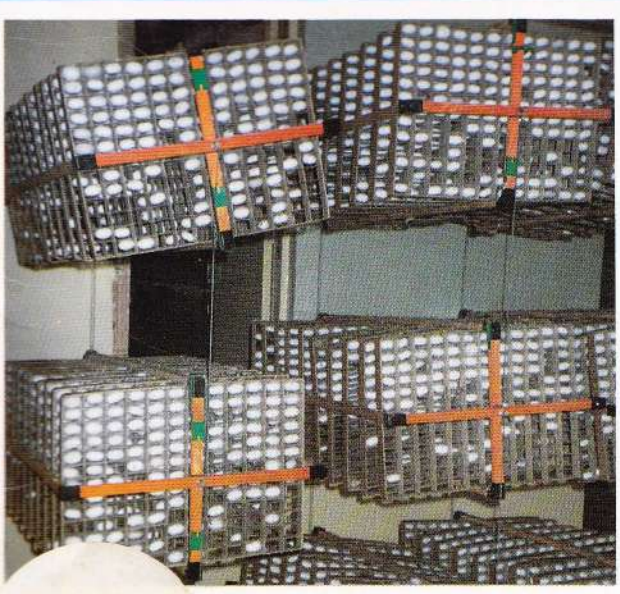
MANUAL ON MOUNTING AND HARVESTING TECHNOLOGY



R. K. RAJAN-TAMIO INOKUCHI-R. K. DATTA

JICA BIVOLTINE SERICULTURE TECHNOLOGY DEVELOPMENT
CENTRAL SERICULTURAL RESEARCH AND
TRAINING INSTITUTE, MYSORE, INDIA

MANUAL ON MOUNTING AND HARVESTING TECHNOLOGY

R. K. RAJAN
TAMIO INOKUCHI
R. K. DATTA

JICA BIVOLTINE SERICULTURE TECHNOLOGY DEVELOPMENT PROJECT
CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE
CENTRAL SILK BOARD
MYSORE, INDIA

December, 1996
1000 Copies

Published by
Dr. R. K. Datta
Director
Central Sericultural Research &
Training Institute
Mysore

Editor :
A.K. Ganguly

Supervised by :
B.S. Pappu

Cover design :
Syed Munawar

Printed at Jwalamukhi Job Press
44/1, K.R. Road, Basavanagudi,
Bangalore-560 004 Ph. 6601064, 623921, 605243

PREFACE

Bivoltine Sericulture Technology Development Project is operational under Japan International Co-operation Agency (JICA) in Central Sericultural Research and Training Institute, Mysore since 1991. The chief objective of the project is to develop bivoltine sericulture technology for Indian conditions by improving the rearing technology developing suitable bivoltine hybrids, control of silkworm diseases, evolution of mulberry variety and suitable cultural practices for it. In this collaborative project Indian counterpart scientists and Japanese experts have made certain significant achivements and this manual is the outcome of the studies conducted in the Rearing Technology and Innovation Laboratory of CSRTI, Mysore during the project period.

Mounting of mature larvae stands as the last activity in silkworm rearing during the process of production of quality cocoons. Even if the silkworm larvae are healthy wrong mounting methods and spinning conditions and the type of mountage used can result in inferior quality of cocoons. During mounting maximum labour is required in a short period. In sericulturally advanced countries, much attention had been given on developing mounting technology and its research has progressed well. But in India, bivoltine cocoons raised using existing mountages suffer from low reelability and deformed shapes. In this context, considerable efforts are made in bringing out this "Manual on Mounting and Harvesting Technology" providing relevant information with updated technology of practical utility with regard to different mounting and harvesting operations.

This manual will serve as a hand book to the technical persons guiding the farmers in the field and also the students and scientists in sericulture to produce good quality cocoons. We are grateful to Dr. Y. Ohtsuki, JICA team leader for his guidance and suggestions. Our thanks are also due to Dr. A. Muroga, Dr. Kuribayashi, Dr. M. Miki, JICA experts for their valuable guidance in bringing out this Manual. We acknowledge the assistance extended by the scientists of Rearing Technology Laboratory for preparing this manual. We are also grateful to Japan International Co-opeartion Agency (JICA) for making this study possible through the BSTD Project.

R. K. Rajan
Tamio Inokuchi
R. K. Datta

CONTENTS

INTRODUCTION

Transferring of mature silkworm larvae to a suitable frame to spin cocoons is called mounting. For silkworms, cocoon making is a necessity and indispensible process to get transformed into a healthy pupa and their moth. Even if the silkworm crop is healthy, wrong mounting methods, spinning conditions, mounting density, mounting of pre or over matured larvae and bad type of mountages can result in inferior quality cocoons.

In sericulturally developed countries, mounting technology has drawn much attention and its research has progressed. Mounting work requires the most intensive labour during a short period. Improvement of mounting technology is a priority area to produce quality cocoons and reduce labour requirement. Proper protection of spinning larvae during spinning has a great efect upon the quality of the cocoon. Improvement has to be done in the structure of mountages, the method of mounting, and controlling the environment for cocooning. Importance should also be given to reduce the labour requirement while improving the mounting.

Behaviour of silkworms at maturation

On the 5th or 6th day of 5th instar, silkworms have reduced appetite. Silkworms discharge soft light brown coloured faeces and slowly stop eating. The skin becomes transparent due to the growth of the silk gland which occupies nearly the whole body. Silkworms at this stage are called mature larvae. Mature silkworms spin silk through the spinneret below the mouth. They crawl around to look for a place to make cocoons. Soon after feeding, mature larvae climb above the leaves as compared to premature ones which continues eating (Fig. 1, 1a). Mature silkworms thus show apogeotropism to climb up. If light in the rearing bed is not uniform, larvae move to the darker side.

On completion of eating phase, silkworms attain maturity naturally. But the larvae which were not fed properly attain the maturation later. The growth of the silk gland becomes poor and the cocoons thinner. This ultimately leads to poor shell ratio, poor filament length and reelability.

On the other hand, if there is a delay in mounting the silkworms after becoming mature, silk is wasted and cocoon become thinner and smaller. If the mature silkworm cannot spin all the amount of silk contained in the silk gland, and if it remains for a longer period in the rearing trays, it disturbs further growth and metamorphosis and larvae may die.

