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Silk cocoon production — Code of practice — Part 2: Mulberry silkworm rearingfor cocoon production

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Foreword

Rwanda Standardsarepreparedby Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 357-2 was prepared by Technical Committee RSB/TC 029, *Textile and Leather Technology.*

In the preparation of this standard, reference was made to the following standard (s):

1) Title TAS 8201-2012 Good practices for silk cocoon production

2) Sericulture training manual for farmers in Rwanda

The assistance derived from the above source is hereby acknowledged with thanks.

DRS 357 consists of the following parts, under the general title *Introductory element — Main element*:

— *Part 1: Mulberry leaves production*

— *Part 2: Mulberry silkworm rearing*

— *Part 3: Silk cocoons handling*

Committee membership

The following organizations were represented on the Technical Committee on *Title of TC*(RSB/TC nnn) in the preparation of this standard.

Ministry of Trade and Industry (MINICOM)

University of Rwanda-College of Science and Technology (UR-CST)

National Agricultural Export Development Board (NAEB)

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

HeWorks Silk Rwanda Ltd

Rene Pharmacy

UTEXRWA Ltd

OXALIS Ltd

LIXIL/SATO

Rwanda Standards Board (RSB) – Secretariat

Introduction

Sericulture is an agro-based sector, involving rearing silkworms to produce silkworm cocoons and raw silk by reeling cocoons. The major sericulture activities comprise of mulberry cultivation to feed the silkworm larvae, silkworm rearing to produce cocoons, reeling of cocoons to unwind the silk filament and silk processing and weaving to gain value added silk products.

The growth and development of silkworm is greatly influenced by environmental conditions. The biological as well as cocoon-related characters are influenced by ambient temperature, rearing seasons, quality mulberry leaf, and genetic constitution of silkworm strains. Different seasons affect the performance of Bombyx mori L.

Silkworm rearing depends on the availability of mulberry leaves. It is occasionally limited by the dry season, which is the time to avoid silkworm rearing because mulberry growing isretarded due to drought and exceeding high temperature gives rise to the retardation of silkworm growing.

Silk cocoon production — Code of practice — Part 2: Mulberry silkworm rearing for cocoon production

1 Scope

This Draft Rwanda Standard provides guidance on good practices during mulberry silkworms (*Bombyx mori*) rearing for cocoon production.

2 Normative references

There are no normative references in this document

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply

3.1

Silkworm

the larva or caterpillar of the *Bombyx mori* moth

3.2

young silkworm

silkworm larva from hatched egg to the full grown third instar larva

3.2.1

first instar larva

larva from hatched egg to before the first moulting

3.2.2

second instar larva

larva after the first moulting to before the second moulting

3.2.3

third instar larva

larva after the second moulting to before the third moulting

3.3

moulting

moulting is the shedding of skin as worms enter into the next instar

3.4

grown silkworm

larva from the fourth to the fifth instar

3.4.1

fourth instar larva

larva after the third moulting to before the fourth moulting

3.4.2

fifth instar larva

larva after the fourth moulting to pupa stage

3.5

mature silkworm

fully grown silkworm at the fifth instar larva that is ready to form its cocoon

3.6

mounting frame or cocooning frame

material on which cocoon is formed

3.7

cocoon

the outer protective shell spun by silkworm larva covering itself before transforming into pupa stage

3.8

fresh cocoon

cocoon that consists of a live pupa and shell with or without de-flossing

dried cocoon

3.9

defect cocoon or poor cocoon

cocoon whose shape is with abnormal characteristics i.e. double cocoon, pierced cocoon, inside soiled cocoon, outside soiled, thin-shelled cocoon, loose-shelled cocoon, thin-ended cocoon, malformed cocoon, printed cocoon, crushed cocoon, and mouldy cocoon

3.10

pebrine disease

protozoan disease of the silkworm, *Bombyx mori L*. caused mainly by *Nosema bombycis Naegeli* and can be transmitted via silkworm eggs

NOTE This is a devastating disease which causes disastrous losses and is under quarantine control by all sericulture countries disease is prohibited

4 Silkworm rearing for cocoon production

4.1 Life cycle of the Silkworm

The silkworm passes through 4 distinct stages i.e. egg, larva, pupa and adult during its life cycle as per Figure 1. The duration may last for 50-55 days depending on the prevailing climatic conditions.

