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June 1931.

THE

Indian Lac Association for Research.

A PRACTICAL MANUAL OF LAC CULTIVATION.

BY

P. M. GLOVER, B.Sc.

Entomologist to the Indian Lac Research Institute,
Ranchi, Bihar & Orissa.

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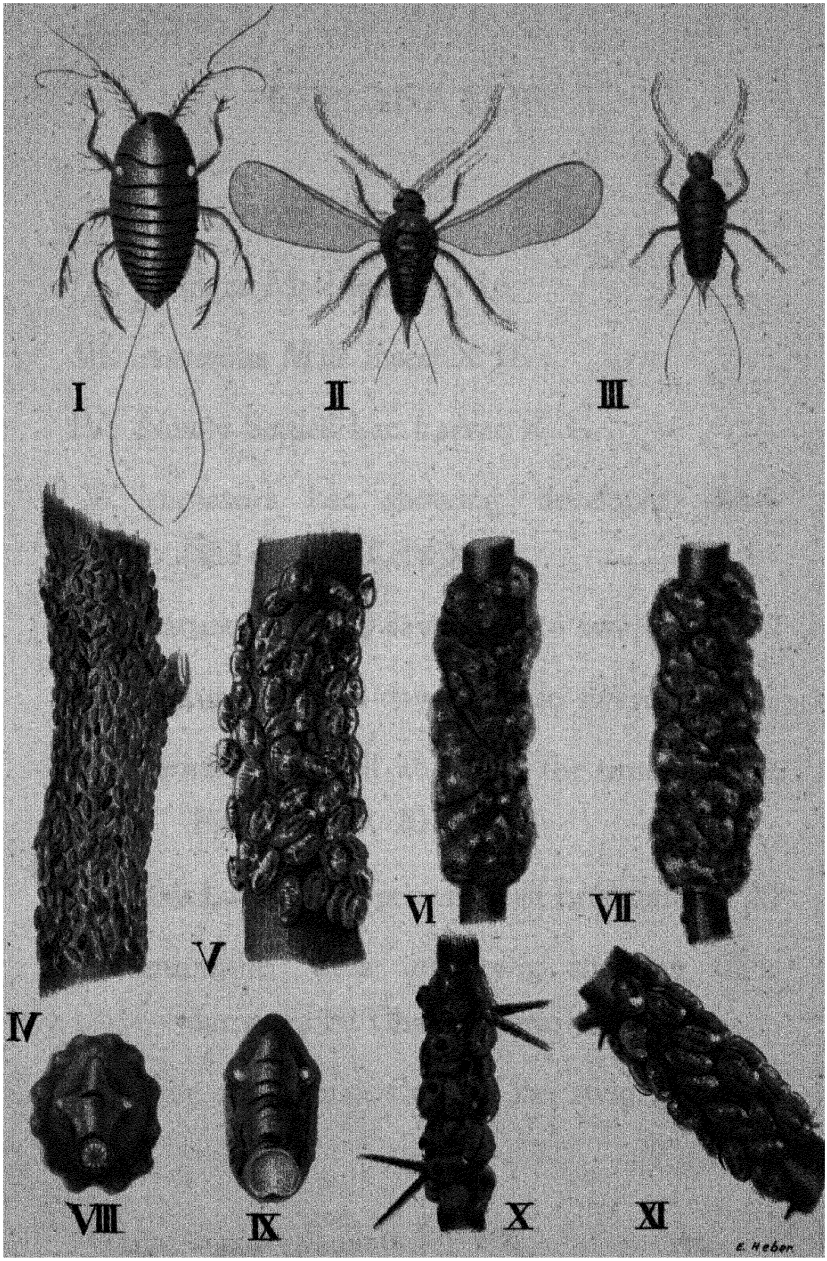
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EXPLANATION.

I. Lac Larva X 40

II. Winged Male Insect X 16

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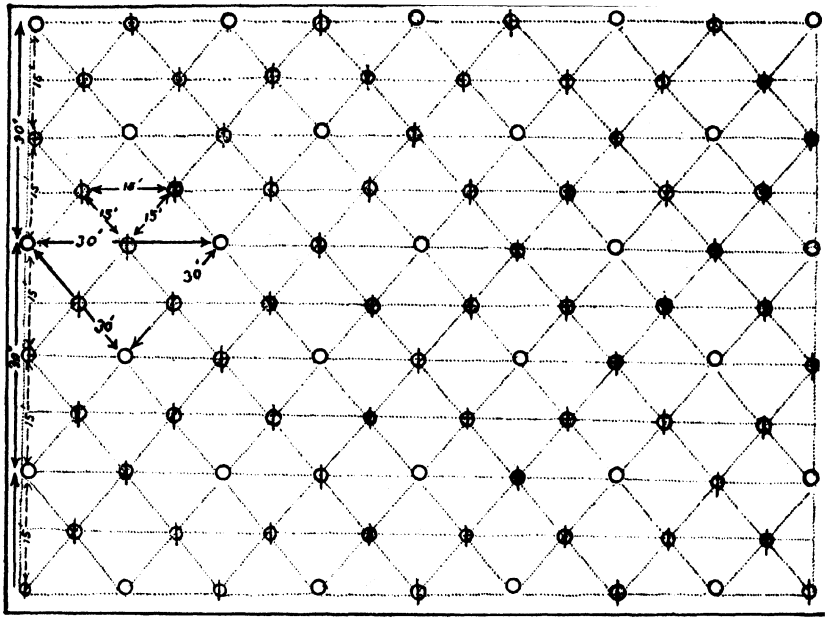


Fig I

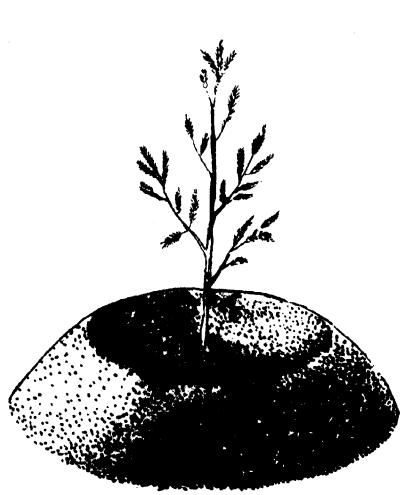


Fig. II

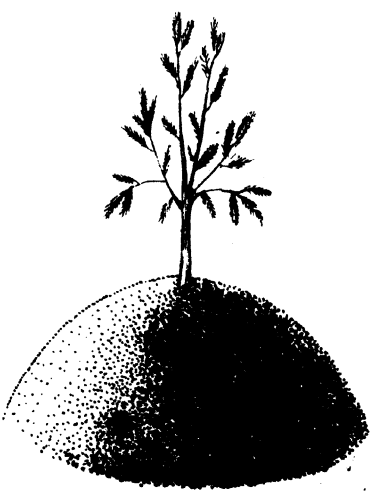
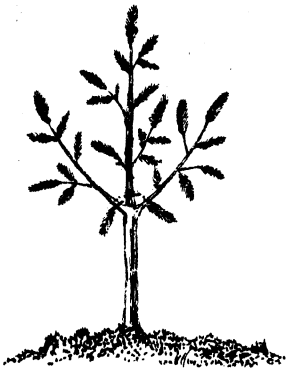
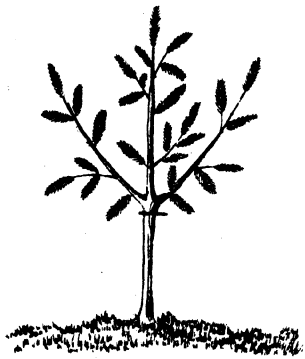


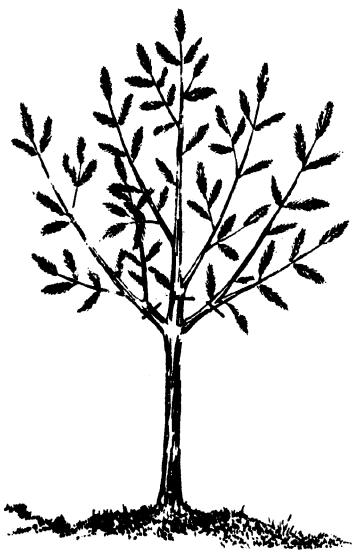
Fig. II (Chppt II)



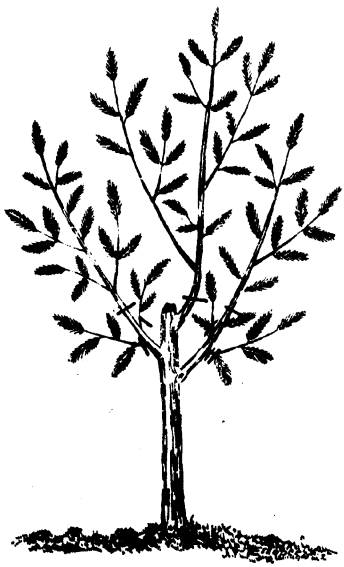
A.1



B. 1



A.2



B. 2

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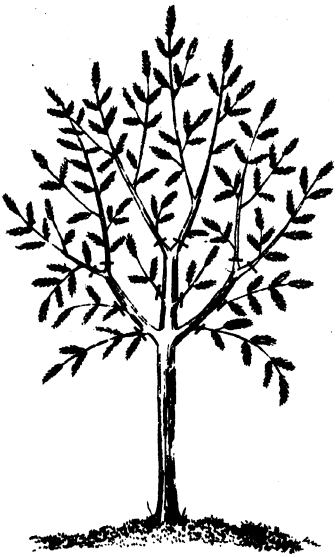
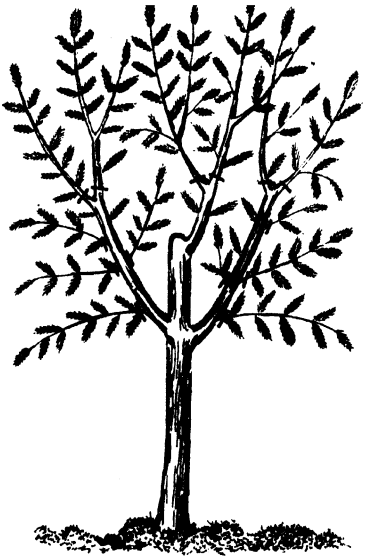


A. 3.



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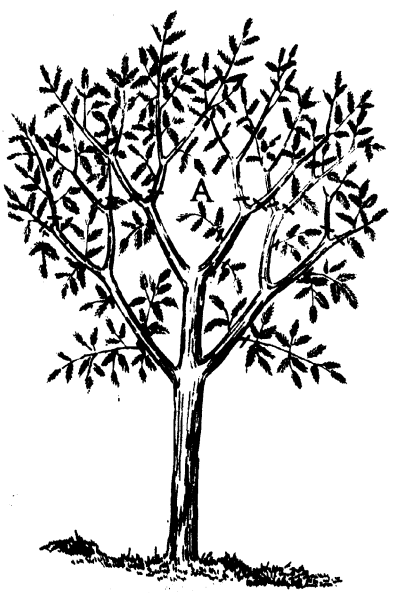
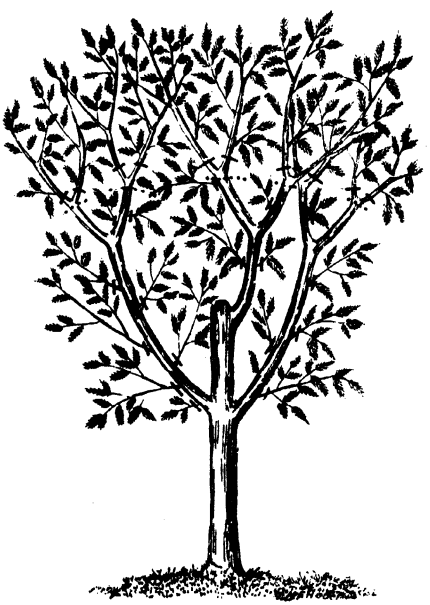


A. 4

(Ref Chapt III)



B. 4

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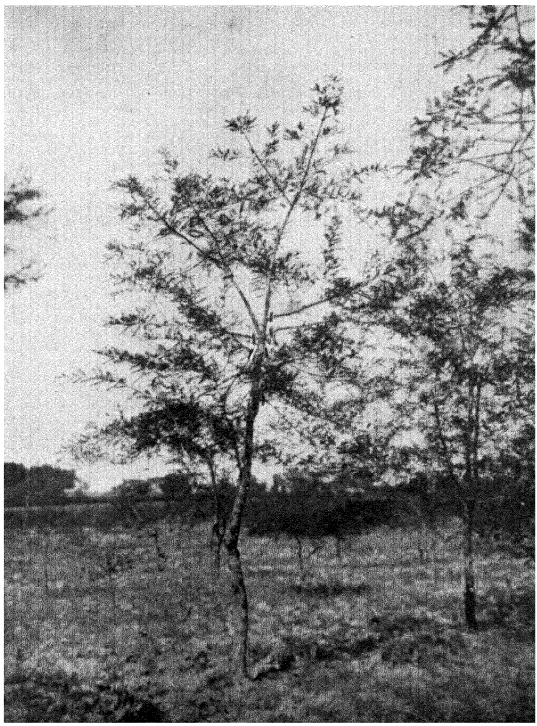

FIG. 4.—METHOD OF PRUNING KHAIR

(Chapt. III).

LINES SHOW SUGGESTED PRUNING CUTS.

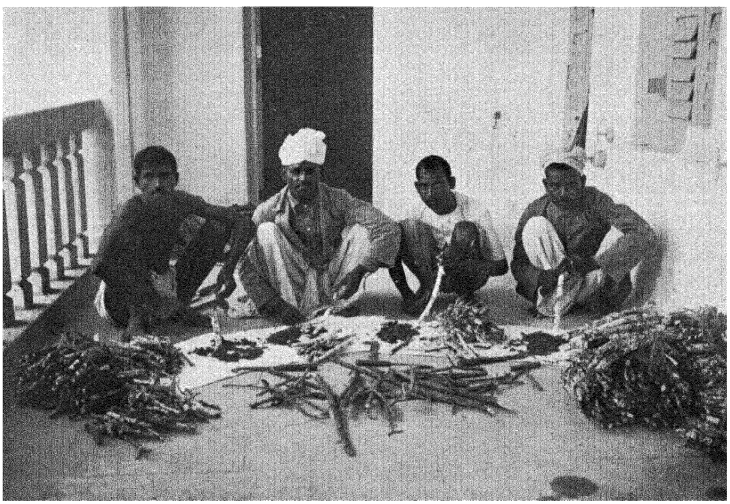

FIG. 5.—SCRAPING BER STICK LAC

(*Chapt. I*).

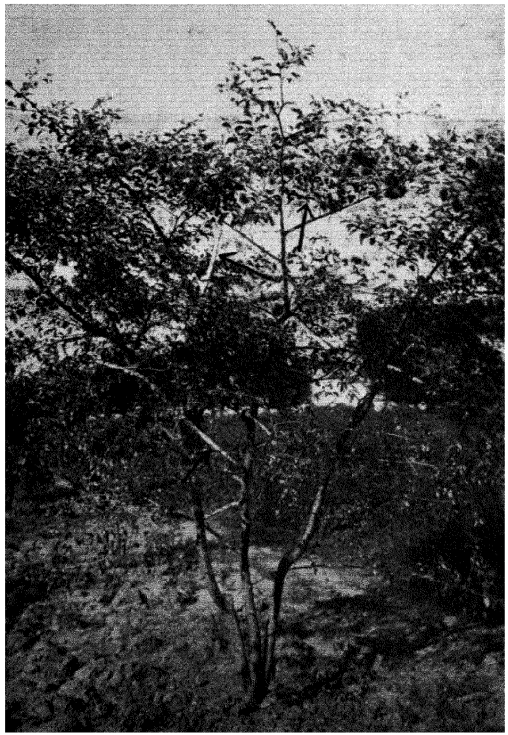

FIG. 6.—SMALL BER SHOWING LATERAL INFECTION
(*Chapts. IV & VI*).

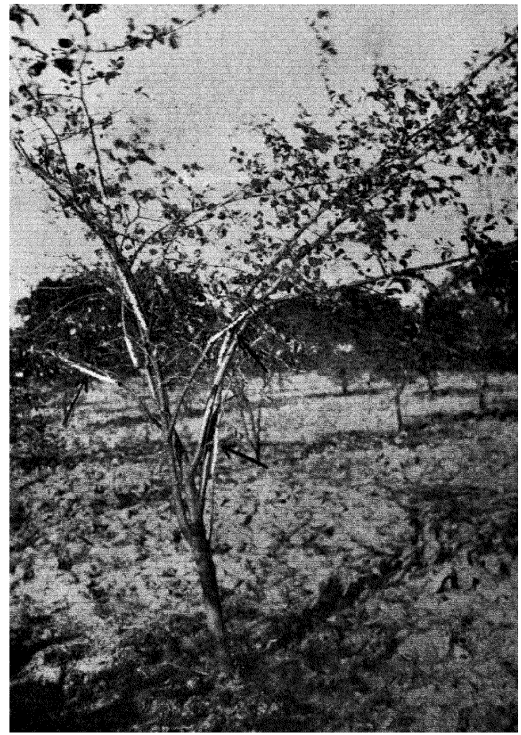

FIG. 7.—SMALL BER SHOWING LONGITUDINAL INFECTION
(*Chapt. V*)

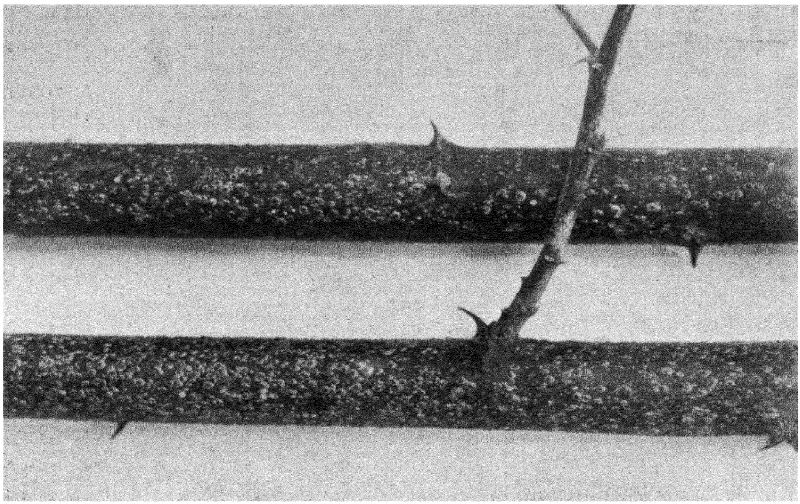

FIG. 8.—ASPIDIOTUS. SP. ON BER
(*Chapt. IX*).

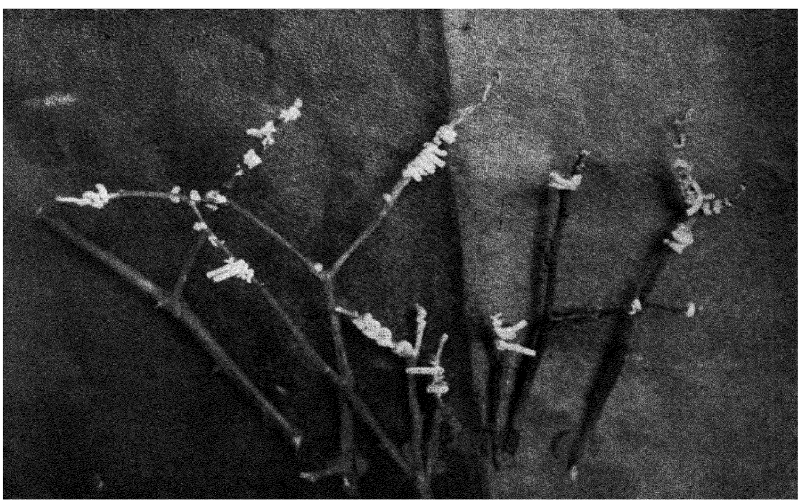

FIG. 9.—MACHAEROTA PLANITIAE ON BER
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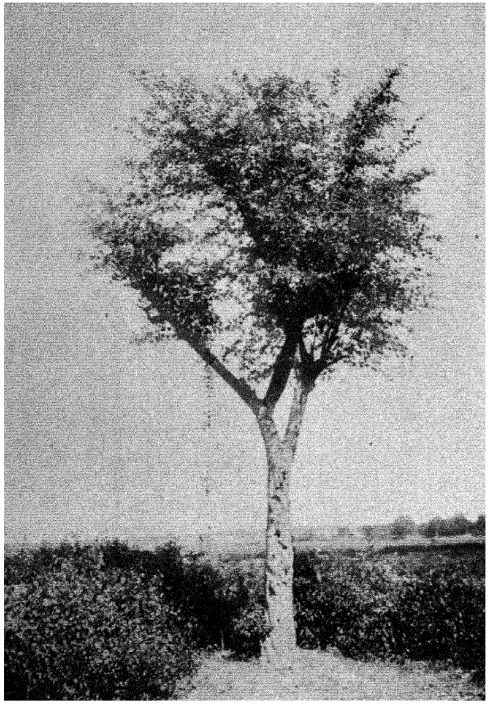


FIG. 10.—YOUNG SHOOTS RESULTING FROM CROP CUTTING, BER TREE

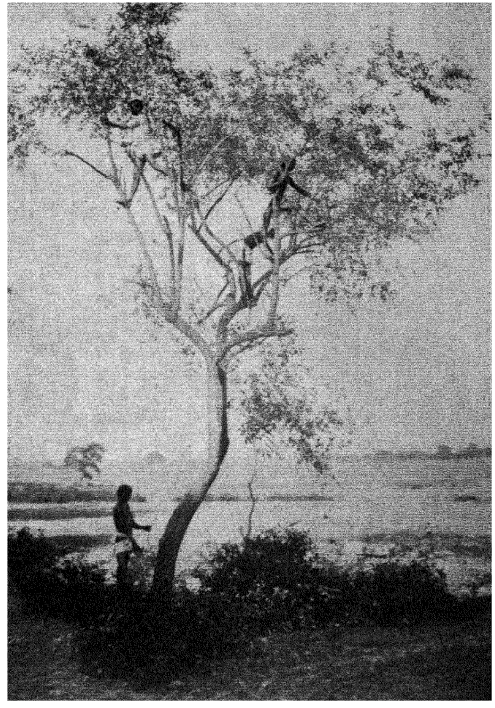


FIG. 11.—CROP CUTTING FROM A LARGE BER TREE (*Chapt. VI*).

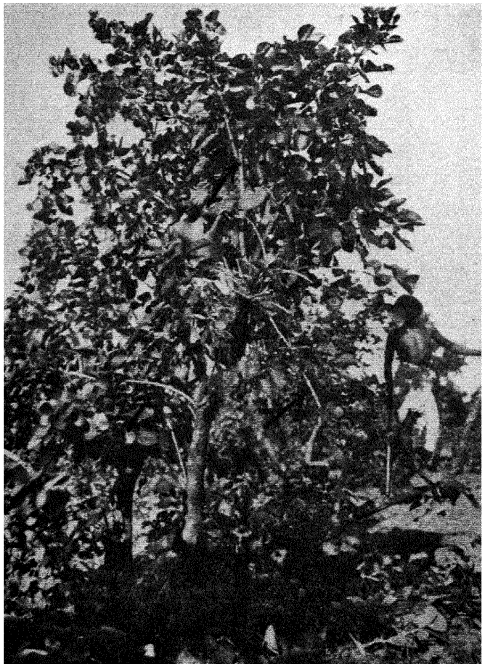


FIG. 12.—CROP CUTTING PALAS. KUNDRI RESERVE OCTOBER 1930

(*Chapts. IV & VI*).