Fig. 1. Mature silkworms

Fig. 1a. Picking of mature silkworms

Silkworms can produce small amount of silk from spinnerets just from hatching to just before pupation except during moulting. Silk is also seen in larval caudal part or abdominal legs in rearing bed when the larvae enter into moulting at every instar. Silk materials are secreted and immediately fixed (hardened) when silkworms touch solid matter. When silkworms move, silk materials are drawn out from the spinnerets to the point where the spinneret touches next.

Process of making cocoons

The mature larvae can connect two points of about 4 to 5 cm with silk to stretch the upper body from front to rear and right to left for supporting their bodies with abdominal legs.The mature larvae can thus stretch silk to both sides when they are put in a space of 4 to 5 cm .These are used as footage first to support a cocoon made by a larva keeping the body at around the centre. When a rough outline of the shape of cocoon is formed, the larva stretches the caudal end to outside for discharging urine. Urine falls in several drops along with semi solid excreta. Single larva discharges about 0.5 ml of urine. Afterwards the larvae continue spinning silk until the end. Spinning direction is indefinite and is made in the shape of S or 8. The larvae swings the head in S or 8 shape inside the cocoon shell and crawls around to make cocoon shell thicker gradually from inside.

Time required to make cocoon from beginning to end is usually around 48 h at 25°C, but it varies with race and temperature. Spinning speed of finer and longer silk filament is faster compared to cocoons with shorter silk filament. A mature silkworm can spin around a range of 500 to 2000 m of silk filament depending on the race, out of which 1 to 2% of the filament are used to make a footage.

Preparation for metamorphosis of larva into pupa inside the larval body begins as soon as spinning is completed which takes two days and the body shrinks to half of its original size. If the mounting is late by more than half a day, the larvae stop spinning as the preparation for metamorphosis has already been initiated inside the body and only flimsy cocoons are produced.

While making the cocoons, the larvae spin the filament like adhering silk from inside. Silk filaments dry as they come in contact with air. But drying become late if the environment is too humid which results in poor reelability. Hence, it is very important to follow these three important conditions during mounting to produce good reelable cocoons.

- Mounting should not be delayed when the larvae mature.
- Mounting should be done on a place where it can be done easily.
- Mounting place should be kept dry with good aeration.

Excretion of urine by mature silkworms

Silkworms discharge liquid excreta two times in its life cycle, the first, at the time of cocooning and the next after emergence as moth. If proper care is not taken, the urination at the time of cocooning can soil the cocoons and the cocoon quality is lowered resulting in poor reelability. This can be controlled by selecting suitable mountage and reducing the number of larvae on the mountage to an optimum number. 100 Dfls of mature silkworm larvae (40,000) discharge a total amount of 20 litres of urine at the time of cocooning. If this urine is left without check, humidity in the rearing room becomes more and spoil the quality of cocoons. Hence, it is necessary that good aeration is provided in the mounting room to drive away the moisture.

It is better to use moisture absorbing material below the mountages to absorb the urine. It is also desirable to have separate mounting room with good aeration.

Identification of mature silkworms

Time of maturing of the 5th instar larvae varies with the temperature during rearing and the silkworm race. For identification of mature larvae, the following observation can be made on the larvae around the fifth day of fifth instar.

- As silkworms mature, the appetite reduces and uneaten leaves are found in the rearing bed.
- The faeces become softer and can be crushed with finger tips.
- A few worms move their upper half of body in front keeping the caudal portion of the body supported firmly with abdominal legs, looking for a place to spin cocoons. Larvae also start moving towards the edge of the rearing beds.
- Front part of the body becomes little transparent.

It takes one day from the time of reduction of appetite to the maturity In a mass rearing if about 40% of larvae show maturation, all the larvae can be collected at the same time for mounting.

Mountages for spinning cocoons

Various kinds of mountages have been used in different countries and areas. Materials used were those easily available at respective places. Improvement of mountages have largely been done in sericulturally developed countries. In many countries adequate studies have not been done about the requirement for the mountage and mounting methods. When the material and the structure of the mountages are not proper, the reelability of the cocoon is reduced and other undesirable features like double cocoons, deformed cocoons and soiled cocoons get increased.

Features of a good mountage

A mountage for producing good reelable cocoon should have the following minimum features.

- Should have sufficient cocooning space between frame works. The size of the cocooning space must be variable according to silkworm races. If the size is not favourable, double cocoons, cocoons printed with cocooning frame, deformed cocoons and soiled cocoons increase. If the cocooning space is too narrow, it affects ventilation and result in poor reelability.
- Material used for mountage should be those which can make the reelability of cocoon filament better. Material which has moderate moisture absorbing power is favourable.
- Material should be cheap, durable, easily available and should be possible to disinfect properly.
- Should be convenient for the process of mounting, and harvesting and all the space could be used efficiently, and should be easy for storage when not being used.
- Should be possible to hang using supporters in order to remove faeces and urine after the mature larvae are mounted.

Disinfection of mountages

Prior to mounting the mature larvae on mountage, it is essential that mountages are properly disinfected to avoid mortality during pupation and for producing good quality cocoons. Mountages should be first cleaned and made free from floss, litter and dust. Disinfection should be done first by spraying 0.3% slaked lime @ 400 ml per sq.m surface. Second disinfection can be done with 2% formalin solution by spraying @ 400 ml. per sq.m.surface. After formalin disinfection, mountages should be covered with vinyl sheet for 30 minutes. Disinfected mountages should not be immediately used for mounting mature larvae since formalin vapour can afect the cocoon reelability. Mounting can be done safely two hours after disinfection.

Type of mountages:

The most commonly used mountages for spinning cocoon are:

1. Rotary card board mountage
2. Bamboo chandrike
3. Plastic collapsible mountage
4. Bottle brush mountage
5. Bamboo spiral mountage
6. Bamboo screen mountage
7. Dried grass/straw/mulberry twigs mountage.

1. Rotary card board mountage

Card board mountages of Japan are made of pieces of card board assembled in a checkered pattern consisting of 13 rows and 12 sections each, providing a total mounting space of 156 sections each of which is 4.5 cm x 3 cm x 3 cm size. Each mountage is 55 cm long, 40 cm wide and 3 cm deep (Fig.2). This can be completely folded when it is not used. Ten such mountages are put in a wooden frame of 4 thin pieces of square wood having a cross section of 1 cm x 2 cm. Size of the wooden frame is 58 cm x 44 cm and length is about 120 cm to accommodate 10 mountages at an interval of 8 cm. At both the ends, the longer and shorter axises are fixed. Also at both points, the whole wooden frame can be hung horizontally It can also revolve by the horizontal short axis and hence, called rotary cocooning frame. The wooden frame can also be folded completely after being used.