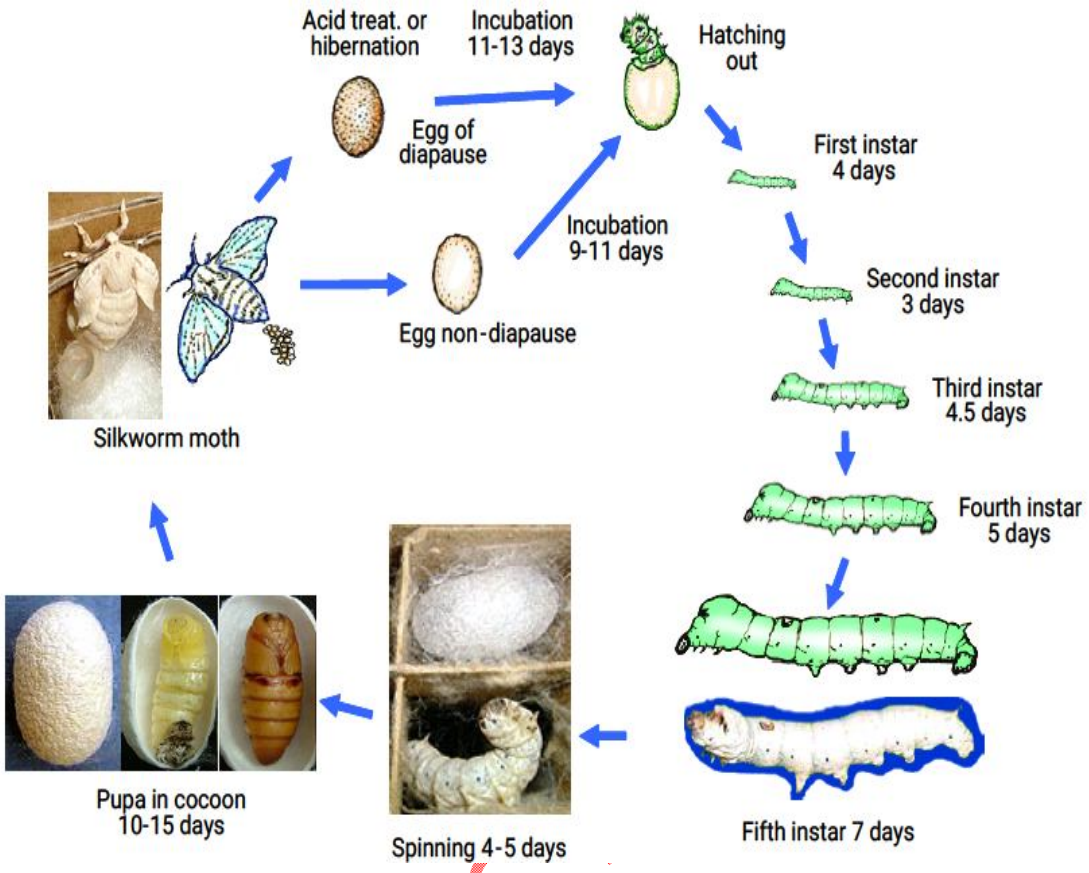

Figure 1: Life cycle of the silkworm, *Bombyx mori*

4.2 Incubationof silkworm eggs

4.2.1 Materials required for incubation

The following are materials used during incubation of*Bombyx mori* eggs :

a) Incubator

b) Incubation trays

c) Egg incubation paper boxes

d) Khaki Papers rolls

e) Polyethylene sheets

f) Foam pads

g) room heating facility (e.g. charcoal and charcoal stoves)

h) Hygro-thermometer to monitor temperature and relative humidity

i) Tables

j) Ant wells / barriers

4.2.2 Procedures

During the incubation of silkworm eggs the following procedures are considered:

a) Put polyethylene sheet underneath khaki paper, as bottom cover in incubation tray

b) Spread eggs (single layer) at the bottom of 'incubation paper boxes' in incubation trays

c) Cover arena with translucent plastic sheet

d) Ensure 24-25^{0}C and 70 – 85% RH are monitored using hygrothermometer

e) Gently mix eggs once a day using bird feather until pinhead stage (allows average conditions)

f) Monitor colour changes daily from grey stage to pinhead

g) At pinhead stage on 8-9 or 9-10th day of incubation cover the incubation tray with a black polyethylene sheet (black boxing)

h) After 2 days of black boxing remove black polyethylene sheet preferably at 06:00 hours to expose eggs to light

i) Silkworm larvae will have finished hatching usually by 10:00 hours and the unhatched ones can be re-black-boxed

4.3 Silkworm rearing

4.3.1 Facilities for silkworm rearing

The facilities for silkworm rearing including the rearing house and tools

4.3.1.1 Silkworm rearing house

4.3.1.1.1 The longitudinal structure of silkworm rearing house should be located in the direction of East-West; doors and windows should be in the North-South direction to prevent the direct sunlight into the rearing room as per figure 2. The trees planted around the silkworm house will help to reduce the radiation heat from outside.