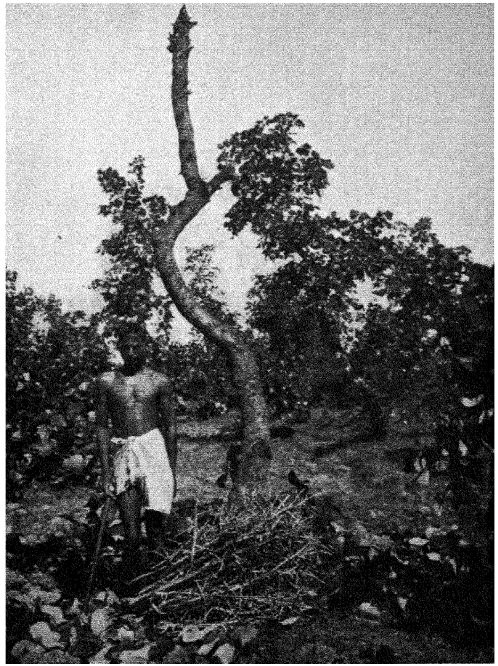


FIG. 13.—A PALAS TREE FROM WHICH THE CROP HAS BEEN CUT KUNDRI RESERVE OCTOBER 1930

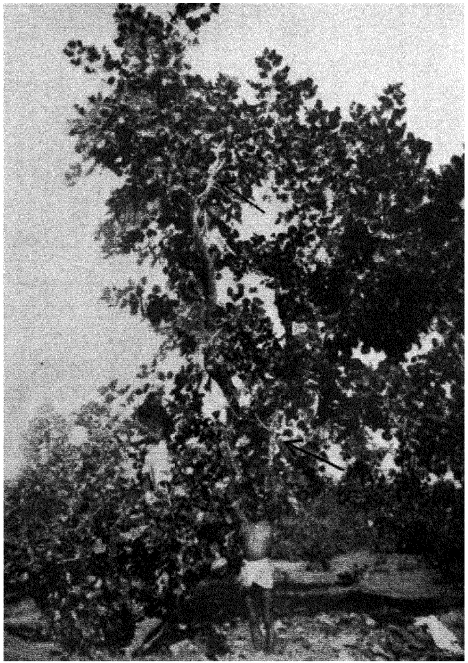


FIG. 14.—INOCULATING A LARGE PALAS. KUNDRI RESERVE 1930 *(Chapt VI).*

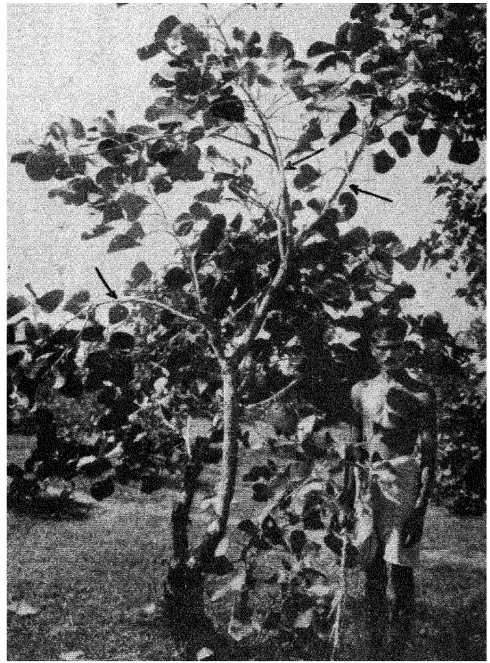


FIG. 15.—SMALL PALAS, KUNDRI RESERVE OCTOBER 1930, LONGITUDINAL INFECTION:

NOTE LEAF STALK ON THE BROOD STICKS

(Chapts. IV & VI).

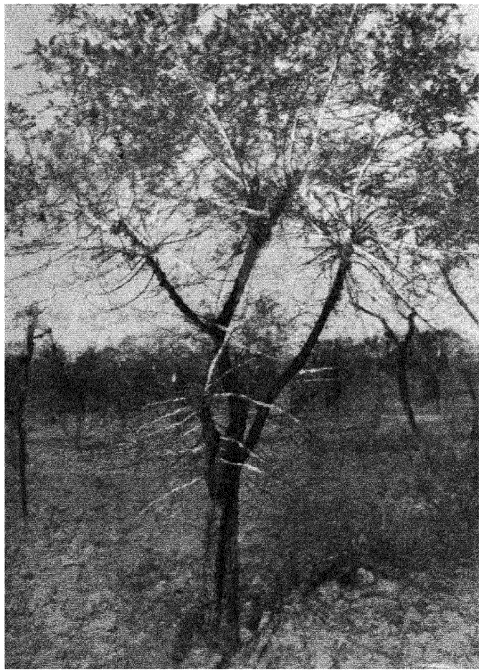


FIG. 16.—MEDIUM SIZED KHAIR INOCULATED WITH KUSUM BROOD, NAMKUM

(Chapt. VI).

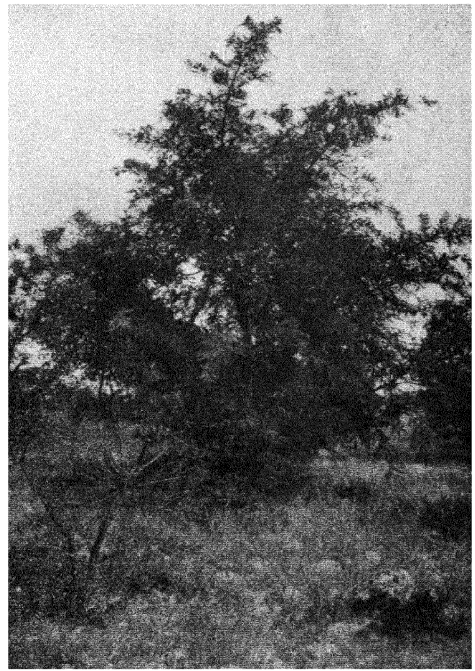


FIG. 17.—LARGE KHAIR TREE, 6 YEARS OLD FROM SEED AT NAMKUM

July 1930.
(Chapt. VI).

Crop **193**

Name of Host ..... Number Inoculated ..... Size... Large / Medium / Small

Host Pruned
or Crop Cut from it .....

Brood Used ..... Mother Brood .....

Date of Inoculation .....

Date Brood Removed .....

Brood Bought From ..... For.....Rs. .....

(If own Brood used this figure does not appear in Cost.)

Cost of Inoculation work Coolies etc. ..... Rs. .....
(including cost of removal of brood)

Phunki from Brood sold after use Stick Cost...Rs. .....
or
Scraped. ..... For....Rs. .....

Weight Brood Sticks used ..... Seers(x) Cost so far...Rs. .....

Weight Yield Sticks obtained ..... Seers(y)

Yield Ratio Figure ..... (y/x)

Name of Host Number Inoculated Size... Large / Medium / Small

Host Pruned
or Crop Cut from it

Brood Used Mother Brood

Date of Inoculation

Date Brood Removed

Brood Bought From For.....Rs.

(If own Brood used this figure does not appear in Cost)

Cost of Inoculation work Coolies etc. (including cost of removal of brood) Rs.

Phunki from Brood sold after use Stick or Scraped. Cost...Rs. For....Rs. *Add* / *Subtract*

Weight Brood Sticks used Seers(x) Cost so far...Rs.

Weight Yield Sticks obtained Seers(y)

Yield Ratio Figure (y/x) *Add*

Date of Cutting

Date of Swarming

Cost of Cutting, Coolies Carting (Scraping etc.) Rs.

Expenditure Rs.

Yield ... Scraped Wt. Rs.
Stick Wt. Rs.
Brood Wt. Rs. *Add*

(If Brood used on own Plantation this figure goes out. On next sheet however there will be no price of brood in the costing side.)

Income .....Rs.

Expenditure Rs. *Subtract*

Grand Total. Rs.

Profit or Loss.

General Notes.

Trees. Under / Correctly / Over ...Inoculated,—by Brood used.

Fixation of young Larvae Good / Fair / Poor

Rough Ratio of Males to Females

Date of Male Emergence

Presence of Predators and Parasites. Heavy / Normal / Slight In the Crop.

Fig 18. (Ref. Chapt. 6.)

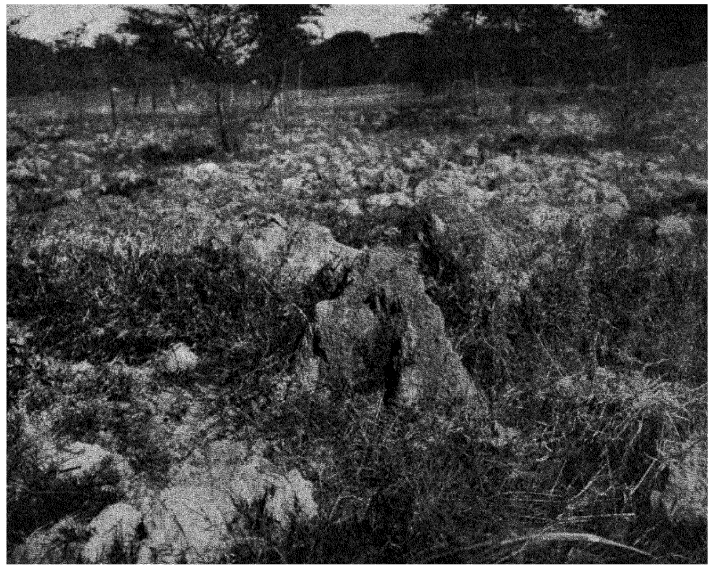


FIG. 19.—TERMITARIUM.

(*Chapt. IX*).

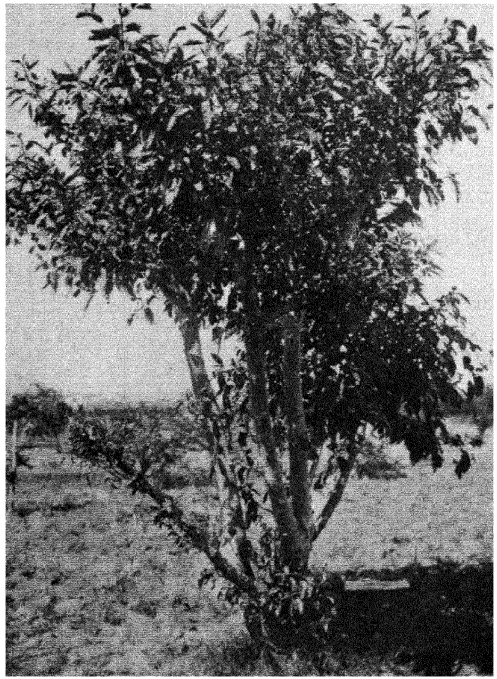


FIG. 20.—SMALL FICUS GLOMERATA (DUMBER)
CROP CUT JULY 1930 READY FOR REINFECTION OCTOBER 1930
(Chapts. IV & VII).

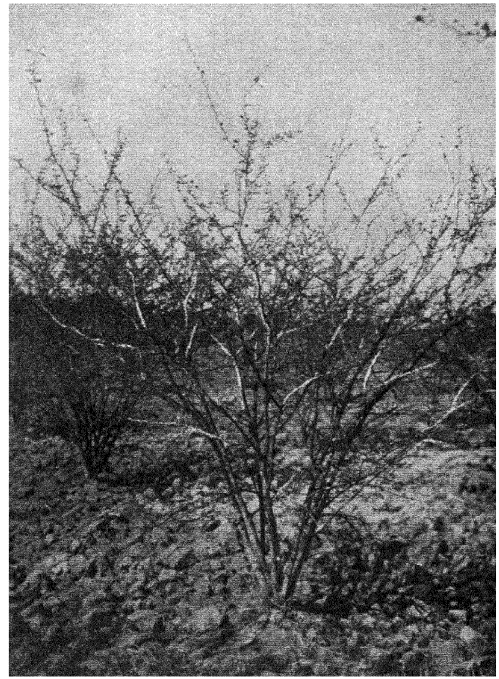
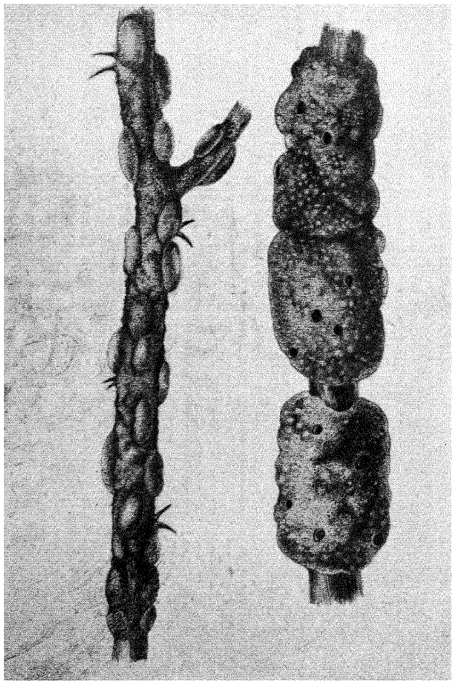


FIG. 21.—ACACIA FARNESIANA INFECTED WITH KUSUM BROOD
Namkum January 1931.
(Chapts. IV & VII).



A B

FIG. 22.—DAMAGE DONE BY EUBLEMMA (*Chapt. VIII*).

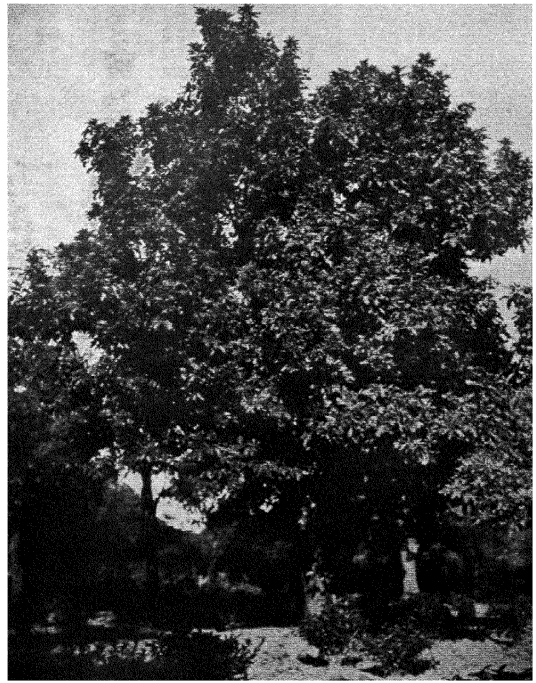


FIG. 23.—MEDIUM SIZED KUSUM TREE GROWING IN A TEA GARDEN AT SABAYA: PRUNED IN FEBRUARY 1930. PHOTOGRAPHED IN DECEMBER 1930.

PREFACE.

This pamphlet was originally intended as an answer to the very numerous letters received at this Institute, asking for information and advice regarding the cultivation of Lac For this reason the major portion of it has been given over to the practical side of the question, and an attempt has been made to produce a pamphlet which explains as clearly as possible, the practical process of Lac Cultivation from the very beginning Morphological description of *Laccifer lacca* has therefore been omitted, excellent accounts however may be had in many of the works quoted in the Bibliography, particularly Negi (1929).

Later it was decided that its value would be much increased if it were expanded to include some of the important practical research results obtained at this Institute Also since the ravages of pests are such an important factor in Lac Cultivation, a short explanation of their method of attack has been included in order to elucidate the control methods which are suggested.

The chapters recounting the various methods of dealing with the several host trees, have been written with particular reference to Bihar & Orissa, and for other districts may require slight modifications, they apply however over a very large percentage of lac growing districts but do not include Assam and Burma.

My thanks are due to Mrs Dorothy Norris, Director of this Institute for very valuable advice and criticism, and for much of the information regarding lac cultivation in Assam and the Central Provinces, to Mr. H. T Bates, Manager, Sabaya Division, Assam Frontier Tea Company, Ltd., for valuable criticism and advice, to Dr C F C Beeson, Forest Entomologist, Dehra Dun for advice and criticism more particularly of the Entomological chapters, and to Mr E Benskin, Conservator of Forests, Bihar and Orissa, for arranging a tour for me round a number of the Lac Plantations and Orchards under his charge Also to the members of the Institute staff, for the loan of photographs, and other practical help, particularly, to Mr. Negi, the Assistant Entomologist who supplied me with data for the paragraphs on forecast of swarming date and to Mr Heber, the Artist and Photographer, who took many of the photographs, developed and printed those taken by myself, and prepared the diagrams and coloured plate for me.

DATED NAMKUM, P. M. GLOVER.
June 1931.

INDIAN LAC ASSOCIATION FOR RESEARCH.

CHAPTER I.

Introduction and General Account of the Lac Insect and Lac Crops.

Lac and Lac hosts.

Lac is the resinous encrustation secreted by a scale insect (*Coccid*) belonging to the bug family, or *Hemiptera*, called *Laccifer lacca* (*Kerr*) It is ordinarily spoken of as the Lac insect, and passes the whole of its life on certain trees, shrubs and creepers, upon which it feeds These plants are therefore known as Lac Hosts.

Life History.

The Lac insect starts its life as a minute red coloured creature called the larva, these larvæ are active, and are capable of crawling a considerable distance.

The Larva.

Plate 1, Fig I figures a much enlarged lac larva, the first or head segment carries the antennae and a pair of eyes; the mouth parts lie entirely ventral in position and consist in two pairs of Setae made up of the specialised mandibles and maxillae which together form a tube, the proboscis The succeeding three segments are the prothoracic and thoracic second and third, each bears a pair of legs, and the prothoracic in addition bears on the dorsal surface a pair of Anterior Spiracular plates. The remaining segments together constitute the abdomen, in relation with the apex of which are a pair of long caudal setæ.

Infection.

The Lac Larvæ are introduced on to a tree by a process called "infection" which will be referred to later They crawl over the tree looking for suitable places to come to rest, choosing particularly the underside of the soft succulent twigs, and here they settle down. The larva next forces the long slender tube or "*proboscis*" through the thin bark, and begins to suck the juices of the tree.

Early growth.

This *proboscis* originates from the lower surface of the head of the larva, it actually represents a mouth drawn out into a long tubular structure adapted for piercing and

sucking. Having once settled down the larva never moves again, it continues to suck the juices from the tree and begins to grow. After a little a thin shining substance can be seen over the backs of the larvæ, this is the secretion which is known as Lac. The larvæ continue to grow, and all the time go on secreting Lac, the original layer is therefore, added to, and thickened from the inside. The Lac of commerce is this secretion together with the cast skins (exuviæ) of the insects.

Lac Secretion.

The reason for the production of this covering is to provide a protection for the lac insects, which are soft bodied and unable to move after settlement and which would be therefore easy prey to predaceous enemies such as birds insects, etc. were they not protected in this way. The Lac insects are not however exempt from this danger in spite of this protective covering (cf *Chapt. IX*).

When the larvæ settle on the twigs of the host tree they do so in very large numbers, often completely covering the lower surface of the twigs, and extending on to the upper surface, each larva touching, or at least being very close to, its neighbour. *Plate 1, Fig 1V* represents a portion of a twig showing newly settled lac larvæ, those of a crimson red colour are alive and healthy those of a dark chocolate brown colour are dead Therefore when the larvæ start to produce the resinous coat over their bodies the secretion from one larva meets and coalesces with that from another larva, and in this way a continuous or semi-continuous coat of Lac is formed, at first slowly, and later more rapidly over all the larvæ While this coat is being formed the larvæ themselves are undergoing changes, and growing; at first they all look alike to the naked eye, but actually they are of two kinds male and female. There are usually more female than male though broods containing more male than female insects are not unknown As growth continues, the Lac secretion continues, so that round each larva a more or less globular cell or "test" is produced, formed of Lac. The test formed round a male larva is thin and shaped like a cigar, that round a female is thicker, and in general shape oval.

Larval Settlement.

Male and Female cells.

Plate I, Figs. VIII and IX represent respectively female and male lac cells at a time just prior to male emergence. The female cell (VIII) is more or less oval in shape, the two holes opposite one another towards the Anterior

end are the Brachial Pores the posterior is the Anal Tubercular Opening Lying longitudinally in the mid dorsal line is a ridge showing segmentation, this represents the cast first larval skin (exuvia) of the insect. The male cell (IX) is roughly cigar shaped, the Brachial Pores are to be seen anteriorly, posteriorly is the circular opening through which the male will emerge covered by the lid or operculum.

Plate I, Fig V shows a number of immature lac cells on a twig the male cells can be readily picked out, on account of their cigar like shape and the circular operculum at the posterior end, from the oval and thickened female cells (See also *Plate I, Fig. XI*)

This coating of Lac over the insects on the twig is called the encrustation. Each cell or test has three openings to the outside through which long waxy white filaments protrude, these filaments may be taken as a sign of healthy insects, and may be so numerous as to give the whole encrustation a woolly white appearance Two of these holes represent Brachial Pores, or breathing holes, the other is the Anal Cleft, or Anal Tubercular Opening, through which a sticky secretion called "Honey Dew" is secreted (*Plate I, Fig. VIII*),

Honey Dew.

The Honey Dew is secreted fairly freely particularly in the *Katki* crop, and forms a sticky covering on the twigs, and drips on to the upper surfaces of the leaves and spreads over them It forms the nutrient material for a black fungoid growth, a species of *Capnodium* or *Fumago*, which overspreads the upper

Fungus.

surfaces of the leaves and the twigs of Lac infected trees with a sooty black covering. The fungus appears to be a harmless *Saprophyte*, and this black appearance is quite characteristic of Lac infected trees, especially *Butea frondosa* (*Palas*) and *Zizyphus Jujuba* (*Ber*) The Honey Dew itself is also attractive to Ants which visit the Lac bearing trees to obtain it (cf. *Chapt. VIII*). The larvæ which have by now grown beyond the larval stage, and may be referred to as Lac insects, are thus shut off from the outside, each enclosed in a cell of Lac, with three small openings to the outside. All their food is obtained in the form of juices from the host tree, sucked in through the *proboscis*.

The next event in the life history is the emergence of the male insects.

Emergence of the Males.

The male Lac insects are creatures of similar appearance to the larvæ, have legs and antennae, and are red in colour. Out of each cigar shaped cell one of these male insects

emerges by pushing open the operculum, or lid situated at one end. This is called male emergence. These male insects may or may not have wings.

Male Insects.

Plate I, Figs. II and III depict respectively a winged and an apterous male lac insect. In colour the male is very similar to the larva, the head bears a pair of eyes and the antennae, mouth parts are absent There are three thoracic segments each of which bears a pair of legs, the second segment carries a pair of hyaline wings, which are absent in the apterous male. The remaining segments compose the abdomen, from the apex of which arises the Genital Sheath containing the penis At either side of the penis is a long seta, these are the caudal setae.

The male insects walk over the encrustation and fertilize the females, each male being capable of fertilizing several females When this function is performed they die The entire encrustation is now composed of female cells, together with the empty cells from which the males have emerged

Excess of Males.

The male insects secrete very little Lac, and their presence is only necessary for the purpose of fertilization. Sometimes males are present in excessive numbers and after male emergence certain twigs may be seen to be entirely covered with empty cigar shaped cells, this often gives the impression that the Lac has died, whereas in reality it merely represents excessive numbers of cells from which the males have emerged. Excess of males is therefore detrimental to the cultivator.

Parthenogenesis.

While referring to the process of Male Emergence, it may be stated that Parthenogenesis has been shown to be a possibility in the Life Cycle of *L. lacca*. This phenomenon may be explained as the full development of the female and the production of young without any intervention on the part of the male. At Namkum it has been shown that the Lac female can for two successive generations grow to normal full size and give rise to a swarm parthenogenetically The third generation produced in this way failed to survive This means to say adverse climatic conditions occurring at Male emergence could prevent fertilization in two successive crops, without harming the yield or the production of a swarm.

In practice this phenomenon of Parthenogenesis is probably of some value in the Rains (*Katki*) Crop, during which heavy rain may kill off many

of the males allowing the process of fertilisation to be hardly or partially completed only.

Further development of the Female.

After the process of fertilization has taken place the female insects begin to secrete Lac at a much greater rate, and the females themselves become less and less insect like, inside their cells Finally they become sack-like objects contained in large globular cells of lac with their proboscides still embedded in the host tree sucking in nourishment Meanwhile in their bodies, the eggs, of which there are very large numbers, are ripening.

