INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1959-60

1961

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ADMINISTRATIVE AND GENERAL

General — On the retirement of Dr. S. V. Puntambekar on 31-3-59, Dr. S. Krishnaswami, Entomologist, took over as officiating Director and continued in that capacity for the whole year (1959-60). Dr. Krishnaswami also took over as officiating Secretary of the Indian Lac Cess Committee on 28-3-60.

The projected re-organization of the Institute, only partially carried out in the previous year, was practically completed with the appointment of the Organic Chemist for the Chemistry Division, and Arboricultural Officer for the Arboricultural Section.

Important new development during the year include the formal inaguration of the Production Unit as part of the Chemistry Division with effect from 1-9-59, and the starting on an experimental basis of a French Polishing Demonstration cum Publicity Unit at Delhi in co-operation with a private firm: the unit is meant to induce the habit of having furniture regularly polished, and thus augment internal consumption of lac. In addition, a new testing laboratory at Jhalda (Manbhum), and a new Field Research Station at Mirzapur were opened. The centre at Mirzapur *inter alia*, is to asses the difficulties in the way of extension of cultivation of lac in the region and evolve through field experiments suitable cultivation practices for the region.

On the cultivation research side *Moghania macrophylla* has been finally established as a very useful alternative host for raising *kusmi* lac and already this species is being propagated on a large scale in all the brood farms and experimental areas.

Genetical studies have been initiated during the year and progeny of irradiated insects are under observation. Also crosses between *rangeeni* and *kusmi* strains have been effected. Further progress has also been made on the study of the feeding habits of the lac insects in an attempt to artificially rear the lac insects.

In researches on the Chemistry side, two results stand out as being of particular interest one, a method of assessing the resin-content of sticklac, which has been already passed on to Testing Laboratories for adoption, and the other, a quick method of determining the hot alcohol insolubles (H.A.I.) in lac, which has reduced the time of determination from two to three days to barely four hours.

Exhibits and Exhibitions — Requests for exhibits of lac and lac products for display at exhibitions, show rooms, Vijnan Mandirs, Museums, etc., were received from 26 parties and these were supplied.

Exhibits were also sent to the following foreign exhibitions or trade fairs:

1. Chicago Fair, U.S.A.
2. Brno International Trade Fair, Czechoslovakia.
3. Frankfurt International Autumn Fair, West Germany.
4. Canadian National Exhibition, Canada.
5. Zagreb International Fair, Yugoslavia.

From 1st July 1959, the sending of exhibits to foreign exhibitions and trade fairs has been taken over by the Shellac Export Promotion Council, Calcutta.

The Institute participated in the World Agricultural Fair, New Delhi, where a stall in the I.C.A.R. Pavilion, was arranged displaying lac and lac products in collaboration with the Shellac Export Promotion Council. The display was very much appreciated by visitors.

The Institute also participated in the following exhibitions during the year:

1. Sikh Educational Conference Exhibition, Patna.
2. Sriniketan Exhibition, Bolepur.
3. Agricultural Exhibition cum Vikash Mela, Khunti.
4. Palandu Exhibition, Palandu (Ranchi).
5. Kisan Mela, Khijri (Namkum).
6. Agricultural and Industrial Exhibition, Purulia, West Bengal.
7. Bihar State Khadi and Industrial Exhibition, Ranchi.

Visitors — As usual, the Institute continued to attract numerous visitors all the year round. There were a large number of students and trainees from career colleges and Government Institutions, as also some important officials and a number of foreigners. A few deserving special mention were:

1. Sri Y. N. Sukthanker, Governor of Orrisa.
2. Mr. R. H. Tedjokusumo, a delegate to Asia Pacific Forestry Commission, New Delhi.
3. Mr. E. W. Massey, Ranchi Agricultural College, Kanke.
4. Mr. M. R. Mundoch, Sydney, Australia.
5. Mr. & Mrs. Orion Woolrey, U.S.T.C.M. University of Missouri, U.S.A.
6. Dr. P. B. Sarkar, Director, Technological (Jute) Research Laboratories, Calcutta.
7. Dr. V. Cadambe, Director, Central Mechanical Engineering Research Institute (C.S.I.R.), Durgapur (West Bengal).
8. Major Sethi, Military Education Department.
9. Shri S. Bunnag, Information Officer, F.A.O., Regional Office for Asia and the Far East, Bangkok.

The President, Indian Lac Cess Committee, Dr. J. S. Patel, visited the Institute in February 1960. The following members of the Indian Lac Cess Committee also visited the Institute: Dr. L. C. Verman, Dr. S. L. Kapur, Sarvashri B. L. Singh, D. Mukherjee, B. L. Jaiswal, Gandharpanath Shahdeo, Sita Ram Singh, S. R. Rao, K. K. Kundu and C. R. B. Menon.

Roads and Buildings — Annual repairs to roads and buildings were carried out by the C.P.W.D., as usual.

Water supply — The over-head tank, which as reported last year has badly deteriorated, is still in service: a detailed plan for its replacement awaits implementation by the C.P.W.D.

Library — The number of books and bound volumes of journals accessioned during the period was 270. In addition, some 40 miscellaneous scientific publications and reports were also received.

The Institute mailed and distributed to various parties in India and abroad over 2,000 publications and reports of its own including propaganda literature, and sold some 35 publications.

Training — There were no fresh admissions to the training courses in lac cultivation or industrial uses of lac. Two Colombo Plan trainees from Burma, originally scheduled to undergo six months' training, had the training period extended to nine months; they completed their training during the year.

Staff — Shri Y. Sankaranarayanan was appointed (by selection) to the post of Organic Chemist and Shri T. Bhowmik as Shellac Utilization Officer vice Shri Y. Sankaranarayanan.

Shri P. R. Bhattacharya, Physical Chemist was admitted to the Ph.D. degree of Banaras Hindu University during the year.

Other details about the staff will be found in Appendix M.

Indian Lac Cess Committee Staff Club — The staff club continued to function as usual with a part of its expenses being met by a grant from the Indian Lac Cess Committee.

ENTOMOLOGY DIVISION

(Dr. S. Krishnaswami, Entomologist)

I—GENERAL

Introduction — Progress was maintained during the year on all the research items under investigation both at the main Laboratory, Namkum and at the Regional Field Research Stations. A Third Regional Field Research Station was opened towards the close of the year at Mirzapur in U.P. for work on *ghont*, *palas* and *ber*. For the first time, genetical research on the lac insect through crosses and induced mutations through irradiations with the object of evolving superior strains of the lac insect was initiated. Also physiological studies were intensified and some progress was made in an attempt to grow the lac insect artificially.

Staff — Towards the later half of the year, all the posts of Research Assistants were filled while a few posts of Junior Research Assistants continued to remain vacant. All the newly recruited staff were given the basic training in lac cultivation research.

Season — The weather conditions for all the four lac crops during the year were favourable. The summer of 1959 being comparatively mild, there was better brood survival and hence a big *Katki* 1959 crop which, in turn, is expected to produce a bumper *Baisakhi* (1959-60) crop.

The enemy insect infestation was somewhat mild in the *Katki* and the *Aghani* 1959-60 seasons.

IIA—RESEARCH AND INVESTIGATIONS

1. Improving Crop Production on *Palas* (*Butea monosperma*) by Partial Defoliation

(i) *Large-scale defoliation experiments at Kundri*

As usual demonstration of lac cultivation on a large scale was carried out at the Kundri forest where the trainees are given practical training in improved methods of lac cultivation. Besides the large-scale cultivation and the working out of economics, the effect of large-scale partial defoliation on the preservation of broodlac is also demonstrated in the summer crop.