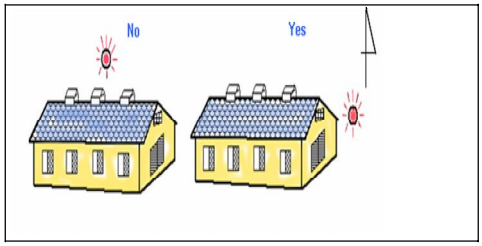

Figure 2: Orientation of the silkworm rearing house

4.3.1.1.2 The site of silkworm house should be 10-20 meters away from the living house for better sanitation and easier disinfection and distance should be kept from the area prone to risk causing adverse health effect on silkworms such as area of pesticide application and air-polluted source. In case of risk, there shall be preventive measures from rain, direct sunlight onto silkworms, silkworm pests e.g. Uzi fly, spider, ant, lizard, gecko, and rat.

4.3.1.1.3 There shall be effective cleaning agents and disinfectants for eliminating mould, bacteria, virus, and protozoa on equipment and rearing house and available treatment plan when the pests attacks the silkworms.

4.3.1.1.4 All the floor of the silkworm house and about one meter wide surroundings may bepaved for easy cleaning and better sanitation. At a corner or next to the door a space for mulberry storage is prepared, which is enough at least for two feedings.

4.3.1.1.5 The house may be built with concrete frame or wood truss with iron sheet roofing with ceiling to reduce heat radiation, a brick or concrete floor, and brick-layered side walls with windows covered by mosquito nets.

4.3.1.1.6 The minimum size of the house is 5 meter wide and 6 meter long (total floor space: 30 m^2) to rear 2 boxes per rearing.

4.3.1.1.7 The rearing beds are 1.5 meter wide, 1.5 m height and 5.0 meter long. Three rows of double rearing beds areplaced on the floor with one meter wide on both sides. And the lower shelf is placed 20 cm high from the floor and the upper shelf is set with 90 cm interval vertically between two shelves.

4.3.1.1.8 The rearing house shall be well ventilated, and with adequate size

4.3.1.1.9 The rearing house should be near the mulberry field in order to minimize the transportation distance thus cutting down on wilting of leaf.

4.3.1.2 Rearing materials and tools

The following are materials and tools required for silkworm rearing:

4.3.1.2.1 Non-recurring materials:

a) Rearing beds

b) bed cleaning net

c) cocooning/mounting frame

d) leaf harvesting baskets or gunny bags

e) feeding basket

f) mulberry storing box

g) hygro-thermometer

h) chopping knife for mulberry leaves

i) chopping board

j) chopping table

k) sterile sprayer

l) masks

m) pruning saw

n) disinfection tanks

o) feathers

p) foam rubber strips

q) ant wells

r) knapsack sprayer

s) secateur

t) clean material lining for rearing containers

u) foot cleaning tray

v) wash basin/stand

w) rearing nets

x) plastic shoes

y) overcoat

4.3.1.2.2 Recurring materials:

a) paraffin paper / plastic sheeting

b) formalin

c) bleaching powder

d) lime

e) charcoal

f) charcoal stoves

g) gloves

4.3.2 Rearing spacing

4.3.2.1 Enlarged area of silkworm bed shall be provided in correspondence with each stage of the silkworm development and the density of silkworms should be managed to prevent heat accumulation, increase in humidity, litter fermentation, accumulation of metabolic gases and insufficient feeding in case of silkworm overcrowding.

4.3.2.2 Different stages of silkworms require different bed space. Spread worms evenly ensuring that they do not overlap each other. The rearing space at different stages of silkworms should be as per Table-3

Table 3 Rearing spacing at different stages of silkworms (20,000 eggs)

Stage	Bed spacing , m^2	
	Early period	Later period
1st instar	0.4	1.6
2nd instar	1.6	3.2
3rd instar	3.2	5
4th instar	5.0	7.5
5th instar	10	15

4.3.3 Environmental factors affecting silkworm rearing

4.3.3.1 Temperature and relative humidity

Maintenance of recommended temperature, relative humidity (RH), light and ventilation conditions for every stage of rearing are of utmost importance for successful silkworm rearing.The optimum temperature required for rearing silkworms of different early instars are as described in Table 1.

Table1—Optimum temperature and humidity requirements of silkworm during various stages

Environmental factor	Incubation	1st instar	2nd instar	3rd instar	4th instar	5th instar	Spinning	Cocoon storage
Optimum temperature, ^{0}C	24-25	26-28	25- 27	24-26	23-25	22- 24	22-23	25
Relative humidity, %	75-80	85-90	80-85	75-80	70-75	65-70	60-70	55

4.3.3.2 Ventilation

Injurious gases such as carbon dioxide produced during silkworms breathing and litter fermentation, carbon monoxide when farmers burn charcoal to raise temperature, ammonia, sulphur dioxide, and so forth are released in the rearing room. Young silkworms are weak against carbon dioxide and ammonia. If the concentration of the carbon dioxide gas in a rearing room exceeds 2%, the growth of silkworm is retarded therefore:

a) Care should be taken to allow fresh air through proper ventilation to keep the toxic gases at a low level. Windows of rearing rooms should be kept wide open for better ventilation. Ventilation is more effective when the humidity of the rearing room is higher than the standard

b) Incubation room or chamber must be opened/ventilated daily for 10 minutes in the morning and evening during incubation.

c) Insecticides and disinfectants are also avoided in the rearing room, during rearing.

