SEPALI Madagascar

« Sehatry ny Mpamokatra Landy Ifotony »
Organization of Silk Producers

INSTRUCTIONS FOR REARING WILD SILKWORMS TO PRODUCE SILK
Antherina suraka SATURNIDAE

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FOREWORD

This manual could not have been completed without the generous assistance of the people who collaborated with me.

First and foremost, I would like to thank my colleagues at the organization SEPALI for their work on the many experiments that had to be completed in order to write this book, including Denis Ramasy, Mario Jaofeno, and Bertrand. I would also like to thank Lalaina Raharindimby and Kerry O'Neill for their help with the layout and graphics in this manual.

Second, this edition of the rearing book could not have been achieved without generous donors and I would like to express my gratitude and appreciation for them and for the organization FAPBM for funding SEPALI's work and allowing us to complete this 100-page edition.

Third, I would like to thank the organization CPALI, or Conservation through Poverty Alleviation International for supporting SEPALI from the beginning to the end and shouldering the expense of the project and the research.

Last but not least, I would like to thank the Wildlife Conservation Society of Mamabaie for providing the logistical and material support necessary to make this book become a reality.

And a Special Thanks to You!

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INTRODUCTION

This manual, entitled “Instructions for Rearing Silkworms to Produce Wild Silk: Antherina suraka SATURNIIDAE”, was designed and written for rural farmers who are interested in working with the organization SEPALI to produce silk. This book was originally written in the language of Betsimisaraka in order to be easily understood by the people living in rural communities of Maroantsetra.

SEPALI, which stands for “Sehatry Mpamokatra Landy Ifotony”, or “Organization of Wilk Silk Producers”, is a small organization that works with people living in the rural communities of the Maroantsetra District to produce a type of wild silk that is endemic and exclusive to Madagascar. This silk variety has never been marketed until now.

The silkworm *Antherina suraka* is found only here in Madagascar. This particular species of silkworm feeds on different types of host plants, depending on the region. In the Northeastern region of Madagascar, it feeds on a species of tree called *th* from the family ARALIACAE. In Malagasy, the tree is called “Talandoha” or “Beloha”.

This book will discuss all of the technical details from the planting technique for the host tree to the silkworm rearing process and silk production. The end of this book contains information about the finished *Antherina suraka* silk product.

This book will help you learn how to rear silkworms that feed on Talandoha and produce silk. We invite you to read and become comfortable with the techniques discussed within.

Thank you!

CHAPTER ONE

INSTRUCTIONS FOR PLANTING THE HOST TREE FOR *Antherina suraka*

I- The Host Tree for the Silkworms

To enable you to produce cocoons, it is important that you have enough trees to feed the silkworms.

This first chapter will help you understand the steps for planting the tree, the best time period for planting, and the planting techniques.

I-1- Explanation and Overview

- The tree, *Polycias bakeriana*, from the family ARALIACEAE, is called "Talandoha" or "Beloha" in Malagasy and is the food source for the silkworms. There are many species of trees in the ARALIACEAE family, so be careful to select the right one.

- The period from September to January is the best time to find the trees in bloom and the fruits will be ripe with seeds starting in the month of March.

- The period from June to August is the best time to find seedlings already germinating on the ground.

- Talandoha trees produce many fruits, as you can see in the picture on the following page. A single fruit can have 10 to 12 seeds inside. One tree can produce about 10,000 seeds.

- The Talandoha is a very fast growing tree. After only 12 to 18 months, it will be mature enough to host the silkworms and you can begin the rearing process.

- Even though the Talandoha is just one species, there are three different varieties. While the silkworms can eat all types of Talandoha trees, the results may vary based on the types of trees you use, so you need to choose the variety of Talandoha that you want to plant.

The pictures will help you recognize the different types of talandoha trees.

EXPLANATION AND OVERVIEW OF the TALANDOHA TREE

Talandoha Leaves
The leaves of the Talandoha grow in pairs or lines of two and the Talandoha leaves are soft and flexible.

Talandoha Tree

Talandoha in Bloom

Seeds of the Talandoha

Ripe Fruits

THE VARIETIES OF TALANDOHA

Talandoha with green leaves and red branches can be used to rear silkworms.

Talandoha with green leaves and green branches can be used to rear silkworms.

Talandoha with red leaves and red branches should not be used to rear silkworms.

I-2- The Planting Technique

There are two ways to plant the Talandoha:

- Planting from branches or cuttings
- Planting from seeds or seedlings

I-2-1- Planting from Branches or Cuttings

The Talandoha cuttings are easy to plant and certainly fast-growing. Adding fertilizer is not always necessary, but the Talandoha really needs moist soil, so it is important to plant during the rainy season (June to September).

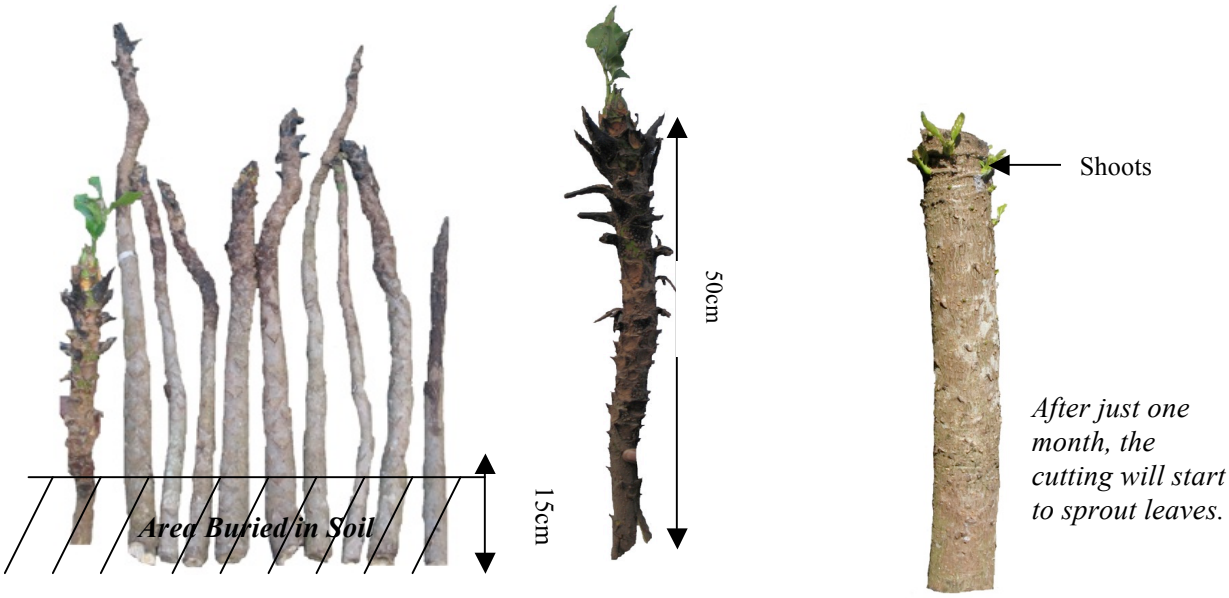
- For cuttings, the trunk of the tree should be cut into half-meter segments and inserted into the soil about 20 cm deep.