The 1959 summer was fairly severe at Kundri and there was heavy mortality up to 90 per cent of the lac insects on an average.

The details of cropping operation and the expenditure on cultivation are given in Table I (Appendix A).

It may be seen that during the year a sum of Rs. 3,636.46 nP. was spent on the various cultivation operations and a total revenue of Rs. 5,927.62 nP. was obtained.

(ii) *Effect of partial defoliation of* palas *on brood preservation*

The experiment was continued for the second year in the 1958-59 *Baisakhi* season with the same experimental layout, i.e. there were two treatments, namely (i) partial artificial defoliation and (ii) no defoliation (control) under randomized block design with 10 replications. In each plot there were 25 trees of which the central 5 trees served as the experimental trees and the rest were border trees.

The crop data and the analysis of variance are presented in Table II (Appendix A).

It may be seen from the crop data that the ratio of brood used to brood yield was 1: 0·63 in the case of defoliation treatment as against 1: 0·50 in the case of control. The

corresponding figures of percentages of selected broodlac for defoliation and control treatments were 31·16 and 14·86 respectively, showing that the defoliation treatment has been helpful in the preservation of broodlac.

The crop data on the percentage of selected broodlac, and yield of broodlac were statistically analysed and the treatments were found to be significantly different.

Also mortality of the lac insects due to heat was assessed on two twigs selected at random from each of the experimental trees at the time of crop harvest. The results are summarized in Table III (Appendix A).

The results indicate that the percentage survival was 13·7 in the case of defoliation treatment as against only 2·14 in the case of control.

2. Preliminary Trials on the Evolution of Cultivation Practices

With the object of evolving cultivation practices that will ensure self-sufficiency in broodlac as also reduce the cost of cultivation, preliminary investigations were initiated for the first time this year.

Five plans of operations are under trial and under each of these plans, 500 trees were inoculated so that the crop performance based on these large-scale trials could be compared.

Details of the plans are as follows:

Plan Nos.: I. Trees inoculated heavily without any defoliation, partially cropped *ari* in April and completely cropped in Oct.-Nov.

II. Trees inoculated heavily without any defoliation, partially cropped in July and completely cropped in Oct.-Nov.

III. Trees inoculated very lightly, without any defoliation, allowed self-infection in July and completely cropped in Oct.-Nov.

IV. Trees inoculated medium light, without any defoliation, allowed self-infection in July and completely cropped in Oct.-Nov.

V. Trees inoculated medium light, after partial defoliation, partially cropped in July and completely cropped in Oct.-Nov.

The crop data are summarized in Table IV (Appendix A).

It may be seen that maximum lac crop was produced under Plan II, while maximum broodlac was produced under Plan III. Hence, for best results, a suitable practice based on both plans II and III will have to be devised.

3. Economics of Utilizing *Palas* for *Baisakhi* Crop only and *Ber* (*Zizyphus mauritiana*) for *Katki* Crop

The experiment was conducted on ten trees with each of the two species of trees in the *Baisakhi* 1958-59 as well as the *Katki* 1959 seasons at Namkum plantation for their relative performance both as crop producer and as brood preserver.

The crop data are given in Table V (Appendix A).

The results indicate that in the *Baisakhi* season *ber* is better than *palas* as a crop producer while *palas* is better than *ber* as a brood preserver. In the *Katki* season, however, *ber* was found to be better than *palas* in either respect.

The above results are in conformity with the findings in the previous years.

4. Comparative Preservation of Broodlac on *Ber* by Partial Pruning Before and After Infection

The experiment statistically laid out in 1957-58 was continued for the second year in the 1958-59 *Baisakhi* season. The treatments tried were: A — Partial pruning in

Oct.-Nov. before inoculation, B — Partial pruning in Dec.-Jan. after inoculation and C — Control. There were ten replications with one tree under each treatment, so that a total of thirty trees was required. The layout adopted is randomized block design.

The crop data are given in Table VI (Appendix A).

The brood yields were very poor and in good number of cases no yield of broodlac was obtained. Hence the crop yield data could not be statistically analysed. However, it may be seen in a general way that the pruning treatments before or after inoculation appear to be slightly better than the control, although in previous years no beneficial effect of the pruning was in evidence.

5. Finding of, and Trials as, Brood Preservers on Lac Hosts for *Baisakhi* Crop Including Certain *Ficus* and *Albizzia* Species and also Trials on Hosts Similar to Those Found in Thailand

In the *Baisakhi* 1958-59 season, the following different species of trees were inoculated with *palas* broodlac with the object of finding out suitable hosts as brood preservers:

Albizzia lebbek	...	5 trees
Albizzia stipulata	...	3 trees
Ficus glomerata	...	3 trees
Ficus glabella	...	3 trees

The first two species took larval settlement fairly well and the larvae thrived satisfactorily till the first moult; after which however, there was almost complete mortality.

Similarly nearly 80 per cent of the shoots of the *Ficus* species also took larval settlement quite well. Although initial mortality was low, the insects died in large numbers later on, finally resulting in very poor crop yields.

6. Proper Time of Harvesting for Maximizing Yield

The large-scale experiment on *palas*, started in 1956-57, was continued for the third year in the *Baisakhi* 1958-59 season with the same four treatments as in past years, namely:

I. Initial heavy inoculation and *ari* cutting in April.
II. Initial heavy inoculation and *ari* cutting in May.
III. Initial heavy inoculation and cropping at maturity.
IV. Initial light inoculation after partial defoliation and cropping at maturity.

The crop data are given in Table VII (Appendix A).

A comparison of the crop yields clearly shows that increased yields were obtained when the crop was harvested *ari* in April or May and not at maturity. In spite of a higher percentage of driage in the case of *ari* lac, the ultimate yield ratio is better for *ari* cutting in April or May. These results are generally in conformity with those of previous years.

7. Determination of Optimum Density of Larval Settlement on Various Hosts

The experiment is being conducted on *palas* and *kusum* (*Schleichera oleosa*) since 1957-58, in the *Katki* season for *palas* and *Jethwi* and *Aghani* seasons for *kusum*. To ascertain the optimum quantity of broodlac required for inoculations of these hosts in the different seasons, three brood rates under three treatments are being tried as follows:

Treatments: A — Half the normal requirements of brood.
B — *Normal requirements of brood.
C — Double the normal requirements of brood.

*Normal brood rate is taken as the quantity required to give satisfactory settlement over 25 times the length of broodlac sticks used for inoculation.

The layout of the experiment was randomized block design with ten replications, the number of trees per plot being one.

The experimental results and the conclusions drawn therefrom are summarized below crop-wise:

Katki 1959 crop on *Palas* — The trees took satisfactory crop inoculations but there was considerable initial mortality due to the shoots being not quite suitable. There was also further mortality later on due to the attack of predators and parasites, so that ultimate crop yield were poor.

The crop data and results of stick examination are shown in Tables VIII and IX (Appendix A).

Conclusion — Statistical analysis of crop data (yield of scraped lac) shows that the treatments are significantly different. Treatment C is superior to A and B which between themselves are not significantly different.

From the stick examination results it is clear that percentage larval mortality is reduced as the density of larval settlement increases. Similarly the percentage of males in the crop also increases with the increase in the density of larval settlement. These results confirm the previous findings.

Jethwi 1959 crop on *kusum* — The progress of crop was not quite satisfactory right from the beginning. Initially, the larval settlement was comparatively poor, later there was an attack of *Chrysopa species* with the result that the crop yields were rather poor.