4.3.3.3 Light

4.3.3.3.1 Silkworms are photosensitive and have a tendency to crawl towards dim light. Late-age Silkworms survive better in 16-hour light and 8- hour dark periods. However, young-age worm prefers 16 hr darkness and 8 hr light period. Rearing under complete lighting or complete darkness is not advisable

4.3.3.3.2 Light should be provided for 12 hours a day, till head pigmentation stage. At blue egg stage, the eggs should be kept in darkness by covering with black paper or cloth to obtain uniform hatching.

4.3.4 Feeding

4.3.4.1 Frequency of feeding

The standard frequency of feeding is preferably five times a day morning (6-7AM) and (9.00-10.00 A.M.), afternoon (1.00-2.00P.M.), evening (4.00-5.00P.M.) and night (9.00-10.00P.M.). The 1st and 2nd instars may do with two feedings a day, 6.00AM and 6.00 PM depending on how fresh the food lasts.

4.3.4.2 Stages of growth and feeding methods

4.3.4.2.1 First instar: The young worms should be fed with young tender leaves; 2nd and 3rd leaves from the tip of the shoot. These are chopped into small pieces with an optimum size is 0.5-1.0 cm^2 and fed to worms for 3 days at least twice a day in the morning and late afternoon. After the3days the worms go into moult which takes 18 - 24 hours (1 day) and the silkworms should not be fed during this period.

4.3.4.2.2 Second instar: feed 3rd and 4th young glossy leaves. Continue feeding chopped leaves with an optimum size of 1.5-2.5 cm^2 for3 days. After this period the worms go into moult again.

4.3.4.2.3 Third instar: continue feeding the silkworms on good leaves harvested from the green part of the stem/shoot for three days. After this period silkworms go into moult.

4.3.4.2.4 Fourth instar: feed worms on whole leaves for 4 Days.

4.3.4.2.1 Fifth instar: feed on whole leaves for 7-8 days. During feeding always maintain a single layer of leaves. Avoid over mature, yellow and diseased leaves.

NOTE The larva duration is variable with the temperature and humidity , in association with the quality and the quantity of supplied food

4.3.4.2.5 Appropriate maturity of mulberry leaves should be considered for each stage of the silkworm development in order to provide sufficient nutrients as per Table 2.

4.3.4.2.6 Unconsumed leaves should be kept at low level to facilitate airflow, maintain their freshness and prevent accumulation of heat and dampness that cause disease to silkworms.

4.3.4.3 Brushing of silkworms

When hatched, silkworms get together in a group. The newly hatched silkworms are carefully transferred and evenly spread over for their healthy growth. The brushing of silkworm is then carried out by evenly spreading chopped mulberry leaf of the appropriate size. Principally young silkworms are reared in a sanitary, balanced nutritional condition and environmental conditions of temperature and relative humidity should be controlled as per Table-1

4.3.4.3.1 Brushing time of silkworms

Silkworms start hatching early in the morning and the first feeding will be given at 9:00 am. Those eggs which do not hatch in the morning of the first day are likely to hatch in the morning of the following day.

4.3.4.3.2 Brushing methods

The following are the methods of brushing:

a) **Feather method of brushing**: This is crude but popular method in the study area. In this method, fresh chopped mulberry leaf is sprinkled over the hatched larvae and the larvae crawl to fresh leaves. Then the egg card is held vertically over the fresh rearing bed and the larvae are pulled by gentle strokes of the feather to fall on the bed.

b) **Husk method**: the powder husk is sprinkled over freshly hatched larvae on the egg card. Freshly chopped mulberry leaves are sprinkled over the husk. The larvae crawl over the husk to reach the fresh leaves. Then the larvae along with the leaves are transferred to the rearing bed by means of feather.

c) **The cloth / paper / net method**: thin muslin cloth, or minutely perforated paper or a fine meshed net (mosquito net) is placed along the egg card with fresh chopped leaves. The larvae crawls to the leaves are transferred to the bed by taking out the cloth / paper / net and placing on the bed. After brushing, the larvae are spread uniformly with the help of chopsticks.

4.3.4.4 Recommended quantity of mulberry leaves for silkworms at different stages.

4.3.4.4.1 The silkworms of the fifth instar ingest 88.6% of the total food consumption, the fourth instar ingests 9.4% and the young silkworm from the first instar to the third instar ingests only 2% of total feeding.

