) Extend rearing bed to 5 trays of 0.9x1.8m area.
		11:00	6			
		18:00	10			
	2	6:00	12	40	16.0m ²	Ceresan lime (40g/m ²), Net setting Bed cleaning
11:00		8				
		18:00	20			
3		6:00	20	36		Net setting Bed cleaning
		11:00	10			
		18:00	6	Total 98		
4		6:00	-			Keep bed in dry condition
		11:00	-			
		18:00	-			
5		6:00	-	20	16.0m ²	After all get up, Ceresan lime (50g/m ²) Extend rearing bed to 10 trays of 0.9x1.8m area.
		11:00	-			
		18:00	20			
6		6:00	24	80		Net setting Bed cleaning
		11:00	16			
		18:00	40			
7		6:00	34	130		Ceresan lime (50g/m ²) net setting Bed cleaning
		11:00	26			
		18:00	70			
8		6:00	48	160		Net setting Bed cleaning
		11:00	32			
		18:00	80			
9		6:00	48	160		Net setting Bed cleaning
		11:00	32			
		18:00	80			
10		6:00	48	160		Net setting Bed cleaning
		11:00	32			
		18:00	80			
11		6:00	40	105		Net setting Bed cleaning
		11:00	40			
		18:00	25			
12		6:00	20	30		Mounting
		11:00	10			
		18:00	-	Total 845		

Grand total 943 kg

6. How to Produce the Commercial Silkworm Egg

In Thailand, the commercial egg (eggs for silk production), used for sericultural farmers, is a hybrid produced by the combination of crossing as provided for by the Sericultural Research and Training Centre of Korat.

Annual requisites for the above silkworm eggs resulting from farmers' demands for each rearing season should be totalized and the planned rearing of the respective parent race is to be prepared. And, "Date calculator for silkworm egg production" (the scale of easily reading schedules for silkworm egg production), as given full information by the term, 6 – 9, is very serviable for the purpose.

The producing process of each commercial silkworm egg, F₁ and F₂ hybrid, can be summarized on reference to Annex 1 and 2.

6-1. Incubation

- 1) Incubation to fulfill the following 3 points:
 - a) Hatching must be uniform with high hatching percentage.
 - b) HAKITATE (beginning of silkworm rearing) shall be done on the day scheduled.
 - c) Parent silkworms must be raised to be strong and healthy.
- 2) In incubation, the environmental conditions in the incubation room, disinfected strictly, are required as follows.
 - a) Temperature : 24 to 25°C, is the most recommendable for preservation.
 - b) Humidity : Proper humidity is between 75 and 80%, but 85% in a day prior to hatching.
 - c) Light : It is necessary to light more than 17 hours a day.
- 3) Incubating period
In case of preservation under 24 to 25°C, the respective periods are required:
 - a) Eggs treated by SOKUSHIN about 9 days
 - b) Eggs treated by REISHIN or Artificial Hibernation about 11 days.

6-2. Rearing of parent silkworm

- 1) HAKITATE (Hatching)
 - a) Newly born larvae from 20 batches (about 4 gr. in about 6,000 larvae's weight) will be considered as an unit and brushed into a rearing tray.
 - b) Rearing card, stating the name of silkworm race and numbers, is put on the rearing tray. The rearing card, on which the dates and times of the First feeding and Last feeding of each instar are recorded, is attached to the tray.

- 2) Rearing must be made in accordance with the Standard Table of the parent Silkworm Rearing (See Annex 3).
- 3) Supplied quantities of mulberry leaves, and temperatures and relative humidities are recorded throughout rearing duration.
- 4) Mounting and harvesting cocoons
 - a) Matured silkworms are picked up one by one and placed into a cocooning frame. The heads per frame to be mounted are 250 to 300.
 - b) Mounting tag, indicating the name of silkworm race and the date and time of the mounting, is put on the cocooning frame.
 - c) Forced mounting of unmaturing silkworms result in less number of eggs laid.
 - d) It is strictly prohibited to mount, mixed together, the different races on the same frame.
 - e) "KOMO-NUKI" (taking away of the mat) shall be made 30 to 40 hours after mounting.
 - f) Harvesting of cocoons shall be done on the 6th or 7th day after mounting. Too early harvesting should be avoided.
 - g) After having removed diseased silkworms, dead worm cocoons, etc., good cocoons can be harvested, removing floss by floss remover, and are weighed out about 2 kgs per rearing tray.
- 5) Data to be recorded and to be kept on each card.
 - a) Number of the eggs hatched.
 "Record on the seed production – 2 – 3 (6)
 – Number of eggs per batch"
 - b) Growing process during larva and pupa stages.
 "Record on the seed production – 1
 –1, Survey on growth"
 - c) Cocoons
 "Record on the seed production – 2
 –2, Survey on cocoon"

6-3. How to manage seed cocoon

1) Inspection of parent cocoon

Inspections must be made on the cocoons of their own characters to the exclusion of different or abnormal cocoons.

2) Selection of seed cocoon

Abnormal cocoon, dead worm cocoon, thin-end cocoon, flossy cocoon etc. will be rejected. Only each good cocoon carrying healthy pupa can be used as the seed cocoon.

3) Cutting of seed cocoon

Take out a healthy pupa from a cocoon, cutting an end of it in the careful manner not to damage the pupa.