The crop yield data as well as the results of stick examination are furnished in Tables X and XI (Appendix A).

Conclusion — The yield of scraped lac was statistically analysed and the treatments were observed to be different. It was seen that treatment C differs significantly from treatments A and B which between themselves do not differ significantly.

Results of stick examination confirm again the previous findings, namely, decreased larval mortality and increased male percentages at denser settlements.

Aghani 1959-60 crop on *kusum* — The crop inoculation was carried out successfully and all the shoots of the experimental trees were properly covered with larval settlement. The crop, however, suffered to some extent owing to predatory enemy insect attack.

The crop yield data as well as the results of stick examination are given in Table XII and XIII (Appendix A) respectively.

Conclusion — Statistical analysis of the yield figures (scraped lac) shows that the Treatment C differs significantly from A, while A and B as also B and C do not differ significantly between themselves.

The results of stick examination again show the same trends as in the previous two experiments.

8. Determination of Optimum Density of Larval Settlement and Proper Time of Harvesting for Maximizing Yield on *Palas* in the *Baisakhi* Season

The two factors, namely the three different brood rates and the three different times of harvest have been combined in this experiment on *palas* in the *Baisakhi* 1958-59 season, so that a total of nine treatments is under comparison. There were four replications with one tree under each treatment and laid out under randomized block design.

The experimental details are as follows:

Treatments	*Replication*	*No. of trees per plot*	*Total No of trees*
Times of harvesting and brood rates			
1. Reaping *ari* in April and half the normal brood rate 2. Reaping *ari* in April and normal brood rate 3. Reaping *ari* in April and double the normal brood rate 4. Reaping *ari* in May and half the normal brood rate 5. Reaping *ari* in May and normal brood rate 6. Reaping *ari* in May and double the normal brood rate 7. Reaping at maturity and half the normal brood rate 8. Reaping at maturity and normal brood rate 9. Reaping at maturity and double the normal brood rate	× 4 ×	1 =	36

The crop data and statistical analysis of the same are furnished in Table XIV (Appendix A). The results of stick examination are shown in Table XV (Appendix A).

Conclusion — Statistical analysis of the yield figures shows that both the times of harvest and brood rates differ significantly amongst themselves. As regards the brood rate, the three brood rates, namely 'half normal', 'normal' and 'double normal' differ significantly from each other.

Stick examination results under this experiment also confirm the findings that increased rates of larval settlement tend to reduce the natural mortality while the male percentage tends to increase with the increased density of larval settlement.

9. Growing of Lac Crops Under Crop and Bush Conditions

During the year trials were conducted mainly with *arhar* (*Cajanus cajan*) as a crop and *Moghania macrophylla* and *Albizzia lucida* as bushes.

(i) *Under crop condition* — During *Jethwi* 1959 crop season, *kusum* strain was tried for the first time on *arhar* plants. The initial larval settlement and development were quite satisfactory and the crop progressed well from January to April. From April onwards irrigation was resorted to to prevent wilting of plants but, in spite of the irrigation, large number of plants started drying up being unable to stand the summer heat. Out of 260 plants inoculated, only 104 survived, giving a brood to brood ratio of 1: 0·52 and a brood to yield ratio of 1: 2·12.

The small quantity of brood obtained was used to inoculate *arhar* in the *Aghani* 1959-60 season, but a very heavy parasite and predator attack completely destroyed the lac crop.

(ii) *Under bush condition* — *Moghania macrophylla* having been established as a successfull alternative host for cultivating the *kusmi* lac, further experiments on its inoculation with the progeny bred continuously on it as also progeny alternated with *kusum* were done. Observations made on the growth of the bushes indicated that the shoots mainly grow between March and September. Further the bushes were ready for inoculation with suitable shoots one year after the previous harvest.

During the year, both *rangeeni* and *kusmi* strains were raised on this species in all the four crop seasons. The results are summarized in Table XVI (Appendix A). It may be seen that the *rangeeni* strain generally fared well in this season. The *Aghani* crop which developed very well, however, suffered a serious enemy insect attack and hence the crop yields were somewhat poor. The *Jethwi* crop suffered due to severe initial larval mortality and poor larval settlement.

Cross infections — With a view to ascertaining whether the *kusum* progeny raised on *Moghania macrophylla* can be successfully alternated on *kusum* trees, trials were conducted on the inoculation of *kusum* trees with the *kusmi* strain progeny from *Moghania* bushes. The development and crop progress were satisfactory on *kusum* trees although the predator attack interfered with the final yield. Small quantity of brood obtained was again used to inoculate the *Moghania* bushes and the resulting crop was found to maintain the characteristics of the *kusmi* strain, in respect of the crop durations and morphological appearance of the lac cells and encrustations.

Bushes of *Albizzia lucida* carrying one year-old shoots were inoculated with *rangeeni* and *kusmi* strains in *Baisakhi* 1958-59 and *Jethwi* 1959 seasons, and they carried successful crops. The crop data are given in Table XVII (Appendix A).

It may be seen that *Albizzia lucida* can be developed as a suitable alternative host for *kusmi* strain to raise the *Jethwi* crops.

10. Control of Enemies of Lac During Storage by Use of Insecticides

The experiment was conducted on the same lines as in previous years with the *Baisakhi* (1958-59) crop. Known quantities of lac sticks and scraped lac obtained from similar quantities of lac sticks were treated with the following insecticides and fumigants soon after the harvest. There were suitable controls for comparison. The treated and control lots were caged and emergence of insects recorded daily till emergence ceased.

Insecticides:

Dusts

Aldrex 2 per cent
Aldrex 5 per cent
Dieldrex 1·5 per cent
Endrex 1·1 per cent
Ekatox 2 per cent
} mixed with lac in the ratio of 1: 100.

Wettable powders and emulsion concentrates

Aldrex 40 per cent wettable powder
Dieldrex 50 per cent wettable powder
Ekatox 20 per cent wettable powder
Endrex 20 per cent emulsion concentrate
} Sprayed at 0·1 per cent strength.

Fumigants

Ethylene dibromide at 600 c.c. per 1,000 c.ft.
Trychlorethylene at 1½ lb. for 1,000 c.ft.
} Exposed for 48 hours.

Table XVIII (Appendix A) records the data on the emergence of insects from the control and treated lots.

The results show that the insecticidal treatments are effective particularly against the predators, Ekatox 2 per cent, Endrex 1 per cent and Aldrex 5 per cent dust being more effective than others. Also the two fumigants were found to be quite effective in controlling the enemy insects under storage conditions.

11. Survey of Lac Enemies and Their Parasites

(a) *Caging study*

During the year under report a few samples from the various field areas were caged and from among the insect emergences, four species of insects probably new, have been recorded. These will be identified in due course.

(b) *Non-insect enemies (birds, squirrels and other rodents)*

Towards the maturity of the *Aghani* (1959-60) crop, considerable damage to maturing lac from birds and rodents like squirrels was in evidence. The damage increased and continued to be more severe to the broodlac used on trees for inoculation, and this interfered with the inoculation. The extent of damage to broodlac sticks was, therefore, assessed at the time of *phunki* removal on a sample basis. The entire lot of brood bundles from six trees in each of the four plots selected at random in four blocks was examined to find out the length of lac encrustation damaged by these non-insect agencies : it was observed that as much as 53·6 per cent of the length of the brood sticks had been damaged.