4.3.4.4.2 The quantity of good quality mulberry leaves shall be sufficient for feeding each lot of silkworms. Mulberry leaves should be fresh, clean, without damage from pests and diseases that affect the health of silkworms. For the better growth, silkworms should be fed with sufficient quantity of mulberry leaves as per Table 2.

Table 2—Quantity of mulberry leaves for fearing of 20,000 silkworms

Stage	Life cycle days	Age/Day	Leaf weight per day	Leaf/shoot remarks per day
1st	1	1st	300 g	Harvest 2nd and 3rd young leaves, chopped at size of 0.5 cm× 1.0 cm
	2	2nd	350 g	
	3	3rd	370 g	
	4	4th	Molting	
2nd	5	1th	750 g	Harvest 3rd and 4th leaves
	6	2nd	1250 g	
	7	3rd	1800 g	
	8	4th	Molting	
3rd	9	1st	3 kg	Harvest leaves that are on the green part of young shoot The 3rd instar larva can feed on entire leaf
	10	2nd	4 kg	
	11	3rd	5 kg	
	12	4th	3 kg	
	13	5th	Molting	
4th	14	1st	10 kg	

	15	2nd	15 kg	Entire leaves
	16	3rd	20 kg	
	17	4th	25kg	
	18	5th	10kg	
	19	6	Molting	
5th	20	1st	30 kg	Entire leaves
	21	2nd	40 kg	
	22	3rd	50 kg	
	23	4th	60 kg	
	24	5th	70 kg	
	25	6th	80 kg	
	26	7th	90 kg	
	27	8th	50 kg	
	30	9th	silkworms start cocooning	

4.3.5 Control of pathogens

Silk worms are prone to various pathogens such as bacteria, fungi, viruses and protozoans. Therefore, maintenance of sanitary conditions through cleaning, disinfection of the rearing house and rearing equipment and isolation of dead silkworms is recommended.

4.3.5.1 Disinfection of rearing house

4.3.4.5.1 The rearing house, its surrounding and rearing equipment should be cleaned thoroughly and washed in 5% of bleaching powder solution before receiving silkworm eggs.

4.3.4.5.2 Washed materials may be dried in the sun;

4.3.4.5.3 Rearing equipment should be arranged inside the rearing house, doors and windows closed airtight and 2% formalin is sprayed evenly to drench thoroughly the ceiling, walls, floor, doors, windows as well as rearing appliances using a power sprayer. Personal Protective Equipment (PPE) should be worn while disinfecting the house as per figure 1

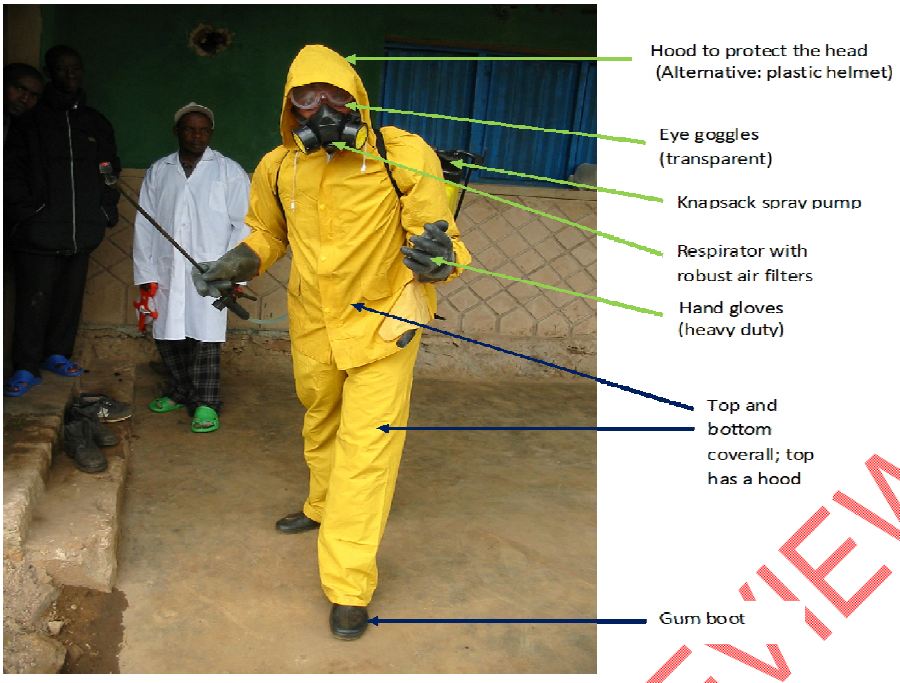

Figure 1 Recommended personal protective equipment

4.3.4.5.4 To allow quick diffusion of formalin molecules the recommended temperature is 25^{0}C and and relative humidity of 65% or more;

4.3.4.5.5 After spraying, rearing house should be closed for at least 24 hours and opened only next morning before introduction of silkworms;

4.3.4.5.6 Display a warning notice in large letters on the door to keep people away. It may read as follows: **WARNING: "DO NOT ENTER, FORMALDEHYDE GAS DISINFECTION TAKING PLACE"**

4.3.4.5.7 Before entering the rearing house, hands should be washed with disinfectant, foot mat soaked in 5% bleaching powder and 0.3% slaked lime solution should be placed at the entrance;

4.3.4.5.8 Lime dust checks viral infections and keeps the rearing bed less humid. Apply a mixture of lime powder (100 grams) and bleaching powder (900 grams) on the floor, verandas of the rearing houses and premises to improve hygiene.