Swarming.

The encrustation of Lac has by now become a thick coating, partly or completely surrounding the twigs of the host plant, due to the confluence of the female Lac tests The eggs in the female body begin to ripen and cracks appear in the encrustation, and an orange-yellow spot can also be seen on the female cells, (*Plate I. Figs VI & VII*), the white filaments do not necessarily disappear at this time, as is believed in some districts Soon after this the eggs ripen and are expelled by contraction of the muscles of the female insect's body, into the incubating chamber of the test Here the small red larvæ hatch out, crawl out of the incubating chamber and start to look for places to settle down All the eggs are not laid at once and this process from any given brood lasts usually from 3—4 weeks (*Chapt V*) This process of the larvæ leaving the female cell is called "Swarming".

Infection.

This is the natural process of which those who wish to cultivate lac must make use; successful cultivation depends very largely therefore on making use of this natural process to the utmost advantage and in such a way as to stimulate, and not retard it. The cultivator necessarily wishes to introduce the Lac larvæ on to a fresh host tree which has been previously pruned in order to provide plenty of fresh young shoots on which the larvæ can settle This introduction is done as follows; several days to a week before the larvæ are due to emerge from the mature female cells, the Lac bearing branches are cut from the tree, the branches bearing a thick healthy looking encrustation are chosen and are cut into pieces of a convenient length say 6″ to 1′ These sticks are referred to as "Brood Lac" because they contain the young swarm. These sticks are then tied to the branches of the tree on which it is proposed

to grow Lac, the larvæ leave the female cells and swarm all over the branches of the new host tree. This process is called "inoculation" or "infection".

All branches bearing unhealthy looking lac, and all lac bearing branches not required for use as brood can be sold for manufacture. They can be either sold as they are, with the lac still on the stick, in which condition it is known as "Stick Lac" or the lac can be scraped from the stick in which condition it is known as "Scraped Lac".

The Lac Crops.

The process of growth from the small red larva to a female cell, fully mature and containing larvæ ready to swarm is called "A Life Cycle" or "Generation". There are two life cycles in a year in practically every district where lac is grown, (in Mysore the lac insect grown on *Shorea Talura* "*Jalla*" goes through three cycles in thirteen months) these are discussed in the following paragraphs and actually refer to Bihar and Orissa, but apply in most districts with slight variation, in Assam and Burma however, they do not apply

The period of the different lac crops is largely decided by the climatic conditions prevailing in any given district *Shorea Talura* brood for example when brought from Mysore and used for inoculation at Ranchi, did not produce three broods per year but was normally two brooded

Katki.

When the lac larvæ are inoculated on host trees in June-July the male insects emerge in August-September, and the females are ready to give out a swarm in October-November. This is called the *Katki* (or *Rangeen*) cycle or crop The larvæ from the brood lac produced by the *Katki* crop, settle down in October-November, on the new host trees, the male insects emerge in February-March, and the females are ready to give out a swarm in June-July. This

Baisakhi.

is called the *Baisakhi* (*Hari*, in the Punjab) crop. Brood lac from this crop is used to infect the trees for the *Katki* crop, and so on. When lac is grown on *Schleichera trijuga* (*Kusum*) or if brood lac from *Kusum* is used to inoculate other host trees, a rather different Life Cycle occurs. When larvæ are inoculated on *Kusum* or larvæ from *Kusum* brood are inoculated on any host tree in July,

Aghani.

the males emerge in September, but the females are not ready to produce a swarm until January-February. This is called the *Aghani* (*Kusmi* or *Nagoli*) crop. The larvæ

from this crop are inoculated on *Kusum* or other hosts in January-February, the males emerge in March-April and the females are ready to produce larvæ in June-July. This is called the *Jethwi* crop, the larvæ from it, infected on *Kusum* or other hosts in July will give rise to an *Aghani* crop again

Jethwi.

The males of the *Aghani* and *Katki* crops are mainly apterous (wingless) those of the *Jethwi* and *Baisakhi* crops are mixed, some winged some apterous

It will be seen therefore that Lac that has not been grown on *Kusum*, will retain the *Katki* and *Baisakhi* seasons for its Life Cycles Lac grown on *Kusum*, and Lac that has been grown on *Kusum* and is then grown on other hosts retains the *Aghani* and *Jethwi* seasons for its Life Cycles.

In this book where a Lac is referred to as *Rangeen* it means that it has not been grown on *Kusum*, and that it takes the *Katki* and *Baisakhi* cycles. Where it is referred to as *Kusmi*, it means that it is either grown on *Kusum*, or is the result of *Kusum* brood, and that it takes the *Aghani* and *Jethwi* Cycles

When all the larvæ have swarmed from the brood lac, it is taken off the trees to which it has been tied, and all the female insects are found to be dead. In this condition it is called "*Phunki*" Stick Lac", and can either be sold as such, or it may be scraped and sold as Scraped Lac; the sticks after scraping are of some use and can be sold as firewood.

Phunki Lac.

A portion of the *Baisakhi* crop is sometimes cut from the tree immature in April-May for reasons explained later (*Chap. IV*) leaving sufficient Lac on the tree however to provide brood in July. This cut lac is referred to as "*Ari*" as it contains living immature insects; it may be sold for manufacture either on the Stick or as Scraped Lac.

April-May cutting.

To summarise, it will be seen that there are three seasons in the year for the inoculation of Lac host trees.

1. *June-July.*—

(*a*) The inoculation of hosts other than *Kusum* with brood from the *Baisakhi* crop to produce a *Katki* crop.

(b) The inoculation of host trees including *Kusum* with *Jethwi* crop brood and in addition the inoculation of *Kusum* with *Baisakhi* crop brood (with certain exceptions) to grow an *Aghani* crop.

Summary of Inoculation times.

2. *October-November.*—

(a) The inoculation of host trees other than *Kusum* with brood from the *Katki* crop to grow a *Baisakhi* crop.

3. *January-February.*—

(a) The inoculation of host trees including *Kusum* with brood from the *Aghani* crop to grow a *Jethwi* crop.

It will be seen also that there are four seasons for cutting Lac crops during the year. The sale of lac for manufacture into Shellac, although in many cases corresponding with these periods, need not necessarily do so

1. *June-July* —

Baisakhi and *Jethwi* crop lac is cut All that is not required for brood and all Lac used as brood after such use is sold for manufacture as stick or as scraped Lac.

Summary of Crop Cutting Times.

2. *October-November* —

Katki crop Lac is cut Lac not required as brood and all brood after use is sold as stick or scraped Lac

3. *January-February* —

Aghani crop Lac is cut All Lac not required as brood and all brood after use is sold as stick or scraped Lac

4. *April-May* —

Part of the *Baisakhi* crop is cut in some districts and is sold "*Ari*" as scraped or stick Lac.

Lac whether stick or scraped, grown on different host plants should be kept separate and not lumped together for sale. This is particularly important where some of the Lac is *Kusmi* (*i e* , grown on *Kusum* or other hosts, using *Kusum* brood) and the rest is *Rangeen* (*i e.*, grown on hosts other than *Kusum* using brood other than *Kusum*). Lac grown on the *Kusum* tree is considered the best in quality and *Kusmi* Lac in general is more

valuable than *Rangeen* Lac. *Baisakhi* Lac also is considered better in quality than *Katki* Lac.

It will be seen therefore that the successful Lac cultivator must depend primarily on the correct use of the Lac insect and its life cycle. The insect is however closely related to the tree on which it is living and feeding, successful Lac cultivation therefore must depend secondarily on correct use and treatment of the Lac host trees. In the following chapters the correct treatment of both insect and host plants is outlined, based on a long period of practical experiment at Namkum.

As regards the areas of lac cultivation, 90% of the lac produced in India comes from an area comprising; Chota Nagpur, the Feudatory States of Orissa, and the Central Provinces Bihar and Orissa is however responsible for more than half the annual output of lac from India Other lac growing areas are Assam, Burma and Sindh, it is also grown in the United Provinces, in certain areas in Bombay and Madras Presidencies, in Bengal, and to a small extent in Rajputana, the Punjab and Hyderabad.

CHAPTER II.

Propagation and subsequent treatment of lac hosts, cultivation and manuring

The propagation of Lac Host trees and their subsequent early treatment such as manuring and cultivation is of primary interest to those cultivators who wish either to start new plantations or to increase the size of, and replace mortalities in, plantations already in existence, in the most economical way.

It is impossible to lay down hard and fast rules which will apply in all cases, I propose therefore to outline the methods of propagation and manuring found to apply at Namkum, and in our experimental area in the Kundri Forest Reserve, Palamau Division, Bihar and Orissa The early manuring of seedlings may be taken as having general application; for the manuring of hosts, in later stages, although the methods outlined have a general application, a soil analysis of the area should be made and the deficiencies in ordinary plant requirements should be remedied.

Method of Propagation.

There are two methods of propagating host trees from seed, these are firstly, planting in Nursery Beds and transplanting later, and secondly, direct sowing With some hosts the first method of treatment is better and with others the second.

Nursery Sowing.

Nursery beds may best be prepared 40 ft. × 2½ ft. and dug to a depth of 9″. In Chota Nagpur at any rate it is advisable not to exceed this depth of 9″. Artificial manure should be given well mixed into the soil at the following rate for each bed :—

Ammonium sulphate	½ oz.
Potassium Sulphate (or Chloride)	½ oz.
Concentrated Superphosphate .	1 lb.—2 lbs.

The optimum time for seed sowing is the middle of March though seeds may be sown at other times The depth of sowing varies with the size of seed, very small seeds should he just below the surface, no seed should however be placed deeper than ½″—1″, water should be given twice daily The young seedlings should be transplanted after the first few showers of the monsoon,

Transplanting.

if growth is very rapid earlier transplanting may be done They should be transplanted into circular pits prepared 2½ ft by 2½ ft. in depth, the soil in each pit being mixed with manure in the following proportions —

Ammonium sulphate	1 oz.	or 2 seers Karunj cake
Potassium sulphate .	1 oz	(not so good a manure but
Concentrated Superphosphate	1 lb	serviceable and cheaper)

Spacing.

The most satisfactory arrangement of pits is equilateral triangular spacing, it being the most economical, the distance apart of the pits depending on the particular host tree. The following host trees are best grown by nursery sowing and transplanting, the figure after each represents distance apart of the pits in feet for triangular spacing.

Butea frondosa (*Palas, Dhak*) (12′) *Dalberia latifolia* (*Sissoo*) (20′)
Schleichera trijuga (*Kusum*) (20′) *Albizzia stipulata* (*Siris*) (20′)
Zizyphus Jujuba (*Ber, Plum*) (15′)
Zizyphus Xylopyra (*Ghont*) (15′)
Acacia Farnesiana (12′).

The value of triangular spacing is that as the trees grow, should it be found that they require wider spacing, this can easily be accomplished. Alternate rows are cut down, and alternate trees in the standing rows are also felled, this leaves the remainder triangularly spaced at double the

previous distance. Actually before it becomes necessary to increase the spacing, at least two or three lac crops will have been taken from the trees to be felled : in this way the most economical use of space and time is made. *Figure 1* represents a plantation set out on 15 ft triangular spacing, if after some years the trees are found to be too crowded, those shown by black circles can be felled, and the trees remaining marked in red will then still be triangularly spaced but now at a distance of thirty feet.

Direct Sowing.

For direct sowing, the seeds should be sown in pits prepared as previously explained, where they are intended to remain, the optimum time again being about the middle of March, seeds however may be sown at other times It is usually best to sow three seeds in each pit to ensure satisfactory germination, should more than one seed germinate the healthiest only should be left; they should be watered once daily prior to germination and after, twice every second day until the break of the monsoon The following host trees respond most satisfactorily to this treatment, the figure in brackets represents the distance apart in feet of the pits, for triangular spacing

Acacia Catechu (*Khair*)	(15′)	*Cajanus indicus* (*Arhar*)	(10′)
Flemingia congesta	(10′)		
Ougeinia dalbergioides	(15′)		

Cuttings.

For the propagation of species of *Ficus* trees, the planting of large cuttings in circular pits 3 ft. by 3 ft. in depth and manured by either of the previously recorded methods gives successful results. The cuttings should be set in the pits fairly deeply, the optium time being in June in the early rains. An alternative method recommended by Mr. Bates is as follows A hole is dug with a crowbar in unprepared soil to a depth of 2′-6″, the *Ficus* cutting is set in this hole, and the soil around it rammed down. No manure is given until some time later when the roots have had an opportunity to form. The following *Ficus* sp. have given good results by these methods the figures in brackets as before represent the spacing

Ficus glomerata (*Dumber, Gular*)	(20′)	[results were not consistently
Ficus infectoria (*Pakaur*)	(20′)	satisfactory with this
Ficus glabella (*Putkul*)	(20′)	species.]
Ficus religiosa (*Pipal*)	(20′)	

Ficus Cunia (*Porho*) (20') has so far failed to grow from cuttings; other methods are being tried.

Some success has been obtained at Namkum with transplanted *Acacia arabica* (*Babul*), though the generally accepted optimum method is by direct sowing. The spacing is 12'.

Both *Khair* and *Flemingia congesta* can be grown by transplanting. In order to have any success with transplanting either of these hosts, it must be done while they are very young This is particularly the case with *Flemingea congesta*. Direct sowing is however the most satisfactory method and should therefore be retained.

Misra (1928) states that in regions where *Ber* seedlings are available, they may be dug from the ground, their root systems pruned to a depth of 9", the stems above ground should be reduced to 6—8" these seedlings can then be planted in pits and will grow satisfactorily This is the usual Forest experience and was recommended by the Forest Department for the Namkum plantation. I have also done this with *Acacia Farnesiana*.

Subsequent Treatment of Seedlings.

Subsequent treatment of these young seedlings and cuttings is of extreme importance and must not on any account be over looked *Water should be given 2—3 times weekly until the monsoon of the following year is established Cultivation is the most important factor and all pits should receive regular cultivation to at least 1 yard radius and a depth of 9". General cultivation of the plantation should also be done, particularly the removal of grass and undergrowth

The thallas round the young seedlings are usually made slightly concave, during the monsoon however a convex thalla is very much more satisfactory (*Fig II*). Water logging is one of the greatest causes of mortality among young seedlings especially *Khair* and must be prevented In plantations where water logging occurs some drainage system should be laid down

Manuring.

Manuring of the young plants will be found to be of great value in increasing their speed of growth and bringing them to a stage suitable for infection in the

*Where practicable, if not water should if possible be given at any rate during April and May to the young seedlings.

shortest possible time A suggested manuring and one that has been used for *Palas* at Kundri with success is as follows :—

Potassium Sulphate	¼ lb	(1 oz.)
Ammonium Sulphate	¼ lb.	(1 oz.)
Concentrated Superphosphate	1 lb —2 lbs per plant	(1 lb)

Figures in brackets represent Annual Manuring done at Namkum

Liming.

At Kundri Limed plots are given 1,000 lbs per acre The value of liming is at present receiving consideration, Soil analysis shows a shortage of Calcium in a number of soil samples taken in Chota Nagpur The use of lime cannot at present be definitely said to be either beneficial or harmful, the majority of trees require a slightly acid soil for satisfactory growth, and it seems possible in Chota Nagpur at any rate liming may be harmful in that it tends to counteract the only slight acidity of the soil. This matter is receiving attention at Namkum.

Method of Manuring.

The first three manures should be dug into an area of about 1 yard radius round each plant to the depth of 6"—9", April-May is a suitable average period For *Leguminous* hosts the nitrogen constituent (*i e* , Ammonium Sulphate) in the manure is relatively less important, but should not be omitted *Leguminous* hosts are *Palas, Khair* and other *Acacias; Flemingia congesta, Siris, Dalbergias, Ougeinias* and *Pithecolobium Saman* (rain tree) also *Arhar*, etc

Where a cheaper manuring is required, 2 seers of *Karunj* cake per plant can be substituted.

Value of Cultivation and Manuring.

The value of cultivation and manuring has been well demonstrated at Namkum with *Khair* Two blocks of *Khair* trees each 2½ years old were examined, one had received cultivation and manure, the other had been entirely left alone. The former at that time contained tall healthy trees of some 15'—20' high, the latter small weedy plants of between 2½ and 3 ft and a great many casualties (See Norris, Bates and Rangaswami 1930 *Figs. I and II*).

Age at which infection can be done.

At Namkum the main lac hosts have been sown using the methods just outlined in order to discover at what age from seed they may be used for inoculation with lac. The following are the results obtained :—

1.	*Kusum*	.. 6 years	(*N B* —Under intensive cultivation and manuring; *Kusum* may take as long as 7—12, or more years untreated).
2	*Khair*	2½—3 years.	
3	*Ber*	. 3—4 years	
4	*Ghont*	3—4 years	(not successful in Bihar & Orissa).
5.	*Palas*	.. 5 years	
6	*Babul*	3 years	(not successful in Bihar and Orissa)
7.	*Acacia Farnesiana*	2—3 years	
8.	*Flemingea congesta*	2 years	

Manuring and the Lac Insect.

It is of course obvious that since the Lac insect is obtaining the whole of its nourishment from the tree on which it is growing, any factors which tend to increase and benefit the growth of the tree will affect the insect beneficially At Kundri the resin secretion of the lac insect grown on *Palas* trees receiving full manuring as above, with or without lime has in 3½ years increased 15% The parasitisation of lac grown on *Palas* trees receiving lime at 1,000 lbs per acre was on the whole found to be less than on the unlimed trees This later conclusion requires confirmation, but there seems to be no doubt that liming is beneficial in this district (Kundri) for *Palas*.

Although lac can be grown under Forest conditions, there is no doubt at all that in order to get really successful results plantation or orchard conditions are better In this Province this statement does not refer so definitely to *Kusum* and *Palas* Where possible the growth of an agricultural crop as a subsidiary to the lac cultivation might be introduced, and would probably be of great value in counter balancing losses in a bad lac season.

It is only necessary to look at the difference in lac produced by uncultivated *Palas* or *Ber* trees, and that produced by *Palas* trees growing in *Paddy Bunds* and *Ber* trees growing in villages where they get a certain amount of cultivation and manuring, to see the importance of manuring and cultivation if a really healthy lac crop is to result.

Reasons for Manuring.

The reason for manuring is as follows, the tree requires for its nourishment 15 elements, these are :—

1.	Carbon	5.	Potash	9.	Sodium	13	Silicon
2	Nitrogen	6	Phosphorous	10	Iron	14	Manganese
3.	Hydrogen	7.	Sulphur	11.	Chlorine	15.	Magnesium.
4	Oxygen	8	Calcium	12.	Aluminium		

Of these *Carbon* & *and oxygen are* obtained from the air and *Hydrogen* and *Oxygen* from the water which the roots absorb from the soil The remainder must come to the plant dissolved in the water which it absorbs Growing plants drain the soil very heavily of *Nitrogen*, *Potash* and *Phosphorous* the remainder need not be considered in a general account, except *Calcium* which I referred to previously. In order to keep the plant well supplied with nourishment so that growth is continually at a maximum, the elements that are drained from the soil must be replaced, this is particularly the case with trees in use for lac cultivation, because the actual presence of the lac insect feeding on the sap increases the drain that the tree makes on the soil Constant pruning and crop cutting, stimulating as it does increase growth activity also increases food requirements Manuring therefore is important if optimum lac cultivation is expected

As regards the previously mentioned elements, they can be supplied to the soil in the following manures —

1. *Nitrogen* is supplied by —Cow-horse-sheep-goat dung, green manure, leaf mould, oil cake, night soil, sodium nitrate. *Ammonium sulphate* Calcium cyanamide.
2. *Phosphorous* is supplied by —Bone meal (also supplies some nitrogen) *Concentrated superphosphate* Fish waste (also supplies some nitrogen)
3. *Potash* is supplied by —Ashes *Potassium sulphate*, Potassium muriate, the latter is cheaper and equally as good as the Sulphate.

Those italicised are used at Namkum.

Green manuring is done by sowing a Field crop broadcast in the plots containing host trees; this crop is usually *Leguminous* as the plants can obtain *Nitrogen* from the *Air* by fixation They are sown as a rule in June in the first early showers of the monsoon and should be ploughed or hoed into the soil at the time when about 1/3rd the crop is in flower before the stems become

woody, at this time their effect is most beneficial. Suitable plants for this purpose are *Sun Hemp* (*Crotalaria juncea*), *Cow Pea* (*Dolichos sinensis*) and *Arhar* (*Cajanus indicus*). This type of manuring adds mainly *Nitrogen* to the soil and organic matter.

Leaf Mould.

Leaf mould as a manure is of great value and as it is universally available for the trouble of making it, the following brief note may help to increase its use All leaves, which can usually be obtained in enormous numbers, and other vegetable refuse such as grass and dead green plants, should be collected and thrown into a deep pit, dug for the purpose and here allowed to decay. This may be speeded up by an occasional soaking with water in the hot weather. The manure will be ready about 18 months after the pit has been filled.

Manures should be applied by broadcasting them round the plants and lightly forking them into the soil

Cost of Manuring.

As regards the cost of manuring, it is not a very expensive item. The following are the approximate prices of the main manures mentioned in this Chapter

Ammonium sulphate	@ Rs 10 per cwt.
Potassium sulphate	@ Rs 9 per cwt.
Superphosphate (Conc.)	@ Rs 6 per cwt.
Karunj cake	@ roughly Rs. 2/- per maund.

CHAPTER III

Pruning

The age at which it was found possible to give hosts sown at Namkum their first lac infection was given in Chapter II These young hosts did not require a pruning before infection In the majority of cases however, certain exceptions are cited in Chapter VI where the cutting of one lac crop acts as a pruning for the next crop, pruning is necessary before infecting a host tree with lac, if a really satisfactory crop is to be obtained.

Necessity for Pruning.

The reason for pruning prior to infection is that the young lac larvæ prefer young succulent shoots, on which the bark is not too thick, on which to settle and feed. In order therefore that the host tree to be used for infection shall have the maximum number of young succulent shoots in suitable condition for the

larvæ, pruning must be done in the correct way and at the correct time. Lac larvæ will settle on unpruned shoots but these do not admit of the greatest fixation and support, and a poor crop is the result. When trees have been taken into cultivation, in certain cases the cutting of the lac crop can be made to act as a pruning and pruning as a separate action need not be done. When crop cutting is being done, very often no thought whatsoever is given to the tree itself. Lac bearing branches are chopped down as quickly as possible and thick branches are often hacked through near the main stem to save time. *Palas* particularly, and *Ber*, are capable of withstanding fairly drastic treatment during these operations but some hosts are ruined by these methods and many if treated in this way give out only a minimum number of new shoots of any length In any case whether pruning, or crop cutting and pruning, or simply crop cutting, the following points should be borne in mind —

Inefficient Pruning.

Method of Pruning.

1 The general health and strength of the tree must be maintained.

2 Branches of over 1½" in diameter should not be cut as this is weakening, except when pruning old trees which have lost their vitality, in which case this is done in order to produce new wood at the expense of old.

3. Cutting should be done in such a way as to keep the good shape of the tree and allow plenty of room for the new shoots.

4 The production of the largest number possible of long healthy shoots.

5 All dead and diseased branches should be cut away.

6 The thinner the branch the nearer the main stem it should be cut.

I propose to outline the treatment of, say a young *Ber* as an example. The tree should be ready for inoculation at 3-4 years of age (for *Khair* 2-3). At this age it will probably have a straight trunk of about 1" or so in diameter and at a height of 3' or so from the ground it will fork or branch, *Fig A 1 & B 1* are diagramatic illustrations of such a tree The cropping cuts are shown by lines and would be made in October if inoculation was done in July. The response to this pruning is illustrated in *A2 & B2;* from each cut surface in *A1*, one or two new shoots have arisen, in *B1*, the new shoots arise from the main stem. The actual time at which a second pruning should be done must be judged by actual observation, it should not be however before

the new shoots have thickened and become to some extent woody near their origin. After the first pruning in this case crop cutting, repruning may be necessary in March-April prior to infection the following July; in any case whether repruning in March-April or crop-cutting in October-November the cuts should be made as illustrated by red lines in *Figs A2 and B2;* if the response to pruning has been more than one new shoot from the cut surfaces the second pruning cut should be made just below the origin of the two new shoots if they are weak *(see A2 short lines)* The object is of course to thicken and strengthen the three main forks as they are to carry the branches of the future tree. The response to this pruning is illustrated diagramatically in *A3 & B3.*

Two new shoots are shown as originating from each cut surface there may however be more.