12. Biological Control of Insects Enemies

(a) *Life-history studies and developing breeding techniques*

Work on *Apanteles tachardiae* and *Perisierola pulveriae* having been completed, attention was paid to the life-history study of *Apanteles fakhrulhajiae,* another Braconid parasite of *Holcocera pulveria.* The breeding technique followed was the same as that developed for *Apanteles tachardiae* and the parasites are being reared at 26°-27°C. and 70-80 per cent R.H. After several initial attempts the parasites were made to accept *Corcyra cephalonica* as an alternative host and from December onwards it could be bred artificially in the laboratory. From the studies so far made it was observed that the development period from the egg laying to adult emergence varied from month to month. The number of females bred also declined towards March. These figures are given in Table XIX (Appendix A).

(b) Mass breeding of *Bracon greeni* and *Apanteles tachardiae*

Bracon greeni — The mass breeding technique developed in the past having failed in the laboratory for the last few years attempts were made to improve the existing technique. In that connection, different foods and different alternative hosts were tried but without much success. However, supply of honeydew excreted by the lac insects, as food for the parasites, appeared to give some encouraging results as these parasites ovi-posited in the laboratory when so fed.

(c) *Large-scale liberation in the field and estimation of the effect of the liberation*

The large-scale field experiment on the biological control of predatory enemy insects is in progress since the *Jethwi* 1958 crop. There are four treatments in all as follows:

Treatments: A — Release of *Apanteles tachardiae* alone.
B — Release of *Bracon greeni* alone.
C — Combined release of *Apanteles tachardiae* and *B. greeni.*
D — No release (control).

There are five replications and the experimental layout is in randomized block design. Each plot contains 24 trees separated from the other plot by at least two furlongs so that there may not be interference from inter-plot flights by the released parasites. The trees in a plot are subdivided into four coupés of six trees each and are exploited for cultivation one by one every season by rotation.

Due to difficulties in rearing *B. greeni* in large numbers, the liberation of parasites was confined to *A. tachardiae* only. During *Jethwi* (1959) crop only 2,064 (1,165 males and

899 females) were released, because the breeding rate at the laboratory was poor due to extreme heat condition and the air-conditioning unit going out of order quite often. However, in the *Aghani* (1959-60) season, the breeding rate was considerably stepped up and as many as 13,089 parasites (8,408 males and 4,681 females) were released.

The crop yield data for the two crops are given in Table XX (Appendix A).

It may be seen that no perceptible difference in the yield figures is in evidence due to the release of *Apanteles tachardiae.*

Besides the yield, lac stick samples were also periodically collected and carefully examined in the laboratory for assessing the effects of parasite releases, but no significant difference in the populations of the enemy insects or the beneficial insects or in the extent of damage could be detected.

13. Rearing Lac Insects Through Artificial Feeding

The work on artificial feeding of the lac insect was initiated in June-July 1957 for the first time by trying to make the lac larvae feed on whole sap of the lac hosts. Both artificial substrates and severed portions of the bark of the *palas* tree were used as the base to settle the lac larvae on. While the insects lived and secreted lac for about three weeks on the bark in contact with plant sap, the attempts did not succeed on other artificial substrate base. There was considerable interference due to fermentation of the sap.

Simultaneously the feeding mechanism of the insect was also studied for a better understanding of the mode of feeding so that suitable artificial feeding technique could be devised.

The work which could not be pursued further due to lack of staff for some time, was, however, taken up on an intensive scale from June-July 1959 onwards and continued in Oct.-Nov. and Jan.-Feb. when lac larvae became available.

Attempts were made to prevent the yeast fermentation as also to find a suitable substrate for settling the larvae.

Phenol, mercuric chloride, salicylic acid, acetic acid and potassium metabisulphite were tried at strengths of 0·01, 0·06 and 0·1 per cent for the prevention of fermentation. These were successful only in delaying fermentation by two days beyond the usual duration of two or three days, during the monsoon period. Salycilic acid was found to be best of all the preservatives tried.

Pith and blotting paper coated with a thin layer of wax and also sponge rubber coated on the surface with wax were tried as substrates for settling larvae. But none of these worked and attempts to rear the insects artificially on whole sap failed, although the lac larvae thrust their proboscis into the substrates offered. Attempts were, therefore, once again made to verify the previous observations made in 1957 whether the insects can feed independently without the help of the living plant. Pieces of bark and even whole severed twigs were used to settle the larvae and to feed. It was observed that the insects could feed on the reserve food material available in the plant tissues, independently of the living plant, and in the case of green twigs which were kept moistened by dipping both ends in water to prevent the early drying of the twigs, the larvae could develop healthily up to the period of male emergence, i.e. for ten weeks.

The above studies finally established beyond doubt that the insects can feed independently of the living plant and that artificial rearing is possible if suitable alternative food could be found.

Besides the above, certain other interesting facts also came to light. The larval mortality was observed to be much lower in the case of larvae developing on such severed twigs than on the living plants which show active growth, confirming our findings relating to the

density of larval settlement and its relation to larval mortality. Further, this is a good laboratory technique for rearing lac insects without much larval mortality up to the stage of male emergence. This will be taken advantage of to study the effect of food on the sex, ratio in developing lac crops.

14. Genetical Studies on the Lac Insects

(i) *Irradiation studies on the lac insect with the object of evolving a superior-quality mutant strain.*

The work was initiated in the *Jethwi* 1959 season by having a *kusum* sapling inoculated with lac insects exposed to gamma rays in April at the Cobalt field of the Bose Institute, Calcutta. Due to a strong dose, the entire population of lac insects died on the sapling.

In the *Katki* 1959 season again, *rangeeni* strain of lac insects settled on two potted plants was irradiated ones again at the Bose Institute from 18-8-59 to 21-8-59. One plant received a dose of 1,166*r* which killed all the insects and even the plant was affected. The second plant received a dose of 130*r* and survived with no apparent damage to lac insects and the plant. The surviving lac insects were under observation but they could not reach crop maturity, as all of them were attacked by parasitic enemies and died within a month of irradiation.

In the *Jethwi* 1960 season, however, instead of inoculated plants, maturing broodlac, cut two to three weeks prior to larval emergence, was got irradiated with varying doses of gamma rays from Cobalt 60 ranging from 100*r* to 5,000*r* at the nuclear reactor in the U.S. Pavilion, World Agricultural Fair, New Delhi on 28-12-59.

The doses tried were 100*r*, 200*r*, 300*r* 400*r*, 500*r*, 1,000*r*, 1,500*r*, 2,000*r*, 3,500*r* and 5,000*r*. Three nine-inch long healthy broodlac sticks were selected for each dose and three untreated broodlac sticks were kept to serve as control. The control and treated broodlac sticks were used to inoculate *Moghania macrophylla* bushes on 3-1-60.

The following observations were made: Doses up to 500*r* did not appear to affect the larval emergence from the treated brood sticks. There was gradual reduction in the larval emergence with further increase in the dosage. In the case of 3,500*r* treatment, only seven lac larvae emerged which also died soon after settlement. There was no emergence at all from 5,000*r* treatment.

The development of the insects also appeared to be somewhat slower.

(ii) *Cross breeding of the* rangeeni *and the* kusmi *strains*

First attempts were made in the *Katki* (1959) season to effect crosses between the *rangeeni* and the *kusmi* strains with the object of improving the quality of the *rangeeni* strain. Crosses were effected with insects developing on potted plants, by crossing *rangeeni* females with *kusmi* males. Only three insects finally survived and three potted plants were inoculated with the F_1 progeny. The *Baisakhi* crop is still in course of development.

In the *Baisakhi* season, again further crosses were made in the field on a large scale by getting *rangeeni* females mated with *kusmi* males on 36 shoots of *palas* trees at the Institute plantation. The crossed females are continuing to develop normally.