4) Sex-discrimination of pupa

Sex-discrimination must be conducted quickly and exactly, observing the imaginal bud for sexual organ of the pupa.

5) Protection of pupa

- (1) Every sexual group of each race is collected, after separation of males from females.
- (2) Cover the pupa with holed paper sheets.
- (3) Non-fertilized eggs may increase unless the temperature is supported above 20°C even in November to January as it goes down.

6-4. Egg production

1) Collection of moth

- (1) First, remove every respective moth freely mating by mistake.
- (2) Next, male moths are placed into the moth collection boxes, attached a tag indicating the varietal name, the emergence date of moth, and time of mating (0 for no use, 1 for 1 time mating, 2 for 2 times mating).
- (3) Finally, female moths are transferred to the rearing trays with 250 to 300 moths per tray. They are to be evenly scattered to mate easily on the tray.

2) Copulation of moth

- (1) Copulation of the moths are to be made between 09:00 and 11:00.
 - a) About 300 male moths kept in the male moth collection box are scattered on the female moths arranged on a rearing tray.
 - b) About 1 hour later, check the mating conditions and remove every single moth having no mate. These single moths can be used to try to couple on another rearing tray.
 - c) Copulation demands more than 3 hours in order to reduce non-fertilized eggs laid.
 - d) The moths under mating are protected from unrest and wind.

- 3) Separation of moth after mating
 - (1) Separation of the moths will be made between 13:00 and 15:00.
 - a) Rough handlings in separation of the moths will be a cause of poor deposition of eggs as their ovipositors are functionally disordered.
 - b) The male moths after separation are restored in the male moth collection box with the tag, indicating the race name and mating time.
- 4) Egg laying
 - (1) After separated, the female moths can be kept within an eggs laying frame on the laying paper in a group of 55 and 50 moths in case of F₁ and F₂ hybrid egg production, respectively.
 - (2) The date to be recorded on the eggs laying paper are as follows:
 - a) Eggs laying paper No.
 - b) Name of silkworm variety (or identification mark of crossing)
 - c) Date of eggs laying
 - d) Kind of treatments: S, R or H.
- 5) Removing of eggs-laid moth
 - (1) The works to be done between 08:00 and 09:00 on the day succeeding to egg deposition.

The female (mother) moths on the same eggs laying paper are protected in a moth-collection box, containing the same data as recorded on the egg laying paper.
 - (2) After the above works, quantities of eggs produced on the same day are classified by three treatments, S, R, and H, on "Daily note on silkworm egg production".

6-5. How to handle egg

- 1) Non-hiberating eggs
 - (1) S: SOKUSHIN (Hydrochlorization shortly after laid)
See "Standard Treatment of Artificial Hatching Method in Thailand" (Annex 4).
 - (2) R: REISHIN (Hydrochlorization after chilling) (Annex 4).
- 2) Hibernating eggs
Preservation and chilling of Egg (Annex 4).

6-6. Pebrine inspection

- 1) The said female (mother) moths protected in each moth-collection box are dried by a drying machine.

- 2) Every group of dried female moths per box (a sheet of paper) are to be microscopically inspected for the centrifugal sediment of the ground moths dissolved in a solution.
- 3) In case the spore of Pebrine in the solution is found, the eggs laid by the moths are to be destroyed immediately by fire together with the concerning eggs laying paper.
- 4) Especially, on the SOKUSHIN eggs, the Pebrine inspection must be finished as quickly as possible in order to hatch the eggs on the scheduled date.

6-7. Arrangement of egg

- 1) After being finished, all the egg production works will be followed by keeping the produced eggs under good conditions in accordance with the kinds of treatments such as SOKUSHIN, REISHIN and Artificial Hibernation.
- 2) All the eggs produced will be arranged according to S, R and H. The quantities of every variety and their usable periods are to be confirmed and recorded on "Whole stock of silkworm eggs".
- 3) The thorough results of egg production must be well preserved as the investigation data, "Record on the seed production – 2–3, survey on the seed production".

6-8. Egg distribution

- 1) When the Centre receives an order for distribution of the eggs, the eggs to be distributed will be taken out from the cold storage and incubated to meet with the expected date of HAKITATE (hatching), based on the said data 6–7, 2).
- 2) The eggs to be delivered should be at body pigmentation stage (Bluish egg).
- 3) Relating to the distribution of the eggs, the name of applicant, date of HAKITATE, date of delivery, varietal name and quantity of the silkworm egg and so on are registered.
- 4) Regarding to the said records, "Monthly register of egg distribution", is completely furnished.

6-9. Date calculator for silkworm egg production

(The scale of easily reading schedules for silkworm egg production) (Fig. 1).

The amounts of silkworms to be reared, annually and seasonally, vary with the estimated mulberry leaf harvest and adjustment of rearing labor with other farm operations. Therefore, each Self-help Land Settlement developed by the Public Welfare Department, Ministry of Interior, and others must have their rearing plans, based on the said factors, to implement their own "HAKITATE" program and quantity through the coming year. And, the plans will gain acceptance with the Silkworm Egg Producing Stations (Center and so on), where have been authorized to produce and to distribute silkworm eggs.