Referring again to *A3 and B3* when the crop is cut or the tree is pruned, the cuts should be made as illustrated, the object being the building up of a strong substantial substructure to hold the future bowl or crown of the tree

The theoretical response to this cutting is shown in *A4 and B4*, two shoots only are shown originating from the cuts though there may be more, the suggested crop cutting or pruning cuts are shown by short lines As this process is repeated it may become necessary to thin out the centre of the tree, especially if more than two shoots originate from each cut, where this becomes necessary the cuts on two or more of the internal branches should be made below the ultimate fork, instead of above it, as illustrated *(See B4 dotted lines)*.

Small lateral branches may be cut through very near their points of origin (see *Figs A3 and A4* showing laterals on the main trunk and main forks). This cutting is particularly valuable in conjunction with the method just outlined, for *Khair, (see Fig IV photograph, representing a small Khair tree, the pruning cuts suggested are shown in red)*

These diagrams and outlines are intended as suggestions not as hard and fast rules for pruning, the actual method to be adopted will depend largely on the particularly host tree to be pruned and even on the habit of the individual tree concerned I suggest however that before setting the coolies to prune or cut a crop, a sample tree should be cut by the Cultivator himself as a pattern.

Pruning of large fully grown trees is very similar, reference being made in particular to large *Kusum*, *Siris* and *Ficus* trees *Fig. 3* represents a portion of such a large tree; the region in the *Fig* marked *A* corresponds with the area A in *Fig A4* Lac growth occurs on the finer succulent twigs at the ends of branches more particularly towards the outside of the bowl of the tree; this point should be borne in mind when pruning this type of tree, as the object is therefore to produce the largest possible number of young succulent shoots at the outside of the bowl Suggested pruning cuts are shown by short lines in the figure.

Correct time to Prune.

As regards the correct time to prune, the general rule in Bihar and Orissa is prune in April for inoculation in July and in May for inoculation in October-November. Shoots of the right thickness will then be produced When trees are already under lac cultivation the cutting of the crop can in a number of cases be made to act as a pruning, in other cases repruning is necessary after crop cutting, before reinfection The particular method applicable to the various lac host trees will be explained in Chapters VI and VII The following paragraph contains the dates found to be satisfactory for pruning hosts prior to an initial infection or hosts which require repruning after crop cutting, before reinfection

Pruning the main Lac Hosts.

Palas —These results are taken from the Kundri experimental area *Palas* should be pruned in May for infection in October which is the most important season for the infection of this host for July inoculation it should be pruned in April Artificial Infection of *Palas* is very rarely done in July (cf. *Chapt. VI*) It has been stated that shoots resulting from May pruning are better than those resulting from April pruning for July infection at Kundri, this is being investigated It can stand fairly drastic cutting. The cuts should not be made on any shoot above the part that has become definitely woody.

Khair —This host should be pruned in May for infection in July. It should not be pruned at any other time. Further investigations are being made.

Ber —Should be pruned in March—April for July infection and in April-May for inoculation in October-November.

Kusum.—Can be pruned in either July or February; the latter season is perhaps the better of the two.

After pruning prior to infection *Kusum* requires rather a long rest period. The Raiyat generally allows 18 months to 2 years rest to trees after pruning; I am inclined to think that 18 months will be found to be the most satisfactory period *Kusum* trees pruned for the first time throw out exceedingly healthy shoots and appear to be ready for infection one year from the date of pruning, it is said however that although lac will take on these shoots, they are not really satisfactory for the maintenance of the insect and a poor crop results. This opinion is held also by Mr Rickford and Mr Fraser of Raidih in this Province.

*A number of pruning experiments with *Kusum* are being carried out at Sabaya, including the infection of *Kusum*, 1 year, 18 months and 2 years from the date of pruning, and it is hoped that definite results will be ready on this subject in the near future.

Crop cutting at either of the two season July or February can act as a pruning and 18 months or 2 years rest should be given before reinfection. *Kusum* should not be pruned in November

Flemingia Congesta —Should be fairly heavily pruned in March for July infection.

Acacia Farnesiana.—Should be lightly pruned in March for July infection.

Ficus Sp.—May be pruned in April for July infection and in June-July for infection in October-November.

The cost of pruning varies with the size of the tree and depends to some extent on whether it is gregarious or not As a rough guide it may be quoted that pruning of *Palas* costs approximately ½ as. per tree and that *Kusum* trees of medium size cost about 1 as per tree, large *Kusum* trees may cost as much as 2 or even 3 as. each to prune

*As regards infection of *Kusum* one year only after pruning; trees pruned for the first time at Sabaya February 1930 and infected February 1931 are at present carrying a satisfactory healthy looking crop. It appears that infection one year after the first pruning is satisfactory in this District

I am inclined to believe that repeated infection one year after pruning, or crop cutting would result in poor shoots and poor crops, 18 months to 2 years rest should be allowed to *Kusum* which is under continuous Lac cultivation, until further data is available

CHAPTER IV.

Inoculation.

The trees for inoculation, if they have been pruned correctly will be well supplied with healthy shoots in suitable condition for lac infection. The

practical procedure during each of the three inoculation periods is exactly similar and they can therefore be treated together.

Brood Lac.

The Brood Lac to be used for inoculation of the new trees should first be examined, whether it has been cut from trees in the owners plantation, or bought from elsewhere. All unhealthy and pest infected sticks should be rejected and only healthy uninfected lac bearing branches should be used as brood lac. The branches and twigs selected should then be cut into sticks of convenient size, say 6″—1′ in length All the selected sticks should then be tied with string This is done as follows at each end of a stick a piece of string about 6″—1′ long is tied so that two free ends of string are left at each end of the stick.

Methods of Inoculation.

These sticks are then tied to the branches of the trees for infection this can be done in three different ways.

1. The Longitudinal *(Fig VII)*
2. The Lateral *(Fig VI)*
3. The Interlaced

1 The *Longitudinal* consists in tying the sticks of brood lac so that they lie along the branches of the tree for infection touching them and fastened to them at each end by the string The sticks should be tied at the base of the branches at the lower side, so that the larvae on emerging can walk directly on to the fresh shoots The optimum position for the brood sticks is along the mother branch from which a new shoot or a number of new shoots have arisen after pruning, close to the point of origin of the new shoot or shoots; or if a number of long new shoots have arisen from the mother branch, a brood stick may be tied along the basal portion of each of them The Longitudinal is the most generally adopted, and in my opinion by far the best method. If on a large tree it is impossible for the coolies engaged in the infection work to climb up to the uppermost crown of the tree or to get out to the ends of any of the lateral branches, a bundle of brood lac sticks may be substituted for the single stick, and should be tied to each of the main branches at the point beyond which the coolie cannot reach. The amount of sticks to be included in a bundle will depend on the number of shoots originating from the branch beyond the point at which the bundle is being tied.

2. The *Lateral* consists in tying the brood lac sticks across the gaps between the new shoots or between the terminal portions of the mother branches, so that one end of the brood stick touches one branch and the other end another, while the body of the stick forms a bridge. This method is at times combined with the Longitudinal, but is not in my opinion to be recommended Should there be any wind, or should rain occur, the two branches will probably be jerked apart or the knots in the string may tighten due to getting wet; if this happens the ends of the stick will no longer touch the branches and the connection will now only be made by a length of string. Under these circumstances the larvæ must cross to the new host by this thin string bridge only, which will not be particularly easy and if the wind causes the brood stick to sway, many may fall while trying to pass across, and die.

3 The *Interlaced* is useful in certain cases, as for example *Khair* and *Ficus* trees in which the new shoots from pruning arise in a close group from the mother branch If these shoots are short and do not require a brood stick each, one or more sticks of brood may be interlaced between them at their points of origin and be made fast with string This is a method to be used where convenient, particularly when labour is scarce and is useful in combination with the Longitudinal.

When all the sticks have been tied, a number of small pieces of broken lac and sticks too small to be tied are usually found left over. These need not be wasted as they also contain quite a large number of larvæ. The most convenient method of dealing with them is to gather them together and put them loose into roughly made wire gauze baskets or small bamboo baskets These may be used in place of the bundles referred to under the Longitudinal method, or they may be tied to the mother branches from which a number of new shoots have arisen near to the point of origin of those shoots

Correct Amount of Brood for Inoculation.

An extremely important point arises out of this at once; that is the decision as to how much brood lac to reserve or to buy to inoculate a given area containing lac hosts. The first step is to ascertain the number of lac hosts in that area and roughly the numbers of small, medium, and large, among those trees. From this data the amount can be fairly easily calculated. The amount of brood lac required to inoculate a tree may be defined as 'That weight of brood lac sufficient to cover all the shoots available

for infection fairly closely with larvæ, leaving no shoots uncovered and no larvæ with no place to settle ' The amount can really only be learnt by practical experience, however a rough idea can be formed from the following table in which amounts found sufficient for various hosts are tabulated as a guide. The correct amount of brood, is important as any shoots left uninfected are so much wasted space, and excess of larvæ is not only a waste of brood lac, but also causes mortality among the larvæ due to over-crowding on the young twigs, and by forcing the larvæ to settle on the thick mother shoots owing to want of space, where they cannot survive —

Host.	Large.	Medium.	Small.
Palas	2-2½ Seers (Fig 14)	½-1 Seers (Fig 12)	4-8 Chittacks
Ber ...	3-6 Seers (Fig 11)	½-1 Seers	3-4 „ (Fig 6)
Ficus sp.	3-4 Seers	1-2 Seers	½-1 Seers (Fig 20)
Ghont	...	1½ Seers	. . .
Khair ...	3-4 Seers (Fig 17)	1-2 Seers (Fig 16)	4-8 Chittacks
Siris .	3-4 Seers	...	.....
Kusum	½-1 Maund	5-10 Seers (Fig 23)	4-8 Chittacks
Flemingia congesta .	Small plants at Namkum	...	2-3 Chittacks
Acacia Farnesiana ...	Small plants at Namkum	(Fig 21)	1-1½ Chittacks.

Over inoculation, under inoculation. Removal of Brood.

If the suggestions given in the next Chapter have been followed correctly swarming will start within one or two days of the tying on of the brood. The date on which the larvæ start to swarm should be noted and the brood should be removed three weeks from this date, if the correct weight of brood has been used, the trees will by then be fully inoculated. The reason for the removal of the brood after three weeks of inoculation is that the great majority of lac larvæ have emerged in this time while quite a number

of insect enemies have not, this is enlarged upon in Chapter VIII. During the inoculation period the trees should be examined periodically to prevent over inoculation occurring and as soon as all the available shoots are seen to be covered with a fairly close carpet of larvæ the brood should be removed. It must be borne in mind however that the larvæ will not go out to the extremities of the new shoots and the last few inches of the twigs will be left uninhabited This brood which has been removed from trees on which too much brood has been put, can be transferred to other trees and be used to inoculate them, but should be removed three weeks from the start of swarming, not three weeks from the date of transference It should be noted also that brood from one branch which is in danger of being over inoculated can be transferred to another which is observed to be under inoculated.

Inoculation where Labour is Scarce.

In certain cases where very large areas have to be infected and it is difficult to obtain labour, rather more haphazard methods of inoculation are used These generally consist mainly of, loosely interlacing brood sticks between the new shoots for infection without tying, the more general use of bundles of brood sticks thereby saving separate inoculation of the smaller branches, and the tying of brood sticks to the branches in the middle of the stick only, by means of a piece of straw. (*See also Chapter VI, Palas*).

The longitudinal method together with interlacing as mentioned early in the chapter is infinitely preferably, but is often impracticable in large areas where many thousands of trees are to be infected, and labour is not plentyful.

All the above methods of infection are known as Artificial Infection as opposed to Natural Infection, which will be discussed later on at the end of the Chapter on account of its more limited application, and of the fact that its indiscriminate use is not to be recommended. (*cf Chapt. VIII*)

The brood lac that has been removed from the tree can then be sold as it is, or after scraping It is known as *Phunki* lac as it contains no larvæ or living insects being composed entirely of the encrustation and the dead shrivelled bodies of the lac females.

Infection in the Rains.

When carrying out this process in the Monsoon infection season, that is June-July, the brood should not be tied to the trees during rain particularly if the larvæ have started to swarm as many will be washed away before they have time to

settle. The mother lac cells are alive at the time of swarming, not dead as was previously believed and can to some extent control the swarm, delaying it if climatic conditions are adverse; this means that if the brood has been tied to the tree with no larvæ crawling on it, the lowering of temperature accompanying rain will to some extent cause the mother cell to delay the swarm. The optimum time for infection in this season is early, on any sunny morning when there is a fair prospect of 4—6 hours of warm, rain free weather, which will give the larvæ a chance to settle.

Measures used for Brood Lac Sale.

Brood lac is sold according to different measures as prevailing in the district concerned. The commonest method in Bihar and Orissa is by the Chittack or Seer for the villager and by the Maund for the more wealthy cultivators Another method common in this Province is the Hath; this is the number of brood lac sticks that can be tied round with a string 1'—6" in length; a two Hath bundle is that amount of brood that can be tied with a string 3' long and so on, roughly a Hath equals 2 seers.

Natural Infection.

The instructions so far given apply to Artificial Infection of lac host trees. There is however another process of infection which is used, this is Natural Infection This process is briefly explained as follows Instead of removing the mature lac from the trees when it is about to swarm, it is allowed to remain on the tree and to swarm *in situ* This process of infection is used for *palas* in July in this Province (*Chapt. VI Palas*).

Natural Infection of Palas.

During the *Baisakhi* crop the larger part of the lac is cut from each *Palas* tree in April-May (*this process is fully explained in Chapter VI the reason for partial cutting is explained in Chapter V*) leaving a small amount on each tree. From this cutting new shoots are produced, and the lac left on the trees in April, when it swarms in July, inoculates these new shoots, for the *Katki* crop.

Natural Infection of Ghont.

Where there is a great shortage of labour as for example Central Provinces, *Ghont* cultivation (*Chapt. VII, Ghont*), this process is often used. Brood lac is tied to a number of trees, if when the lac matures the tree is completely covered with lac it is cut, if it is not, the tree is left to reinfect itself; if after this self-infection the tree still has branches which are not lac encrusted, it may again be left to reinfect itself. This treatment is continued until the tree is completely covered, after which it is cut.

In some districts there may be shortage of labour in one season only, say July, and to overcome this natural infection is allowed at this season, the two crops being cut simultaneously when the second matures

Natural Infection of Kusum

Natural infection is used by the Raiyat, particularly with *Kusum* A well grown *Kusum* is a large tree and may require ½ a maund or more of brood lac for infection The Raiyat cultivator quite often cannot afford this amount of brood, or is not prepared to risk this amount at one venture He therefore inoculates with as many seers as he can afford and allows the tree to self inoculate itself at the first crop maturity and usually again at the second. The tree is then cut and is at this time bearing lac from three successive crops, after which it is rested generally for 2 years

Disadvantages of Natural Infection.

This process is however not to be recommended where it is possible to avoid it, in spite of its simplicity The trees do not get the regular rest which is given under Artificial Infection and uniform inoculation and regular crops cannot so readily be obtained The crop when cut after natural infection has been allowed in this way, is less valuable as brood as it contains a relatively large amount of *Phunki* lac from the previous crop The main objection however is that it allows the multiplication of predator and parasite enemies of the lac insect This is discussed in Chapter VIII

CHAPTER V

Suggestions regarding the forecast of the date of swarming and the cutting of the lac crop

Seasons of Crop Cutting.

In the seasons June-July, October-November and January-February the crops become mature and must be cut for sale for manufacture, and to obtain brood For this former purpose also April-May cutting is done under certain circumstances explained in this chapter

Swarming, and disadvantages of premature cutting.

The female lac cells as previously stated are alive at the time of swarming and can to some extent control the swarm, delaying it if climatic conditions are such that the young larvæ will be adversely affected. Examples of such adverse conditions are heavy rain and intense cold. Premature cutting of lac to be used as Brood is

extremely harmful, the reason being that the living female cells are cut off from their food supply, the host tree This necessarily weakens the female insect and causes her to lose this power to a less or greater extent, and it also affects the vitality of the young swarm adversely as they, through the mother, are cut off from their food supply Early cutting is therefore detrimental to the cultivator on two scores Lac for use as brood should on no account be cut any earlier than 8—10 days before swarming is due, and later cutting is preferable In any given District swarming occurs at approximately the same time each year but the actual starting date of swarming may vary as much as three to four weeks from one year to the next

Variation in Swarming Date.

The following Table shows the variation in swarming time of *Palas* lac in the Kundri Plantation, Palamau Division, from 1920 —

	1920.	1921	1922	1923.	1924.	1925	1926	1927	1928	1929.	1930.
Katki ...	Oct. 25th	Oct. 21st	Oct. 10th	Oct 24th	Oct. 23rd	Oct. 6th	Oct. 31st	Oct 17th	Oct. 10th	Oct. 12th	Oct. 18th
Baisakhi	July 21st	July 10th	July 22nd	July 23rd	July 4th	July 24th	July 16th	July 9th	July 14th	July 17th	

It is therefore important to know how to tell that lac is nearing the swarming period.

In some places where cultivation is done on a small scale only, it is the practice to leave the lac to be cut for brood, on the tree until the crawling larvæ are actually observed, then it is cut quickly and tied on to the new trees This practice may be possible on a small scale or where there is no dearth of labour, but in other cases may result in a very large number of larvæ being lost before the brood can be got on to the new trees

Method of waiting until swarming is observed.

In nearly every lac growing district the Raiyat cultivator is able to forecast the date on which lac will swarm with very fair accuracy simply by the appearance of the encrustation Misra (1928) describes a method of forecasting emergence by means of a microscopic examination of the developing ovules in the lac cell, this however is quite unsuited to the average cultivator and moreover although fairly accurate in June-July and October-November (except in certain cases) is by no means accurate in January-February.

Forecast of Swarming Date.

The following simple phenomena may be used to determine when crop maturity and swarming will occur.

1. *Granular appearance of the body contents of the female cells.*—If a cell be crushed between the fingers, the body contents will appear granular about 3—4 weeks before swarming in the *Baisakhi*, *Jethwi* and *Katki* crops; 5—6 weeks before in the *Aghani*. From the time this is first observed the granular appearance becomes more and more prominent up to the time of swarming.

2. *Appearance of cracks in the encrustation* —Cracks make their appearance in the encrustation about 2-3 weeks before swarming is due in the *Baisakhi*, *Jethwi* and *Katki* crops, in the *Aghani* 4—5 weeks.

3. *General appearance of the encrustation in all lac crops* —The encrustation has a drier appearance about 2 weeks before swarming is due, and can be peeled off from the host twig or branch with greater ease.

4. *Appearance of the yellow orange spot on the female cells.*—The spot actually is the colour of the female test which is translucent because the body of the female insect has contracted away from it. This yellow orange spot makes an excellent means of forecasting swarming.

In the *Baisakhi* and *Jethwi* crops, emergence begins about 5—8 days after the appearance of the *light* yellow spot

In the *Katki* swarming begins 7-12 days after its appearance.

In the *Aghani* swarming begins 12-20 occasionally 30 days after its appearance. (*Plate I, Fig. VI*)

The spot enlarges and deepens in colour, when it has become yellow to bright yellow and has reached the Anal Tubercular Opening (the largest of the three openings mentioned in Chapt I waxy white filaments project through it and it is the opening through which the honey dew is secreted), swarming will occur after 3-4 days in all seasons 3-6 in the *Aghani*, provided that the day temperature does not fall below 20°C (68°F) This then is the time for crop cutting in fairly large areas. (*Plate I, Fig VII*)

Under favourable conditions emergence actually begins when the *yellow area* has become almost a straight line on both sides of the lac test and has reached half way between the Brachial Pores (the breathing holes, the other

two holes out of which waxy white filaments protrude) and the Anal Tubercle; and generally stops when the yellow area actually reaches or is slightly anterior to the Brachial Fores, on either side.

The Assistant Entomologist who has been working on this method of forecast, hopes to have a paper on this subject explaining the matter fully, with diagrams, ready in the near future.

These signs of impending swarming should be carefully observed, and the crop should be cut 2-3 days before swarming is due; it should be cut just sufficiently long before swarming to allow time for cutting and tying on to the fresh hosts before swarming starts

Brood Lac for despatch over long distances.

Brood Lac which is to be sent long distances should be cut just long enough before swarming to allow it time to reach its destination and be tied to the trees before swarming occurs To get satisfactory results however 8-10 days is the earliest that it should be cut and this even is somewhat premature I have been able to despatch brood lac from Namkum over long distances, say, as much as a 4 days journey up to Assam, by packing it loosely criss cross fashion in bamboo baskets with no covering beyond a roped or sewn on lid, and sending it per passenger Express Train.

Crop cutting and pruning.

When cutting the crop it should be remembered that the tree is required for further use and indiscriminate lopping of branches should never be done This is particularly the case if this crop cutting is to act as a pruning in addition, and the general remarks on pruning made in Chapter III should be borne in mind.

April-May Crop Cutting.

In the Introductory Chapter, the crop cutting period of April-May was mentioned and it seems to me in place to explain the significance of this process before going any further In both the short crop, the *Katki* (4 months) and the long crop, the *Baisakhi* (8 months), approximately the same amount of resin is built up by the lac insects, that is to say the same number of insects will make roughly the same amount of lac in either crop In the *Katki* crop, lac secretion continues practically until the time of swarming, in the *Baisakhi* season, resin secretion decreases very considerably about 6-7 weeks before swarming, therefore in April-May the greater part of the lac secretion is over. In many

districts as for example Daltonganj, very high temperatures occur in April-May-June and are extremely trying to the lac and also to the host tree and the problem arises how to get sufficient lac to survive these months and live to become brood lac in July. The Raiyat method is as follows, from some trees the majority of the lac is cut, from some the whole crop, this relieves the tree to a certain extent from the drain the lac insects are putting on it for their food, and does not lower the selling price of the lac, which is termed *Ari* or Wet lac, as the major portion of lac secretion is over. It also saves the expense of Chowkidars to prevent theft from the trees Sufficient trees are left partially cut to produce brood lac in July sufficient for the requirements of inoculation Usually the lac is left towards the top of the tree in a position where the greatest shade is available For *Palas* partial cutting is done on all trees in April-May and acts as pruning and the new shoots are ready in July for infection with the brood that has been left on the tree *i e.*, Natural Infection In districts in which these months are very hot, the same treatment is used for *Ber* in this case however the brood that has been left on the trees is cut in July and inoculated on to new hosts, the partial cutting acting as a pruning gives shoots suitable for infection in October (cf. *Chapter VI Ber*).

Partial cutting in April-May for Palas & Ber.

Cutting the lac crop can be made to act as a pruning in a number of cases, this matter will however be discussed in the Chapters VI & VII in which the uses of the various lac hosts are outlined

The yield that can be expected from different lac host trees varies to a very large extent, being dependant upon a variety of factors, the chief of these are, weather conditions including temperature and rainfall and humidity during the crop, the prevalence of parasites and predators, the condition of the soil, and the correct pruning and use of the host This matter is discussed further in Chapter VI.

Yield.