- When the cutting is planted, cover the exposed tip of the cutting with a water-proof material such as a plastic bag to protect it from desiccation and insects.

- The cuttings should be spaced at least 2 meters apart, and be careful not to bump or disturb the cutting after planting.

- In order to prevent desiccation, avoid planting the Talandoha during a hot period. The Talandoha needs shade and moisture, so it is important that you water the tree as soon as you plant it.

The months of June, July, and August are the best months to plant from cuttings for the residents around the Makira forest area.



1-2-2- *Planting from Seeds or Seedlings*

a- Preparing the Seeds

- The fruits of the Talandoha appear dark red or black when ripe.

- The fruits should be sorted during the collection process and only the ripe fruits should be kept to harvest the seeds.

- Do not wait until the fruits dry out to harvest the seeds, but instead cut open the fruits when they are ripe and remove the seeds from within.

- When the seeds are separated from the fruit, they should be washed and dried in the sun.

- When the seeds are dry, removed the rotten and damaged seeds, and place the good seeds in a paper packet or envelope.

- Store the seeds in a cool, dry place that is protected from the sun and out of reach of insects and animals.

If you take good care of them, the seeds will stay viable for many months.

b- Sowing the Seeds:

- The seeds should be broadcast in an area that is rich in fertilizer and protected from the sunlight.

- The seeds need to be watered and weeded often to prevent other grasses from growing.

- Two months after planting, the seeds will begin to sprout.

- It is best to fill plastic pots with rich, dark soil and germinate seeds at the same time so that the pots are ready for the seedlings.

- When the seedlings have grown to a height of 5 cm, they are ready to be transplanted to the plastic pots in a tree nursery.

- The seedlings should still be watered and weeded often.

- Four months after transplanting the seedlings to the nursery, or after they have grown to a height of 20 cm, they can be transplanted to your land.

Preparing the seeds and seedlings

The ripe Talandoha fruits

Submerge the fruits in water and message until the seeds are free. Then sort the seeds and dry them in the sun for about 30 minutes.

The Talandoha seeds freshly washed and sorted

Talandoha seeds sown in a seed bed

Spread or broadcast the seeds on soil that contains good fertilizer, water often, and protect them from the sun. After only 2 months, the seeds will start to germinate and grow.

Newly sprouted Talandoha seeds

Talandoha nursery

After the seeds have germinated, wait one month for them to grow, and then transplant them to plastic pots in the nursery. It is important for the nursery to have a roof because the seedlings shouldn't be exposed to too much sunlight.

- After 2 months in the nursery, the trees will be ready to plant. When planting, cut open the bottom of the plastic pot before you place the tree in the ground.

c- Planting the Seedlings in the Ground

- First, make a hole that is at least 40 cm in depth and width.

- Add dry leaves or fertilizer in the bottom 30 cm and fill the top 10 cm with soil.

- Cut open the bottom of the plastic pot wrapper.

- Before planting, trim the tip of the main root; the longest and straightest root protruding from the bottom of the plastic pot.

- After the root is cut, plant the seedling with the plastic pot still attached to the sides.

- Leave at least two meters between each seedling.

- The Talandoha tree needs a moist environment, so it is important to water it when planting to protect it from drying out.

- After the planting is complete, cover the ground with grasses to protect the tree and prevent desiccation.

- With proper care, the tree should reach over 1 meter in height after only 6 months.

- After 12 to 18 months, or a little over 1 year, the tree should be mature enough to begin rearing silkworms.

- The Talandoha tree can be intercropped with other types of plants, including cassava, greens, and other types of trees that don't crowd the area.

- For the residents living in and around the Makira forested area, the Talandoha tree can be planted at any time of the year. The season is not important for sowing seeds, building nurseries, or planting seedlings.

- You are free to choose how to plant the Talandoha. The trees can be intercropped on your land or planted as a fence around your property.

- The silkworms will not harm your trees during the rearing process, so don't be afraid to begin rearing once your trees have reached maturity.

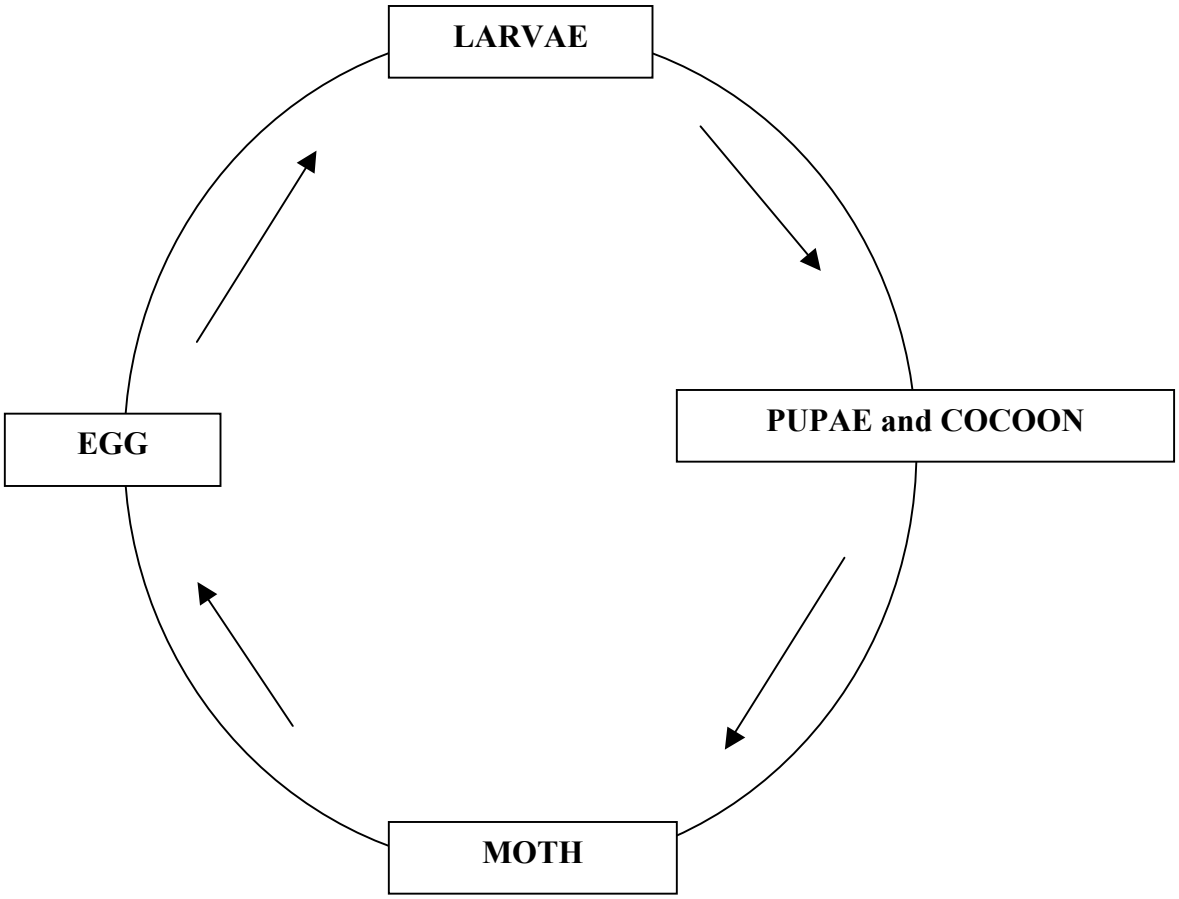
CHAPTER TWO **THE SILKWORM, *Antherina suraka***