At the silkworm eggs producing stations these "HAKITATE" programs submitted by the users must be totalized and the silkworm eggs production plan should be decided to distribute necessary quantities of silkworm eggs on the dates required. In making up the yearly production plan at the Centre, it is advisable to keep the following matters in mind, because

the silkworm eggs produced may not always be used for a long period in the cause of their physiological characters and thus, planless production makes the silkworm eggs useless:

- (1) The silkworm eggs of available races for each rearing season are to be produced.
- (2) Produced silkworm eggs are to be exactly and timely distributed to rearers according to their scheduled rearing plans.

It is very troublesome jobs to meet everything with all plans of rearers, since their HAKITATE-schedules will be very changeable under the climatic, social, and economic conditions. This calculator, a device for easily reading schedules of silkworm eggs production, is very serviceable to the planning of production and distribution schedules of the eggs.

1) Aim of manufacturing the scale

This calculator is devised to set up easily and quickly the most proper schedules relating to the following two points, based on the standard data on the rearings of parent stocks, and the production and artificial hatching of silkworm eggs in the tropical zone:

- (1) To foreknow the proper time (or period) of availability for use (HAKITATE) of silkworm eggs to be distributed, basing on the date of laying eggs.
- (2) To foreknow the time of HAKITATE (rearing of parent stocks) and the time of their egg deposition, basing on the proposed date of HAKITATE (rearing) by rearers.

2) Composition of the calculator

- (1) This calculator consists of 2 piled-up disks with different diameter which separately turn on its axis.
- (2) The dates are printed on the edges of these 2 disks. Each circumference of circles indicates 365 days, graduated into 73 sections having 5 days each.
- (3) The large disk (hereafter called the Date-disk) indicates the name of months with the order of month.
- (4) The small disk (hereafter called the Guide-disk) indicates numeral figures with every 10 days, starting from 0 to 350 days, and also indicates usable time or period of silkworm eggs treated by SOKUSHIN, REISEIN or ARTIFICIAL HIBERNATION. This Guide-disk also shows the date of HAKITATE for parent stocks in correspondence to their egg laying time ("0").

(5) Explanation of words on the disks

- i) HAKITATE HAKITATE of parent silkworms. This shows the beginning of the parent stocks rearing.
- ii) Laid Date laid; this shows the time of laying eggs and is available as the starting point.
- iii) S SOKUSHIN; this shows the hydrochlorized eggs shortly after laid.

- R REISHIN; this shows the hydrochlorized eggs after chilling.
- H HIBERNATION; this shows the artificially hibernating eggs.
- iv) 5°C, 15°C, 25°C etc. Temperature required for preservation (or refrigerating) of silkworm eggs
- v) HCl Acid treatment
- vi) Usable Usable period (available period for hatching)

3) How to use the scale

- (1) To see the usable period of the silkworm eggs from the egg laying date.

First, the "0" point on the Guide-disk must meet with the egg laying date on the Date-disk. And, read each usable period on the Date-disk with every treatment, S, R and H.

- (2) To produce the silkworm eggs in correspondence to the expected rearing date:

First, fix the expected date of hatching on the Date-disk. Then, meet the date with the commencing date of usable period of S (or R or H).

As a result, the date on the Date-disk corresponding to the "0" point of the Guide-disk shows the most proper date of silkworm eggs production (the final date of laying eggs). Furthermore, the HAKITATE date of parent stocks to meet with the production (egg laying) of required eggs can be read as the date on the Date-disk which corresponds to the "HAKITATE" on the Guide-disk.