NOTE Slaked Lime powder available in local markets is sieved first to get fine powder

4.3.4.5.9 Entry of person other than those involved in rearing should be avoided;

4.3.4.5.10 Clean the rearing floor with 2% bleaching powder solution before and after bed cleaning;

4.3.4.5.11 bed disinfectant should be used when the larvae come out of moult; and

4.3.4.5.12 Ensure optimal environmental conditions of temperature, humidity, light and aeration.

4.3.4.5.13 Estimation of recommended amount of disinfectantis per Annex A.

4.3.5.2 Disinfection of equipment

The rearing equipment can be disinfected by dipping as follows:

a) First wash equipment thoroughly with soap, sun dry and then dip into 5% solution of bleaching powder or 2% formalin solution for a minimum of 30 minutes in a disinfection tank;

b) Large equipment such as bed stands, leaf storage chambers, mountages can be disinfected by washing and spraying with either 5% bleaching powder solution or 2% formalin; and

c) Disinfection tank may be of the size 200 cm x 150 cm and 60 cm deep and a thickness of 15 cm constructed using bricks and cement (water proof).

4.3.5.3 Bed cleaning

4.3.5.3.1 Bed cleaning is an important process to ensure the hygiene in the immediate vicinity of silkworms in order to protect them from infection. It should be done in the morning before feeding silkworms, once in first instar, twice in second instar after moulting and preferably daily in third, fourth and fifth instar.

4.3.5.3.2 It is done after every moult for the young silkworms and every day for the mature worms.

4.3.5.3.3 During bed cleaning, un-eaten leaves, faeces, abnormal, weak, scrubby, diseased and dead silkworm which accumulate on the rearing bed should be collected and disposed properly to protect silkworm from bad gas and disease-producing germs on the bed.

4.3.5.3.4 To clean the bed, a net is spread over the silkworms and fresh leaves are evenly distributed on top of the net. Silkworms will crawl up to feed on the fresh leaves on the net which, in turn, are shifted to new beds. Any remaining silkworms are transferred using the net to another clean bed/tray, then the wastes are discarded.

4.3.5.3.5 There shall be disposal measures for wastes e.g. silkworm excrete, mulberry branches and leaves after each rearing cycle both inside and surrounding area of the rearing house to prevent the spread of diseases.

4.3.5.3.6 For the proper disposal, infected larvae should be put in 2% formalin solution before burning or burying.

4.3.5.3.7 In the preparation of 2 % formalin solution, 1 litre of 40% formalin (commercial) will be mixed with 19 litres of water to make 20 litres of spray solution of 2% formalin;

4.3.4.5.3.8 Hands shall be washed after bed cleaning to prevent disease from spreading

4.3.5.3.9 Polyethylene sheets used as bottom cover should be washed with soap and dried in the sun and then disinfected in 5% bleaching powder before use. The following is the procedure for bleach solutions preparation:

a) Dissolve 60 g of slaked lime powder in 20 litres of water (0.3%);

b) Dissolve 1 kg of bleaching powder in 0.5 litre of slaked lime solution and make a paste;

c) Pour the above bleaching powder paste to the rest of the slaked lime solution and shake thoroughly.

d) Cover the container with a lid and keep the mixture undisturbed for 15 minutes to settle down the un-dissolved matters.

NOTE Use freshly prepared solutions

4.3.6 Management of moulting larvae

4.3.6.1 Moulting and post- moulting signs

4.3.6.1.1 Silkworms undergo 4 moultings in the larval stage and instars are fed accordingly. The rearer must be able to identify when the worms are getting into and out of moult apart from counting days. During moulting the bed should be kept dry and uncovered.

4.3.6.1.2 Moulting Signs: swollen heads, heads raised upwards, reduced movements.

4.3.6.1.3 Signs of getting out of moult: the worms are active and move around, the mouth part is broader, the body is dull with loose skin and shed off skins are easily seen on the bed.

4.3.6.1.5 Once the silkworms come out of moult, they should be spread evenly to enhance dryness in the bed and to increase the bed space to match with their increasing body size. Silkworms are fed when all of them have come out of moult.