IIB—REGIONAL FIELD RESEARCH STATIONS

1. Jhalda (West Bengal)

(i) *General*: The field area was fenced and further developed by clearing bushes, etc.

(ii) *Research*

(a) *Investigations on the spurious emergence of lac larvae*

With a view to ascertain the causes of spurious untimely emergence of lac larvae, the following mixed and cross inoculations are being tried on *kusum* trees:

A — Inoculation of trees with *kusum* (pure strain) brood.
B — Inoculation with *ber* brood.
C — Inoculation with *palas* brood.
D — Mixed inoculation of *ber* and *kusum* brood in equal proportions.
E — Mixed inoculation of *palas* and *kusum* brood in equal proportions.

During the *Jethwi* 1959 season, the progeny from E treatment from the *Aghani* (1958-59) crop was used to inoculate one tree. The rest of the trees under the above treatments were inoculated with *kusum* brood. Regular observations were made on the progress of crop as also for any early larval emergence. Periodical examination of lac stick samples were also carried out.

There was no early larval emergence in this season anywhere. The crop showed some heat mortality in May 1959. The crop was satisfactory and a brood to yield ratio of 1 : 2·61 was obtained.

For the *Aghani* 1959-60 crop, however, all the inoculations under the various treatments could be made. There were eight trees under each of the treatments A, D and E, and only five trees under each of the treatments B and C. It was generally observed that cross inoculation with *ber* and *palas* brood either alone or mixed with *kusum* brood resulted in the larvae dying out in large numbers at the initial stage itself.

The few surviving ones of the *rangeeni* strain also ultimately died out. The crop on the whole was observed to develop rather faster in this season and male emergence was in evidence within seven weeks of larval settlement. Further the untimely early emergence in the fourth week of October (October 20th) was observed to take place on almost all the trees under all the treatments indicating that this phenomenon is directly related to seasonal conditions and not due to mixtures or cross inoculations. Some of the trees showing vigorous emergence necessitated the harvest being undertaken in October itself. Wherever there was only limited partial emergence, the trees were left uncropped which showed regular larval emergence in December (17th December 1959).

Attempts were made to isolate this early emerging brood as a pure strain and crops were raised with the early emerging brood. The resulting crop progressed well and attained maturity towards the end of April, although the brood survival was very poor.

Examination of samples of lac sticks was carried out to assess the extent of maturity among the insect population with completely mature embryos. It was found that the percentage of cells that showed complete maturity ranged from 2 to 12·3 per cent.

(b) *Alternative lac hosts for the* kusmi *strain*

Experiments were continued with *Bursera serrata, Dalbergia latifolia, Ficus infectoria, palas* and *ber*. The new hosts as well as *kusum* were alternated in one set of experiments, and in another set, the *kusum* progeny was tried continuously on the new hosts to see if the performance of the resulting crops is satisfactory in respect of both yield and crop durations.

The crop data are furnished in Tables XXI and XXII (Appendix A).

2. Damoh (Madhya Pradesh)

(i) *Research*

(a) *Response of* ghont (Zizyphus xylopyra) *to pruning*

The experiment laid out last year for evolving suitable pruning methods for raising *Katki* and *Baisakhi* crops on *ghont* were continued.

Details are as follows:

Katki crop (1959)

Treatments: A — Pruning in 1st week of December } Exploited
B — Pruning in 2nd week of February } every year
C — Pruning in 2nd week of May } Exploited in
D — Pruning in 2nd week of May } alternate year

Number of trees under each treatment: Five comparable trees.
Number of replications: Ten.
Layout: Randomized replicated block design.

Baisakhi crop (1958-59)

Treatments: A — Pruning in the second week of April.
B — Pruning in the third week of April-May.

Number of trees under each treatment: Five comparable trees.
Number of replications: Ten.
Layout: Randomized and replicated block design.

After pruning, ten trees under each treatment were kept under observation and the shoots developed from them were measured at fortnightly intervals.

The results obtained are summarized below:

Katki crop 1959 — For the *Katki* 1959 crop (inoculation in July 1959), the growth of shoots by the time of inoculation in the three treatments was as follows:

Trees pruned in December 1958 put forth buds by the 3rd week of January 1959, i.e. three weeks after pruning and ultimately produced 28 primaries and 187 secondaries and numerous tertiaries. In the case of trees pruned in February 1959, i.e. two months later the buds appeared by 1st week of March 1959, i.e. approximately two weeks after pruning and a week earlier than those pruned in December 1958; these buds developed into primary shoots averaging 32 per tree with 226 secondaries and nearly as many tertiaries.

On the other hand from trees pruned in May 1958 buds appeared very late, i.e. about five weeks after pruning and developed into primaries which gave rise to secondaries. However, from May-pruned trees, much longer and more numerous shoots developed which did not give rise to any tertiaries although these shoots were the oldest.

The crop yield does not indicate at the present moment which treatment is the most suitable.

Katki 1960 — During the current year, pruning for *Katki* coupé in treatments A, B and D has been done for raising *Katki* 1960 crop. In shoot growth they show the same trend, details will be reported later.

Baisakhi crop 1958-59 — Following pruning in April and May 1958, inoculation for the *Baisakhi* crop was done in November 1958 and the crop was harvested in July 1959.

Almost an equal number of shoots was put forth by the trees under both the treatments in the case of trees pruned earlier although the average length of primaries was less, the ratio of yield of lac was better.

Table XXIII records the growth of shoots under different treatments during *Katki* 1959 and *Baisakhi* 1958-59.

Baisakhi crop 1959-60 — Pruning was done in April 1959 and May 1959. Up to the time of inoculation in October 1959, more numerous shoots developed from those pruned earlier, these shoots were also longer. It was observed that the condition of the crop to be harvested in July 1960, was better in treatment A.

(b) *Trials of regional hosts to find out their suitability to fortify lac cultivation on* ghont

Under-mentioned species occurring locally were selected for trial as hosts, and preliminary experiments to grow the *Katki* and the *Baisakhi* crop have been planned on a

small scale in which five trees of each species are to be used. Necessary pruning of these trees was carried out with subsequent inoculation. The species selected are: (1) *palas*, (2) *ber*, (3) *airma* (*Acacia sp.*) and (4) *renja* (*Acacia leucophloea*). The pruning schedule of these trees is similar to that stated in section (i) (a) (supra). Regular observations were taken for larval settlement, survival, mortality, development of insects, etc.

(c) *Investigations on the preservation of broodlac*

Following the preliminary trials carried out last year details of a layout on the basis of randomized block design for the experiment were worked out. The other details are similar to those being followed at Namkum.

Necessary pruning and inoculation have been carried out for the *Baisakhi* 1959-60 crop for all the three treatments A, B and C; only pruning has been carried out for *Katki* 1960 crop. There are 450 trees in all for the three coupés @ 150 for each coupé.

(d) *Evolution of a suitable cultivation practice to be followed for* ghont

A new experiment was initiated in the current year: the object is to take one full *Katki* crop only in each year grown as a result of self-inoculation in June-July from the preceding *Baisakhi* crop. For this purpose 500 *ghont* trees in compartment No. 105 and 200 trees in compartment No. 109 have been kept apart.

(e) *Comparison of performance between trees situated in open tracts and those in shaded areas along tank bunds*

Crop was raised in the shaded areas (shade being provided by existing Teak plants) and relatively open tracts (afforestation plot having no shade). The following observation was made.