For mounting mature larvae on this mountage, old news papers are first spread on the floor and then the cocooning frame is kept on the news paper horizontally Mature larvae are collected and transferred on the frame using a plastic comb or directly (Fig.2a). Some of the silkworms may fall on the news paper, but ultimately climb on the mountage within one or two hours. Each frame can be provided with 1200 larvae or 80% of the capacity so that each mature larva gets a cocooning space. A wooden box of 120 cm width and 13 cm depth can be used for measuring and transferring 1200 larvae to the mountage. When all the mature larvae climb on the mountage and start spinning, the frame is lifted and suspended from the ceiling (Fig.2b). Urine can be collected below the frame by providing old newspaper on a vinyl sheet or plastic tray without soiling the cocoons. Mountage may be rotated gently to 180° for uniform distribution of larvae and when all the larvae start spinning, the frame can be fixed and prevented from rotation to avoid breakage in the filament (Fig.2c). The rotary cocooning frame is designed with a principle that if the centre of gravity of the frame with the worms comes higher than the revolving axis, the frame turns naturally to 180° or upside down.

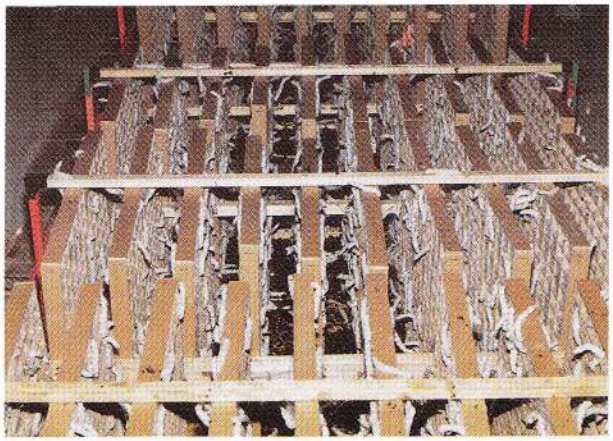


Fig. 2. Rotary mountage with spinning larvae

Fig. 2a .Transferring of mature worms on rotary mountage

Fig. 2b. Hanging of rotary mountage

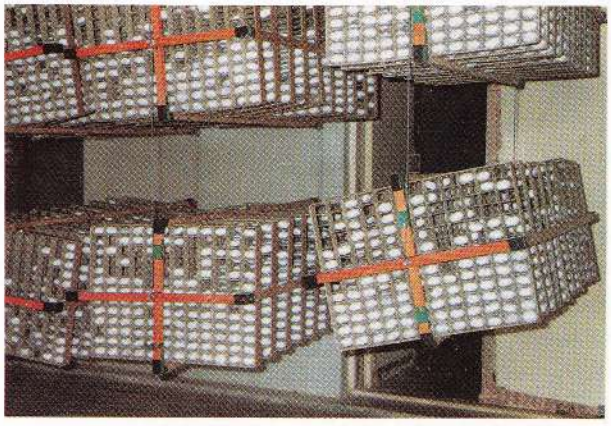


Fig. 2c. Rotary mountage with cocoons

Merits of this cocooning frame are, providing the easiest space for mature larvae to make cocoons, avoiding double cocoon formation and keeping cocoons away from urination and being soiled by dead worms, maximum utilization of space in mounting rooms, easiness in mounting and harvesting, easiness in storage after using, minimise appearance of defective cocoons etc. The major demerit is its high cost. In view of the over all merits, it is better to manufacture it in sericulturally developing countries as neither highly developed machines nor technology are required to make this mountage. This mountage can also be easily disinfected by sun drying and fumigation with formalin. This mountage is durable for a period of ten years if handled properly

2. Bamboo chandrike

Bamboo chandrikes are the most commonly used mountages in India. Chandrikes are made of bamboo spirals woven on a bamboo mat with two supports made of bamboo sticks. It is of 1.8 x 1.2 m size. The spirals are made of mat base tapes of 5 to 6 cm width. Small holes are made on the mat base to provide ventilation. Mature silkworms are transferred to the chandrikes at the rate of 40 to 60 worms per square foot. After mounting, the chandrike is kept inverted at an angle of 45° to allow the urine to fall on the ground and prevent staining of cocoons.

The chandrikes are easily available, simple and cheap. Durability is 3 to 4 years. The demerits are, high floss formation, irregular cocoon shape, formation of double cocoons, stained cocoons and low reelability. It was also observed that the rough bamboo surface can injure the soft body of mature silkworms and result in melting of pupae inside the cocoon. Bamboo mountages require a lot of space for storage (Fig.3).

3. Plastic collapsible mountage

Plastic collapsible mountage is made of plastic mesh having eleven folds of 6 cm height and can be fitted to a wooden tray of 60 x 90 cm size. It can be folded and preserved when not in use.

300 to 400 larvae can be mounted on this mountage. At the time of mounting, old news paper is spread below the mountage for absorbing urine. The mountage should be placed on the tray with the corrugation uniformly arranged, after which mature worms are transferred on the mountage. For getting easy anchorage for spinning worms, it is advisable to keep few strips of paddy straw on the mountage.

Plastic collapsible mountage can also be used for self mounting. The mountage is kept directly on the rearing bed, after the last feeding when about 20% larvae mature. These mountages have several advantages. It is easy for handling and disinfection, requires less space for storing and does not require additional space for mounting. It is durable and helps in maintaining hygienic conditions. It produces uniform cocoons and also easy for harvesting. The demerits are, it is often destroyed by rodents while storing and the corrugations are lost by frequent use resulting in uneven space for making cocoons (Fig.4). Occurrence of soiled cocoons increases especially in rainy seasons due to heavy urination by the worms.

4. Bottle brush mountage

Different types of bottle brush mountages are available depending on the material used. The bottle brush mountages are made of plastic, bamboo or coconut leaf veins.