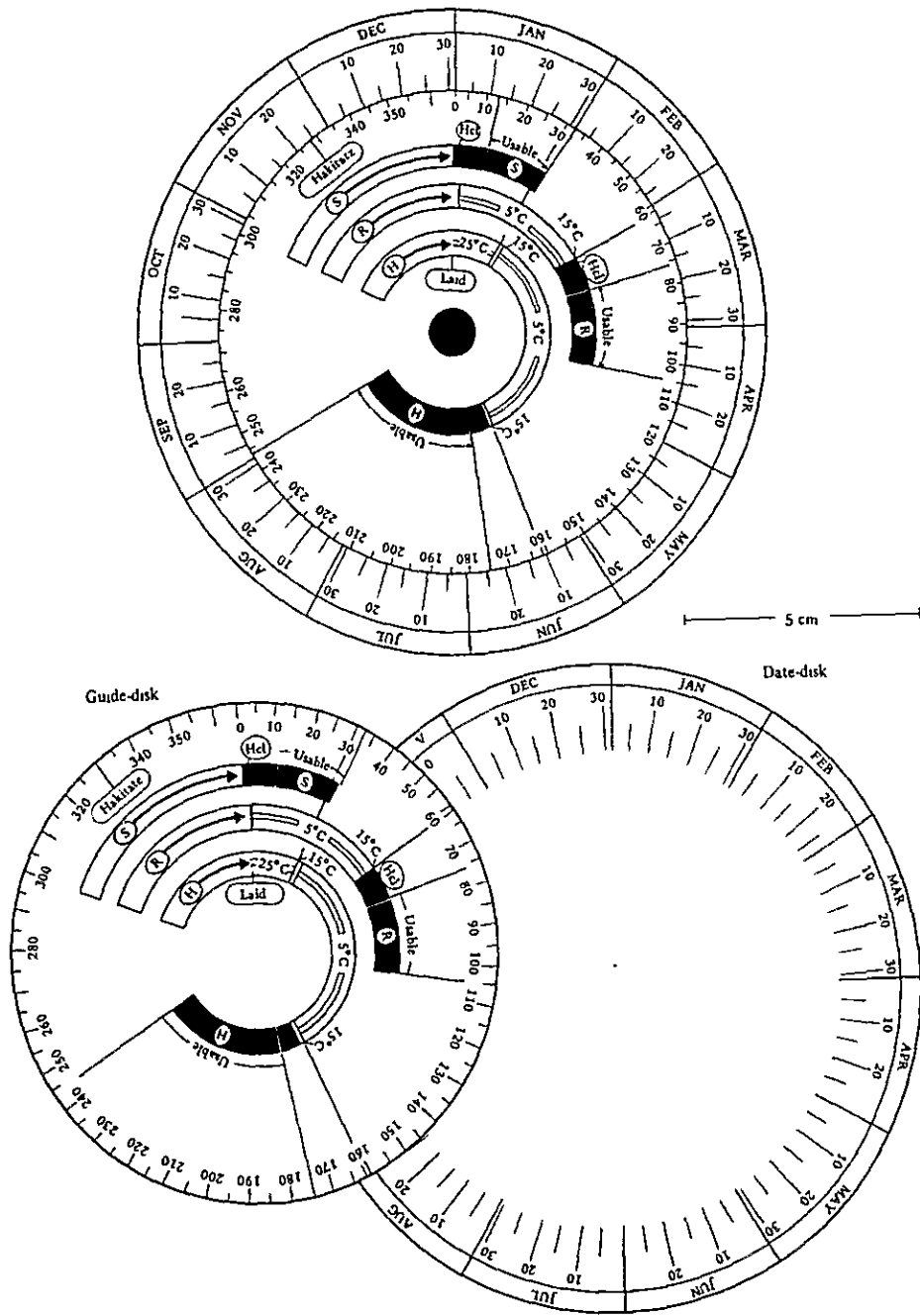
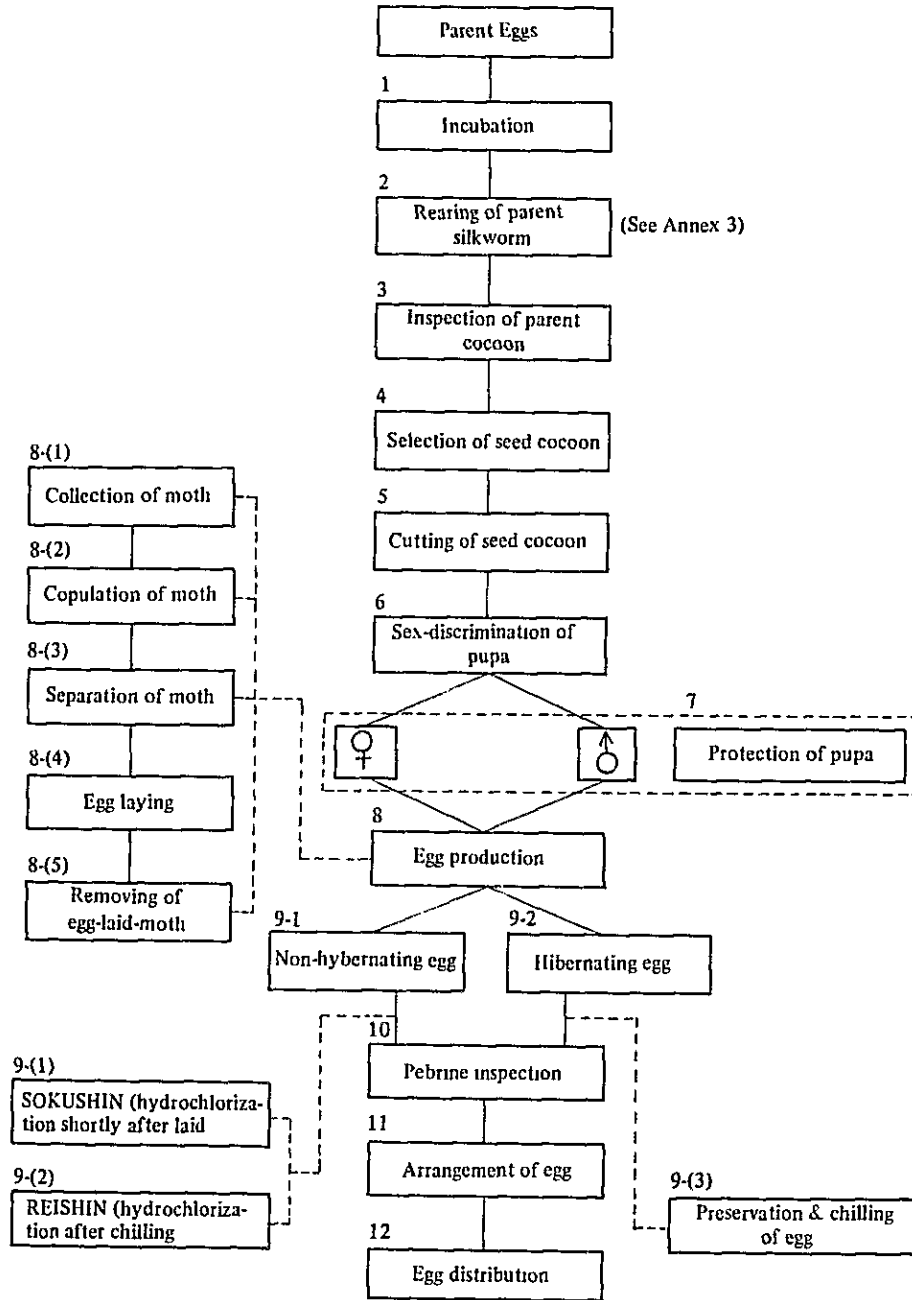