4.3.6.2 Precautions for handling the moulting larvae

4.3.6.2.1 Generally moulting is uniform when incubation and rearing are done properly while poor uniformity of moulting takes place due to diseased larva and handling of moulting larva in a wrong way. When about 70-80% of larvae are completely in the moulting stage, feeding should be stopped; unconsumed leaves and excreta should be removed and humidity reduced from the rearing house.

Figure9:Moultingsilkwormlarva

4.3.6.2.2 When 90% of silkworms go into the moulting stage, lime powder is dusted or husk is applied to reduce the humidity to 60-65% RH facilitating the moulting process and the temperature should be controlled as per figure 4.

The moulting temperature is per figure 4 below:

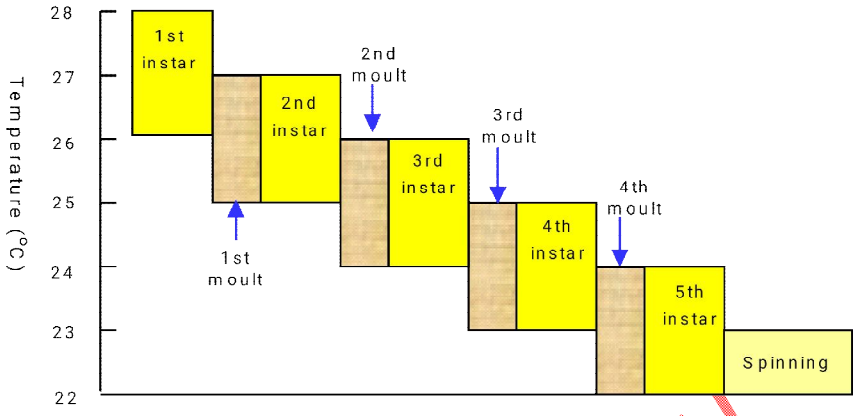

Figure 10: Optimum temperature for each instar of silkworms

4.3.6.2.3 The newly moulted silkworms crawl around in search for mulberry. When about 95% of silkworms have completed the moulting the first feed of mulberry leaves as given. This first feed is slightly less than the standard dose.

4.3.6.2.4 After post-moulting of silkworm and before feeding of first meal of each development stage, there shall be prevention and disinfection from silkworm diseases by application of lime powder.

4.3.6.2.5 Slower post-moulting or under grown silkworm than that of the same development stage should be collected to rear separately.

4.3.6.2.6 Moulting period lasts for about 24 hrs and care should be taken not to disturb silkworms during this period.

4.3.7 Mounting of mature silkworms

4.3.7.1 Mature silk worms signs and handling

4.3.7.1.1 In about a week of the 5th instar, after completing the feeding silkworms reaches the maturity and are ready to spin silk. Mature silkworms are identified by the following maturity signs: larvae cease to feed, crawling restlessly away from light in search of a corner to attach themselves for spinning, reduction in size by one-third and transparent light yellowish appearance as they are full of silk, release of wet faecal matter

4.3.7.1.2 Ripened silkworms are transferred to the mounting or cocooning frames for spinning cocoons. Then the mature silkworm spins thread from its mouth to make the footing for cocooning. This footing is called the cocoon floss. Typical examples of mounting frames are shown in figure 17.

4.3.7.1.3 Silkworms ripened on different days should be put in separate mountages and unripe silkworms should be allowed to continue feeding.

4.3.7.1.4 Silkworms should not be disturbed during cocooning for the continuity of the silk thread.

4.3.7.1.5 The mature worms are picked from the rearing beds and trasferred to mountages. Care should be taken to put the right number of worms on the mountages to avoid overcrowding and formation of double cocoons.

4.3.7.2 Cocooning frames

In selection the type of cocooning frame, the following factors should be considered:

a) Adequate and equal cocooning space should be provided.

b) The frame should be made of a proper material for the reeling ability of cocoons.

c) It should be durable.

d) Mounting can be done easily.

e) Easy handling and harvesting from the aspect of labour requirement for mounting.

3) Although few cocooning frames satisfy all these conditions, either rotary cocooning frame or plastic cocooning frame is recommended.

4.3.7.3 Typical frames

4) This is made of plastic and each frame is usually made up of about 20 mountains of which height is of which about 6 cm. When mounting, the mountain-shape is straightened out and the frames are spread over the tray or rearing bed. Fifty frames are needed per one case of silkworm seeds. The plastic frame seems to be used for a small scale rearing.

5)

Figure 12: The plastic mounting frames (left) and the bamboo stick frames

4.3.7.4 Methods of mounting

Method of mounting and control of environmental conditions during mounting affect the quality of cocoons considerably. There are several methods of mounting.

4.3.7.4.1 Picking-up method

When about 10% of silkworms become transparent, they are picked up by hand to place on the cocooning frame. By this method, silkworm can be mounted at the right time but it takes a lot of labours. This method is adopted for a small scale rearing of silkworms.