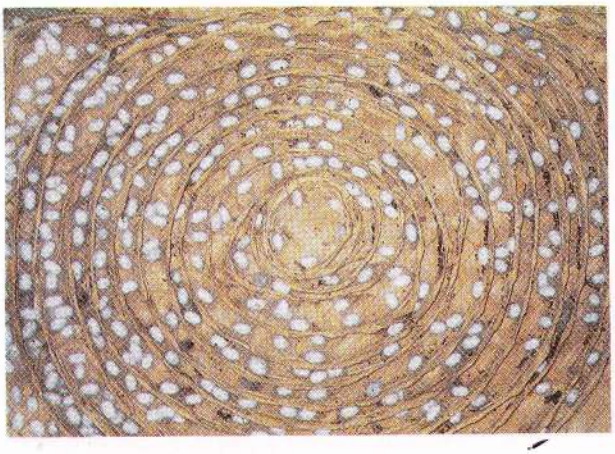


Fig. 3. Chandrike

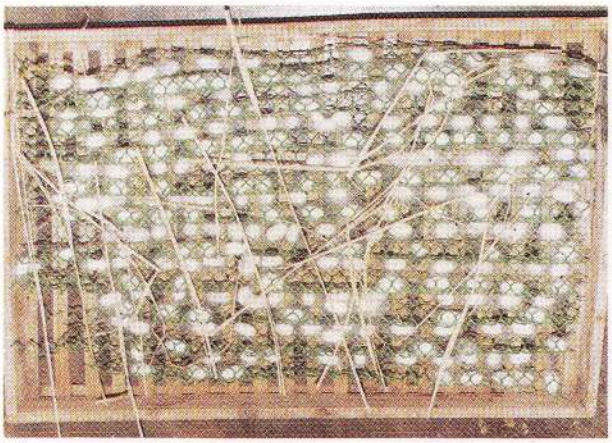


Fig. 4. Plastic collapsible mountage

Fig. 5. Plastic bottle brush mountage

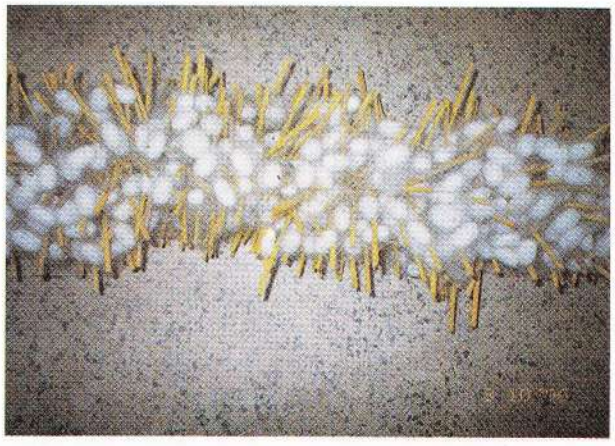


Fig. 6. Bamboo bottle brush mountage

Fig. 7. Bamboo spiral mountage

a) Plastic bottle brush mountage

It is machine made plastic material with individual detachable pieces. Normally 50 individual pieces are joined together by an iron rod and at the end of it is an iron stopper Each bottle brush mountage assembled is of one metre length. Each individual piece has eight branches of 1.5 cm length, with two sub-branches of 9 cm length. These branches are equally distributed at a distance of one cm at the base and four cm at the end in a circular fashion. Distance between two sub branches is 3 cm. The circle formed by branches and sub branches is 24 cm in diameter Surface of the plastic material is granulated to provide grip to the silkworm for spinning (Fig.5).

This mountage can be used for self mounting by keeping the mountages on the rearing bed when the worms start maturing or mature worms can be picked up and transferred to the mountage at the rate of 500 larvae per mountage. When the worms start spinning, the mountage can be lifted up and hung from the roof. During mountings care should be taken to avoid high density of worms on the mountage.

Plastic bottle brush mountage is durable and can be disinfected easily Premounting, mounting and post mounting operations are easy due to its light weight and detachable nature. Number of urinated cocoons are reduced and individual cocoon character and reelability are improved. It also provides good aeration during spinning. Since the shape and size of the mountage remains intact, it can be used for a long time. But it is not possible for the farmer to manufacture it locally.

b. Bamboo/coconut bottle brush mountage

The structure of the mountage is same as the plastic mountage except that coir rope is used as a support and bamboo pieces or coconut leaf veins of length 15 cm are inserted into the coir rope at a distance of 3 cm in groups of eight (Fig.6).

Mounting is done as in plastic bottle brush mountage. Mountage of 1 metre length can accommodate 500 silkworms to spin cocoon. This mountage can be easily made by farmer himself and is very cheap. It is easy for mounting operation but the branches become loose in due course and space for cocooning becomes irregular.

5. Bamboo spiral mountage

It consists of two bamboo supports of length 100 cm and on it bamboo net is woven as tapes at a distance of 5 cm spirally. When the larvae are ready for mounting they are picked up from the rearing tray, old news paper is placed on the tray and the bamboo spiral structure is inserted into the rearing tray and the mature silkworms are mounted. 300 silkworms can be mounted in a round bamboo tray of 90 cm diameter. Mounting of more larvae result in double cocoons. This type of mountage is easy for mounting and require less labour and space. Durability is less and hygienic condition can not be maintained as same rearing tray is used for mounting (Fig.7).

6. Bamboo screen mountage

Bamboo screen mountage is made of bamboo sticks arranged one over the other by cotton thread leaving a space of 3 cm which can provide space for silkworm spinning. The support provide anchor to the spinning worms. When the worms start maturing, they are picked up and sprinkled on the mountage slowly. 50 worms are mounted in an area of one square foot and after mounting it is hung from the roof. This mountage is more durable than other bamboo mountages and it can be easily made and require less space. It also provides good aeration during spinning. Maintenance of hygienic conditions in this type of mountage is dificult.

7. Dried grass/straw/mulberry twigs mountage

When the silkworms start maturing, a thick layer of dried grass or straw is spread over the rearing bed. In the case of dried mulberry twigs, they are spread in a three dimensional way. Mature larvae crawl through the bed on to the mountages and spin cocoons. For mounting 100 dfls, 80 m^2 space is required. This method in simple, labour saving and is ideal for shoot rearing method. Because of the semi absorbent nature of the material used, cocoon quality is improved but it has many disadvantages. Floss formation is more in this type of mountage. Deformed cocoon, double cocoon, etc. increase as the mountage fall flat after sometime as there is no sufficient space for spinning. Harvesting of cocoons require more time and material used for mounting could not be used again and can be mulched in the soil for getting organic manure.