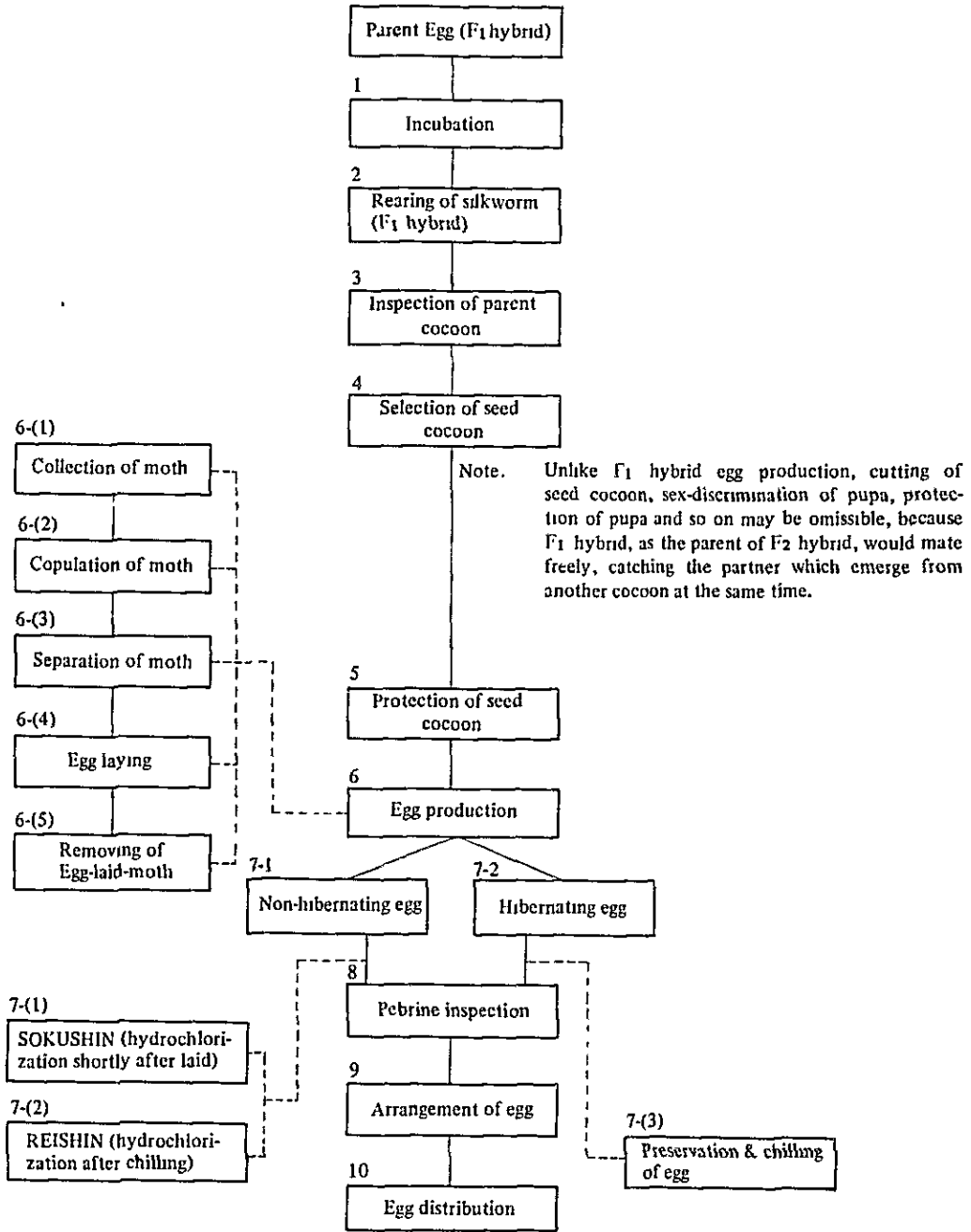