4.3.7.4.2 Self-mounting / Natural mounting

In this method, the cocooning frames are placed on the rearing bed and the matured silkworms climb up to search spinning places. This method saves labours required for mounting and the cocoon quality improves, as only matured silkworms mount the frame.

4.3.8 Management of silkworms during mounting

4.3.8.1 Protections during mounting

The following precautions should be observed:

a) The temperature should be maintained close to 22-23^{0}C principally and the humidity between 60-70%. At high temperature above 25°C, the cocoon quality deteriorates.

b) As high humidity lowers the reeling ability of cocoons, it needs to keep dry condition by using fan or ventilator.

c) The direct sun light should be avoided.

d) Attention should be also paid on the damages by rat and ants, because they favour pupa inside a cocoon.

e) papers should be spread on the floor below the mountages to absorb urine from the worms and changed when they become damp.

f) When about 40% of silkworms have become matured, the cocooning frame is placed on the bed.

g) The frame is placed on the bed for 10-15 hours. When 80-85% of spaces are filled with matured silkworms, the frame is transferred to the mounting room.

h) 90 - 100 larvae should be mounted per square foot

Figure 13 Spaced silkworms on mounting **A mature spinning silkworm**

4.3.8.2 Silkworm care during cocoon spinning and pupation

During cocoon spinning and pupation the following should be taken into account:

a) The good aeration is required and can be controlled by opening all windows but strong winds and strong sunlight should be avoided.

b) Ensure moderate and uniform lighting in mounting room. Silkworms move away from strong light which may cause overcrowding on one side, formation of double cocoons or poor quality cocoons (e.g. uneven thickness)

c) Fallen silkworms on the floor should be mounted on separate mountages. Such worms produce inferior cocoons

d) Keep mountages undisturbed until cocoon harvest to minimize possible injury of delicate immature pupae

4.3.8.3 Management of silkworm 'urine' during mounting / spinning

4.3.8.3.1 Urine must be checked as it raises relative humidity in the rearing room besides staining the cocoons

4.3.8.3.1 Absorbent khaki paper should be put under the mountages to dry off the urine and one is using plastic sheets change them frequently.

4.3.8.3.1 When using wooden frames, these should not be stacked on top of each other but rather have the frames stand at an oblique angle to give quality cocoons with minimal stain problems

4.3.9 Silk cocoon harvesting

4.3.9.1 Pupae maturity

4.3.9.1.1 Cocoons shall be harvested when pupae become mature enough. Generally the majority of silkworms complete cocooning in 2 days after preparing footage and in another 2 days it can become pupa at 25°C. The pupa, immediately after pupation, is very soft with yellowish body colour and may rupture even with slight mechanical stress. But after 2-3 days at 25℃, its skin turns to dark brown and hard.

4.3.9.1.2 Pupal maturity is checked by dissecting randomly selected cocoons and examining condition of pupae.

4.3.9.1.3 Hard and dark brown pupae with dry cocoon shells best time for cocoon harvest (7th or 8th day after mounting)

4.3.9.1.4 Early harvesting injures the delicate pupawhich stains the cocoon with their bleeding. Conversely, delayed harvesting of cocoons bears a risk of cocoon spoilage by emerging adult moth.

6)

Figure 14- Fully formed pupa

4.3.9.2 Harvesting method

Spoiled cocoons are firstly sorted out. This is important because dirty fluid from dead pupae soils good cocoons and lowers their value. After removing dead pupae and thin shelled cocoons, the cocoons are harvested by hand. Waste cocoons should be put in separate bags not to mix with good cocoons.

Annex A
(normative)

Estimation of the quantity of disinfectant

A.1 Calculation of total area of rearing room

The following is the procedure to calculate the total surface area to be disinfected:

E.g. Rearing house size: 20.5m long, 8.5m wide and 2.8 m in height – up to ceiling)

a) Area of floor and ceiling: L x W x 2 = 20.5 m x 8.5 m x 2 = 348.5 m^2

b) Area of 2 long side walls: L x H x 2 = 20.5 mx 2.8 mx 2 = 114.8 m^2

c) Area of 2 other side walls: W x H x 2 = 8.5 m x 2.8 mx 2 = 47.6 m^2

d) where L stands for length, W for width and H for height.

e) Total surface area to be treated = 510.9 m^2

A.2 Estimation of formalin solution to be used for rearing house and equipment

A.2.1 The disinfection of about 17.5 m^2 requires 1 litre of 2% formalin solution. Therefore, 510.9 m^2 will require $\frac{510.9}{17.5}$litres=29.2 litres of 2% formalin

A.2.2 An equal amount of formalin solution may be required to spray rearing equipment (following washing with bleaching powder).

A.2.3 A total of 58.4 L of formalin (2%) will therefore be required to disinfect rearing house of 510.9 m^2 and the rearing equipment (for specified house above)

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