With regard to the sale of the lac produced there are certain pitfalls which must be avoided. *Phunki* lac can be sold as stick lac or scraped lac and there are no difficulties. *Ari* lac however must be treated with care, it can be sold on the stick, but should not be packed tightly into boxes, but be conveyed to sale in open baskets; as scraped lac, however even more care

Treatment of the Lac after Cutting, 'Blocking'.

must be taken with *Ari* lac; the scraped lac, of course contains as well as the encrustation, the bodies of the female insects, and if it is put into bags warmth and pressure will cause the whole lot to stick together into a block which may become almost unbreakable, this is termed "Blocked Lac" or "Blocky Lac" The scraped lac should be spread on floors in a layer about 4" deep and be allowed to dry for a fortnight or more before sale, it should be raked over once per day, even then it is better not to bag it With mature crop lac this danger is very much less and if the scraped lac is spread on the floor for a short period a week or so, the young larvæ will emerge leaving the lac fairly dry, it can be safely sold on the stick

In order to give some idea of the prices realised by sale of brood and stick lac the following are quoted, taken from the accounts of the Indian Lac Research Institute, Namkum, and of the Bihar and Orissa Forest Department, for lac of various sorts bought or sold It will be noticed that there is a remarkable fluctuations in price through the year

STICK AND SCRAPED LAC.

		Per maund. Rs. A
July 1929	... Palas (Ari)	44 0
August 1929	. Lac dust ...	2 0
September 1929	.. Palas (Phunki) .	41 0—49 0
	Ber .. .	49 0
	Lac dust	2 0
December 1929	. Palas (Phunki) . .	22 8
	Lac dust	2 0
January 1930	. Palas (Phunki) ..	20 0—28 8
February 1930	... Palas (Phunki & Ari) ...	43 0
	Kusum × Khair (fresh) ...	61 0
April 1930	.. Kusum ...	45 0
	Kusum × Khair .	45 0
	Rangeen (Katki lac) (Palas Assam mixed) ...	24 0
	Baisakhi (Arhar) ...	34 0
	Ber (Stick lac) ..	27 8
September 1930	. . Palas	28 0
	Ber	27 0
November 1930	. Palas	12 8
	Ber	12 8

BROOD LAC.

		Per maund. Rs. A.
July 1929	... Palas, Ranchi (very scarce)	67 0
	Ber, Ranchi ..	22 0
	Kusum, Ranchi ..	78 0
	Kusum, Palamau ...	40 0—60 0
Oct.-Nov. 1929	Palas, Ranchi ...	20 0
	Palas, Palamau ...	13 8—20 0
	Ber, Ranchi ...	37 0 small
	Dumber, Ranchi ...	34 0 quantities
Jan.-Feb. 1930	... Kusum, Ranchi ...	61 0
	Kusum × Khair ...	61 0
June-July 1930	.. Kusum, Ranchi . .	28 0—36 0
	Palas, Ranchi ..	20 0—22 0
	Ber, Ranchi ..	20 0
Oct.-Nov 1930	... Palas, Ranchi ..	26 0
	Ber, Ranchi ...	26 0
Jan.-Feb. 1931	... Kusum, Ranchi ...	20 0—23 0
	Kusum, Purulia . .	12 0—20 0
	Kusum × Khair, Ranchi ..	20 0—25 0
July 1931	.. Ber, Ranchi ...	13 0
	Palas, Ranchi ...	12 0
	Kusum, Ranchi ...	15 0
	Kusum × Khair, Ranchi ...	17 0

Note on Shellac manufacture.

I do not propose to mention the process of manufacture used to convert lac into Shellac as this does not fall within the scope of this book.

CHAPTER VI

The systematic cultivation of lac and the systematic use of the main lac hosts (e.g., Kusum, Ber, Khair and Palas).

In order to make lac cultivation worth while and to set it on a firm footing, it must carried out in a systematic manner. This chapter does not refer so necessarily to Raiyat cultivation, which consists in innumerable small holdings, each man having his little group of trees; (a system is followed and the use of *Palas* in this Chapter is based on this). It is well worthy of

note that the Raiyat holdings produce by far the greater part of the total lac outturn from India The Chapter is intended particularly for Forest Officers in charge of lac areas, and for cultivators owning areas or plantations containing lac hosts, including lac orchards, tea gardens, coffee gardens, etc.

Aims of lac cultivation.

The aim of the cultivator should be to use the lac hosts at his disposal to their greatest advantage, and to make his area self-supporting as far as possible as regards brood lac. This latter is an important point, as the purchase of brood is often expensive especially during a bad season, and may even be impossible if the season has been very adverse and each cultivator has enough for himself and no more, whereas its sale is remunerative. Each cultivator should evolve a plan on which he intends to use his available material, his primary objects should be —

1 To produce brood lac at the seasons of infection (*i e* June-July and October-November, also January-February if he wishes to use *Kusum*).

2 To have ready for infection trees correctly pruned and treated to take the brood produced, at each season.

3 To use the trees in his area in such a way that the largest possible number are always in use.

Of the lac produced in the area, then the most important and valuable potentially is that used for brood within the area, the scraped lac from which is sold after use The remainder of the lac is used in two ways, either it can be sold as brood for infecting new areas, or to less fortunate, or less provident cultivators; or it can be sold as stick lac or scraped lac for manufacture into shellac.

Marking of Trees.

It is impossible to evolve a scheme of cultivation unless the various host trees and their number is known, this therefore is the first step which must be made prior to bringing an area into cultivation. Some method must then be devised for marking the trees in order to simplify instructions in regard to their use. This must be left to the individual in some cases numbering, in some cases blazing certain batches of trees, in some cases where there is natural grouping naming or numbering the groups, will be found the most convenient.

When this has been done a programme of lac cultivation can be drawn up which will include—

Programme of cultivation.

1. Manuring, if any, date to be done manure to be given,
2. Pruning.
3. Inoculation for each host or group of host trees
4. Cutting

Necessity for coupes.

It will of course be at once obvious that if the whole area is made up of *Ber* trees and nothing else, that inoculation of them all say in July will be disastrous as when the crop is cut in October-November, there will be no trees to inoculate, and in the next July when the *Ber* is ready for inoculation new brood will have to be purchased In this case the *Ber* would have to be divided up into blocks or coupes which would be used alternately Before proceeding any further the meaning of the word "alternation" must be explained

Alternation.

The growth of lac alternately on two different kinds of host trees is extremely valuable as a practical method of lac cultivation, and one that is becoming increasingly important It is really very simple and can be explained briefly thus Suppose that in a given area there are two different lac hosts "A" and "B" A is prepared, pruned and inoculated, say, in July, in the meantime B is being pruned and prepared In October-November the lac is cut from A, and part used to inoculate B, A is now rested, in July the lac is cut from B and part of it is used to inoculate A, in each case the surplus is sold, and so on. Certain types of lac hosts lend themselves particularly well to this scheme of cultivation.

Record of lac cultivation.

In order that a satisfactory idea may be formed of the income obtained from lac cultivation and which inoculations are successful and which failures, proper records of lac cultivation must be kept. I have made out a sheet on which inoculations of lac host trees may be recorded. (*Table in Fig. 18*) it is intended only as suggestion and each cultivator must make the alterations and additions which are necessary to make it suit his particular case.

If a record is kept accurately in this way over a number of years, it will be found extremely valuable; not only will it give an excellent idea of the amount of brood that must be used and the yield that can be expected from the various infections, but it will show which inoculations are worth keeping on, which should be discarded, and the actual financial profit or loss from each.

When keeping correct records of lac collection the following system of designation will be found both useful and simple

Lac is termed after the tree on which it is grown, that it to say lac growing on *Khair* is referred to as *Khair* lac and that on *Kusum* as *Kusum* lac The brood lac produced also takes the name of the host, for example brood cut from a *Kusum* tree is called *Kusum* brood In many cases however it may be convenient to refer also to the mother brood, and in alternations it is often necessary to quote the ancestry of a given brood more fully, citing the mother of the mother brood and even at times broods antecedent to this For the sake of uniformity and simplicity the following method has been adopted at Namkum

The host trees are referred to by the initial letter of their vernacular name, in cases where mistakes could arise the first few letters are used Thus *K* stands for *Kusum*, *Kh* for *Khair*; *P* for *Palas*, etc To refer to any given lac, the brood is given first then a multiplication sign, then the host Thus the crop produced by inoculating *Kusum* brood on *Khair*, would be written—*K* X *Kh* When the crop was cut the brood would be termed *Khair* brood, progeny of *Kusum* and would be written—*Kh* (prog *K*) brood.

If this brood then be inoculated on *Kusum*, the crop will be written—*Kh* (Prog *K*) X *K* This brood again inoculated on *Khair* will be written—*K* (Prog. *K* X *Kh*) X *Kh* and so on.

It is quite simple to interpret a symbol such as the above and the method is as follows. The letter after the bracket is the host tree in use, and that before it, the brood used for infection The letters in the bracket represent the ancestors of the brood, the mother brood being at the right hand side and its mother second from the right, and so on.

Example.

Ber (Prog. *P X P X Ber*) X *Kh.*

Palas brood was originally inoculated on *Palas*, the brood produced was inoculated on *Ber*, the brood from this also was put on *Ber*. This inoculation yielded the *Ber* brood now put on *Khair*.

The remainder of this chapter and the whole of the next will be devoted to the various important host trees and methods of using them. A cultivator knowing the trees in his area, will find that from among these methods he will find one, or a combination of two or perhaps three that will suit his particular case.

General note on resting, host behaviour etc.

However while reading the remainder of the chapter there is one point of absolute major importance which must be understood and borne in mind It is impossible to lay down hard and fast rules in nature, in one district a tree may be a poor lac host in another a good one As regards resting a tree from which the lac crop has been cut, no rule can be given except a general one and each cultivator must use his own common sense. If a tree from which a *Baisakhi* crop was cut in July has "come away" *i e* , given out many long suitable shoots for infection in October. by all means infect it for another *Baisakhi* crop; if the shoots are poor and short in October, let the tree rest and infect in the following July or October If the shoots on the tree are found to be woody and hard in April-May and likely to be unfit for infection in July or October, then reprune according to the suggestions in Chapter III This applies to all hosts and all seasons.

The following cultivation methods are based on practical experience but must be used by each cultivator combined with his own observation and common sense. It should be borne in mind that continuous use as a lac host is a heavy drain on the resources of the tree and it should therefore be rested at intervals as required.

Kusum.

Kusum (*Fig 23*) The pruning times for *Kusum* as stated in Chapter III are February and July After the first pruning one year's rest may be sufficient in some cases, though 18 months is more usual. As the crops are cut from *Kusum* in July and February the actual crop cutting may be used as a pruning, and the tree must be rested prior to reinfection, either for one year or more usually 18 months to 2 years (*See Chapter III*). This means that when using *Kusum*

trees a coupe system must be introduced to allow for this rest. The lac however grown on *Kusum* is of superior quality and the encrustation is thicker, making it a valuable host. It fetches also a price some Rs. 5/- or more per maund more than does lac grown on other hosts.

Brood and yield for Kusum.

A large *Kusum* tree may require from ½ maund to 1 maund of brood lac, and may yield 2-3 maunds in return A tree 60 ft. high in Raipur pruned in August 1920 yielded a crop of 2 maunds 35½ seers of brood lac and 35 seers of broken lac . 23 trees of varying sizes infected with *Kh.* (Prog *K*) brood, 2 maunds 32 seers, at Sabaya gave a yield of 14 maunds 6 seers, this gives a brood yield ratio of approximately 5 ·1 It should be mentioned that these trees had not been pruned prior to infection

Methods of use of Kusum.

The following table is a diagramatic representation of the use of *Kusum*, allowing 18 months' rest; it can be satisfactorily used to carry either an *Aghani* or a *Jethwi* crop Four coupes A B C D are necessary to make the area entirely self supporting While coupe A is in use, coupes B C D are undergoing pruning and rest, so that they are ready for use in the season that they are required. By the time that D coupe has been infected and yielded a lac crop, A which has been resting is ready for reinfection

Coupe	A	B	C	D.
Prune	Feb 1930	July 1930	Feb 1931	July 1931
Infect	July 1931	Feb 1932	July 1932	Feb 1933
Cut and prune	Feb. 1932	July 1932	Feb 1933	July 1934
Ready for re-infection	July 1933	Feb 1934	July 1934	Feb 1935

(Arrows indicate transference of brood)

If 2 years' rest was found to be necessary an extra coupe would have to be added, if 1 year, only 3 coupes need be used. This means that supposing

an area has 1,000 *Kusum* trees and that the coupes are of equal size, and that 18 months rest is given, only 250 trees are used for each successive crop (6 months roughly), the other 750 trees are resting, that is to say the whole 1,000 are used once in 2 years, and if each tree yields 1 maund of lac, the yearly produce will be 500 maunds. Even giving a year's rest only, the whole number of trees is used once only in 18 months If therefore a suitable host can be used in alternation with *Kusum* the potential value of the latter can be greatly increased The ideal host for this purpose is *Khair* (The Raiyat method with naturally infected *Kusum* was mentioned in Chapter IV).

A method based on this, and useful in areas where there is shortage of July labour because it allows Natural Infection at that time, is the two-year method The trees are infected in January-February with sufficient brood to give 50% coveration, in July, Natural infection is allowed, covering the remainder of the tree together with all the new shoots The crop is completely cut the following January-February Allowing *Kusum* 2 years' rest between infections, it will be seen that three coupes will be necessary . should it be proved that one year's rest is sufficient only two coupes would be required.

Kusum & Khair

Khair and its use as an alternative host to Kusum —Khair as previously mentioned is a very rapidly growing host and can be infected at an age of 2½ years from seed; its second characteristic is that it must only be infected in July and is incapable of carrying a *Baisakhi* or *Jethwi* crop This is firstly because *Khair* has not sufficient vitality in the Winter months or in the hot weather to sustain a lac crop, and secondly because the actual cutting of a crop or pruning *Khair* in July seems to be detrimental to the tree. And thirdly because no matter when *Khair* trees are pruned they cannot be induced to throw out shoots suitable for infection in either October-November or in January-February It is however a suitable host for use in alteration with *Kusum;* it can be introduced into areas or near areas where *Kusum* is already established and during its growth one of the previous coupe methods can be used on the *Kusum* trees. *Kusum* brood 'takes' extremely well on *Khair* and the encrustation produced is equal in quantity and quality to that produced on *Kusum*, the brood produced from *Kusum* lac inoculated on *Khair* (*Khair* progeny of *Kusum*) takes excellently on *Kusum* and fetches the same price as *Kusum* brood. The stick lac

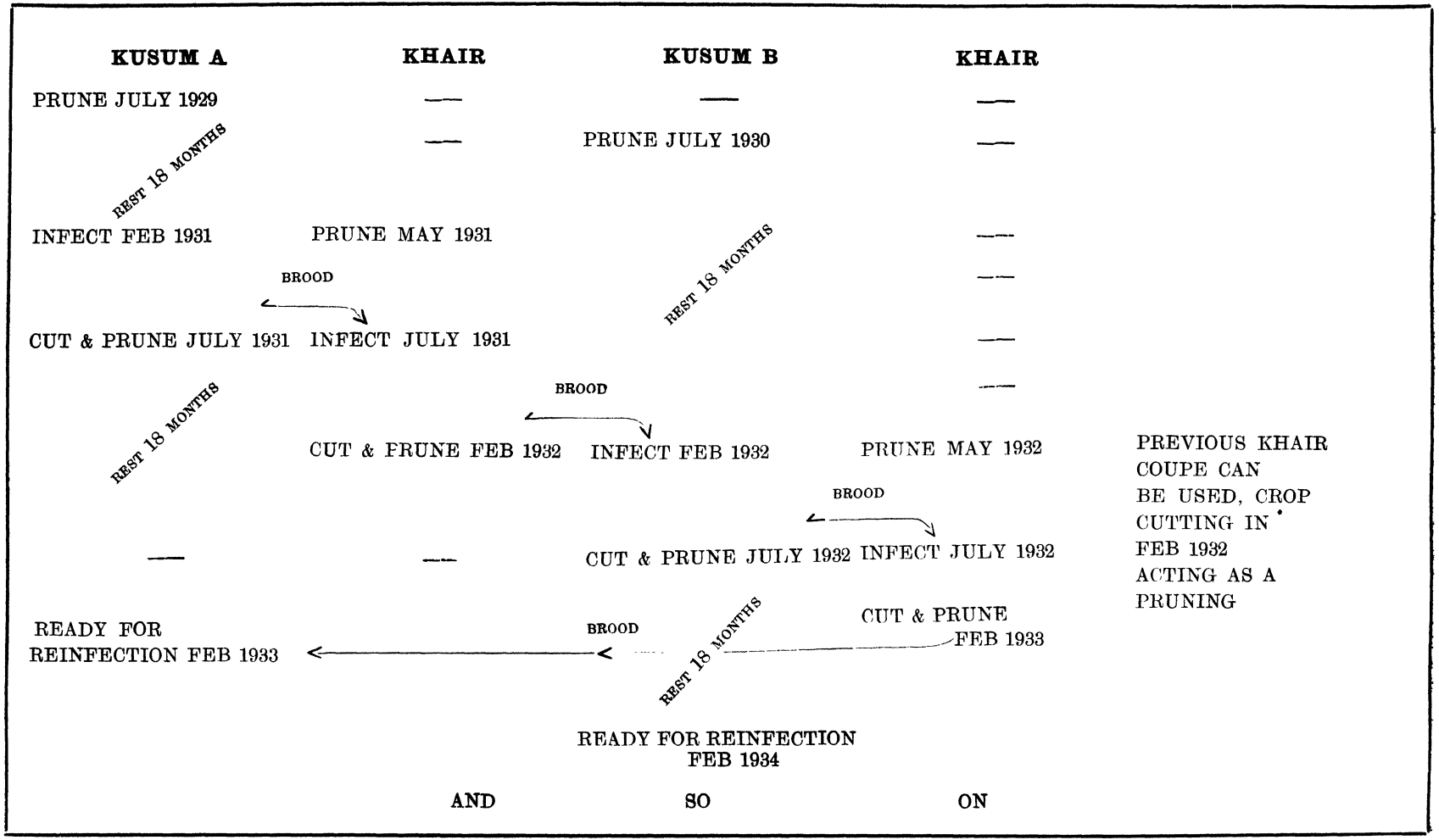


DIAGRAM FOR CHAPTER VI—PAGE 39.

produced by inoculating *Khair* with *Kusum* brood is of the same quality as *Kusum* stick lac and can be sold as such for manufacture

Method of using Kusum and Khair.

The method of running this alternation is therefore to inoculate *Khair* in July with *Kusum* brood; and to cut the brood produced on *Khair* in February and put it back on to *Kusum* and so on That is to say a continuous alternation, *Kusum* carrying the *Jethwi* crop and *Khair* the *Aghani*

It will be seen that using this alternation only 2 coupes of *Kusum* trees are required allowing *Kusum* 18 months' rest Presuming as before 1,000 *Kusum* trees, the whole thousand are still used once in 2 years, 500 being used in each second crop (*i e*, the *Jethwi*) That is 500 trees are used each year and presuming as before 1 maund per tree, the yearly produce is as before 500 maunds During the two *Aghani* periods however the *Khair* trees are in use producing lac equal in quality to *Kusum*. Presume 4000 *Khair* then even if 2000 only are used in each *Aghani* crop and that each produces only 5 seers, the extra produce of lac of the same value as *Kusum* lac is 250 maunds per year For *Khair* trees that definitely require pruning prior to infection, May is the best time for this operation, excellent shoots are then produced for infection in July After *Khair* has been taken into cultivation however, crop cutting in February can be made to act as a pruning, this is referred to further on.

The diagram facing this page explains the method on which a *Kusum* and *Khair* alternation is run

Referring to the diagram, the *Khair* blocks are each shown as having been pruned in May, in actual practice however it is found that crop cutting in February can be used as a pruning, and that the *Khair* infected in July 1931 and pruned in February 1932 produce shoots suitable for infection in the following July 1932 Thus in the diagram the two blocks of *Khair* could really be the same block

Resting of Khair.

This can be done for two successive crops, however after the second use of the same block of *Khair* (infected *July* 1931 cut February 1932; infected July 1932, cut February 1933) the trees may need to be rested as the shoots from the February 1933 crop cutting may no longer be strong and vigorous. Therefore a system must be introduced which can if necessary allow the *Khair* to

be rested after every second use The most economical method of doing this is to divide the *Khair* trees into two equal coupes A and B, presuming 1000 *Khair* trees, each coupe will be 500. Now referring to the diagram above, in July 1931 infect both coupes A & B, in July 1932 infect coupe A only, in July 1933 coupe B only, and in July 1934 both coupes A & B can be infected again. This resting may not necessarily be required, the division into blocks should be made however, and this scheme roughly adhered to, if very good shoots are produced there is no harm in using both blocks for reinfection. If the shoots in either block are poor, that block should be rested. Thus every 3rd year 1000 *Khair* trees are under cultivation and in the other two years there are 500 under lac cultivation.

Kusum and Ber.

Kusum brood can be put on to *Ber* trees also in *July*, but no alternation has however been proved successful as has been done with *Khair* The infection of *Ber* with *Kusum* brood is not considered expedient by the Raiyat, who with years of experience behind him seldom makes a mistake If however a *Kusum Ber* cross is used, the *Ber* should be rested for 15-18 months between each reinfection, that is trees from which the crop was cut in February 1931 or trees pruned in March 1931, should not be infected with *Kusum* brood till July 1932 The infection is however not advisable in my opinion, the resulting crop is not to be compared with that produced by the inoculation of *Khair* with *Kusum* brood, the *Ber* progeny of *Kusum* brood has not the vitality of the *Khair* progeny of *Kusum* and practically every *Kusum* on *Ber* infection that I have seen has been badly damaged by parasites and predators.

Khair.

Khair.—The most valuable use of this host is in conjunction with *Kusum* as already explained.

Brood and Yield from Khair alternated with Kusum.

The *Khair* tree shown in *Fig 16* required 1 seer of *Kusum* brood lac, and yielded 9 seers, the large *Khair* in *Fig 17* required about 3-4 seers of *Kusum* brood, and gave 13 seers 8 chittacks as yield.

Alternation of Khair with hosts other than Kusum.

Khair can however be infected with broods other than *Kusum* in July and should previously have been pruned in May. Either *Palas* or *Ber* brood can be used, *Khair* giving quite a good *Katki* crop. The brood obtained in October-November can be used on *Palas* or *Ber*. Quite a satisfactory alternation can be used with *Khair*, and *Palas* or *Ber* or *Ficus* sp the former carrying the *Katki* crop, either of the latter three the *Baisakhi*. As *Khair*

will not carry a *Baisakhi* crop, it is obvious of course that you cannot run an inoculation sequence using *Khair* only. It is interesting to note that *Rangeen* lac grown on *Khair* tends to be somewhat more affected by parasites than *Rangeen* lac grown on *Ber*.

Ber.

Ber.—This tree is a valuable lac host and is known in most lac growing districts in India, its value is increased by the diversity of its uses In very many districts [*i e*., Ranchi] if the climate is moderate *Ber* will carry a *Katki*, or a *Baisakhi* crop, it is however a better host for the former, than for the latter, where brood is required As regards the infection of *Ber* with *Kusum* brood, I have already stated that this infection is in my opinion inadvisable. A *Jethwi* crop is never a success on *Ber*.

Partial cutting of Ber in April-May.

In more or less temperate districts as for example Ranchi, *Ber* will carry a *Baisakhi* crop through the hot weather to brood in July In hot areas it is a common practice to cut most of the crop from *Ber* in April-May, leaving certain trees either fairly fully, or only partially infected so as to give brood in July. The reasons for this treatment are outlined in Chapter V. This April-May cutting acts as a pruning and the trees are ready for reinfection in October-November. Natural infection as used for *Palas* in July should not be used for *Ber*, the brood should in July be cut from the trees left bearing lac, and tied to new hosts.

Ber in Districts of intense heat.