Evaluation of mountages

Evaluation of different mountages were conducted in the laboratory at an optimum temperature of 26-27°C and humidity 70-75%. The data indicate that among the mountages, the rotary cardboard mountages are best in producing good quality cocoons with increased reelability and less defective cocoons (Table.1).

Table 1 : Comparative Study of Different Mountages

Race: NB4D2 x CC1

Mountages	Cocooning %	Defective cocoon wt (g)	Floss % (g)	Single cocoon wt. (g)	Single shell wt.(g)	Shell ratio %	Filament length (m)	Reelability %
Rotary	95.22	1.96	1.76	1.92	0.377	20.15	1039	89.96
Plastic bottle brush	93.46	5.92	2.82	2.02	0.389	19.15	962	87.29
Bamboo bottle brush	90.74	6.02	2.80	1.99	0.396	19.57	934	85.39
Plastic collapsible	89.35	7.96	3.31	2.03	0.406	19.76	884	81.63
Paddy straw	76.01	14.52	3.46	2.03	0.388	19.09	850	83.89
Chandrike (control)	90.22	9.12	4.10	1.89	0.388	20.38	993	81.36

Methods of mounting

Mounting operation is one of the most busy works in silkworm rearing and if the mounting method is wrong, the quality of cocoon will sufer and result in economical loss. There are different methods of mounting depending on the type of mountage used and method of rearing. These are pickup method, natural mounting (self mounting), shoot shaking method and netting method.

1. Pickup method

This is a method by which properly matured larvae, *i.e.* when about one third of the body becomes transparent are picked up one by one and put on the mountage. By this method, the silkworms can be mounted at the right time and is most favourable for getting good cocoons, but labour requirements are high causing economic loss. As silkworms become simultaneously

mature between 10 AM to 3 PM, some of the larvae may become over mature and produce poor quality cocoons, when the labour required for picking is immediately inadequate. However simultaneous mounting of mature and immature larvae by picking one by one is undesirable for the purpose of getting good cocoons, as immature larvae take longer time of spin, waste silk and form thinner cocoons.

2. Self mounting method (Natural mounting)

This method make use of the negative geotropic character of the mature silkworm to climb upwards. When about 20% of the larvae mature, mountages like plastic collapsible mountage, dried grass or paddy straw or bottle brush mountage are placed on the rearing bed. After a while when the expected number of mature larvae have crawled up, it can be hanged from the roof as in the case of bottle brush mountage. The above operation is repeated two or three times and the small number of larvae left on the bed are mounted by pick up method (Fig.8).

By this method, labour can be saved to a certain extent and the changing of mountages become convenient for the progress of maturation of larvae, as only properly matured larvae are mounted, and at the same time the quality of cocoons are also maintained. However if the operation of hanging of mountage is not performed as in plastic collapsible mountages, paddy straw and mulberry twigs mountages, there is a chance that density of mounting will be more and it will decrease the quality of cocoons; in this case percentage of floss also increases. In order to improve the quality of self mounting, it is necessary to follow the following steps.

a) The progress of the growth of the larvae is made uniform from fourth moult by making small groups. Earlier and later moulted larvae are reared separately in fifth instar

b) At the time of putting the mountage on the rearing bed, the upper surface of the bed is made even and the mountage is kept later when sufficient worms mature. In shoot rearing method, it is better to give last feeding with leaf to make the bed flat and make all the larvae to come to the top.

c) When sufficient number of larvae climb on the mountage, it should be removed and hanged.

d) Acceleration of mounting of larvae by applying saw dust or paddy husk mixed with cresol soap solution. One part of three hundred times cresol soap solution is mixed with ten parts of paddy husk in volume and applied on worms before keeping the mountage when the larvae start maturing. This acts as a repellent and help in the mounting of mature larvae without afecting the cocoon quality (Table 2). Using saw dust 80% larvae and with cresol 90% larvae were mounted within 18 h of application. There was no significant effect on the cocoon quality and reelability.

Table 2: Effect of Repellant on Accelerating Self Mounting
Race: NB4D2 x CC1

Treatment	Time taken for mounting larvae (h)			Single cocoon wt. (g)	Single shell wt. (g)	Shell ratio %	Fila-ment length (m)	Reelability %
	0-8	8-16	16-24					
Saw dust	35	48	17	1.698	0.348	20.77	998	90
Cresol	39	50	11	1.777	0.363	20.65	1017	90
Control	10	43	47	1.759	0.356	20.47	1109	89

Fig. 8. Self mounting

Fig. 9. Mechanised shoot shaking method of mounting

Fig. 9(a). Manual shoot shaking method of mounting

3. Netting method of mounting

When considerable number of larvae become mature, straw rope, mat or rush nets are put on the rearing bed after feeding mulberry leaves and they are left as such for sometime. When the mature larvae crawl on the net, the nets with larvae are lifted from the immature ones which are still eating leaves under the net. The mature larvae thus collected are shaken off from the net and mounted .

4. Shoot shaking method *(Jobarai)*

For collecting mature worms by shaking shoot method, worms are shaken down on a vinyl sheet under a shaking stand. Shaking can also be done manually by holding few shoots with worms or hitting the mulberry shoots lightly on a Jobarai table or using a vibrating machine. Silkworms thus collected are mixed with faeces and remains of mulberry leafage. They may be separated by using a net. *Jobarai* method is ideal for shoot rearing method and 40% of labour required for picking mature worms for mounting can be saved without afecting cocoon quality (Fig. 9a).

Evaluation of mounting methods

Mounting of 40,000 larvae takes about 18 hrs labour in pickup method whereas Jobarai method takes 12.4 h and self mounting about 2 h. Evaluation of the diferent mounting methods indicate that self mounting requires minimum labour for mounting whereas pickup method gives the best quality of cocoons. However, Jobarai method of mounting is found effective without affecting cocoon quality and 40% of labour required for mounting is saved compared to pick up method (Table.3).

Table 3 : Evaluation of Mounting Methods
Race:NB4D2xCC1

Treatment	Cocooning %	Time required to mount 40000 larvae (h)	Single cocoon wt. (g)	Single shell wt. (g)	Shell ratio %	Fila-ment length (m)	Reelability %
Pickup (Control)	90.73	17.53	1.92	0.398	20.71	1044	90.15
Jobarai	88.84	12.37	1.91	0.392	20.83	1002	89.53
Self	86.38	1.53	1.80	0.370	20.50	929	81.07

Use of hormones for uniform maturation of larvae

Spraying of β-ecdysone 12 hours before maturation at the rate of 0.1% per litre per 10,000 larvae accelarates uniform maturation of 90% of larvae within 16 h of treatment without any bad effect on cocoon quality (Table.4). Spraying of cheaper plant extract containing phyto-ecdysone is also found effective in uniform maturation of silkworm larvae.