II-1- The General Life-Cycle of the Silk Moth

The silk moth goes through four stages before it reaches the silk production phase. The four stages are as follows:

- Moth phase
- Egg phase
- Larvae phase
- Pupae phase

The abbreviated life-cycle of the silk moth is depicted below:



The General Life-Cycle of a Silkmoth

II-1-1- The Moth

- The moth stage of the silkworm, or “papillion” in French, is the last stage that the silkworm goes through before reproduction.

- *Antherina suraka* is classified as a macro Lepidoptera (a large species of moth). The female’s body measures 4.5 cm in length and has a wing-span of 10 cm.

- Only slightly smaller than the female, the male’s body measures 4 cm in length with a wing-span of 8.5 cm.

- The moth is nocturnal, meaning it flies only during the night and rests in a dark place during the day.

- There are four, color varieties for the moth *Antherina suraka* that look very similar except for the pattern on the body.

- The life-span of the moth is very short and often lasts only 4-5 days before death.

- Nectar from the trees is the food source for the moth.

There are three ways to distinguish between the male and female moths:

- ***The antennae:***

The male’s antennae are thick and hairy while the female’s antennae are thinner.

- ***The top of the wings:***

The edge of the male’s wings are curved while the female’s wings are straight.

- ***The body:***

The tip of the male’s body is thin and pointed while the female’s is rounded and blunt.

- During the night, the male and female will mate for about 12 hours.

- The female moth attracts the male to her using pheromones during the mating phase.

- Six hours after separating from the male, the female will begin laying eggs and will continue for a period of 3 days. The male dies shortly after mating with the female.

Distinguishing Characteristics of the Male and Female:

The antennae of the male moth are thick and branching.

The antennae of the female are thinner than the male.

The edge of the male's upper wing is curved and dips inward at the center.

The edge of the female's upper wing is straight and smooth.

The tip of the male's body is narrow and pointed at the end.

The tip of the female's body is big and rounded at the end.

II-1-2- The Eggs

- The eggs of *Antherina suraka* are spherical in shape, smooth, and white. Each egg is less than 2 mm in diameter.

- The shells of the eggs are strong and bind to the leaves tightly due to the sticky substance that the moth produces when she lays her eggs.

- *A. suraka* will lay many eggs in a big cluster, in contrast to other species of moth which will lay one egg at a time.

- One female *Antherina suraka* moth can lay from 60 to 150 eggs.

- After 5 to 10 days, the eggs will hatch. The temperature and the climate conditions will determine when the eggs hatch.

II-1-3- The Larvae

- The caterpillar or larvae stage is the longest phase that the silkworm passes through in its life cycle.

- The leaves of the Talandoha tree are the food of the silkworm *Antherina suraka.*

- During the larvae growth phase, the food source of the larvae does not change.

- One *Antherina suraka* larva can eat three times its weight everyday. Larvae eat continuously throughout the day and the night.

- There are five distinguishable stages of growth for the larvae.

- The color and length of the body help to indicate each stage.

- When the larvae are ready to move into the next phase, they will molt their skin. This molting process will be explained shortly.

- The larvae molt four times during their life-span, and during the last phase, they build a cocoon and pupal case and change form. This phase is called metamorphosis.

- Twenty to 30 days after hatching, the adult silkworm enters the silk-production phase.

Growth Phases of the Silkworm Larvae

Larvae Stage 1:
When the larvae are newly hatched, they are considered stage one. The larvae measure 4 to 5 mm in length and are black in color with yellow spikes.

Larvae Stage 3:
Stage 3 silkworms measure 2.5 to 3 cm in length. They are dark in color, but with pronounced green/ yellow spikes.

Larvae Stage 2:
Stage 2 silkworms measure 10 to 15 mm in length and are still black in color.

Larvae Stage 4:
Stage 4 larvae measure 5 to 6 cm in length and are bright green in color. The body will fill out and spines will cover its whole body.

Larvae Stage 5:
The fifth stage is the last stage before the larvae change into chrysalides. They measure 7 to 10 cm in length and the colors will change to bright green with red/pink spines covering its whole body.

Clarifications:

- There are four color varieties of the larvae Antherina suraka, but only three are found in the Makira Area.

- The life-span of all varieties are the same and all varieties produce silk.

- It is not possible to distinguish gender by looking during the larvae stage.

THE VARIETIES OF *Antherina suraka* FOUND IN THE MAKIRA AREA:

Variety 1:
The whole body is bright green

Variety 2:
Green on its back, but the sides are black

Variety 3:
The whole body is black

II-1-4- The Pupae

- The pupal case (or chrysalide) is the hard casing that the larva forms around itself when it is ready to metamorphose. The pupa is contained within the cocoon.

- The pupa stage is the most crucial phase of the silk-rearing process because this is the time period when the silk cocoon is produced.

- It is possible to distinguish between males and females during this phase.

- The cocoon or “silk” is a kind of thread that is produced by the silkworm when it makes a small sack to protect itself from predators.

- The silkworm goes through many stages of development that will be explained below.

II-2- Growth Stages of the Silkworm

- There are two ways that the silkworm grows:

A- Molting

- The molting process of the silkworm occurs when it sheds its skin so its body can grow, but it does not change form.

- After molting, the amount of food that the larvae will consume each day will increase in accordance with its size.