In districts where intense heat occurs in April-May such as Daltongunj, *Baisakhi* lac will not survive on *Ber*, and the whole crop is cut in April-May and sold as *Ari* stick lac; *Palas* brood is used to reinoculate; in such districts I suggest the use of *Ber* for the *Katki* crop only, inoculated with either *Palas*, *Ficus sp*. or other brood, as self supporting alternations. In certain Districts such as Manbhum, *Ber* is inoculated purposely to obtain a stick lac crop in April-May.

Method of using Ber.

In more moderate districts it is therefore possible to grow lac using *Ber* trees only. The *Ber* trees are divided up into coupes, the first coupe is infected in July and cut in October-November, the trees may or may not need repruning and will be ready the following July for reinfection. The second coupe is infected with brood from the first, in October-November and

is cut in June-July, when the first coupe is reinoculated. The *Baisakhi* coupe after cutting, most probably will not be ready till the following July or October, it may require repruning. This would mean having one coupe for use in each *Katki* crop and two for use alternately for the *Baisakhi.*

During the present *Baisakhi* crop 1930-31 at Namkum, lac on *Ber* suffered badly from heat and dry weather in March-April-May, and only a fairly small percentage of the lac will survive as brood A number of inoculated *Ber* trees however were being watered daily and on those practically all the lac is surviving as brood.

Alternation of Ber with hosts other than Kusum.

Ber lends itself very readily to *Rangeen* alternations much in the same way as *Khair* does. The following alternations have been found satisfactory.

I. *Ber and Palas.*—*Ber* carries the *Kathi* crop and *Palas* the *Baisakhi*

II. *Ber and Ficus sp.* the former carries the *Katki* crop the latter the *Baisakhi.*

III. *Ber and Khair* in this case *Ber* carries the *Baisakhi* crop and *Khair* the *Katki.*

Ber has also been alternated with *Flemingia congesta*, the latter carries the *Katki* crop and seems to produce a poor grade unhealthy looking lac though this brood when inoculated on *Ber* for the *Baisakhi* crop seems to have a relatively large covering power, that is, a small amount of brood is sufficient to cover quite a large sized tree and the encrustation produced is very thick and healthy. (*cf Chapt. VII Flemingia congesta*).

Brood and yield for Ber.

A small *Ber* trees of the size shown in *Fig. VI* would require some 3-4 chittacks to inoculate it and would yield under good conditions from 1½—2½ seers. A big tree such as the one shown in *Fig. XI* would require about 3-6 seers of brood lac and should yield as much as 1½ maunds.

Ber in most ways an excellent host for introduction for lac cultivation, is unfortunately attacked by a number of host tree pests mainly while a small tree, including *Machaerota* and *Aspidiotus* (*see Chapter IX*).

Palas.

Palas.—This is perhaps the most abundant host in Bihar and Orissa and is very widely used for lac cultivation on account of its ready growth in districts suited to it, and its excellent response even to very severe pollarding. It will carry either a

Baisakhi or *Katki* crop It is not advisable to inoculate it with *Kusum* brood in my opinion, although this can be done The crop produced by so doing is intermediate in character between *Kusmi* and *Palasi* Lac and is called *Bastard Palas*, subsequent crops are more and more *Palasi* in character.

Artificial infection of Palas in July.

The artificial inoculation of (tying of brood lac to) *Palas* in July has always been attended by failure in this Province, this is not however due as was previously supposed to the fact that rain occurring, after brood had been tied to the trees, washed the larvæ away *Palas* brood in July is successful for example on *Ber* The phenomenon is far more likely to be due to the shoots from ordinary April pruning being unsuited to the lac larvæ; for the present however Artificial infection of *Palas* in July should be avoided. In the meantime this Institute is carrying out research into the subject at *Kundri*

Method of using Palas.

The Raiyat method of using *Palas* is simple, and very effectual, and the following scheme is based upon it, it is being used by the Forest Department at the *Kundri* area with great success Trees are infected with *Palas* brood in October, having been previously pruned in May, the lac crop is partially cut, usually $\frac{2}{3}$rds, and sold as *Ari* stick lac in April-May, leaving sufficient lac on each tree to inoculate the new shoots resulting from this April-May pruning, in July The entire crop is cut in October-November, and fresh trees inoculated It is therefore necessary to have two coupes of *Palas*, the one in use, the other which was cut in October resting, and being repruned for use the following October. In actual practice it is usual to find that certain *Palas* trees will not carry lac to brood in July, these trees are generally those on high ground; these then are entirely cropped in April-May: other *Palas* will carry lac to brood in July and these are partially cropped, these are generally trees on low land or in depressions, where there is a certain amount of sub-soil moisture The coupes must be arranged therefore to allow for brood producers in each, and in practice the whole coupe will not be infected during the *Katki* crop, some of the trees having yielded a stick lac crop only, having been completely cropped in April-May. At the end of every third year, that is after the sixth crop, fresh brood should be obtained, (*Palas* or *Ber*, from outside) as this in-breeding tends to weaken the stock, starting from October 1931 new brood should be introduced in October 1934.

Palas and in-breeding.

Leaf stalk Palas.

Palas trees are leafless in February-March and therefore all lac insects which attach themselves to the leaf stalk in the *Baisakhi* crop are unable to reach maturity as they fall with the leaf prior to February-March When prices are high the leaf stalks are collected, and being too thin to scrape, are cut into short pieces of $\frac{1}{8}$"—$\frac{1}{4}$" long, these are often added in with the *Baisakhi* crop to increase its bulk. As the lac on the stalks is very immature it should I think be kept separate and sold as such.

In the *Katki* crop, the lac insects swarm on to the leaf stalk, but as the leaves are not shed during these months the lac reaches maturity and even when the brood is cut, the stalks do not break off In Kundri this fact is made use of when inoculations for the *Baisakhi* crop are done; the leaf stalks on the brood sticks arising as they do at an angle, are used as hooks, and brood sticks with many of them may often be interlaced between the new shoots and held in position by the leaf stalks alone; this saves the use of a certain amount of string and also a good deal of time which is important when some thousands of trees have to be infected (*Fig 15*)

Alternations with Palas.

The use of *Palas* in alternation with *Ber* has already been referred to, in the usual way *Palas* will always carry the *Baisakhi* crop in these alternations, and in this lies about its greatest value as a lac host. *Palas* and *Ber* brood are interchangeable, *Palas* brood can also be used to inoculate *Ficus* trees *Palas* and *Khair* can be used in alternation in the same way as *Ber* and *Khair* In alternations or where *Palas* lac is required for brood in July, partial cutting in April-May is not done, except where climatic conditions render it necessary

If *Palas* is required for July inoculation, which I think inadvisable, it can be pruned in April-May.

Brood and Yield for Palas.

A medium sized *Palas* tree as shown in *Fig. 12* would require about 1—1½ seers of brood and would yield about 5—6 seers A large *Palas* of the size shown in *Fig 14* would require about 2—2½ seers of brood and might be expected to yield from 8—10 seers. The leaf stalks referred to in the previous paragraph are shown clearly on the sticks used as brood in *Fig. 15*

These four *Kusum*, *Khair*, *Ber* and *Palas* are the most important lac hosts in Bihar and Orissa; less important hosts are discussed in the next

chapter, with their uses and possible alternations with the main hosts already mentioned.

CHAPTER VII

Other and Minor Lac Hosts.

As this book is written more particularly to refer to Bihar and Orissa, and includes as far as possible research results which have been tested at Namkum, I include under this heading lac hosts, for which, though they are under test and observation, rules of treatment cannot be definitely laid down as yet; also hosts which though they may be of importance in other Provinces are of little or no value to lac cultivators in this Province.

The following are important among these *Ficus sps Acacia Farnesiana, Flemingia congesta, Zizyphus Xylopyra* (*Ghont* an important host in Central Provinces) *Acacia arabica* (*Babul* an important host in Sindh) *Cajanus indicus* (*Arhar* an important host in Assam) *Albizzia sp* (*Siris*)

I have also included brief notes on lac cultivation in other Provinces Central Provinces are referred to under *Ghont* and Assam under *C. indicus* The Punjab and Burma are mentioned at the end of the Chapter.

Ficus Host Trees.

Ficus Sps.—Under this heading are included the following species of *Ficus* —

1. *F glomerata* (*Dumber, Fig Gular*) (Fig 20)
2. *F. infectoria* (*Pakaur, Pakri*)
3. *F. glabella* (*Putkul*).
4. *F. religiosa* (*Pipal*)
5. *F. Cunia* (*Porho*)

Possible use of Ficus trees for brood production in July.

A number of other species of *Ficus* trees can be used as Lac hosts also. The use of them however is still more or less in the experimental stage. The actual quality of the lac produced is not good but a number of them seem to have the power of carrying lac in the *Baisakhi* crop to brood in July and in this lies their value. With *Dumber* results were not very satisfactory although small amounts of brood were produced in July, *Baisakhi* infection of this species at Sabaya was a failure,

(see Chapt. X), *Porho* and *Pipal* have successfully done this at Namkum, and to a less extent *Pakaur* and *Putkul*. This suggests the use as July brood producers of those that will carry brood through the hot weather, they can be inoculated with *Palas* or *Ber* brood in October-November and the brood obtained in July can be put on *Ber* or other hosts. No more can be said at present the subject is however being investigated here. I should suggest that each individual cultivator should make a trial with the *Ficus* hosts at his disposal on a small scale on the lines above suggested. Once their behaviour in his own particular neighbourhood is discovered the infections can be increased or dropped as results show

I can however suggest that an alternation of one or more of these *Ficus* hosts be tried with *Ber* or *Khair*, the *Ficus* carrying the *Baisakhi* crop and *Ber* or *Khair* the *Katki*. I have seen *Porho* and *Pipal* inoculated with *Kusum* brood with fair success but have not tested the matter fully. *Ficus sp.* will also carry a *Katki* crop, so many hosts however will do this, and as the lac is poor, they are not very valuable as far as this crop is concerned.

Pruning of Ficus host trees.

Pruning in May-June gives excellent shoots for October-November infection Crop cutting in July may also be used as a pruning and at Namkum I have cut lac from *Porho* and *Dumber* in July and growth has been so rapid that in October-November reinfection has been possible. After this treatment perhaps for two successive *Baisakhi* crops the trees will probably require resting. Pruning in April gives suitable shoots for infection in July.

Ficus sp. with a few exceptions produce poor lac encrustations, and are much more valuable as brood producers than as hosts for production of a lac crop for sale.

Acacia Farnesiana.

Acacia Farnesiana (Local name *Kastura*) —This is a rapid growing lac host. It is best inoculated in June-July, for which it should be lightly pruned in March. It may be infected in July with *Palas* or *Ber* brood and yields a satisfactory *Katki* crop. In some of the local villages round Namkum, this host is used for the *Baisakhi* crop as well, *Acacia Farnesiana* brood is used for inoculating purposes and brood lac is obtained in July. It seems possible that an alternation using *A. Farnesiana* for the *Katki* crop and *Palas* or *Ber* for the *Baisakhi* would be successful.

Infection with Kusum brood.

Infection with *Kusum* brood in July has given satisfactory results and it looks as though this host might be alternated with *Kusum* in the same manner as has been done with *Khair*. (*Fig. 21*).

Pruning.

Crop cutting in October-November or January-February acts as a pruning and trees may be reinoculated in July, continuous treatment of this sort however will probably be harmful and a coupe system should be introduced as has been done for *Khair*.

Brood & Yield.

At Namkum infecting small plants with 1—1½ chittacks of *Palas* brood, a yield of 4—5 chittacks was obtained.

Flemingia Congesta.

Flemingia congesta is a rapid growing shrub well known in Assam. It should, judging from results obtained so far, be reserved mainly as a host to carry the *Katki* crop, certain shrubs at Namkum however infected with *Ber* brood in October at Namkum have at present (June) quite a healthy looking encrustation and will probably give brood in July; infection with *Kusum* brood though not a complete failure is far from successful It should be fairly heavily pruned in March and infected in July with *Ber* or *Palas* brood. The resulting Lac appears poor in quality but is valuable as brood lac, on account of its good covering power The crop cutting in October-November appears to act as a pruning.

Alternation with Ber.

At Namkum an alternation between this host and *Ber* is being tried with fair success, *Ber* carrying the *Baisakhi* crop and *Flemingia congesta* the *Katki*. The *Flemingia congesta* yield is very poor but the brood produced takes very successfully on *Ber* and produces an excellent crop *Flemingia congesta* to give successful results must be only very lightly infected.

Brood & Yield.

On the small plants at Namkum using 2—3 chittacks of brood only 1½—2 chittacks yield was obtained. The infecting brood was *Ber; F. congesta* being used as a brood producer only, not for a stick lac crop.

Ghont.

Host trees in the Central Provinces.

Ghont.—This host is practically speaking a failure in this Province and attempts should not be made to introduce it. In the Central Provinces it grows in tremendous numbers particularly in the Damoh district together with *Ber, Khair, Palas (Chheola), Kusum*

and *Acacia pennata* (*Arma, Gurra*). *Ghont* is however the important host. Other hosts in this district are *F. religiosa* (*Pipal*), *Dalbergia latifolia* (*Shishum*), *Ougeinia dalbergioides* (*Tinsa*), *Albizzia odoratissima* (*Airma bonsa*), on which I have seen quite good samples of encrustation, and *Caesalpinia Coriaria* (*Angrezi imli*). In the Damoh centre, *Ber, Khair*, and *Palas* brood are all successful on *Ghont*, and *Ghont* brood will take on *Ber, Khair* and *Palas*, it will not take successfully on *Kusum*. The swarming seasons are the *Baisakhi* and *Jethwi*, early July, the *Katki* early November, and the *Aghani* late November-December. Lac cultivation is not carried out on any definite plan owing to the very great shortage of labour; the Forest Department are trying to overcome this difficulty by the establishment of Forest villages, whose inhabitants will take a share in the work. The present system with *Ghont* is extremely improvident and unsatisfactory, but due to lack of labour, it is a case of making the best of a bad job The *Katki* is the main crop, the *Baisakhi* which suffers badly in the cold and the hot weather is really only used as a brood supply for the *Katki* The brood is not tied to the trees, but roughly interlaced among the branches, a medium sized tree receives about 1½ seers of brood and may yield up to 5 seers The tree after infection is allowed to infect itself naturally until there is no further room for the lac to settle, it is then cropped and rested. After carrying three successive crops in this way the tree is cut and rested for 3 years

Lac Cultivation in the Central Provinces.

The Bhandara District lies between Nagpur and Raipur, here *Palas* is an important host, the trees are cropped and rested when they are fully covered; in good years a tree inoculated with 2 seers may yield as much as 15 seers in return. In South Raipur, *Kusum* is fairly common, the method of use is to crop entirely well covered trees and allow them 2½ years rest; lightly covered trees are allowed to go on for a second season and are then cropped and rested Other lac growing areas are Hoshangabad, Gondia, Kotah and Narsingpur.

Babul.—This host also is not a success although it occurs in this Province, and is not worth introducing. It is however an important host in Bombay Presidency and Sindh, and to a lesser extent in the Punjab. It occurs also in Madras and Bengal.

Babul.

It occurs mainly along canal banks, on lands flooded annually, or on land where there is some sub-soil moisture. It will carry either *Baisakhi* or *Katki*

crops, the former suffers badly in the Hot Weather; *Babul* brood is said to be the best for inoculation of *Babul; Kusum* brood however will take on *Babul* and gives good results; it may therefore be possible to alternate *Babul* with *Kusum* as has been done with *Khair*.

Dalbergias.

Dalbergia Sissoo, Dalbergia latifolia and *Dalbergia lanceolaria* have all so far been failures at Namkum as regards lac infection This however does not necessarily mean that they will be failures in other districts.

Panjan.

Ougeinia dalbergioides (*Panjan*) has not yet reached a stage where infections are possible in our plantation As regards this host however Lyall (1928) states that in the Daltonganj area its behaviour is somewhat like that of *Palas*, and that it grows practically exclusively under forest conditions, he states that its seeds are almost always infertile this is not the case however (*see Chapter II*) According to him when inoculated with *Palas* brood it yields a high quality stick lac crop.

Siris.

Siris —Under this name a number of *Albizzia Sp* are included, those used commonly as lac hosts are *A Lebbek* and *A stipulata*. The latter host has been grown from seed at Namkum and is not yet sufficiently well grown for infection Very little can be said about *A stipulata* as yet, Mr Bates has had success with it at *Sabaya*, inoculating with *Palas* or *Ber* brood for the *Baisakhi* and *Katki* crops and was able to obtain brood lac in July and October

The infection of *Albizzia Sp* is attended by considerable risk. Their identification is not easy as many species resemble one another, care should be taken to make a correct identification before money is spent on their infection. (*see also Chapter X*)

Arhar.

Cajanus indicus (*Arhar*) —This host is an important shrub host in Assam, elsewhere it seems to be valueless commercially, it is used in Assam in conjunction with certain tree hosts.

Lac Cultivation in Assam.

The swarming times in Assam are April-May and September-October thus the two lac crops are of roughly equal length. *Kusum* is practically unknown and therefore *Kusmi* crops are not grown to any

extent. The main lac growing areas are Shillong, the Umraon District, the Garo Hills and the Mikir Hills, and Nowgong.

The lac hosts in the first two are —

1 *Leea crispa*

2. *Flemingia congesta*

3 *Cajanus indicus*.

Each is a shrub host and will yield one crop in the year *L. crispa* is planted in April, 12′ × 12′ and by the following May is 10′—12′ high and ready for infection Some 2-3 chittacks of brood are used and a yield of up to 3 seers is obtained the following October The shrub is well cut and is ready for reinfection the following May and is therefore a *Katki* host F *congesta* is planted in the early rains and is ready for infection after 18 months, it is used therefore as a *Baisakhi* host *C indicus* is sown in May-June 7′ × 7′ and infected the following October, the crop is cut in May and *C. indicus* may be rooted out and a fresh crop sown or left. (*cf paragraph on lac cultivation on Arhar*) It is therefore also, a *Baisakhi host*

The Garo Hills comprise an area bounded to the north by the Goalpara District, Someswari to the South, the Khasia and Jaintia Hills to the East, and by the Jinari river to the West

The tree hosts are —	Local Name
Grewia laevigata	*Bolmengo*
Ficus Rumphii	*Prop*
Ficus bengalensis	*Giting*
Kydia calycina	*Boldabok*
Engelhardtia spicata	*Wokken*

C. indicus (*Arhar, Nandu*) is sown in "Jhumed" areas in May and infected the following October-November for the *Baisakhi* crop, which matures in May-June. The brood is used to infect the tree hosts mentioned above for the *Katki* crop. The *C indicus* after yielding one crop and its own seed is generally pulled out, and the area resown. No pruning as such is done, beyond the actual cutting of the crop.

Some 1-2 chittacks are used to infect the *C. indicus* shoots, and from 4 chittacks to 1½ seers are used on the trees such as *G. lævigata.*

The Mikir Hills.—The main lac growing districts are the Rongkhong and Duar Amla Hill Ranges.

Tree hosts are.	Shrub hosts are.
1. *Grewia multiflora*	1 *Cajanus indicus*
2. *Albizza lucida*	2 *Flemingia congesta*
3 *Ficus sp.*	3 *Leea robusta (the giant Leea)*

C. indicus receives from ¼—½ chittacks and may yield 2 chittacks to 1 seer. *L. robusta* receives about 1 seer of brood and may yield 2 or more seers. No special pruning is done, beyond the process of crop cutting.

Of these hosts, *C indicus* and *F. congesta* are the *Baisakhi* hosts, the rest are *Katki*.

The single crop method for *C indicus* is not the only scheme of cultivation in many districts as for example Nowgong, as many as three crops are obtained from *Arhar* before it is removed from the soil

Method of Lac Cultivation on Arhar.

This is done as follows; say 1,000 *Arhar* are sown in April-May 1931, these are infected with lac in October 1931. In May 1932 the crop matures, all weak unhealthy *Arhar* plants are removed and the lac is scraped for sale From the remainder say 500, much of the lac is broken off with the fingers and they are left for natural infection This crop matures in October 1932 and the same process is repeated perhaps same 100 plants being left for the third crop In May 1933 all the lac is cut and the *Arhar* pulled out. The area is then resown Thus the *Arhar* is in the ground for 2 years and carries 3 crops, two of which are *Baisakhi*, and one *Katki*.

Lac cultivation on *Arhar* has been tried at Namkum but was not a success, in this district it will not carry a successful *Baisakhi* crop, most probably due to the difference in climatic conditions. *Palas* and *Ber* broods gave some results during the *Katki* crop, the lac was of a dark colour and so far *Arhar* in this Provinces cannot be recommended as a lac host.

Lac Cultivation in the Punjab.

In the *Punjab* lac cultivation is carried out on a small scale only, the main lac growing district is Hoshiarpur, other districts are Ambala, Kangra and Gurdiaspur; lac also grows in Sialkot, Jullundur, Ludhiana, Karnal, Jhang, Gurgaon, Rohtak, Rawalpindi and Amritsar, very little systematic cultivation occurs in these latter districts.

The lac crops are the *Hari*, October-November to June, it corresponds to the *Baisakhi* and is the main crop, and the *Katki*, June to October-November.

The main host tree is *Ber*, minor hosts are the following in order of importance *Malhar* or *Ghunt Ber* (*Zizyphus Xylopyra*); *Kikar* (*Acacia arabica*); *Dhak*, *Chhichra*, *Palas* (*B. frondosa*); *Khair*; *Fig.* (*F. Carica*); *Gular* (*F glomerata*), *Siris* (*Albizzia Lebbek*); *Pipal* (*F. religiosa*); *Banyan* (*F. bengalensis*).

Lac cultivation in Burma.

In *Burma* lac cultivation is carried out in a very haphazard manner, if it were to be properly systematised, there is no doubt about it that Burma would become an important centre of lac cultivation The information to hand on cultivation in this Province is uncertain and needs verifying and increasing The Director of this Institute is proceeding to Burma during this year 1931 to obtain information and to suggest methods of systematising the work.

Lac grows in 4 out of the 7 Forest circles into which the Province is divided, these are the Delta, the Northern, the Central and the Chindwin, Circles. The Federated Shan States however produce 70% of the lac out-turn of Burma, they consist of two divisions the Northern and the Southern.

In the *Northern division* lac is found in the Hsipaw and North Hsenwi States; in the *Southern* it is found in the following states —Lawksawk, Maw, Yengan, Kyaukse, Yawnghwe, Mawnang, Samka, Loilong, Mongpai, Sakoi, Namtok, Wanyin, Nawngwan, Namhkok, Hopong, Monhnai, Laikha.

In the *Central circle* lac is found in the Maymyo Division; in the *Northern Circle* in the Katha, Mansi and Bhamo divisions; in the *Chindwin Circle* in the upper Chindwin, Yaw, Minbu, Myithlha and Mu divisions; in the *Delta Circle* in the Thayetmyo and Henzada divisions.

The method of cultivation is very largely to cut the lac from inoculated trees and to sell it as stick lac making no provision for future crops. The trees get reinfected from the casual twigs of lac left by accident; *Kusum* is rested after every seventh crop, *Palas* and *Ber* after every third In the Northern Shan States however some ordered lac cultivation is carried out.

The Principal host trees in the Federated Shan States are the following, roughly in order of importance.