Table 4: Effect of β-Ecysone on Uniform Maturation
Race: NB4D2 x CC1

Spraying of ecdysone before	Per cent of mature larvae					Single cocoon wt (g)	Single shell wt (g)	Shell ratio %	Fila-ment length(m)	Reelability %
	0–4	4–8	8–12	12–16	16–20					
18 h	2	32	48	18	–	1.779	0.363	20.61	988	90
12 h	10	49	23	18	–	1.848	0.378	20.65	980	90
Control		5	12	45	38	1.942	0.423	21.87	999	91

Time of mounting

When the larvae appears translucent, excrete soft faeces and search for the cocooning places, they are to be picked up and mounted. In the case of self mounting, mature larvae crawl up on the mountage freely.

If immature larvae are mounted, mortality of larvae in cocoons will be increased and the amount of silk will be reduced. If over mature larvae are mounted, double cocoons and soiled ones will be increased; when immature larvae are mounted mixed with over mature ones, soiled cocoons will be increased.

Density of mounting

Number of mature larvae to be mounted on a mountage depends upon the race and also type of mountage used. In Chandrike 50-60 larvae are mounted per square foot. In the case of rotary card board mountage only 90% of the capacity of the mountage is utilised. In bottle brush mountage, 500 larvae are mounted per metre length and in plastic collapsible mountage 50 larvae are mounted per sq.ft. If the number of larvae mounted are more, bad cocoons such as soiled cocoons, double cocoons etc. will be increased, making the cocoon quality low and if the number is too small, mounting becomes laborious and uneconomical.

Requirement of environmental conditions on mounting

After selecting a suitable mountage and adopting a rational mounting method with optimum density of mounting improvement for reelability, cocoon filament and quality of silk can be affirmed by providing ideal environmental condition required for mounting.

Temperature

The optimum temperature for the health of larvae and for making good quality cocoon is 25 - 27°C, and the temperature above the optimum makes the cocoon quality poor and below the optimum increases the pupation period. Yield by weight, shell weight and shell ratio percentage were higher for cocoons when larvae spun at 27°C as compared to higher or lower temperature treatments. Further, reelability and non breakable filament length were also improved in the cocoons spun at 27°C (Table.5).

Table 5: Effect of Temperature on Spinning Larvae
Race: NB4D2xCC1

Temperature (°C)	ERR No	ERR Weight (kg)	Single cocoon wt. (g)	Single shell wt. (%)	Shell ratio %	Filament length (m)	Reelabilty %
24 Control	8725	17.250	1.965	0.375	19.09	912.20	90.40
27	8850	17.350	2.000	0.382	19.15	1110.35	92.12
30	8250	16.250	1.930	0.355	18.39	840.38	82.15

Humidity

In order to keep the health of the larvae and good reelability of cocoon filament, the relative humidity of mounting room must be low in the range of 60 to 70%. If the urine produced by the silkworm larvae at the time of spinning is left without check, humidity in the rearing room becomes higher. In addition to the above, the moisture released by silkworm during mounting will be about 20 litres by respiration and 40 litres as contained in the spun silk material for 40,000 larvae.This moisture can raise the mounting room humidity and spoil the quality of cocoons.As to the effect of the rise of humidity upon the quality of cocoon, the efect of the rise of humidity from 60 to 70% upon the quality of cocoon is comparatively less. However if the humidity is raised from 70 to 90% quality of cocoon is deteriorated remarkably. At low humidity there is a significant improvement in shell weight of cocoons, shell ratio, reelability percentage and non breakable filament length (Table.6).

Table 6: Effect of Humidity on Spinning Larvae
Race NB4D2xCC1

Humidity %	Single cocoon wt. (g)	Single shell wt (g)	Shell ratio %	Filament length (m)	Reelability %
60 (Control)	1.490	0.320	21.4	950	87.75
70	1.596	0.342	21.4	970	89.16
80	1.394	0.247	17.7	930	82.67

Air Current

If the humidity is lowered by ventilation, the effect of rise in temperature upon the quality of cocoons becomes less. Extreme low temperature with high humidity or temperature above 30°C with high humidity has bad effect on cocoon quality. The bad effect of raising temperature by 27°C upon the quality of cocoon is about the same as the good efect of lowering humidity at 10-13%. In short, raising of temperature by 1°C over the optimum can accompany the lowering of 4% or more of humidity up to 30°C is effective for improving the quality of cocoons. When the temperature of the mounting room is lower than 20°C, the spinning operation of larvae becomes slow making the quality of cocoons poor. Air current speed of 0.5 to 1.0m per second improves the survival of pupae and cocoon quality (Table.7).

Table 7: Effect of Air Current on Spinning Larvae
Race: NB4D2 x CC1

Air current (m/sec)	ERR		Single cocoon wt. (kg)	Single cocoon wt (g)	Shell ratio %	Filament length (m)	Reelabilty %
	No	Weight					
1.0m /sec	9433	18.28	2.07	0.441	21.34	1000.68	92.58
0.5m /sec	9667	18.10	2.01	0.425	21.14	1006.75	91.38
0.25m /sec	8744	16.61	1.98	0.409	20.65	999.00	90.40
No air cur	8455	16.52	1.82	0.384	19.80	900.57	83.31

Light

During the period of mounting to the beginning of spinning cocoons, the inside of mounting room must be lighted moderately and evenly avoiding strong light. Mature silkworms favour dimlight of 15 - 30 lux. When the mounting room is lighted only from one side of the room, mature larvae move to the opposite side and increase the percentage of double cocoons.

Regulation of temperature and humidity during spinning

When the temperature of mounting room is low and humidity is high, the temperature is raised by heating the room, eliminating moisture at the same time. In case the temperature is over 28°C and humidity is also high, the elimination of moisture must be made by ventilation and by avoiding heating of the room.