Baisakhi crop 1958-59 — Three brood rates, viz. (1) normal (1 : 25 — approximately 1 kg. of brood per tree), (2) medium (1 : 50 — approximately ½ kg. of brood per tree), (3) light (1 : 100 — approximately ¼ kg. brood per tree) were tried.

The trees in open tracts produced more shoots than those in shaded areas, but more and better crop was obtained from the latter areas. Maximum brood was obtained from (1), i.e. from use of normal brood rates.

Katki crop 1959 — The same three brood rates as above were tried in this crop.

No dependable conclusion could be drawn; however, the trees in the open tract fared better in crop production.

(ii) *Introduction of new hosts for brood preservation* — Raising of exotic species:

In addition to *Albizzia lucida* and *Ougeinia dalbergioides* which were transplanted last year, *Moghania macrophylla*, and *Samania saman* were raised in the nurseries during the year and transplanted during the rainy season.

3. Mirzapur (Uttar Pradesh)

(i) *General* — The Third Regional Field Station, namely at Mirzapur, as part of the Second Five Year Plan, started functioning from February 1960 when the office and laboratory accommodation was secured. Prior to this the experimental field area had been located and all the preliminaries connected with the marking, coupéing, pruning, etc., had been carried out. Except two laboratory helpers, all the staff required for the station were appointed during the year. Equipments, etc., are being provided.

The area itself, at some distance from the field headquarters, has three species of hosts, viz. *ghont*, *palas* and *ber* in fair numbers.

(ii) *Research* — The following experiments have been laid out:

(a) *To study the response of* ghont *to pruning to grow lac crops and systematic cultivation of lac on this host*

The layout based on randomized block design has been done by selecting 400 *ghont* trees divided into three coupés: *Baisakhi* coupés I and III with 100 trees each and *Katki* coupé II with 200 trees.

Two different times of pruning have been decided upon to find out the proper time for pruning which will result in maximum growth of infectable shoots for *Baisakhi* crop. Thus the treatments A and B will have pruning in April and May respectively. Each treatment will be carried out on a unit of five trees with ten replications. The two *Baisakhi* coupés will be exploited in alternate years.

Likewise in the *Katki* coupé to be exploited every year, the pruning treatments will be slightly different, viz.

A — December pruning } To be used every year.
B — February pruning }
C — May pruning } To be used in alternate years.
D — May pruning }

Each treatment will be tried on five trees as stated earlier and there are ten replications in each treatment.

The pruning as detailed above has been carried out and by the middle of March buds appeared on trees pruned in February. Buds appearing from December pruning dried up.

(b) *To determine the optimum density of larval settlement on* ghont

For this experiment two *Baisakhi* coupés I and III and one *Katki* coupé II having 150 trees in each have been formed and after necessary pruning inoculation will be carried out with three brood rates on the same lines as described in Part II, para 7 for *palas* and *kusum* at Namkum.

Each treatment is applied on five trees with ten replications.

III — PLANTATION AT NAMKUM

General maintenance of the plantation was looked after. Irrigation pipe lines laid out last year were mainly used for irrigating the bush crop, *Moghania macrophylla*. Regular weeding and hoeing were carried out to keep down the weeds and provide good soil in a mulched condition. Pits have been prepared adjacent to our plantation nurseries for planting *Moghania macrophylla* in the coming rainy season and for manural and other sylvi-cultural experiments during the coming year. Those pits which had been dug in the *kusum* plots last year, seeds of *M. macrophylla* were sown during the rainy season of the current year, the plants are growing well. It is expected that these plants will be ready for inoculation in 1962.

A large number of seedlings of various lac hosts was raised in nurseries both for filling up gaps in the plantation and for potting for experimental studies. *Crotolaria saltiana* was also raised all the year round for a constant supply of its pod borer (*Etiella zinckenella*) for the laboratory breeding of parasites.

Termites, infesting the plantation area, were kept down by application of insecticides.

IV — TRAINING AND ADVISORY SERVICE

1. *Training* — During the year no new trainees joined.

In the begining of the year, four were on the roll — one of them was relieved in April, and of the remaining three — two left in June, and the last one in early August after completing the course.

No Instructors were deputed at this Institute for a short course training under the scheme of training Instructors from the Extension Training Centres. However, lectures in lac cultivation were delivered to the Extension Trainees in Betul.

During the year lectures on improved methods of lac cultivation and practical demonstrations in certain cases where opportunities were available, were given to the Forester Training Schools and Forest Guards Training Schools at each of the following places: Balaghat, Betul, Govindgarh, Angul, Chaibassa (two batches) Koderma and Kathikund, Mahilong (two batches) and Betla.

Lectures were also delivered to students of II year Agricultural class at Kanke Agricultural College and students of Government Basic Agricultural School, Kanke.

2. *Advisory* — As usual technical advice on lac cultivation was given to both private individuals and Government Institutions. A large number of samples of lac from various agencies including the Lac Extension Officer, Indian Lac Cess Committee, were examined and recommendations on technical points were made.

3. *Publicity* — Exhibits and literature on lac cultivation were sent to a large number of interested parties and Vigyan Mandirs.

As usual, large number of visitors including student parties were shown round the working and the activities of the Entomology Division.

Part was taken in a large number of exhibitions big and small in various parts of the country including that of the World Agricultural Fair held at Delhi from December 1959 to February 1960.

CHEMISTRY DIVISION

During the year under report work of the Division had to be carried on with depleted staff. Even so progress has been recorded in all aspects that were under study, viz. grading and analysis, refining and manufacture, fundamental studies such as the constitution and physico-chemical investigations, as well as utilization, extension and technical service.

1. Grading and Analysis

1.1 *Assay of sticklac* — One of the biggest gaps in the standardization of lac in various stages was the absence of a scientific method for the determination of the resin content of, and seedlac yield from, sticklac. This has now been made good by the formulation of a new method based on acid value. Attempts to make use of other factors such as volume displaced on immersion in a liquid and specific gravity were unsuccessful (*Indian Lac Research Institute Annual Report*, 1958-59, p. 26).

In the new method described in detail in Appendix 'C', a known weight of the sticklac sample is freed from dust, crushed to 40 mesh, sieved and the residual wood, bark, etc., separated. Ten gm. of the crushed sample is dissolved in 100 c.c. neutral alcohol, the insolubles allowed to settle and 5 c.c. of the clear solution pipetted out and titrated against standard decinormal alcoholic alkali. From the data obtained and the application of a single factor, the resin content and seedlac yield are calculated.

The method is simple and yields reproducible results. Statistical analysis of the results with 25 samples shows that seedlac yields determined by this method and those obtained by actual washing do not differ significantly.

1.2 *Determination of 'impurities' or matter insoluble in hot alcohol* — The most important analytical data for lac for trade purposes is the 'impurities' content, i.e. the matter insoluble in hot alcohol. The method at present in use is time-consuming — it takes two to three days for completion — and requires the use of thimbles which are comparatively costly and have to be imported. A new and rapid method for this determination has now been worked out which needs only ordinary filter papers in place of thimbles and can be completed in about four hours. The method is described in detail in Appendix D.

The results of 54 determinations by this new method as well as by the current (U.S.S.I.A.) method (Appendix B, Table I) were statistically analysed.

The method gave higher results in 34 cases, lower results in 19 cases and identical result in one case. The range of variation was from 0·34 to 0·26. The average difference was 0·0306 and the S.D. of the difference 0·1045. This gives 't' = 2·15166 which is significant at 5 per cent level, that is, two methods give significantly different results. A further batch of samples is being examined for confirmation.