- The silkworm molts four times, or every time it changes growth stages.

- From the first stage to the fifth, you will be able to find the old skins of the larvae after molting.

- The first four molting phases will be similar in appearance.

- During the fifth and final stage, you will not see the molt because it is in this stage that the silkworm will change form, or metamorphose.

B- The Process of Changing Form, or Metamorphosis

- When the silkworm emerges from this phase, it will emerge with a very different form than the one it had before.

- The fifth stage of the silkworm is the last stage in the larval development and the one in which the metamorphosis begins.

- After the larva builds its cocoon, the larva molts and folds its body into a pupal form with a hard outer case inside the cocoon.

- The silkworm goes through many physical changes inside the pupal case, and ultimately emerges as a moth.

- This whole phase change process, beginning with the stage 5 larva and continuing through the pupa phase is called metamorphosis.

The picture below will help to clarify the silkworm growth process.

Demonstration of the Molting Process for the Silkworm

Molting Process of the Stage 4 Silkworm:
- When the time comes to molt, the larvae will stop eating and moving altogether.
- The larvae will begin to produce silk threads and its feet will stick to the leaves.
- It will retract its head in close to its body.
- It will continue this behavior over the course of one day.

Stage 4 Larva During the Molting Process:
- The skin begins to wrinkle.
- The body begins to emerge from the skin and the skin begins to rip.
- The skin near the head rips first, followed by the rest of the body.

A Newly Emerged Stage 5 Larva:
After the skin rips open, the larva moves its legs to remove the rest of the skin which is left behind on the leaves. Last, the larva moves away with its new, larger skin.

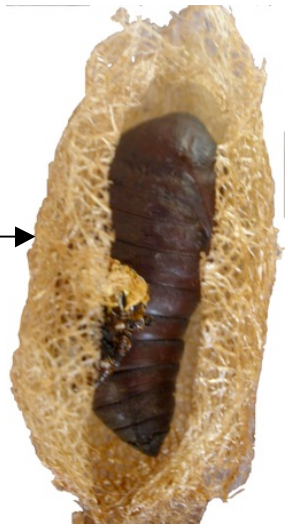
The Process of Metamorphosis and Cocoon Production

The cocoon is constructed starting with the mouth and acts like a small pouch for the silkworm to protect it from predators.

2 days →

Two days after producing the cocoon, it will begin to change form and produce the chrysalide.

2 days →



After two more days, the chrysalide will harden and become darker in color.

There are five colors of cocoons that can be produced depending on the rearing techniques.

Once the chrysalide is formed, you can distinguish between the male and the female.

II-3- Potential Threats to the Silkworm Lifecycle

There are many natural threats to the development of the *Antherina suraka* silkworm that can prevent it from reaching maturity and spinning a cocoon. The threats to the silkworm can be classified into three groups:

- Climate and surroundings
- Predation from other insects and animals
- Disease

We will examine each of these potential threats below.

II-3-1- The Climate and Surroundings

In this section, we will consider the three most common environmental threats and strategies to overcome these challenges in the rearing process.

A- Air Quality

- All stages of silkworm development are very sensitive to air quality. They require a space with a nice breeze, clean air, and lots of space.

- The silkworms are especially sensitive to smoke and strong smells, so it is important to be careful about the location of your breeding house and where you plant your host trees.

- The larval phase is the most sensitive out of all four phases of development.

B- Heat

- Excessive heat is the biggest problem for all stages of the silkworm, including the egg, the larva, the pupa, and the moth.

- Natural, normal temperatures are extremely important to the silkworm's health. If the temperature becomes too hot or too cold, the silkworms will die.

- The ideal temperature range for rearing larvae is from 20°C to 30°C. When the temperature exceeds this range for a few months each year, the rearing must be put on hold until more favorable conditions return. To prevent unnaturally high temperatures inside the breeding house, avoid using aluminum as a roofing material.

- Each stage of silkworm development has a preferred temperature range.

- It should be noted here that all stages of development (the egg, the larva, the pupa and the moth) are not reared in direct sunlight.

C- Humidity

- Relative humidity is the third condition that is important to control during the silkworm rearing.
- It is important that the pupae be reared in a place with natural humidity. They should not be left in standing water or exposed to the rain.
- A humidity range between 55% and 65% is ideal for silkworm rearing.

II-3-2- Silkworm Predators

- One problem with breeding and rearing *Antherina suraka* on farms is that it attracts many predators. Each predator is associated with a certain season.
- Many species of insects and animals feed on *Antherina suraka* and each stage of silkworm development has its own set of predators.
- Through our research and experience, the following species were found to kill or injure the silkworms:

- Mosquitos: *Mosquitos can puncture and feed on the silkworm during the larval phase and can kill the larva within a few days. This predator is present during the months of June, July, and August.*

- Spiders*: Spiders can kill the larva during the first two stages of development through their venom and spider webs.*

- Ants: *Ants are one of the most difficult predators to defend against. The ants can kill larvae at any stage of development and can also carry diseases that can affect the silkworms.*

- Stink Bugs*: Stink bugs can bite and kill the silkworm larvae. They are most common during the dry, hot season.*

- Wasps: *Giant wasps suck fluids from stage 4 and 5 larvae, leaving an empty skin behind. They are most active from September to April.*

- Praying Mantis*: Praying mantis can be found almost year-round and feed on the younger larval stages.*

- Geckos: *Geckos can climb the trees and eat the silkworms as well.*

- Other species that occasionally feed on silkworms include rats, beetles, and birds. The presence of these species also varies by season.

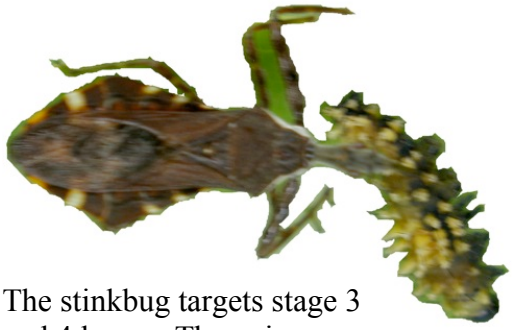
All of the above predators combined are capable of killing up to 100% of the silkworms in a single rearing if they are not properly controlled. Therefore, it is important to take certain precautions.

THE PREDATORS OF THE SILKWORM DURING THE REARING PROCESS

1- Predators of the Larvae

If many mosquitos bite the silkworm together, they can kill the silkworm before it is able to spin its cocoon.