Local Name.	*Latin Name.*
Gyo	*Schleichera trijuga*
Pauk	*Butea frondosa*
Petwun	*Berrya Ammonilla*
Zi	*Zizyphus Jujuba*
Taung-magyi	*Albizzia odoratissima*
Thitnu	*Engelhardtia spicata*
Yindaik	*Dalbergia cultrata*
Bawdi	*F religiosa*
Kadut	*F. hispida*
Nyang-gyin	*F. infectoria*
Nyang-peinne	*F nervosa*
Nyaung-thabye	*F indica*
Sinthapan	*F. Roxburghii*
Thadut	*F. Cunia*
Thapan	*F glomerata*
	also
Awza	*Anona squamosa*
Bonmeza	*Albizzia stipulata*
Ingyin	*Pentacme suavis*
Kokko	*Albizzia Lebbek*
Ngu	*Cassia Fistula*
Pauk-nwe	*Butea superba*
Thitya	*Shorea obtusa*
Nanwngyain	*Acacia Farnesiana*
Sha	*Acacia Catechu*
Tamalan	*Dalbergia Oliveri*
Tanaung	*Acacia sp.*
Tayaw	*Grewia sp*
Thayet	*Mangifera indica*

In the Maymyo Division the most important hosts are *Schleichera trijuga*,

Dalbergia cultrata, *Engelhardtia spicata*, *Butea superba* and *Pentacme suavis*, other hosts are :—

Anona squamosa
Garuga pinnata (*Chinyak*)
F. Cunia
Caesalpinia Bonducella (*Kalein*)
Albizzia Lebbek
F. indica
Butea frondosa
Xylia dolabriformis (*Pyinkado*)
F. bengalensis (*Pyi-nyaung*)
Acacia Catechu
Acacia concinna (*Subok*)
Albizzia odoratissima
Berrya Ammonilla
Albizzia lucida (*Thanthat*)
Enterolobium saman (*Thinbaw kokko*)
Dalbergia lanceolaria (*Thitpagan*)
Zizyphus Jujuba.

In the Katha Division the principal hosts are, *Pentacme suavis*, *Anona squamosa*, and *Zizyphus Jujuba*. In the Mansi Division, *P Suavis*, *Dalbergia Oliveri*, and *F. nervosa*. In the Bhamo Division lac grows on the climber *Entada scandens* and on *Zizyphus Jujuba*, it is cultivated on a small scale on *Engelhardtia spicata* In the upper Chindwin Division the hosts are, *P. suavis F. indica*, and *Dalbergia Oliveri*, in the Yaw Division *P suavis*, *Shorea obtusa*, *F sp* , *Zizyphus Jujuba*, and *Anona squamosa*, in the Minbu Division, *P. suavis*, *Albizzia Lebbek*, *Enterolobium saman*, *Zizyphus Jujuba* and *Anona squamosa*.

C. indicus has been tried on a small scale but not on commercial lines.

Burma lac has not commanded a good price on the market, this is due *largely* to the fact, that all grades of lac, and lac from various hosts are lumped together for sale instead of being kept separate, and that adulteration some-

times occurs, sticks, stones and rubbish etc being used to increase the quantity. This has lead to a false judgment of the quality of Burma lac, which could easily be rectified if cultivators would keep their grades of lac separate and would refrain from adulteration

There are two lac crops in Burma these are February-March to September-October, the minor crop and September-October to February-March, the major crop producing a superior grade lac and corresponding to the *Baisakhi* crop In the Federated Shan States the periods are a little different, the Summer Crop begins in April, and the Winter or *Baisakhi* in September early October There appears to be no different swarming time for *Schleichera trijuga* lac as is observed in other lac growing areas.

I do not claim to have touched on all the lac growing areas, in this Chapter, by any means, I have however mentioned the more important or more interesting districts, especially those in which some host predominates. Neither do I claim to have mentioned any thing like all the trees, shrubs and creepers which can be used as lac hosts, I have mentioned however those that are important commercially in addition to a number of lesser economical value Among other hosts not mentioned in these Chapters are *Shorea Talura*, *Atylosia albicans*, (a creeper) *Nephelium litchi*, *Anona squamosa* (custard apple), these two latter are said to produce an encrustation of the *Kusmi* type, and have been introduced at Namkum for experiment, also *Mangifera indica*, *Pithecolobium Saman* the rain tree on which excellent encrustations are produced in South India and which is being tested at Namkum, and many others. *Acacia moniliforms* a possible host in the Sambalpur District is worth mention however, the tree is very rapid growing and at 3 years old was 18 feet high, it is an ever-green with scandent (weeping) habit Infected with *Palas* brood it produced quite a fair crop.

Other Lac Hosts.

CHAPTER VIII.

Insect Enemies and Friends of Lac.

The damage done to lac crops throughout India, by insect pests is tremendous; an average of 60% of the potential crop is destroyed annually. This means that the actual lac crop produced is 30% only of the crop that could be produced in the absence of these enemies.

Damage done by Lac Enemies.

Predators.

There are two groups of lac enemies, these are the predators and the parasites The predators are insects which lay their eggs on or near the lac encrustation, the larva which hatches from the egg feeds on the lac insects, it may continue to feed from the surface or it may eat its way in to the encrustation until it comes to lie entirely concealed inside The attack however is from the outside and the larva never inhabits one single lac cell. Pupation occurs and the adult emerges, later to fly away and lay its eggs on other lac encrustations.

Parasites.

The parasites are all small insects, which lay their eggs through a tube or ovipositor which is placed at or near the apex of the abdomen This tube is inserted into the anal opening of the lac cell and an egg or several eggs are laid inside. The larvæ hatch out and live on the surface of the lac insect or actually within its body feeding on it Finally pupation occurs within the lac cell, and the adult emerges ready to fly away and repeat this process

Plate I Fig X represents a twig bearing immature lac cells, a number of these are represented with dark circular holes in them These holes are the openings through which the adult parasite has escaped after the larval stage has destroyed the immature lac insect within the cell

I do not propose to enlarge upon this subject of lac enemies to any great extent, beyond some general remarks about the more important ones and sufficient information to make the general controls suggested, intelligible

Among the predators there are two insects of extreme importance and one of minor importance, these are *Eublemma amabilis, Moore (Noctuidæ)*, (also some other sps. of *Eublemma*) *Holococera pulverea, Meyr (Blastobasidæ)*, and *Chrysopa sp (Chrysopidæ)*

Eublemma and Holcocera.

Eublemma and *Holcocera* are both moths, the eggs are laid on the lac encrustation or beside a lac cell, the larva hatches out and begins to eat its way into the encrustation until it is finally completely hidden, both eat as they go, both the encrustation and the lac insects I do not propose to enlarge upon the Life Cycles of these two Predators, that of *Eublemma* is recounted in full in Misra, Negi and Gupta 1930, that of *Holcocera* has not yet been completely worked

out in this Department, but it is hoped that it will be ready for publication towards the end of this year (1931).

Of the two, *Eublemma* is the more serious on account of its very wide distribution. Lac samples from very many lac growing districts have been examined at this Institute and not a single sample received has been free from the attack of *Eublemma amabilis* *Holcocera* is also a serious pest but not to the same extent as *Eublemma.*

The type of damage done by *Eublemma amabilis* is shown in ***Fig. 22*** which shows two sticks of lac, *A* is *Ber* and shows the domes formed by the *Eublemma* caterpillar; *B* is *K X Ber* and shows the exit holes of the adult moth, see also Glover 1930, *Plate IX* and Misra 1928, *Figs 14, 26 and 27. Holcocera* damage is similar but less obvious from the exterior, domes are not formed.

The larvæ of *Eublemma* are a dirty yellow white colour and are fairly inactive, while *Holcocera* larvæ are chocolate ~~black~~ colour and very active. The pupa of *Eublemma* is at first pale yellow in colour, later all parts except the abdomen turn deep brown; that of *Holcocera* is a deep rich brown colour.

Natural Enemies of Eublemma and Holcocera.

General controls are given at the end of this chapter; the following however must be mentioned here. Certain insects feed on larval or pupal stages of *Eublemma* and *Holcocera* and these are therefore friends of the lac insect The Entomological Department at Namkum is investigating these friends and is attempting to find practical methods of increasing their activities and making them valuable controls of these enemies. These friendly insects fall into the two groups Predator and Parasite, the following table shows their activities :—

1. *Predators.*

   a. *Ephestia sp.* (*Pyralidae*) feeding on *Eublemma* larvæ in stored lac.

   b. *Camponotus compressus. Fabr* (*Camponotinæ*) the common big black ant attacks *Eublemma*, *Holcocera* larvæ.

   c. *Solenopsis geminata rufa. Jerdon* (*Myrmecinæ*) the common little red ant attacks, *Eublemma*, *Holcocera* larvæ.

2. ***Parasites.***

a. Bracon tachardiæ Cam. (*Braconidae*) parasite of *Eublemma* larvæ

b. Brachymeria tachardiæ (*Chalcidiidæ*) *Cam.* parasite of *Syn Chalcis tachardiæ* *Eublemma* and *Holcocera* pupæ.

c. Elasmus claripennis (*Elasmidae*) *Cam.* parasite of *Eublemma* larvæ.

d Apanteles tachardiæ Cam. (*Microgasterinae*) parasite of *Holcocera* larvæ.

e Black Chalcid (No V) (*Chalcidiidæ*) parasite of *Holcocera* larvæ

f Bethylid Sp (*Bethylidæ*) parasite of *Holcocera* larvæ.

g. Pristomerus marginicollis (*Ichneumonidæ*) *Cam.* parasite of *Holcocera* larvæ.

Chrysopa.

The other Lac predator mentioned was *Chrysopa Sp* the adult is a green fly with golden eyes and transparent wings which are net veined, it lays its eggs each on a thin pedistal, on the encrustation or near it, the larva is a small fairly active creature which walks over the surface of the encrustation, it feeds by pushing its long mouth parts, the mandibles and maxillæ which together form an imperfect sucking tube, into a lac cell and sucking the juices of the insect. The larva conceals itself by covering its back with bits of rubbish leaves etc. and above all a mass of the white filaments from the lac, these are held in position by hooked hairs The larva pupates in a small circular cocoon and finally the adult emerges

Chrysopa is only present in large numbers in the *Katki* crop and on the early stages of the *Aghani* crop Spraying the lac with 2-4% phenyle is being tested as a method of control and will probably need to be done once or at the most twice.

Chrysopa cocoons are parasitised by an *Ichneumonid* which is therefore a lac friend

Among the Parasites there are a number of important insects the following may be mentioned .—

Lac parasites.

Tetrastichus purpureus Cam (*Eulophidae*) (*BI*)
Brasema annulicaudis Cam (*Eupelminae*) (*BII*)
Black Chalcid (unidentified)) (*Encyrtidae*) (*BIII*)
Coccophagus tschirchii Mahd (*Eulophidae*) (*YI*)

Tachardiaephagus tachardiae How (Encyrtidae) (YII)
Spotted Chalcid (unidentified) *(Encyrtidae)*
2 Yellow Chalcids (unidentified) *(Encyrtidae).*

(The symbols in brackets are those under which these insects were referred to, in Institute reports prior to their identification).

Alternative hosts of Lac parasites.

Several of these are suspected of parasitising also, insects other than lac, where this is the case, destruction of these other or alternative hosts affords one possible control, because the alternative host forms a convenient breeding ground for the parasite and also is a refuge for it at times when the lac is too immature or in seasons when lac cultivation is, for some reason or other, suspended.

Aspidiotus referred to in the next chapter as a pest on host trees, is even more worthy of destruction as it forms an alternative host for *Spotted Chalcid* *Spotted Chalcid* is mainly a parasite of male cells of Scales, and is found particularly abundantly at about the time of male emergence Wild scales occurring in the neighbourhood of lac plantations should always be regarded with suspicion; where possible a number of sample sticks should be sent to this Institute for investigation In Badami, Bijapur Division Bombay the lac is attacked by a Predator, *Eublemma scitula*, and a wild Scale, was found in the neighbourhood on *Premna integrifolia (Narvel)* by the Range Forest Officer and was sent here for examination, both *Eublemma scitula* and *Spotted Chalcid* were found infecting it and its destruction has been advised, using methods described in the next chapter for *Aspidiotus.*

Machaerota also mentioned in the next chapter as a tree pest is doubly worthy of destruction as it is an alternative host for *Brasema annulicaudis.* This latter enemy not only harms lac but is also a hyperparasite (parasite of a parasite) of the lac friends *Apanteles tachardiæ* and *Bracon tachardiæ.*

Tetrastichus purpureus is also hyperparasitic on the two lac parasites *Coccophagus tschirchii* and *Tachardiæphagus tachardiæ*, its main function however is that of a lac parasite and it must be considered therefore as an enemy.

Two further *Braconids* are found in connection with lac, whose function is doubtful, these are *Apanteles fakrulhajiae Mahd* and *Black Braconid C*

(unidentified). From their times of emergence it seems probable that they are lac friends, probably parasitic on Lac Predators.

Beetles.

Before outlining the General Control of lac enemies, there is one more group of insects associated with lac that must be mentioned, this is the *Coleoptera* (*Beetles*). Work on this group has not proceeded very far as yet, the beetles commonly found are *Tribolium sp.* (*Tenebrionidae*) *Silvanopsis sp* (*Cucujidae*) (and two others of this group) and a *Dermestid* (*Dermestidæ*); the larvæ, pupae and adults are found in lac cells in which the lac insect is dead, and are fairly abundant in stored lac. They appear to be scavengers feeding on the remains of dead lac insects and other organic rubbish and are probably not to be considered as lac enemies.

General Controls.

General Control of Lac Enemies —The methods of General Control are based on the following facts which are results obtained by the Entomological Department of this Institute over a number of years.

Firstly the very large majority of lac larvæ emerge from brood lac within 21 days (3 weeks) of the date that swarming began.

Secondly, at the time of crop maturity, that is to say June-July for the *Baisakhi* and *Jethwi* crop, October-November for the *Katki* crop and January-February for the *Aghani* crop, tremendous numbers of lac enemies emerge from the Mature Lac. This emergence of enemies continues from 3-4 weeks after the crop has been cut, but is at its height in the first and second week after cutting. This is particularly true in the case of the Parasites This emergence occurs also of course from lac used as brood but in this case is delayed somewhat and continues in large numbers even after three weeks when the majority of lac larvæ from it have already emerged.

From the *Katki* crop very large numbers of Enemies both parasite and predator emerge at and after crop Maturity, parasite emergence is at its height in October-November and continues into December; this emergence infects the *Aghani* crop and also in December the *Baisakhi* which is unaffected till then *Eublemma* emergence at its height in October-November continues in small numbers in each month up to March, the emergence infects the *Aghani* crop. *Holcocera* emergence is also high in October-November, is practically nil in December-January-February, and starts again in large numbers in

March; the early emergence infects the *Aghani* From the *Aghani* crop very large numbers of parasites emerge at crop maturity, there is also however tremendous *Eublemma* and *Holcocera* emergence in February-March-April a short while after the crop has been cut This emergence together with the Predator emergence from Stored *Katki* at this time infects the *Baisakhi* crop and the young *Jethwi*. The same applies to the *Baisakhi* and *Jethwi* crops, particularly with *Holcocera* the emergence of which in July-August is very large; this Predator and Parasite emergence is free to infect the young *Katki* and *Aghani* crops which become pest ridden at an early age on account of their rapid growth.

The enemies emerging at any of these times are able also to reach alternative hosts where these occur.

The controls that can be applied are the following .—

1. The use of healthy brood lac for infection purposes. Unhealthy pest infected brood should be discarded, as these pests emerge while the brood is tied to the tree and can reach other lac in the vicinity or go to alternative hosts.

2. The complete rejection where practicable of Natural Infection particularly in October-November, because of the pest hibernation in the *Katki* lac; at present the Natural Infection of *Palas* in July is an exception.

3 The removal of all brood three weeks after the date that swarming began.

The reasons for the above two rules (2 & 3) are that once the larvæ have emerged from lac used as brood, it is of no more value as brood, and since lac enemies are still emerging from it, it is only acting as a distributing centre for lac enemies and should therefore be removed

4. The destruction wherever found of all alternative hosts of Lac Enemies.

5. The treatment of all lac cut from the tree and not required as brood and of all brood lac after use, by one of the following methods :—

(*a*) Fumigation with Carbon bisulphide at 1 oz. per 10 cu. ft. of space.

(*b*) Immediate scraping grinding and washing, it can then be sold or stored in this condition, which is called seed lac or Safa Chowrie.

(*c*) Scraped and dipped in water for short periods, and then dried.

During the coming year I hope to publish from the Entomological Department a full and detailed account of this later control (5).

Any of these three (a. b. c) methods would prevent incredible pest emergence from the mature cut crops, and would stop these enemies from seeking out other lac in the vicinity or reaching alternative hosts. Treatment of all fresh cut mature lac and all brood after use as suggested in Control 5 would, if carried out systematically in all lac growing areas, in a short time reduce the damage by pests to lac in India by at least 50%. This control is particularly important in those plantations where the fresh cut crop is stored before sale in an open godown in close vicinity to the plantation.

In addition the treatment of the fresh cut crop before storage by one of the methods just suggested, would prevent practically 100% of the depreciation in stored lac due to the damage done by *Eublemma* and *Holcocera* caterpillars feeding on the lac.

Ants and their relationship to the Lac Insect.

Before closing this chapter, it is necessary to refer to the *Formicidæ* or true ants and their relationship to the lac insect. Many species of ants visit lac infected trees and are to be seen walking over the encrusted branches stopping every now and then and stroking and even apparently biting at the lac. No ants have yet been found at Namkum which harm the lac or the encrustation, which they visit to obtain the "Honey Dew" (*cf Chapt. I*). This in itself is beneficial as the "Honey Dew" at times becomes excessive and mixed with dust is capable of blocking the breathing holes of the lac cell and suffocating the insect inside.

Lac grown on trees visited by ants is often found to have none or only short, white filaments, as these are broken off by the ants walking over the encrustations. This is not harmful as is supposed by some cultivators; the white filaments are not part of the Tracheal Respiratory system and are developed primarily to ensure that the respiratory and anal holes are not blocked during lac secretion.

Certain ants, particularly *Camponotus compressus* and *Solenopsis geminata rufa*, will attack and kill the larvæ of *Holcocera* and *Eublemma* and also *Chalcid* parasite grubs if these are exposed; and these forms are definitely beneficial.

Control of Ants.

Some Ants however are harmful at the times of male emergence and of swarming, in that they pick up and kill some of the male lac insects and lac larvæ. *Solenopsis geminata rufa* is among these Where these enemy ants occur and are found to be doing harm quite simple controls may be used Any of the following will be found satisfactory :—

1 Bands of gun may be pasted round the trunks of the infected trees; they tend however to loose their stickyness and hence the power of catching ants

2. Cheap molasses may be pasted round the trunks of the trees or scattered on grasses and tied round them

3 A counter attraction bait of crushed sugar cane or honey comb from which the honey has been extracted, or other sweet substances may be strewed on the ground, and will be found a much greater attraction for the ants, than is the lac insect.

Should ants be found in any district and be proved to be definitely harmful to the lac insects and the encrustation, these controls may be applied and their nests (*Formicaries*) destroyed by pouring hot 10% Phenyle into them wherever found Alternatively the *Formicaries* can be fumigated, (*cf. Chapter IX* Fumigation of *Termitaria*).

The more important ants visiting the lac insects are the following :—

1 *Camponotus compressus Fabr*—Friendly, attacks *Holcocera Eub lemma*, and *Chalcid* larvæ where exposed, comes for 'Honey Dew'.

2 *C near varians Roger*—Picks up crawling lac larvæ and male insects.

3. *Meranoplus bicolor Guér*—Picks up crawling lac larvæ and male insects.

4 *Solenopsis geminata rufa Jer*—Attacks *Eublemma* and *Holcocera* larvæ, also picks up lac larvæ, males and male pupae.

5. *Iridomyrmex anceps Roger*—Attacks injured *Eublemma* and *Holcocera* larvæ, uninjured *Eublemma* cautiously, also picks up lac larvæ.

6. *Cremastogaster dohrni Mayr*—Picks up crawling lac larvæ and males.

Other common ants are :—

Camponotus mitis Smith. Monomorium near *indicum Smith, Cremastogaster subunda Mayr, Sima* near *allaborans Walker, Solenopsis geminata Fabr* and *Tapinoma melanocephalum Mayr.* There are very many more species but those recounted above are the commoner, more important ants met with in lac cultivation.

There are in addition other Agents that must be mentioned in this Chapter, these are the Arboreal Animals. Of these I propose to mention Birds, Squirrels, Monkeys. These animals served their purpose to wild growing lac in that the larvæ were accidently transferred by them from one tree to another. To the cultivator they are often detrimental.

Birds, Monkeys, Squirrels.

Birds may pick up the crawling larvæ and damage the young larvæ by alighting on the twigs and crushing those which have just settled.

Monkeys are damaging chiefly from mischievousness, pulling down the sticks of brood tied to the trees and breaking off the lac from the twigs. For either of these, some form of scare worked by the wind may be used if the damage is serious

Squirrels in some districts break off the encrustation, where this occurs, the heaping of branches covered with prickles such as *Babul, Khair,* etc. round the trunks of the trees may be tried, to prevent their access to the trunk

CHAPTER IX.

The Insect Enemies of Lac Host Trees.

This is an important side of lac cultivation as tremendous damage can be done by these pests, and in many cases quite easy methods of preventing and checking them can be applied, I propose to classify them for practical purposes, into four groups.

Types of Enemy.

1. *Biting insects.*—These insects are those that devour the leaves, the bark and the young shoots or buds, by biting them. This group includes, the *Caterpillars, Grasshoppers, Beetles, etc.,* also the *White ants,* and *Locusts,* (these latter are discussed at the end of the chapter).

2. *Sucking Insects.*—These are the *Bug* like insects and include the *Scale* insects, *Aphids* and *Mealy bugs* They live by sucking the sap from the trees

3. *Boring Insects.*—These include the *Caterpillars* of certain moths and the *caterpillar* like larvæ of some *Beetles.*

4 *Insects attacking below the soil.*—This group includes, ***White ants,*** larvæ of *beetles* and certain *caterpillars* which live in the soil and come to the surface and attack at night or live and attack from under the ground.

It would be impossible in a pamphlet to mention even half of these enemies I propose however to outline a method of control for each of the four groups which can be used generally and to mention certain important pests observed at Namkum, as examples.

In all cases where spraying is advocated, the spray must be made up in the same proportions as I have given, the exact quantities need not be the same. The solution should be sprayed from a Spraying Machine, so that the whole tree is covered by the liquid.

Defoliating Caterpillars and Leaf miners.

Group 1 Biting Insects.—The most satisfactory method of attack is spraying the plants with a stomach poison, this applies particularly to defoliating caterpillars and leaf miners. The insects take in the poison as they eat the plant tissues and are killed. One of the most effective is

Lead Arsenate Paste	.		...	1 oz.
Water	...	...	...	1 gallon.

Or Nicotine solution may be bought, this should be diluted according to the directions and an addition of 1 oz of soap per gallon made.

Both these sprays are poisonous A spray of 10% Phenyle can also be used if preferred; this should be used at 2—6% if the tree is infected with lac at the time. *Hieromantis ioxysta Meyr* (*Schrechenstineidae*), a leaf miner on *Kusum* was successfully checked at Namkum by the application of Lead Arsenate and also with 10% Phenyle.

Beetles Grasshoppers.

Hand picking and destruction of the adults is probably the most effective check on *Beetles* and *Grasshoppers* as for example *Teratodes monticollis Grey* (*Catantopinae*) a reported pest in the Chaibassa District; for Beetles biting into the bark near the ground, a coating of pitch to which some *Lead Arsenate* has been added

may be given *White ants* and *Locusts* are of such importance that they will be dealt with separately later.

Group 2—Sucking Insects.—As these insects obtain all their nourishment from the sap of the tree, stomach poisons are of no use. The most satisfactory method of eradication is to use a contact poison spray. For *Scale* pests far the most efficient spray is *Lime* and *Sulphur* prepared thus :—

Lime and sulphur spray.