Fig. 1 Date calculator for silkworm egg production

Annex 1. Producing process of silkworm egg, F₁ hybrid



Annex 2. Producing process of silkworm egg, F₂ hybrid



Annex 3. The standard table of parent silkworm (10 batches) rearing in the young stage for the seasons, in June, August and October

Stage	Order of day	Feeding time	Amount of leaves (g)	Remarks
I	1	9:00	5+15	HAKITATE, disinfection of newly hatched larval body by 5% cerasan lime, 5g of finely chopped tender leaves, 15g of tender leaves chopped in 0.5cm x 0.5cm, making rearing bed: 10cm x 12cm
		14:00 16:00	25	Extend bed to 15cm x 18cm
	2	6:00 11:00 16:00	30 25 45	Extend bed to 20cm x 30cm
		3	6:00 11:00 16:00	45 40 70
4	6:00 11:00 16:00		50 — —	Cut leaves into small pieces Molting Extend bed to keep in dry condition
	II	5	6:00 11:00 16:00	60 80 120
6			6:00 11:00 16:00	100 90 150
		7	6:00 11:00 16:00	140 120 50
8	6:00 11:00 16:00		— — 100	Keep in dry condition After all silkworms get up, disinfection and net setting before feeding
	III	9	6:00 11:00 16:00	150 200 300
10			6:00 11:00 16:00	300 350 550
		11	6:00 11:00 16:00	300 150 100
12			6:00 11:00 16:00	— — —

Total amount of food: I stage = 365 g
 II stage = 910 g
 III stage = 2,500 g
 Total = 3,775 g

Annex 4. Standard treatment of artificial hatching method in Thailand

Order of date	O'clock	Hydrochlorization shortly after laid (SOKUSHIN)	Hydrochlorization after chilling (REISHIN)	Artificial hibernation
1	9-11 13-15 18-20	Copulation Separation Laying	Copulation Separation Laying	Copulation Separation Laying
2	8-9 9-10 11-12	Moth removing Soaking in formalin solution Hydrochlorization (15 hours after being laid)	Moth removing Soaking in formalin solution Preservation at 25°C for 45 hours after laid	Moth removing - Preservation at 25°C for 30 days
3	11 16-17	Refrigeration 5°C -	Refrigeration 5°C	
31	16-17	-	-	Preservation at 15°C
32	16-17	-	-	Refrigeration at 5°C
Term of refrigeration		0 - 20 days	60 - 100 days	130 - 200 days
Condition of artificial hatching		Formalin solution: 2.5% for 5 minutes Hydrochlorization: HCl S.G.: 1.10 (at 35°C) Temp.: 35°C Time : 35 min.	Formalin solution: 2.5% for 5 minutes Hydrochlorization: HCl S.G.: 1.11 (at 35°C) Temp.: 35°C Time : 40 min	No hydrochlorization

7. Diseases of Silkworm and Their Controlling Methods

The most important factor to stabilize the cocoon crop is to protect the silkworm from diseases. Diseased silkworms are caused by such parasites as pebrine, moulds, bacteria, and virus.

7-1. Diagnosis and control of silkworm disease

Among various kinds of silkworm disease, muscardine, *Aspergillus* disease, flacherie, grassery and pebrine are regarded as main diseases in the tropics. They sometimes bring an unexpected large damage in the sericultural practices. Silkworm diseases are diagnosed by the symptoms. For the purpose the dissection of the tissue to observe pathological change, microscopic observation to detect pathogen, isolating and culturing from dust, containing possible pathogen in the rearing sites, biological assay etc. are indispensable to know the kinds of disease and to have suitable countermeasures on protection of diseases in order to harvest a good cocoon crop in the coming rearing season.

In the tropics the dead body of silkworm killed by diseases get rot due to high temperature in many cases. And, under this environmental condition the rotted bodies of silkworm do not give satisfactory data for the diagnosis of diseases. As reported, for example, body hardening with its surface in color (white, yellow, green or black Muscardine), covered with mycelia, conidiophores and conidia of the causal fungi, was found below 25°C

7-1.1 Muscardine and *Aspergillus* disease

7-1.1.1 Muscardine

Five kinds of the diseases are found in Thailand as follows:

<i>Spicaria prasina</i> (MAUBLANC) SAWADA	Green Muscardine
<i>Isaria farinosa</i> (DICKS) FRIES	Yellow Muscardine
<i>Beauveria bassiana</i> (BALSAMO) VUILLEMIN	White Muscardine
<i>Matarrhizium anispliae</i> (METOHKOFF)	Black Muscardine
<i>Spicarianrubido purpurea</i> AOKI	

This disease is communicated through skin, though these kinds differ from each other in pathogen and symptoms. Generally, silkworms are sensitive to the disease in their young stages, in the 1st – 2nd day of each stage, and in the matured stage. The period from infection to death varies with 3 – 4 days in the acute case and 7 – 14 days in the chronic one. Attacked silkworm becomes inactive, its appetite declines, and the respective characteristic disease specks appear on the skin. Furthermore, we can microscopically observe hyphal bodies in the body fluid. The satisfactory diagnosis by the specks on the skin will be limited in about 10 hours after death of silkworm, as high air temperature hastens the process of black rotteness to have difficulty in distinction.

7-1.1.2 *Aspergillus* disease

Pathogens include many species of the genus *Aspergillus*. The damage of silkworm from *A. Flavus* LINK, one of the species, is most serious. Young silkworm is very susceptible to the disease, followed by matured silkworm and grown silkworm in order. As the disease advances rapidly, if attacked, silkworm eats mulberry poorly on the second day; its body is strained, becoming lustrous; growth becomes ununiform; it dies on the 2nd to 3rd day. So, this is the disease which must be most guarded against at a cooperative rearing house for young silkworm. On the dead body pathogens, yellowish green or brown in color, propagate. If attacked in the grown stage, silkworm cannot make a good cocoon, resulting in dead worm cocoon with soft-rot body.