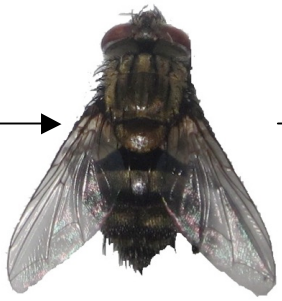
The giant wasp feeds on the larger stages of larvae and can kill and eat up to 30 silkworms per day.

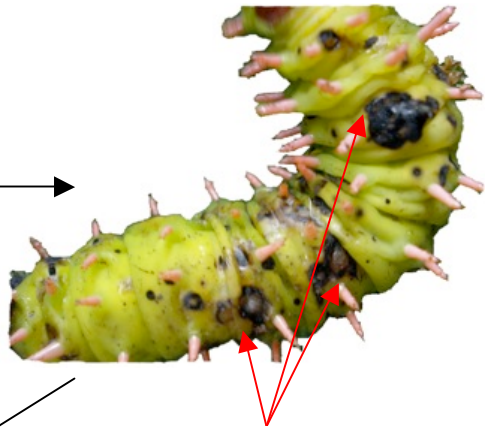


The stinkbug targets stage 3 and 4 larvae. They pierce the larvae with their mouth and suck out the insides of the larvae.

The praying mantis targets all stages of larvae. It can also kill and eat about 30 larvae per day.

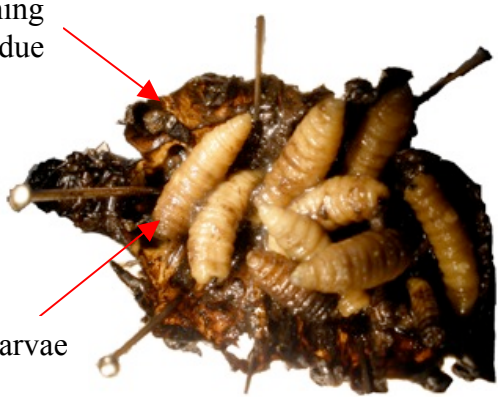
The fly lays eggs inside the body of the stage 5 silkworm larvae. As the fly larvae develop, they cause the silkworm to lose its appetite.





These black marks indicate that a fly has already laid its eggs inside the silkworm and the fly larvae are growing within.

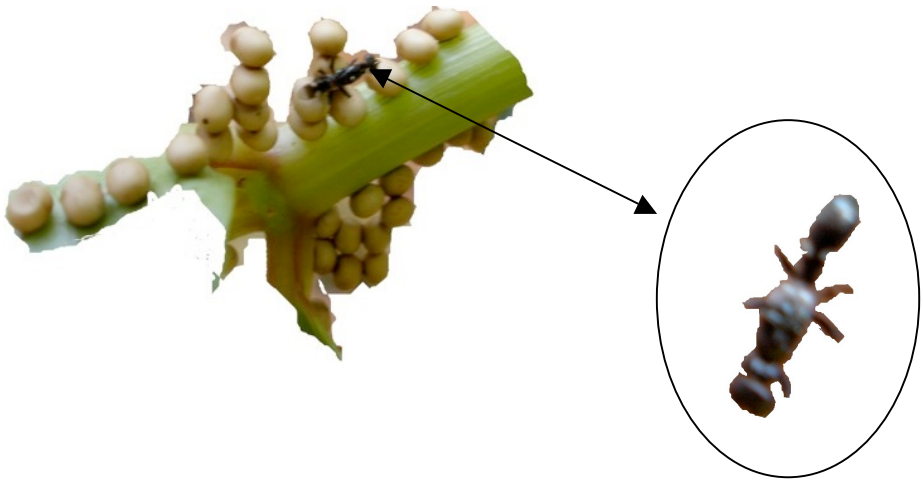
The remaining silkworm residue



Fly larvae

When the fly larvae hatch inside the body of the silkworm, they begin to eat the larva from the inside out. The fly larvae continue to eat the silkworm until the silkworm dies and they break out of the skin.

2- The Predators of the Silkworm Eggs



This small insect, measuring just 4 mm long, punctures the silkworm eggs with its proboscis and sucks out the yolk inside before the larvae is fully formed. All that is left is a tiny hole in the egg.

3- Diseases of the Silkworm

Diseased stage 5 silkworm larva:
A diseased silkworm will often grow normally through the stages, then die 1 to 2 days before it would spin its cocoon.

Diseased silkworm larva:
Once deceased, the body of the diseased silkworm can become stuck on the tree and can pass disease on to other healthy larvae.

II-3-3- Diseases of the Silkworm

All animals are susceptible to disease and silkworms are no exception. In addition to the predators listed above, Antherina suraka can fall victim to disease in various stages of development.

- One common vector of silkworm disease is the mosquito.

- Silkworms are also susceptible to viruses (entomopathogenic viruses), which can be transferred through the air or through contact.

- There are also diseases spread by fungus (entomopathogenic fungus) that can be spread through direct contact with infected hosts.

The table below lists susceptibility to predators and disease by each stage of silkworm development.

The number of stars (*) corresponds to the level of devastation inflicted by each predator.

(****): Up to 100% fatality
(***): Up to 80% fatality
(**): Up to 50% fatality
(*): Less than 25% fatality
(): No impact

Table: List of Threats to the Silkworm Antherina suraka by Stage of Development

Stage	Predator
Egg	Disease****; ants*; beetles*
Silkworm 1	Disease****; ants***; geckos**; wasps**; stink bugs**; mosquitos**; spiders**
Silkworm 2	Disease****; ants***; geckos**; wasps**; spiders**; stink bugs**; mosquitos**; praying mantis*
Silkworm 3	Disease****; ants***; geckos**; wasps**; stink bugs**; mosquitos**; praying mantis*
Silkworm 4	Disease****; ants***; geckos**; wasps**; stink bugs**; mosquitos**
Silkworm 5	Disease****; praying mantis*; mosquitos*; ants*; birds*
Pupae	Disease ****; rats**
Moth	Disease****

Of all the threats listed in the table above, disease remains the most serious threat to *Antherina suraka* due to fact that it can wipe out up to 100% of the silkworms in a single rearing cycle.

Every stage of silkworm development is susceptible to disease, starting from the egg to the larva to the pupa to the moth.

A- The Egg

- Some diseases seem to be contracted as early as the egg stage, so it is very important to care for the eggs strictly by the scientific rearing methods to prevent the spread of disease during the rearing.
- Ants and beetles are also capable of killing up to 25% of the egg stage.

B- The Larva:

- The larval phase has the greatest abundance of predators and threats. Infectious disease alone can kill up to 100% of the larvae through airborne transmission or direct contact; therefore, it is very important to protect the larvae during the rearing cycle.
- Insect and animal predators such as ants and geckos can also kill up to 80% of the first stage of larval development.
- Stink bugs can kill up to 50% of the stage 2 and 3 larvae.
- By stage 4 and 5, predation by flying insects such as wasps and stink bugs intensifies and together they can kill up to 50% of the larvae by stage 5.
- The final stage also attracts birds, which can eat up to 80% of the stage 5 larvae.