Lime	. .	50 lbs.
Sulphur	. .	100 lbs.
Water	.. ..	140 gallons

Method of Preparation —The amounts of course can be varied as long as the same proportion is maintained The water should first be warmed and the whole of the Lime added as *quick* Lime, the Lime becomes slaked when it has all melted The Sulphur is then added, the solution should then be heated and stirred until it boils, and should be kept boiling until it becomes a dark brownish yellow colour The spray should be used tepid

It must be remembered of course that this spray is also fatal to lac

Aspidiotus. *Aspidiotus sp.* (*Fig 8*) an extremely serious scale pest of *Ber, Ghont* and *Kusum* has been satisfactorily checked at Namkum by this treatment The infected trees should be heavily pruned and the prunings burnt, the tree should then be sprayed This is perhaps the most noxious of all scales and will, unchecked cause the death

Other Scales. of the tree attacked, it spreads with extreme rapidity The above treatment may be used also on other scales such as *Chionaspis sp* , and also *Lecanium sp* a pest on *Khair, Flemingia congesta, Cajanus indicus* and *Acacia Farnesiana*

Machaerota planitiæ. Dist (*Cercopidae*) (*Fig. 9*) is a serious pest on *Ber* and

Machaerota. also to a less extent on *Ghont*, the nymphs form small calcareous tubes in the feeding stage, on the branches, and cause "die back" by sucking the sap from the terminal shoots. Badly infected branches should be cut and burnt, trees should be sprayed with 10% Phenyle solution when the young nymphs are on the trees just preparing to secrete the tubes.

For other members of this group such as *Mealy Bugs* and *Aphids* there are a number of suitable sprays which may be adopted; any one of the following may be used.

Sprays.

1. *Crude Oil Emulsion* —This is a valuable general spray for hos enemies, I found that two separate sprayings, 4 days apart were sufficient to cause practically tota mortality in *Aspidiotus;* it can also be used as a control of Biting Insect Group I.

Place 6 oz. of Fish Oil Soft Soap in a tin and just cover it with water place on a stove and just melt. When melted stir in 1 quart of crude oil gradually The mass will cool and finally set into a dark coloured jelly. As required for use, 2 ozs of this jelly should be dissolved in 4 gallons of water, a milky solution results which preferably should be sprayed just warm

The soap can be obtained from the North West Soap Company, Garden Reach, Calcutta in 40 lb tins and is very cheap

2. Soap solution, made by dissolving soap in water at 2 ozs per gallon, best soaps are soft Naptha, or Nicotine soap

or 3 10% Phenyle solution may be used

Borers.

Group 3 Boring Insects —These insects are by far the most difficult to control Where the borer is the larva of a *Beetle*, collecting and killing the adults is often the easiest and cheapest way of reducing their activities This method can be applied to *Buprestid* Beetles and to *Coelosterna scabrata* (*Cerambycidæ Longicornia*) whose larva is a borer on *Khair* in the Chaibassa District. Where the borer is the *Caterpillar* of a moth such as *Arbella tetraonis Mo.* (*Arbelidæ*) (a borer on Siris and other trees) control is much more difficult In order to provide satisfactory controls it would be necessary to study the particular Borer in any given district However the following are suggested for all types of Borers.

1 Catch and kill the adults, where the borer is a *Bettle*, this is usually fairly simple If it is a moth, light traps should be set at the times when the moths are known to be emerging

2 Where it is known that the borer restricts its activities to within a certain distance from the ground say 2—3 ft , a painting of pitch mixed with *Lead Arsenate* can be applied

3 If the borer affects the growing tips or terminal shoots badly infected ones should be cut and burnt.

4. Where practicable a lethal liquid can be put into the holes made by the borers; in order not to damage the tree, soap solution as previously mentioned would be most satisfactory, the holes can then be blocked up with small pieces of putty or earth.

Subsoil insects.

Group 4—Insects attacking below the surface of the soil.—The best remedy for these pests is to apply 10% Phenyle round the bases of the plants, this will kill soil *caterpillars*, *caterpillars* pupating in the soil and also *White ants*. This remedy is chiefly of value with well grown trees; if it is applied to young plants the Phenyle should be well mixed with soil; a little of the soil round the plant should be removed and this treated soil substituted It is as well to remember that direct contact with phenyle is very harmful to young plants

White Ants.

White Ants (Termites) —These pests are so harmful as to be worthy of separate treatment In Nurseries they attack young seedlings and plants, they bite through the stems just below the surface of the soil On trees they build covered earth tunnels up the trunk, under which they attack the bark and do considerable damage, not the least of which is that this removing of the bark and attack on the tree, provides an excellent place of attack for other enemies

The following controls are of extreme value and properly applied will reduce *White ant* damage to a minimum

1. The earth tunnels should always be scraped from tree trunks as soon as they are observed, the *White ants* do not care for the light and the removal of their tunnels allows other insects to attack them

Control of White Ants by natural enemies.

2 Many true *Ants* are enemies of *White ants*, in particular the very common little red ant which stings painfully (*Solenopsis geminata rufa*) This ant may be used as a control In Nursery beds in which *White ant* is found, the soil at the surface should be turned over to the depth of about 1—2 inches this should be done every now and then after the seeds have germinated. A nest of red ants should then be found and a kerosene tin of the loose earth which is well mixed with ants can be brought from the nest and spread over the Nursery beds The red ants will not harm the seedlings and will rapidly seek out and kill the *White ants*, they may possibly

remove a few of the seeds, but this treatment is not suggested until the seeds have germinated and are safe.

Solenopsis geminata rufa the small red Ant is very common in this district, the Ant is a fairly dark reddish yellow colour and 2·5—3 mms in length. The surface of the nest is characterised by a roughly oval patch of fine sand, which may in a fresh nest show small round entrance holes at the bottom of slight depressions The nests are commonly found either on flat ground or in the sides of bunds

3. Animal manure (*Dung*) should always be examined before use: immature manure, that is manure which has not properly decayed and requires further rest before use, nearly always contains *White ants*.

4. On the earth round the trunks of trees up which *White ants* have built tunnels 10% Phenyle may be sprinkled Or cheaper and I have found most effective fork up the soil round the tree trunk, scrape the tunnels from the tree and sprinkle over the opened up soil half a kerosene tin full of the surface soil (which is full of red ants) from a red ant nest.

Fumigation of White ant nests.

5. This control is of vital importance as it goes to the root of the matter; the destruction of all *White ant* nests (*Termitaria* Fig. *19*) in the neighbourhood of the Lac Plantation The old method of digging out the nest and killing the queen is not satisfactory, as there are in the nest various other *White ant* individuals which can take upon themselves the functions of the queen under these circumstances; digging out followed by a heavy dosing of 10% Phenyle is more effective.

There are however on the market some excellent machines which destroy the nests by fumigating them The principle is as follows; air from a hand pump is blown over the surface of a small brazier containing burning charcoal On the charcoal is sprinkled a powder which produces poisonous fumes, these are led down a flexible tube ending in a nozzle The method of working, is to insert this tube into a hole in the nest and vigorously pump the poisonous fumes into it, as the fumes are seem to come out of other holes in the nest these are blocked up Finally the tube is withdrawn and this hole blocked up The nest can then be opened after three days, when all the *White ants* are found to be dead These machines are extremely efficient and very well worth the money, they are cheap and easy to use. I have had very satisfac-

tory results from a machine of this type entitled. The *Blue Mysto White Ant* Exterminating Machine, price Rs 70, the Mysto Powder costs Rs. 1/4 per tin imported by the General Export Co 55—58, Ezra Street, Calcutta.

5. Tree prunings and old wood should not be left lying in the plantation, they should be removed entirely or else burnt, otherwise they are an attraction to *White ants*.

Red ant a lac friend or enemy.

Solenopsis geminata rufa Looking at this and the last chapter shows that this ant is more of a friend that an enemy to lac, and its nests should be favoured in lac plantations. It is an enemy of the *White ant*, and may be transferred to areas, which are *White ant* infected, it is also an enemy to *Holcocera* and *Eublemma* larvæ; and will attack various soil living grubs and caterpillars Its presence in the nursery is not to be encouraged as it probably will carry off seeds, except at such times as the seeds have germination or *White ants* are present It is harmful to lac at times of male emergence and swarming, but may be otherwise employed at these periods by supplying it with a counter attraction bait

Locust control.

The possibility of Locust invasion is one that must not be overlooked These pests coming in swarms as they do, are capable of committing extensive damage, particularly to nursery seedlings and young plants The subject of Locust control is becoming increasingly important and I propose only to outline the simpler control methods here, which require no apparatus, such as flame throwers, powder sprayers etc Cultivators interested in the problem or in areas where locust swarms are frequent are advised to obtain the leaflet on the subject published by the Imperial Council of Agricultural Research (1930) the following notes are based on this pamphlet. Locusts to the cultivators may appear in two forms.

1. The Hoppers or very immature form
2. The flying swarm of which there are two kinds
   (*a*) Insects composing the swarm of a pinkish colour. These are immature and may settle and feed.
   (*b*) Insects composing the swarm of a dark brown to black colour These are mature and may settle, mate, and lay eggs, from which hoppers will develop.

A flying swarm can very often be prevented from settling and feeding by noise When a swarm is observed all coolies in the vicinity should be collected and sent out into the area with drums, tins, and sticks and be ordered to make as much noise as possible

Should the swarm settle in spite of this, the insects may be collected by hand, and by sweeping, and burnt, they should be shaken down from the trees If they settle and mate, they may be crushed or collected and burnt.

Locust eggs are laid in holes in the ground, a few inches deep, usually over a restricted area, and there may be as many as 100 eggs in a hole. The hoppers emerge after about 2 weeks Breeding grounds should be ringed round by trenches 1 ft wide, and 18" deep, the hoppers fall into the trenches and may be killed with a mixture made by mixing kerosene oil with soft soap It should stirred till no more kerosene will go into the mixture. The semi liquid mass produced is diluted with water, 4 gallons of water to each gallon of kerosene oil used.

The same treatment can be applied to hoppers which after they have hatched, move across the country in a large body feeding as they go. Trenches should be built in their line of progress The older the hoppers the larger the trenches must be They should be driven into these trenches and destroyed in them.

The Locust most commonly met with is the Migratory Locust, *Schistocera gregaria, Forsk.*

CHAPTER X.

Biological Races of Lac Hosts.

Among lac hosts there are sometimes found two types of a given species, one of which will take a lac infection and yield a crop, the other of which will not These two types are in some cases botanically indistinguishable or practically so, the lac insect however markedly prefers one to the other, and is successful on one and either will not grow at all, or only attains minimum growth on the other. These two types are termed Biological Races of the host, because although they are to all intents and purposes identical botanically, yet biologically they are easily separable by means of the preference of the lac insect.

Two types of Palas.

An excellent example is afforded by *Butea frondosa* (*Palas*) There are two races of this host in this Province, one of which is the excellent lac host referred to in previous chapters, the other will not take a lac infection, there is however no apparent botanical difference between them. The Raiyat method of differentiation is to make an incision into the bark, if the inner wood is reddish in colour, the tree is a lac host, if the inside colour is whitish the tree will not take an infection.

Ficus hosts.

Among Ficus Lac Hosts a number of Biological Races seem to occur, also the behaviour of any given Ficus host seems to vary very greatly from one district to another. *Dumber*, *F. glomerata* for example in some districts is a good *Baisakhi* host whereas in others it is a failure during this crop *Pakri*, *F infectoria* on which lac is cultivated extensively in the Ranchi district in this Province is, according to Mr Fraser divided into several races, one of which is a good *Baisakhi* host, and another of which, though a poor *Baisakhi* host, is quite valuable for the *Katki* crop, infection. A number of types of *F religiosa*, (*Pipal*) are recognised in Bihar and Orissa separated by small differences in the length and shape of their leaves, some of these are considered more valuable as lac hosts than others by the villagers

Albizzia stipulata (*Siris*) occurs fairly commonly in Bihar, of this host also there are two races, these are known by the villagers round Namkum as *Kala* and *Safed*, *Siris* and appear exactly alike, the former is perhaps slightly darker in colour in leaf and trunk than the latter. *Kala Siris* is a good lac host; if *Safed Siris* is inoculated however, the larvæ although they settle on the twigs, die after a few weeks Samples from these two trees were taken and tested for Hydrogen ion, Ph value (acid-alkaline value), and *Kala* was found to be 5 6 whereas *Safed* was 6 1. This however requires further investigation.

Types of Kusum.

In Bihar and Orissa, two distinct types of *Schleichera trijuga* (*Kusum*) occur, these are known as *Kareya* and *Charka*. *Kareya* is the excellent host referred to as *Kusum*; *Charka* if inoculated "takes" badly and either a fairly poor or negligible crop is produced. The differences between these two are in colour, leaf shape and even in habit but are not marked, and intermediate types are believed to occur.

At Bhinjpur near Raidih according to Mr. Fraser, three races of *Kusum* are distinguished, there are however intermediates between them The first type bears small crinkled or curled leaves and is a good lac host, it produces however only short shoots and therefore long encrustations cannot be obtained. The second type has medium sized leaves which tend to be narrowed towards their apex and may be so much so as to resemble somewhat the jungle mango, this type takes a poor lac infection The third type is the best lac host, the leaves are large and shiny green with some slight resemblence to the *Mahua* (*Bassia latifolia*) An interesting point is that after pruning the leaves produced in the first year on all three types tended towards the large leaf, of type three, later however they become once again segregated

In Assam it seems possible that there may be two races of *Leea crispa*, as some trees give yearly, better lac than others

This phenomen of Biological Races is being examined at Namkum the possibility of sex taking some part in this is being considered and a number of experiments are being carried out. Lac cultivators in areas where these races occur or are suspected to occur, should obtain the Raiyat opinion on proposed lac hosts, and can be fairly certain that it is correct; experimental infections of such trees as *Albizzia sps.* should be carried out on a small scale primarily until the behaviour in that district is ascertained

APPENDIX.

The following Lac Host trees are mentioned in this book.

Proper name	*Vernacular names*	*Family*
Acacia arabica	Babul Kikar (Punjab)	Leguminosae
,, Catechu	Khair Sha (Burma)	,
,, concinna	Subok (Burma)	,,
,, Farnesiana	Kastura, Nanwn-gyain (Burma)	,,
,, Moniliformis	(Sambalpur)	,,
,, pennata	Arma, Gurra (C P)	,,
,, sp.	Tanaung (Burma)	,,
Albizzia Lebbek	Sirıs, Kokko (Burma)	,,
,, lucida	Thanthat (Burma), (Assam)	,,
,, odoratissima	Airma bonsa (C P). Taung-magyi (Burma)	,,
,, stipulata	Sirıs, Bonmeza (Burma)	,,
Anona squamosa	Custard apple, Awza (Burma)	Anonaceæ
Atylosia albicans	Creeper (Madras, Namkum)	Leguminosae
Berrya ammonila	Petwun (Burma)	Tiliaceæ
Butea frondosa	Palas, Paras, Chheola (C. P) Dhak Pauk (Burma) Chhichra	Leguminosae
Butea superba	Pauk-we (Burma) La Palas	,,
Caesalpinia Bonducella	Kalein (Burma)	,,
,, coriaria	Angrezi imli (C. P)	,,
Cajanus indicus	Arhar, Rarhar, Turvar, Nandu (Assam)	,,
Cassia Fistula	Ngy (Burma)	,,
Dalbergia cultrata	Yindaik (Burma)	,,
,, lanceolaria	Thitpagan (Burma) (Bihar)	,,
,, latifolia	Shishum (C. P.) Sissoo	,,
,, Oliveri	Tamalan (Burma)	,,
,, Sissoo	Sissoo	,,
Engelhardtia spicata	Wokken (Assam), Thitnu (Burma)	Juglandaceæ
Entada scandens	Creeper (Burma)	Leguminosae
Enterolobium saman / Pithecolobium Saman	Rain tree Thinbaw Kokko (Burma)	,,

Proper name.	*Vernacular names.*	*Family.*
Ficus bengalensis	Banian, Gitting (Assam), Pyi nyaung (Burma)	Moraceæ
,, Carica	Fig (Punjab)	,,
,, Cunia	Porho, Thadut (Burma)	,,
,, glabella	Putkul	,,
,, glomerata	Dumber, Gular, Fig, Thapan (Burma)	,,
,, hispida	Kadut (Burma)	,,
,, indica	Nyaung-thabye (Burma)	,,
,, infectoria	Pakaur, Pakri, Nyang-gyin (Burma)	,,
,, nervosa	Nyang-peinne (Burma)	,,
,, religiosa	Pipal, Bawdi (Burma)	,,
,, Roxburghii	Sinthapan (Burma)	,,
,, Rumphii	Prop (Assam)	,,
Flemingia congesta	(Assam), (Namkum)	Leguminosae
Garuga pinnata	Chinyak (Burma)	Burseraceæ
Grewia laevigata	Bolmengo (Assam)	Tiliaceæ
,, multiflora	(Assam)	,,
,, sp.	Tayaw (Burma)	,,
Kydia calycina	Boldabok (Assam)	Malvaceæ
Leea crispa	(Assam)	Ampelidaceæ
,, robusta	(Assam)	,,
Mangifera indica	Thayet (Burma)	Anarcardiaceæ
Nephelium litchi	Litchi	Sapindaceæ
Ougeinia dalbergioides	Panjan, Tinsa (C P)	Leguminosae
Pentacme suavis	Ingyin (Burma)	Dipterocarpaceæ
Pithecolombium Saman Enterolobium saman	Rain tree. Thinbaw Kokko (Burma)	Leguminosae
Schleichera trijuga	Kusum, Gyo (Burma)	Sapindaceæ
Shorea obtusa	Thitya (Burma)	Dipterocarpaceæ
,, Talura	Jalla	,,
Xylia dolabriformis	Pyinkado (Burma)	Leguminosae
Zizyphus Jujuba	Ber, Plum, Zi (Burma)	Rhamnaceæ
,, Xylopyra*	Ghont, Malhar, Ghunt Ber	,,

*Care should be taken not to confuse this species with Z rugosa (Pithaur) which is some what similar and is not a lac host

Dictionary of Entomological terms and terms used in Lac cultivation, as used in this book.

Abdomen (*Ent.*) —Hind part of the body of an insect.

Adult (*Ent*).—Full grown sexually mature insect.

Aghani.—The Rains crop grown on Kusum, or an other hosts using Kusum or progeny of Kusum brood (In Bihar, June-July to January-February).

Alternation.—Method of Lac cultivation in which lac is grown on two different kinds of host tree for alternate crops.

Alternative host (*Ent.*).—When a parasite, usually found living on a certain host, is found also to parasitise some other insect or insects, these other insects are called Alternative Hosts.

Anal Cleft or Anal Tubercular Opening (*Ent.*).—The third and intermediate hole in the lac cell through which filaments proceed and through which 'Honey Dew' is secreted

Antennae (*Ent*) —Jointed feelers arising from an insects head.

Anterior (*Ent.*) —Forward or head end

Apterous (*Ent.*).—Wingless

Arhar.—*Cajanus Indicus.*

Ari Lac.—Immature Lac containing living insects

Artificial Infection.—The process of tying brood lac on to a tree on which it is proposed to grow lac : often referred to simply as infection.

Babul —*Acacia arabica.*

Baisakhi.—The cold and hot weather crop, grown on host trees other than Kusum using brood other than Kusum or progeny of Kusum (in Bihar, October-November to June-July).

Ber.—*Zizyphus Jujuba*

Blocky lac.—Lac which owing to mishandling has set into a hard cake like mass usually occurs in Ari lac which has not been properly dried and caused by the decomposition of the insect bodies.

Brachial Pores (*Ent*).—The two holes in the lac cell opposite to one another, through which white filaments proceed and through which which Respiratory change is affected.

Brood Lac.—Mature lac containing the young lac larvæ ready to swarm ; it is used for infecting lac host trees.

Chowrie.—See Seed Lac.

Crop maturity.—The times at which the lac crop is fully grown and contains the lac larvæ

Domes (*Ent.*).—Excrescences raised by Eublemma in lac.

Dorsal (*Ent.*) —Upper surface of the body.

Encrustation (*Ent.*).—The cellular resinous material secreted round themselves by the Lac insects, together with their cast skins.

Exuviæ (*Ent.*).—Cast skins of an insect.

Generation (*Ent.*) —See Life Cycle.

Genital Sheath (*Ent*).—Sheath protecting Penis in the male lac insect

Ghont.—Zizyphus Xylopyra.

Hari.—Punjab name for *Baisakhi crop.*

Hyaline (*Ent.*).—Clear, transparent.

Hyperparasite (*Ent*) —Parasite of a parasite

Host (*Ent*) —The insect with which and upon which a parasite lives and feeds.

Infection —See inoculation

Inoculation —The process of introducing lac larvæ on to a tree on which which it is proposed to grow lac (see Artificial and Natural)

Jethwi —Hot weather crop grown on Kusum or on other hosts using Kusum or progeny of Kusum brood (in Bihar, January-February to June-July).

Katki.—The rains crop grown on host trees other than Kusum using brood other than Kusum or Progeny of Kusum (in Bihar, June-July to October-November)

Khair.—Acacia Catechu.

Kusum.—Schleichera trijuga.

Kusmi.—Synonymous with Aghani, used in this book to refer to lacs grown on Kusum or any tree using Kusum or progeny of Kusum, brood.

Lac.—General term embracing the encrustation, insects, &c.

Lac Cell.—See Test.

Laccifer lacca.—The lac insect which produces the lac encrustation.

Lac Host.—Any tree, creeper or shrub on which the lac insect can be grown.

Larva (*Ent.*).—The young insect which hatches from the egg of insects having complete Metamorphosis (*i.e.*) having definite egg, Larval,

pupal, and adult stages, and may be caterpillar like or 'Silver fish' like.

Life Cycle (*Ent.*).—The process of growth from the newly laid egg, to the adult insect ready to lay eggs.

Male emergence.—Process of emergence of the male lac insects.

Nagoli.—Synonymous with *Aghani.*

Natural Infection —Method of infection whereby mature lac is left on the host tree and allowed to swarm *in situ.*

Nymph (*Ent*) —The young insect which hatches from the egg of insects having incomplete Metamorphosis, *i e* no definite pupal stage, the nymph is like the adult and gradually becomes converted into the adult by a series of changes effected at ecdysis (moulting) Technically Lac larvæ should be termed Lac Nymphs

Ovipositor (*Ent*) —A specialised structure for laying eggs possessed by some insects found towards or at the apex of the abdomen

Ovule (*Ent.*) —Egg of small size

Palas.—Butea frondosa

Parasite (*Ent.*) —Insect which at some time of its Life History usually the Larval, lives and feeds entirely upon the body of another insect individual, living with it or within it.

Parthenogenesis (*Ent*) —The growth of a female to maturity and the production of young without any intervention on the part of the male.

Penis (*Ent.*) —Male copulatory organ.

Phunki.—Lac from which the larvæ have swarmed and which consists solely in the encrustation plus the dead bodies of the lac females.

Posterior (*Ent.*).—Hinder end.

Predator (*Ent.*).—An insect which at some stage of its life usually the larval feeds upon the bodies of other insects.

Proboscis (*Ent*).—Tubular mouth parts; adapted for piercing and sucking in the lac insect.

Pupa (*Ent.*).—The Stage succeeding the larva in an insect Life Cycle, often known as the Chrysalis or Cocoon.

Rangeen.—Synonymous with Katki; used in this book to refer to lacs grown on hosts other than Kusum using brood other than Kusum or progeny of Kusum.

Saprohyte —Organism living in dead or decaying organic matter and using it as food

Scavenger (*Ent*) —Insect which feeds on dead or decaying organic matter.

Scraped lac —Lac scraped from the stick (may be Phunki or Ari)

Seed lac —Scraped lac that has been ground and washed

Segment (*Ent*) —A division.

Shellac —The resultant product manufactured from lac by a melting process.

Sirs —*Albizzia Sp.* (*Lebbek* and *Stipulata*).

**Stick Lac.*—Lac on the stick (may be Phunki or Ari).

Swarming.—Process of emergence of the lac larvæ from Brood lac.

Thallas —The raised mounds in which seeds sown direct are planted and which are maintained round seedlings and transplants while they are young.

Test.—The coating of lac encrustation surrounding a single lac insect.

Thorax (*Ent*) —Part of the body of an insect lying between the head and abdomen It carries the paired legs, and wings, when they are present.

Ventral (*Ent*) —The lower or under surface of the body.

*It must be pointed out, that in the trade "Stick Lac" is used to refer to lac scraped from the stick Practically all Lac for sale is sold in this condition

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