The disease is caused by pathogen which has invaded the body through skin. Pathogen is distributed widely in the natural world. It multiplies easily on the rearing room, tools, wooden and bamboo parts, rice straw, woven cloth, silkworm feces, litter etc. The high humidity is very comfortable for occurrence of the disease.

The disinfection of the body of silkworm and rearing bed is important, especially on the 1st to 2nd day of 1st instar and the 1st day of 2nd instar, when silkworms are most susceptible to the disease. Diseased silkworm, being the source of transmission, must be picked up at sight and burned away or buried in the ground as deep as about 50 cm.

7-1.2 Flacherie

Flacherie is a generic name of diseases, Nucleopolyhedrosis (grassery), cytoplasmic polyhedrosis, and infectious flacherie by virus are described as under. It will be important to stabilize cocoon crop in Thailand with the progress of sericultural development.

7-1.2.1 Nucleopolyhedrosis (Grassery)

This disease can be discerned easily, as its symptoms are characteristic. As the disease advances rapidly, the intersegmental membrane is swollen and its skin is readily broken, issuing milky white pus, containing polyhedra formed in the cell nucleus.

The infection way of this disease is in many cases (a) through the mouth and (b) through the skin. The essential of the control of this disease is the removal of pathogen (disinfection of rearing room and tools) and a proper rearing (to keep good environmental condition, to feed good leaves, to handle well worms etc.).

7-1.2.2 Cytoplasmic polyhedrosis

This disease is produced by virus which forms visual polyhedra under microscope in the cytoplasm of cylindrical cell in the midgut. The infection way is the same as that of nucleopolyhedrosis. In case silkworms discharge whitish, soft feces and soil the bed, this disease may be suspicious. Accordingly, infected silkworms, discharging polyhedra in feces, if mixed with other silkworms, become the source of the secondary infection.

The progress of the disease is chronic, and infected silkworm doesn't make a cocoon after mounting, or it dies in the thin shelled cocoon.

7-1.2.3 Infectious flacherie

The existence of this disease has remained unsettled in Thailand. Pathogen is orally communicated. This disease is caused by virus that doesn't form polyhedra, and its pathogen cannot be recognized under optical microscope. In general, silkworm has the various symptoms of the so-called flacherie and it is difficult to make a diagnose from the symptoms. When young silkworms in a cooperative rearing house are infected by this disease, they are sometimes annihilated after distributed to sericultural farmers. This disease is chronic and the period from the adherence to the death of silkworm is between 7 to 21 days. It is difficult to make a correct diagnose with naked eyes even after the dissection. The diagnosis, by the addition of victim's ultrafiltrate (3,500 r.p.m., for 15 minutes by centrifugal machine) to feed the newly hatched silkworm, is used at times. If the disease percentage was 100%, the possibility of infection is higher, though before attempting this biological assay, it has to be checked that no polyhedra exist in the infected dead body.

7-1.3 Pebrine

Pathogen (*Nosema bombycis* NÄGELI) is the most dreadful disease to cocoon raisers. It is said that the eradication of pebrine will assure the promising development in the sericulture.

In the early stage, the growth of diseased silkworm becomes ununiform; laggards, thin silkworms, nonmolters, transparency after molting are seen. The victims that have fallen ill during young worm stage die without exception. In the grown stage, the most distinguishable symptom is the blackish brown specks, large or small, on the skin, though the infected grown silkworms can survive to lay eggs. And, the silk glands, which are transparent in the healthy silkworm, are dotted with white, opaque specks.

The disease is transmitted from mother to child through egg carrying pathogen, laid by a sick moth that has fallen ill during larval stage. And, the disease are transmitted through mouth when silkworm eats leaves polluted with pathogen in feces, discharged by an attacked silkworm.

The controlling methods are disinfection of pathogen, removal of the source of infection and inspection of mother moths. The pathogen (spore) in the cell can be detected easily by its light refractive ability under microscopic observation. Among the silkworm diseases, pebrine must be made the most correct diagnose.

7-2. Preparation of formalin solution

3% formalin solution is most available for disinfection of rearing room, tools etc. in the sericultural practices.

Preparation of 3% solution of formalin

Undiluted solution of formalin (specific gravity, 1.081) contains 35% of formaldehyde. If 200 litres of 3% solution of formalin are required, 182 litres of water added will be calculated as follows.

$$\frac{35 - 3}{3} = 11 \dots\dots\dots \text{Dilution index}$$

$$\frac{200}{11} = 18 \text{ (litres)} \dots\dots\dots \text{Undiluted solution of formalin}$$