C- The Pupa (or Chrysalide)

- The pupal phase is susceptible to diseases with a mortality rate of up to 100%. Ants and rats are also a threat to this phase and can consume up to 50% of the pupae. It is therefore very important to follow the technical rearing methods in order to properly protect the pupae.
- The pupae should be reared in a separate location from the silkworm-rearing site so that the pupae are not exposed to disease.
- The pupal phase is one of the most valuable and sensitive phases of the rearing. Follow the instructions outlined below in order to successfully rear *Antherina suraka*.

e- The Moth

- Moths are also susceptible to diseases, which can be transmitted via sex organs to the eggs.

CHAPTER THREE **TECHNICAL REARING METHODS FOR THE SILKWORM *Antherina suraka***

Each species of silkworm has its own characteristics and requires rearing methods designed specifically for that species. Therefore, the rearing methods for *Antherina suraka* will be not be the same as for other well-known silk moth species. The steps below outline the procedure for successfully producing *Antherina suraka* cocoons.

III-1- Requirements to Produce Cocoons

1- One silkworm larvae will eat 3 times its weight in leaves each day. Therefore, it is important to have enough host trees to feed the silkworms before you begin the rearing. In order to successfully produce silk from *Antherina suraka*, you must have mature host trees that are at least 12 to 18 months old.

2- Cocoon production depends heavily on the number of trees planted. The more trees you have, even up to 1,000, the greater the potential returns for silk production.

3- Silkworm rearing takes time and patience and breeders must enjoy their work. Rearing *Antherina suraka* requires love and passion and a high level of comfort with the larvae.

4- It is very important to follow all instructions outlined in this manual in order to be able to produce high-quality silk cocoons. The first step is to make sure that you keep all of your rearing equipment clean as well as your own clothing. Silkworms are very sensitive to contamination, chemicals, and smells so it is important to keep everything clean.

5- Silkworms, pupae, and moths are very sensitive to smoke as well, so breeders should strive to keep fires as far from their rearing sites as possible.

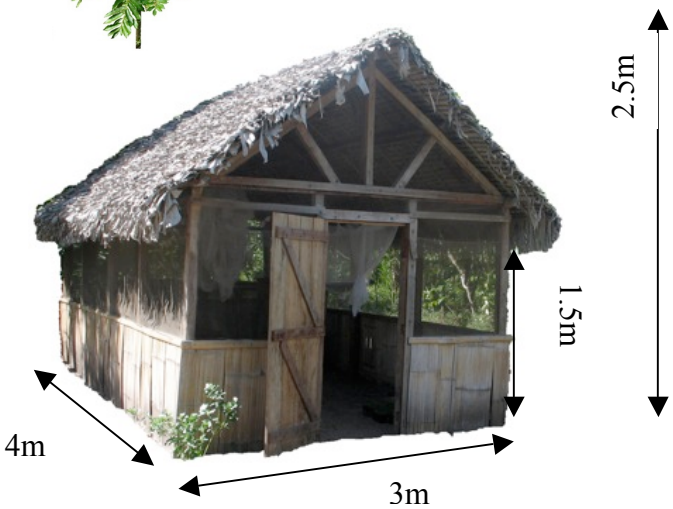
III-2- The Rearing Equipment

The rearing equipment is designed to be as simple and affordable as possible to the breeders in the local communities.

a- Equipment for Tree Farming

Essential Equipment for Silkworm Rearing

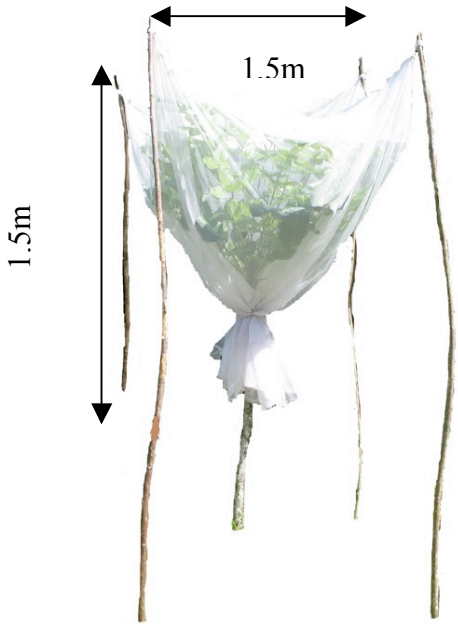
1- ***Talandoha host trees:*** *Each breeder must plant at least 250 trees in order to sustain a profitable rearing operation.*



2- Rearing House

Each breeder must build a small rearing house close to the Talandoha field. This rearing house will be used to care for the moth and pupae.

The size of the rearing house is 4 meters long by 3 meters wide and 2.5 meters high. The walls are optional, but the roof must be strong and waterproof.



4- Silkworm Rearing Net

Each breeder must have 10 nets for the rearing. Each of the four sides is 1.5 meters wide and 1.6 meters high.

3- Pupae Rearing Basket

This basket, made with local Penja grass, was specifically designed for the silkworm rearing. The size of the basket is 0.6 meters by 0.6 meters and it holds the pupae during the rearing.

5- Silkworm Basket

The basket to the right was specifically designed for the larvae rearing. It is made with local Rambo leaves.

As mentioned above, the first step of the process is to set up the host tree nursery. The necessary equipment is listed below:

- Appropriate location
- Plastic pots for the seedlings
- Nutrient-rich soil with compost
- Viable Talandoha seeds
- Bamboo branches and coconut leaves

b- Necessary Equipment for Rearing the Silkworms

It is very important to keep everything clean, so it is important to invest in clean equipment. Below is the list of rearing equipment that each breeder must have:

- Simple soap without perfume to wash your hands
- Powdered soap to wash rearing equipment such as nets and baskets
- 10 rearing nets for the larvae (see picture on previous page)
- 5 pupae baskets for each breeder (see picture on previous page)
- 5 cocoon baskets for each breeder (see picture on previous page)
- 1 rearing house to insure moth mating and pupae emergence

III-3- Rearing Instructions

Silkworm rearing begins at the egg stage. Over the course of its life cycle, *Antherina suraka* will go through 4 main stages of development:

- The egg
- The silkworm larvae
- The pupae or chrysalides with cocoon
- The moth

III-3-1- Caring for the Host Tree

The success of the rearing depends heavily on the quantity and quality of the host trees. It is important to care for the host trees properly in order to give the larvae the best chance for survival.