1.3 *Bleach index/Bleachability* — Nearly half the total exports of lac from this country these days is in the form of seedlac, most of which goes to the United States. American importers purchase seedlac on the basis of a bleach test which is the second most important test in lac analysis — next only to "impurities". The method currently in use is the one developed by the U.S.S.I.A. and involves the use of a 'standard' seedlac obtainable from that organization or its representative and also requires slightly different procedures to be followed for different grades. A "universal" method which also avoids the need of 'standard' seedlac was developed by the Indian Lac Research Institute a few years back [Sankaranarayanan. Y. and Bose, P. K., *J. sci. industr. Res.*, **13B** (1954), 506-512]. On the recommendations of the I.S.O. T.C./50 bleach indexes of seven samples of seedlac were determined by this method as a round robin test in a few laboratories in the U.S.A., U.K. and India and in one Laboratory in France. The results received, showed on statistical analysis, wide variations (from one laboratory to another) except for

those in India. The discrepancies were explained as due to difficulty in matching the colour of the bleached lac solution against $N/1000$ iodine in a Dubosq colorimeter. One of the suggestions made by more than one of the above laboratories was to use a photo-electric colorimeter for the colour matching in place of a Dubosq colorimeter. The study has been taken up.

2. Refining and Manufacture

2.1 *Improved method of lac washing* — The first step in the refining of sticklac into seedlac and shellac is to wash the former with water to remove all water-soluble materials including lac dye. A small amount of washing soda is generally used particularly when the lac is dry, for easier removal of the dye. The Indian Lac Research Institute had developed an improved washing process making use of caustic soda and borax and the Shellac Export Promotion Council claimed to have developed another using ammonium oxalate (private communication). On the recommendations of the Committee a comparative study was made of these two washing methods *vis-à-vis* soda washing. Five lots each of 17·5 kg. (20 seers) were washed by each of the three processes and the yield of seedlac, its bleach index and impurities determined in each case.

The results (Appendix B, Table II) showed that taking an average of the data, the bleach index in the two cases under test were 5 c.c. lower than the soda-washed sample. There was not much to choose as regards the yield. But whereas ammonium oxalate and soda methods gave consistent and reproducible results-regarding bleach index, the results varied widely in the case of the caustic soda-borax method.

This requires re-examination and further standardization which has been taken up.

Regarding the ammonium oxalate method it was suggested that the method should be applied to seedlac and not to sticklac during washing and that the seedlac should be ground to pass through 20-30 mesh for the purpose. This was also tried, again (*vis-à-vis* soda washing) under the same conditions. It was found that (i) a considerable amount of dust (namely 33 per cent) was formed during the crushing of seedlac in the usual corn crusher to make it pass through 14-30 mesh, (ii) the washing with both soda and ammonium oxalate resulted in the lowering of bleach index by about 5 c.c. and if the dust had not been sieved off, the loss in yield was also nearly the same. If the dust were removed, however, there was practically no loss in yield by the oxalate washing.

2.2 *Bleaching of lac* — As a result of investigations commenced in 1954 it has been possible to determine conditions for the preparation of bleached lac of satisfactory keeping qualities. Bleached lacs prepared according to this improved method generally keep well for 9-12 months before showing any signs of deterioration such as slow filtration, increased insolubles, etc. Bleached lac by this improved method is now being produced regularly in the newly established Production Unit of the Institute and sold to the public. No complaint about quality has so far been received from practically any of over seventy parties who have purchased the material from us during the past 8 months.

Attempts were made to improve the material, if possible, still further, particularly with regard to keeping qualities, ' life ' and flow.

2.2.1 *Keeping quality* — It had been reported (*I.L.R.I. Annual Report,* 1958-59) that conducting the bleaching operation at 25°C. instead of the conventional 35°C. resulted in an economy of about 20 per cent in the bleach liquor requirement and that the chlorine content of the resulting bleached lac was also about 20 per cent less. It had also been observed that the less the chlorine content the better the keeping quality of bleached lac.

In order to see whether still lower temperatures would be of any advantage, the bleaching operation was conducted at 15°C. and 8°C. It was found that the bleaching at these lower temperatures was extremely slow. It took 43 hours and 109½ hours respectively at

these two temperatures as against about 10 hours at 25°C. and 7 hours at 35°C., besides, there was no saving in bleach liquor requirement or reduction in the chlorine content of the bleached lac produced. 25°C. would therefore appear to be the best temperature for the bleaching operation.

2.2.2 *Life and flow* — Although as indicated above, bleached lacs produced by the improved method have satisfactory keeping qualities, their 'life' (i.e. life under heat) and flow are usually poor. Typical samples have only a life of 10-15 minutes at 150°C. and most of them except those from *kusmi* seedlac do not flow at all. Even the bleached lac from *kusmi* seedlac flows only extremely slowly. To see whether these properties could be improved in any way, samples were prepared with conditions changed one after the other, such as the amount of soda used for the seedlac extraction and precipitation of lac from the bleached solution portion-wise; (in addition the samples were also subjected to an after treatment with very dilute sodium bicarbonate and caustic soda to remove the last traces of chlorine and mineral acid, if any. None of the treatments produced the desired result. Conducting the bleaching operation in the absence of light was also found to be of no advantage (Appendix B, Table III).

The use of other antichlors and also of bleach liquor of different free alkalinities (*p*H) is being investigated.

2.2.3 *Pilot plant for the manufacture of bleached lac* — Some of the units of the bleached lac pilot plant (output capacity about 40 kg. per day) which was on order were received during the year under report. Two of them were put into use.

(i) The centrifuge which has been put to use was found to be capable of handling 5 to 10 kg. per charge depending upon the moisture content of the bleached lac. The operation required about 30 minutes. The moisture content of the centrifuged bleached lac depended upon the temperature to which the lac had been exposed. Lac precipitated at 20°C. and further untreated retained a moisture equivalent of 200 per cent on the dry material. If however, before centrifuging the precipitated lac was warmed up to 40°C. for 10 minutes the moisture retained in the centrifuged material was only 40 per cent. This was accompanied by a slight change in apparent colour but the colour index remained unchanged.

(ii) *The dryer* — Bleached lac was dried in the electrically heated thermostatistically controlled drying oven. A layer of moist bleached lac (as obtained from the centrifuge) was spread as a layer 17 mm. (0·75 inch) thick on the aluminium tray and dried: 18 hours at 40° ± 2°C. was found to be sufficient for bringing down the moisture content from 40 to 2-3 per cent. A little raking in the initial stage was beneficial and avoided the possibility of lump formation. Each tray 60 cm. × 90 cm. could hold about 2·5 kg. of the bleached lac (on dry basis). The colour of the dried material appeared to be a little creamy as compared with that of the air-dried material but here again the colour index remained unaffected. Drying at lower temperatures is being tried.

2.2.4 *Mechanism of bleaching* — As has been mentioned earlier, the chlorine content of bleached lac appears to govern its keeping qualities. If this be so, a bleached lac without any chlorine content should show a great improvement in this respect. Reference to literature, however, indicates that according to some (Gidwani B. S. and Kamath N. R., *Ind. Chem.*, **22**, 1946, 414-19), bleaching of lac is due to chlorination so that a certain amount of the halogen in the resulting lac is unavoidable. This would naturally preclude the possibility of any chlorineless bleached lac. It was, therefore, considered desirable to verify the accuracy of the above view before proceeding any further.