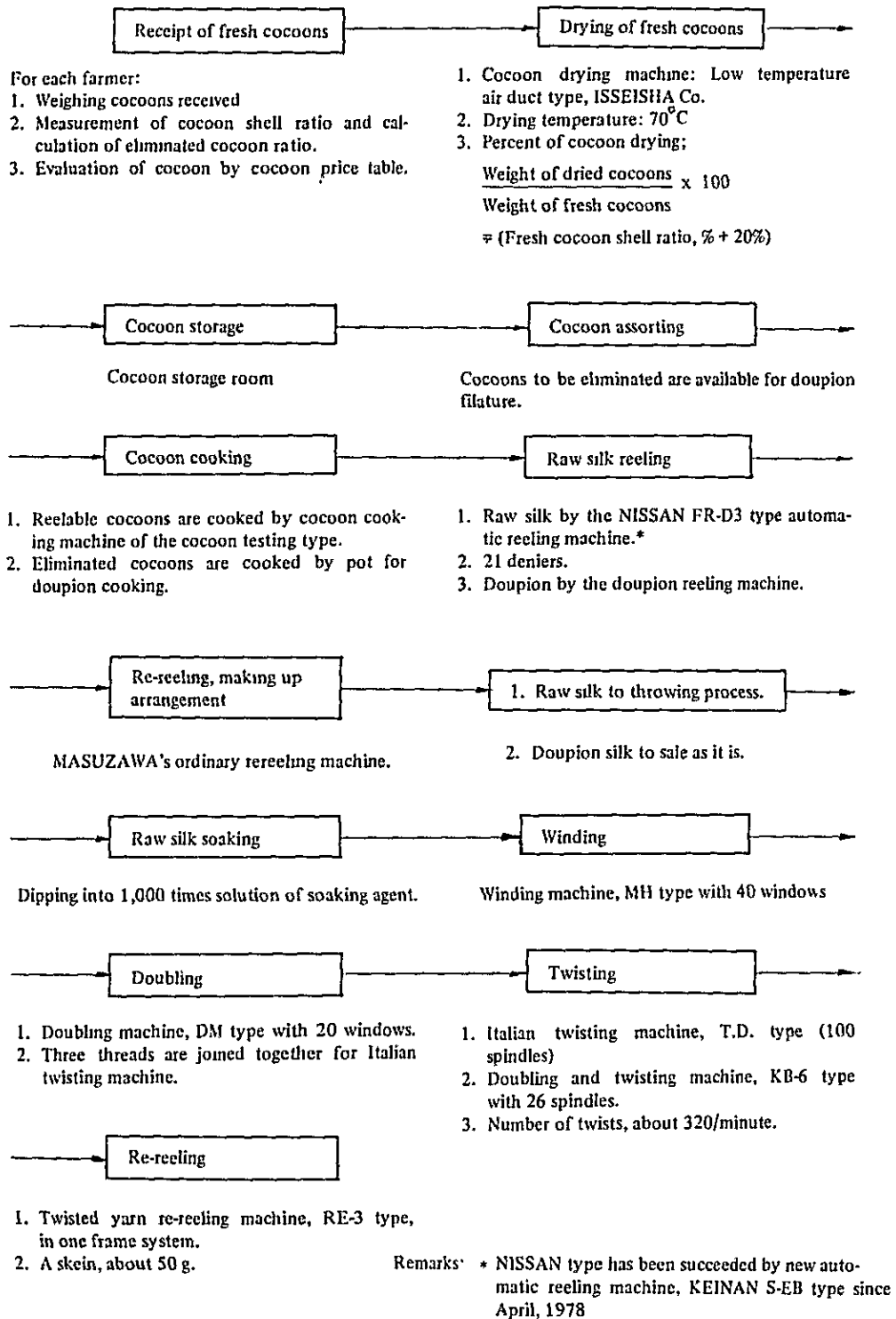
$$200 - 18 = 182 \text{ (litres)} \dots\dots\dots \text{Added water}$$

The solution (prepared at a rate of 1 litre per m² of floor area) can be sprayed with a pump to walls, ceilings, outside of walls, ground surrounding of the rearing room.

7-3 Time and dosage of disinfection of silkworm body and rearing bed (a standard)

Stage of silkworm	Time of disinfection	Area of rearing bed	Ceresan lime	Dosage
1st	Hakitate (Newly hatched worm)	0.1m ²	1 g	10 g/m ²
	2nd day	0.4	4	
	3rd day	0.8		
2nd	1st - 2nd day	0.8	16	20
	3rd day	1.6	32	
3rd	1st - 2nd day	1.6	48	30
	3rd - 4th day	3.2	96	
4th	1st - 2nd day	6.0	240	40
	3rd - 5th day	8.0	320	
5th	1st - 3rd day	13.0	650	50
	4th day	16.0	800	
Total			2,207	

8. Manufacturing Process of Fresh Cocoons to Twisted Yarn in the Centre



9. List of the Current Silkworm Races (1978)

Name	Voltinism	Hybrid of	Marking	Cocon color	Cocoon shape	Characteristics
K ₄ x T	Bivoltine	Japanese-Chinese races	Plain	White	Oval	Short rearing period, stout, good reability, small cocoons in size
K ₁ x T	Bivoltine	Japanese-Chinese races	Normal	White	Oval	Short rearing period, very stout, cocoons in medium size, good reability
K ₆ x K ₇	Bivoltine	Japanese-Chinese races	Normal	White	Oval	Heavy cocoon weight and high cocoon shell ratio, good reability
K ₁ x K ₁₄	Bivoltine	Japanese-Chinese races	Normal	White	Oval	Heavy cocoon weight and high cocoon shell ratio, good reability
$\begin{pmatrix} K_6 \\ K_1 \end{pmatrix} \times \begin{pmatrix} K_{10} \\ K_9 \end{pmatrix}$	Bivoltine	Japanese-Chinese races	Normal	White	Oval	Stout, heavy cocoon weight, very good reability
K ₁ x K ₈	Bivoltine	Japanese-Chinese races	Normal	White	Oval	Stout, heavy cocoon weight, and high cocoon shell ratio, good reability