1- Proper tree care includes trimming back the old leaves near the bottom of the canopy. The silkworms only require the fresh leaves and shoots found near the top of the tree. It is important to make sure the tree is disease free and not inhabited by other insect predators (praying mantis, spiders, etc.).

2- Host trees must be routinely coppiced in order to keep the trees at a reasonable height for the rearing. The breeder should be able to reach all the leaves from a standing position. Trees should be coppiced once a year.

III-3-2- Caring for the Eggs

The mating process is very important for the fertility of the eggs. Mating typically lasts approximately 24 hours for *Antherina suraka*, beginning at night and continuing through the following day until 6 or 7 PM. Disrupting or breaking up the moths before this time can result in infertility. Below, we propose two different ways to handle the females once mating is complete:

Option 1: For breeders with rearing sites far from the village: Once the mating is complete, the female will lay her eggs on the host tree. Because the mating is typically finished around 7pm, it will be difficult to go to the rearing site at night if your land is far from the village. The solution is to carefully move the male and female during the day while they are still mating. To do so, breeders must use a small branch of the host tree to transport the moths without disrupting the mating process.

Option 2: For breeders with rearing sites close to the village: Ideally, breeders with host trees close to the village should wait for the end of the mating period to collect the female. This method requires the skills to distinguish between the male and female. Then the female can be taken and placed on the host tree to lay her eggs. Cover the tree with a net so that the female stays on the tree that you place her on.

Note 1: The female will lay her eggs every night for a period of 3 nights. Each day, the breeder should move the moth to a new tree so that her eggs are spread between multiple trees. This gives the larvae the best chance of survival.

Note 2: Only the eggs that are laid directly on the leaves of the host tree will survive. If the female lays her eggs on the rearing net, they are unlikely to survive even if they are moved to a host tree afterwards.

III-3-2- Caring for the Silkworm Larvae

- The whole host tree should be cleaned before using, including leaves, branches and trunk.
- Check to make sure that there are no other insects or predators inhabiting the tree, including ants, spiders, praying mantis, lizards, or other species of moth.
- All rearing equipment including the clothing of the breeder must be kept clean. It is especially important to clean your hands before handling the leaves. We recommend using soap without perfume for all the washings and cleanings.
- If the eggs are well protected from predators, they will hatch after 5 to 7 days, depending on the weather.
- When the eggs hatch and the larvae are healthy and feeding properly, it is time for the breeders to move the larvae to a new tree. The ideal number of larvae per tree is dependent on the size of the tree (1 larvae for 7 branches of leaves).

- After moving the larvae to a new tree, the tree must be labeled in order to keep track of the rearing properly. The label should include the date that the larvae were moved to the tree and the number of larvae that were moved.

Male and Female Moth Mating

Moth Eggs

a- Monitoring the Rearing Site

- The rearing site must be carefully surveyed by breeders in order to monitor predator populations. Domestic animals must be kept away from the rearing site. Avoid burning fires near the rearing site because the larvae are very sensitive to smoke. Make an effort to spend about 5 minutes of time to take care of the larvae in each tree.

b- Monitoring the Larvae

- Larvae need daily attention to monitor predator populations and apply appropriate protection measures. (Please refer to the previous sections about the larvae predators.)

- In order to keep the larvae healthy, silkworm waste should be brushed from the leaves each day. The nets should also be cleaned if they become soiled with soap and water.

- Larvae should be counted once a week. If the rearing is going well, breeders should experience less than 10% mortality rate among larvae.

- Breeders should also check if there are other animals praying on the larvae, such as birds or rats.

- In addition to insect and animal predators, there are many diseases that may kill the larvae. The only way to avoid larval illness is by keeping everything clean.

III-3-3- Caring for the Pupae

One of the behaviors that characterizes *Antherina suraka* is that they spin their cocoons on the ground under the leaf litter. If the breeder allows his larvae to move down the tree and spin on the ground, however, the cocoons may become lost or dirty.

- To prevent this from happening, the breeder must be able to recognize the 5th stage of larval development. Five days after the larvae have molted into stage 5, the breeder should collect all stage 5 larvae, concentrate them on a few trees, and cover them with a net. The bottom of the net must be tied to prevent the larvae from descending.

- When the larvae are ready to spin, they will change color and become very dark or striped. Two hours after changing color, the larvae will excrete all the waste from their bodies. Spinning will begin 30 minutes later.

- After the last excrement, breeders should collect the larvae and put them in a cocoon basket. The basket must be filled halfway with clean, fresh leaves.

- In order to produce grade A cocoons (large and clean), it is very important to wait until the larvae poop for the last time before you move them into the clean basket. The number of larvae in one basket will be limited by the amount of space they need to spin their cocoons.

- Make sure never to put more than 50 larvae in one basket.

- Avoid touching the cocoon until the pupal case becomes dark brown and firm. At the beginning of the metamorphosis, the pupal case will be soft and yellow.

Note:

If breeders deviate from the instructions above, the following issues could occur:

1- The larvae could begin their pupal phase without spinning a cocoon. This is usually due to the disruption of the larvae during silk production.

2- The larva finishes spinning the cocoon, but dies before it enters the pupal phase. This situation is usually a result of predation by flies or ants.

3- The larva dies before it is able to spin a cocoon. This is usually due to disease. It can also be a result of starvation if the larva was moved into the basket before it was finished feeding on leaves.

SUMMARY OF CARE THROUGHOUT THE BREEDING CYCLE

The breeder carefully checks all the eggs to ensure that there are no egg predators on the host plant.

This picture shows how to set up the net in order to keep the larvae contained.
The net offers protection against most predators.
In order to give the larvae enough space, we recommend using 4 sticks to keep the sides of the net away from the tree.

When the silkworm develops dark stripes along its back, it is time to move it into a rearing basket lined with leaves so that it can spin its cocoon.

Once the silkworms are inside the basket, breeders must tie the basket shut to keep rats and other predators out.

This picture shows how to set up the pupae baskets. The pupae baskets should hang from the ceiling and should not touch the walls.
Pupae are sensitive to sun and rain and must be kept in a shady, dry place. Each rearing hut must have roof to provide shade.

Pupae baskets

Once the cocoons are removed, the pupae should be moved into clean, dry baskets with no more than 50 pupae to one basket.