Mature larvae excrete soft watery faeces during the period from mounting to the start of spinning of cocoons. In mass rearings, this water evaporations make the air of the room moist. In order to eliminate the moisture of the room, ventilation must be facilitated. During rainy season and moist night, the induction of outside air must be avoided and elimination of moisture must be facilitated by heating or using exhaust. When outside air is more dry than inside, the elimination of moisture is done by inducing dry air inside, opening doors and windows. Soft faeces and urine excreted by mature larvae can be collected on a mat under the mountage and can be taken out from the mounting room before it evaporates. There is close relationship between temperature, humidity and air current during spinning. Even at optimum temperature and humidity, reelability of cocoon is improved when there is an air current. Similarly at high temperature and high humidity also reelability of cocoons can be improved if air current is provided at the time of spinning (Table 8).

Table 8: Interaction of Temperature, Humidity and Air Current on Spinning

Temperature (°C)	Humidity (%)	Air current (cm/sec)	Reelability (%)
20	65	0	75
		50	90
	90	0	78
		50	92
25	65	0	92
		50	96
	90	0	55
		50	90
30	65	0	85
		50	93
	90	0	30
		50	80

Important period for improving cocoon quality during mounting

The period from mounting to the end of spinning is important for improving cocoon quality If the environmental conditions of mounting room are not suitable during this period, the reelability of cocoon filament becomes poor and the quality of silk becomes inferior The effect of humidity is more important. Hence the urine excreted by the larvae must be eliminated from the room and moist air in the room should be removed by ventilation, especially during the later half of spinning cocoons. The period from mounting to the end of spinning is about 60 hours at 25°C and 48 hours at 27°C in 65 - 70% humidity.

Cause for unreelable cocoons during cocooning and counter measures

During cocooning few cocoons are produced which are unreelable due to genetic character silkworm diseases, improper mounting, harvesting and transportation etc. These unreelable cocoons are classified as follows:

1) Double cocoons

A cocoon jointly formed by 2 or more worms in called double cocoon. These cocoons are large and thick and cannot be reeled. Double cocoons are used to produce dupion silk. The occurrence of double cocoons depends on kind of mountages used, quantity of worms mounted and also the silkworm variety.

2) Perforated cocoons

Cause for this defect is mainly due to silkworm variety or due the penetration of cocoon by maggot of uzifly.

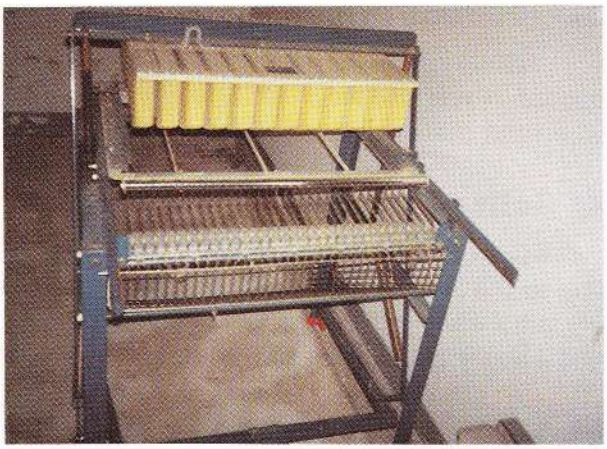


Fig. 10. Cocoon harvester for rotary mountage

Fig. 11 a. Wooden cocoon harvester for rotary mountage

Fig. 11 b. Harvesting of cocoons

3) Cocoon frame printed cocoons

While cocooning a part of cocoon surface adhered to the cocooning frame make a print on cocoon. Even if it is small raw silk cannot be reeled from such cocoons. This problem comes when the material for mountage is too hard or cocooning space is too small.

4) Soiled cocoons

Cocoons which are soiled by urination or diseased larvae cannot be reeled well. This occurs due to the kind of mountage and high density of worms in the mountage. Some times the worms die after spinning silk or just after pupation and soil the inner layer of the cocoon shell. Thus one should be careful during mounting and handling of cocoons.

5) Thin end cocoons

One end or both ends of a cocoon become very thin and not suitable for reeling. It is often due to genetic character, or high temperature during incubation, malnutrition during rearing or strong wind under humid condition in the mounting room.

6) Deformed cocoons

A cocoon which is partly swollen or deformed in general cannot be reeled. It is formed when irregular space exist in the cocooning frame or when larvae are not healthy

7) Thin shell cocoon

Thin shell occurs when the crop is generally bad due to malnutrition or disease.

8) Loose shell cocoons

Cocoon shell is formed loosely as in multivoltine cocoons due to silkworm race and high temperature during cocooning.

Percentage of such defective cocoons can be limited to 5% or less if mounting is done properly. But if care is not taken during mounting, the percentage of such cocoons can go as high as 30%. These defective cocoons reduce the price of cocoons. To reduce such unreelable cocoons, the following care can be taken.

a) Mature worms should be mounted as early as possible.

b) Choose mountage where mounting operation is simple and avoid crowding of larvae.

c) Optimum temperature and humidity should be maintained inside the rearing room with moderate aeration and keep the mountage away from direct sun light and strong wind.

d) Harvesting should be done only after completion of pupation and care must be taken during cocoon transportation.

Cocoon harvesting

Mounted silkworm can complete cocooning in about two days. In another two days it can become pupa. At the beginning of pupation the skin of pupa is soft and gets wounded easily If cocoons are harvested at this stage the inside of cocoon shell is soiled and afect the reelability.

Fig. 12 a. Manual deflosser

Fig. 12 b. Deflossing using iron rod

Fig. 13. Good harvest of cocoons

It takes another 2 or 3 days after pupation to harden the skin that can resist injury Hence cocoon should be harvested only on the 6th day after mounting when temperature is 25-27°C. It will be safe to harvest the cocoon after testing the hardening of the pupal skin.

Cocoon harvesting method depends on the kind of mountage used. Before harvesting all diseased and unspun larvae alongwith deformed cocoon should be removed from the mountage. Those can soil other good cocoons. In most of the mountages like chandrike, plastic collapsible mountage, etc., harvesting has to be done manually, and it takes lot of labour. In the case of bottle brush mountage, harvesting can be done by hand using a short iron rake. For collapsible mountage, the frame is stretched to both sides to deform the wave shape and cocoon can be collected from both the sides.

For rotary cocooning frame, first each of the ten cardboard mountages are removed from the wooden frame after keeping it vertically. Then the dead worms, flimsy cocoons etc., are removed from the mountages. The cocoon frame is inserted on a wooden frame and cocoons are pushed out one line after another by a cocoon pusher (Fig.11a & b). Cardboard frames are then folded and bundled. Pushed out cocoons hanging on the silk filament are collected by hand. If a treadle machine for pushing out cocoons from the cardboard mountage is employed, it can be ten times faster than the hand pusher and more eficient in a mass rearing (Fig.10).