CHAPTER 4 SUMMARY OF THE REARING ACTIVITIES
Antherina suraka

IV-1- HOST TREE FARMING

	TALANDOHA BRANCHES	TALANDOHA SEEDS
Best time for planting	June → August	June → August
Number of seedlings from one host tree	10 branches	10,000 seeds
Growing time to maturity	16–18 months	16–18 months

II- LIFE CYCLE PHASES OF THE SILKWORM

Egg	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Pupa	Moth
5–10 Days	4–6 Days	4–6 Days	4–6 Days	4–6 Days	6–8 Days	25–30 Days	3 or 4 Days

III- INCOME ESTIMATION BASED ON PRODUCTION:

Farming Host Trees across an Area of Land			
Number of host trees	*Area of land needed*	*Approximate yearly cocoon production*	*Income (ariary)*
250	45m/45m	2500-12,500	30,000ar-180,000ar
1000	2 hectares	10,000- 50,000	150,000ar-750,000ar

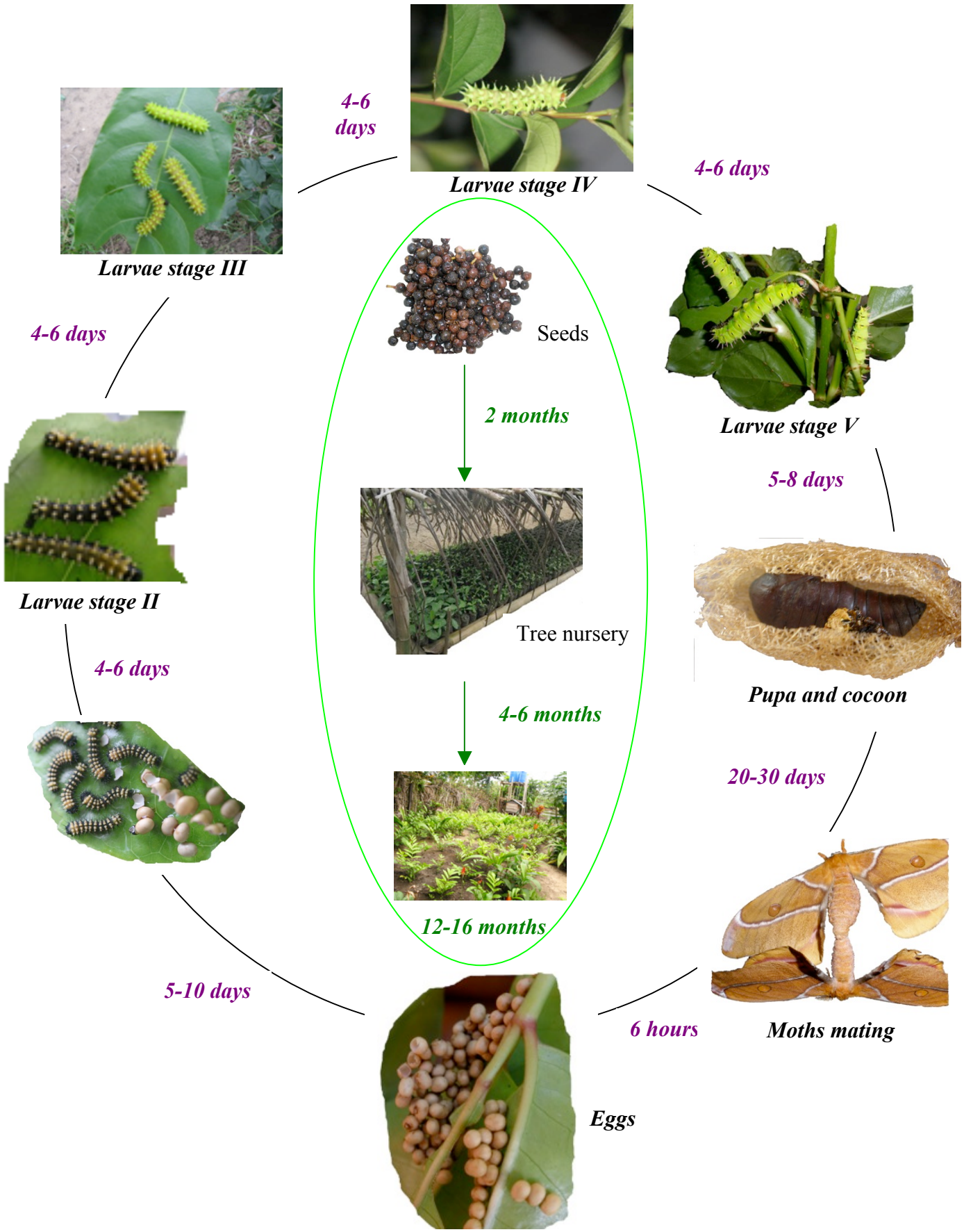
Farming Host Trees as a Perimeter Fence			
Number of host trees	*Area of land needed*	*Approximate yearly cocoon production*	*Income (ariary)*
250	60m/60m	2500- 12500	30,000ar-180,000ar

IV- ESTIMATION OF SET UP COSTS

The table below lists cost projections per breeder.

Equipment	Number	Unit Cost (Ariary)	Total (Ariary)
Plastic Pots	250	20ar	5,000ar
Host Tree Seeds	1000	1ar	1,000ar
Rearing Nets	10	12000ar	120,000ar
Pupae Basket	5	1000ar	5,000ar
Cocoon Basket	5	2000ar	10,000ar
Total = 141,000 ariary			

Life-Cycle of *Antherina suraka*:



SUMMARY

If you are interested in rearing *Antherina suraka*, remember that the first step is to locate or grow seedlings so that you can plant the Talandoha host trees on your land.

We recommend planting at least 250 trees in order to make silkworm production profitable.

The Talandoha host tree is a fast growing tree species and easy to plant. If you are interested in planting many trees, we recommend starting from seeds rather than branches. If you follow the planting techniques listed in this book, the host trees should be mature enough to host silkworms after 12 to 18 months. At that point, they will be ready for active rearing. Remember that one tree can be used up to three times a year.

Rearing *Antherina suraka* is not difficult work. If the rearing instructions listed in this manual are followed appropriately, the larvae will spin their cocoons after 25 to 30 days. It is important to master the rearing methods, especially with regard to preventing predation.

If breeders are rearing continuously, it is possible to complete up to 6 rearing cycles per year. The ideal rearing season occurs over 6 months. Breeders can choose when to start and end their rearing programs according to their schedules.

As listed on the Income Estimation Table, two hectares of land are needed for every 1,000 trees. Cocoon production depends heavily on the number of host trees. It is also important to mention that 4,000 cocoons make 1 kilo.

For this program, the NGO SEPALI provides seeds, training, and support to all interested breeders. At any time during the year, SEPALI can distribute seeds as well as this rearing instruction manual to all breeders. In addition, SEPALI keeps a stock of pupae and can provide pupae to the breeders at any time they want to start the rearing. SEPALI insures that the breeders are using disease-free pupae.

Thank you for reading this manual!