Storing of mountages

After cocoons are harvested, the mountages which are reusable can be exposed to sun for one or two days, disinfected and can be stored properly for next rearing.

Floss removal

It is necessary that, floss covering the cocoons be removed before marketing for getting a good price. Floss can be removed by hand if the quantity is small. If quantity is more, a floss removing machine, can be employed (Fig.12 a,b). While using a machine only a small amount of cocoon should be fed each time to avoid crushing of cocoon, and also thin shelled cocoons should be removed (Fig.13) before feeding to the machine.

Assortment of cocoons

After harvesting and floss removal, the bad cocoons are assorted as follows:

1) Double cocoons
2) Cocooning frame printed cocoons
3) Soiled cocoons
4) Thin end cocoons
5) Malformed cocoons
6) Thin shelled cocoons
7) Pierced cocoons
8) Loose shell cocoons

These cocoons are selected out in a separate lot from good cocoons to be marketed. It is very difficult to select unreelable cocoons completely by farmers.

Quality of cocoons and cocoon filament

Quality of cocoons and cocoon filament are heritable characters which vary according to environmental conditions or those formed by the combined act of heredity and environmental factors. All these characters have close relation to the value of cocoon filament. Some of these important characters are given below:

a) Cocoon colour : In India, generally bivoltine cocoons are white and multivoltine cocoons are golden yellow, greenish yellow, light green, pink or white in colour. These colours, except green, are due to the colouration of sericin and will disappear after degumming of raw silk.These colours also change under the influence of temperature and humidity during rearing.

b) Shape and size of cocoons: The shape of a cocoon is a racial character and can be classified into four types as constricted, elliptical, spherical and spindle shaped and can be further subdivided into long, short, lightly constricted, deeply constricted etc. Japanese and European races are usually constricted, Chinese races are elliptical or spherical and tropical races are spindle shaped. The size of cocoons is usually indicated by the number of cocoons per litre.

c) Tightness of cocoon shell: The tightness of cocoon means the compactness or stiffness of the cocoon shell. Extremely loose cocoons are unfit for reeling and can be judged by the feeling. It is a racial character and is also influenced by rearing and mounting conditions.

d) Wrinkles of cocoon shell: There are many wrinkles on the outer layer of the cocoon shell but little in the inner layer. Appearence of wrinkles is also a racial character but is also affected by environmental conditions. Extremely rough wrinkled cocoons are not suitable for reeling.

e) Weight of single cocoon: It is very important from the point of reeling. Cocoon weight is dependent on race. But female cocoons are heavier than male cocoons. Weight of cocoon is also variable according to the rearing condition and amount of mulberry leaves fed.

f) Weight of single cocoon shell: The larger the weight of the cocoon shell, the more the raw silk is obtained. Weight of cocoon shell is dependent on race, rearing condition and quantity of mulberry leaves fed. It is also more in females.

g) Percentage ratio of cocoon shell to cocoon weight: This value is obtained by dividing the weight of single cocoon shell by single cocoon weight and multiplied by 100. Shell ratio is higher in male cocoons than female cocoons and is also dependent on race, environmental conditions, quantity of mulberry leaves fed, mountages and mounting method used.

h) Length of cocoon filament: Length of cocoon filament has an intimate relation to the efficiency of reeling operation. Length of cocoon filament difers with respect to the silkworm race, rearing and mounting conditions and quality of mulberry leaves fed.

i) Weight of cocoon filament: This is the amount of cocoon filament reeled from a single cocoon. It is proportionate to the weight of cocoon shell but changes according to the reelability of cocoons. The weight of cocoon filament corresponds to 80 - 90 % of the weight of the cocoon shell.

j) Size of the cocoon filament: The size or thickness of cocoon filament is expressed in denier. When a thread of 450 m (400 rotations of the single reel) weighs 0.05 g, its size is called one denier. Size of the cocoon filament is dependent on silkworm races and condition of rearing and mounting. When the late age worms are fed with soft leaves the size of the filament

becomes thick. Larvae which are heavier in body weight spin large sized filament. The size of cocoon filament of outer layer of cocoon shell is thicker than that of inner layer of shell. Cocoons having small difference in size between filament of outer and inner layer are superior

k) Reelability: This is indicated by the easiness of unwinding the cocoon filament and is measured by the percentage ratio of the length of unbroken filament to the length of whole filament. Reelability is different among different silkworm races. Humidity during spinning cocoons plays, however, a major role in determining reelability of cocoons.

l) Percentage ratio of raw silk to cocoon weight: This is the percentage ratio of raw silk to cocoon weight and has a direct relation with determination of the price of cocoons. It is calculated by dividing the weight of raw silk reeled by weight of cocoons used and then multiplied by 100. It also depends on the silkworm race and conditions of rearing and mounting.

m) Cleanness: Sometimes large knot appear on the silk filament and it is a defect for the raw silk. This defect is mostly due to problems in the cooking and reeling techniques.

n) Tenacity and elongation: The tenacity and elongation are important characters of raw silk in comparison with synthetic fibre. The tenacity of raw silk is represented by the endurable weight (g) per denier and the elongation is shown in percentage ratio of the length of extended part of the thread as maximum to the original length. Usually the tenacity is 3.5–4.0 g and elongation is about 20%.

o) Lousiness: Lousiness of silk filament appears as white spots on the filament and is due to the splitting of fibroin in silk gland in the fifth instar. The most important factor for lousiness spots is the silkworm race. The defect is less in Chinese races and small sized cocoon filament and more when cocoon filament is large. Mounting of over mature larvae increase lousiness in cocoon filament.

Conclusion

Mounting the silkworms at the right time of maturation and harvesting of cocoons after the completion of pupation are very important in the production of quality reelable cocoons. Even if the silkworm larvae are healthy, wrong mounting methods, spinning conditions and the type of mountages used can result in inferior quality of cocoons. Recently many farmers in large scale rearing have started practicing self mounting to save labour requirement without knowing its efect on cocoon quality and reelability. Since mounting work requires the most intensive labour during a short period, methods were suggested in this manual to reduce labour requirement without affecting the cocoon quality. This manual also provides information on the requirement for mounting in seed crop rearing and commercial hybrid rearing as well as the merits and demerits of different mountages which are in use in India.