It was observed that all samples of bleached lac prepared under the improved conditions contained chlorine and that the amount varied from 1 to 1·4 per cent for lac of bleach index 60 to 100. Experiments were therefore carried out, in which the same sample of seedlac was bleached with different amounts of bleaching liquor: It was found that for the same seedlac the chlorine content of the bleached lac depended upon the amount of bleach

liquor used. The same seedlac was then bleached to the same shade by carrying out the bleaching operation at different temperatures (35°C. and 25°C.) and consequently with different amounts of bleach liquor. The chlorine contents were found to be different and again dependent upon the amount of bleach liquor used. Thus it was possible to produce, starting from the same seedlac, bleached lacs of the same shade but different chlorine contents. A justifiable inference is that chlorine content (chlorination of the resin) is not directly related to the colour discharge (bleaching).

Next, the progress of colour discharge (bleaching) and chlorination of the resin were determined by treating seedlacs with different amounts of bleach liquor and precipitating out the lac after specific durations. It was found that the progress of colour discharge was not identical with that of chlorination. The maximum chlorination took place much earlier than the maximum colour discharge. As a matter of fact for some time the colour discharge was going on while at the same time the chlorine content was coming down. This would indicate that chlorination of the resin and bleaching (colour discharge) are two independent reactions taking place side by side obviously at different speeds. By altering one condition at least, viz. temperature, it is possible to shift the reactions involved away from chlorination towards bleaching thus providing additional support to their mutual independence.

Next lacs with different intensities of colour (colour index) were treated with the same amount of bleach liquor with the expectation that if the colour discharge was due to chlorination, the chlorine content of bleached lac from these lacs should be in proportion to their original colour (intensities). It was found that this was not only not the fact but on the contrary the lac with the lightest colour had taken up the most chlorine and darkest the least. The following tentative conclusions appear to be justified.

(i) Bleaching of lac is not related to the chlorine in-take of the resin, (ii) Bleaching (colour discharge) and chlorination of the resin are two independent reactions taking place side by side perhaps at different speeds, (iii) The extent of chlorination of the resin depends only upon the amount of chlorine (hypochlorite) present and not upon the colour of the starting material.

If these are confirmed, there is the possibility of preparing a hypochlorite bleached lac free from cholorine or at least with much less chlorine than at present with a corresponding improvement in keeping qualities.

2.2.5 *Fractionation of bleached lac* — In order to see if lac undergoes any major change in its constituents during bleaching and also how the chlorine is distributed, bleached lac was fractionated using low temperature fractionation technique with dry acetone as the solvent. The bleached lac used was wax-free and had been prepared from *kusmi* seedlac having a bleach index of 84. The yield was 85 per cent.

The various chemical constants together with percentage of different fractions are given in Table IV.

A comparison with Appendix B, Table V will indicate that in bleached lac, the different fractions are present more or less in the same proportions as in dewaxed, decolorized lac. Chlorine was found in all the fractions.

2.3 *Recovery of dye-products*

2.3.1 *Lac dye* — The precipitation and recovery of crude lac dye by sulphuric acid treatment of lac wash water as well as a method of refining this crude dye into a technical grade of 70 per cent purity has been reported already. (*I.L.R.I. Annual Report*, 1958-59).

The refining process of the crude dye which involved dewaxing with white spirit, extraction of the dewaxed material with 0·1 per cent borax solution and precipitation of the borax solution with dilute sulphuric acid was further improved during the year under report. Soxhleting with white spirit was adopted in place of hot extraction on an open

pan, which resulted in considerable saving in white spirit. The process could be improved still further by the use of *n*-hexane in place of white spirit. But with hexane, a soxhlet extraction preferably in conjunction with a solvent recovery unit has to be used to reduce the loss of the low boiling solvent. The improved process is described in detail in Appendix E.

2.3.2 *Dyeing of wool and silk with lac dye* — After a series of experiments, conditions were standardized for the dyeing of wool and silk in different shades with our technical grade lac dye. The method is described in Appendix E. The dye was also found suitable for dyeing jute. (For steps taken to study the market and popularize lac dye, *see* 6.1.)

3. Fundamental Researches

3.1 *Constitution studies — Separation and study of the constitution of the various components of shellac*

The present work on the constitution of lac was started in 1947. Uptil now two new constituent acids, viz. butolic acid and an aldehydic acid have been isolated. Paper chromatographic studies of seedlac and shellac were also carried out which have revealed the presence of at least seven acid constituents in these. Simpler methods were also worked out for the isolation of butolic acid and shellolic acid.

3.1.1 *Isolation of shellolic acid* — The isolation of dimethyl shellolate from the alcohol-insoluble lead salts of hydrolysed lac has been already described (*I.L.R.I. Annual Report*, 1958-59). During the year under report the isolation of shellolic acid from this ester was standardized. This consisted in saponifying the ester by means of aqueous alkali, neutralization of the resulting solution with an exactly equivalent amount of sulphuric acid and allowing to evaporate to dryness at room temperature. The residue was extracted with absolute alcohol and the extract allowed to evaporate slowly when colourless crystals of shellolic acid separated. M.P. 204°-205°C. with decomposition which was not depressed by admixture with an authentic sample.

3.1.2 *The aldehydic acid* — The presence of an aldehydic acid in hydrolysed lac to the extent of about 25 per cent has been already reported (*I.L.R.I. Annual Report*, 1958-59). Attempts to isolate the acid in the pure state had not been successful. The most promising way to purify it was through its lead bisulphite compound but the resulting product was contaminated with acetic acid (from the lead acetate used in the preparation of the compound). It has now been possible to prepare a purer product by dissolving it in alcohol, diluting the alcoholic solution with water till slight turbidity and then salting out with sodium chloride. Even this apparently purer acid could not be crystallized from water or alcohol nor could crystalline derivatives be obtained by treatment with hydroxyl amine hydrochloride or hydrazine hydrate.

3.1.3 *Fractionation of aleuritic acid* — Aleuritic acid is the first acid constituent of hydrolysed lac to be obtained in the pure state. Recrystallized from boiling water or aqueous alcohol, it forms colourless needles melting at 100°-101°C. By means of cold methyl alcohol it was possible to separate the crystalline acid into two fractions melting at 102·5°C. and 97·5°C. (*I.L.R.I. Annual Report*, 1955-56, p. 42). The relationship between these two fractions was now investigated. By oxidizing with potassium permanganate under boiling water temperature, the dibasic acids produced were identified as azelaic and pimelic acids by paper chromatography indicating that the two fractions were geometrical isomers.

3.1.4 *Butolic acid* — The isolation of butolic acid from the hydrolysis products of lac was first reported in 1949 [*I.L.R.I. Annual Report*, 1949-50, p. 20; *J. sci. industr. Res.*, **11B** (1952), 459]. It has now been found that butolic acid can be obtained from lac even without hydrolysis by repeated extraction of a 30 per cent alcoholic solution of (dewaxed decolorized) lac with excess of petroleum ether (60°-80°C.). The first extract

yields a semi-solid resinous mass in a yield of 3 per cent on the weight of lac, butolic acid crystallizing readily from the second, third and fourth extraction in a yield of 1·5 per cent. This would indicate that the major portion of the butolic acid content of lac (the total is 2·0 to 2·5 per cent) is present in the free state.

3.1.5 *Fractionation of lac resin* — Lac resin is known to be a solid solution of several inter- and intra-esters of hydroxy carboxylic acids of varying molecular weights. Several attempts have been made to separate these into simpler fractions by use of solvents in which the resin is only partially soluble, such as ether, toluene, chloroform, etc. The separation in such cases is quite laborious and often incomplete due to the swelling action of these solvents, which makes their further penetration of the solvent into the mass extremely difficult. Separation has also been effected by dissolving the lac completely in acetone and cooling down so as to allow a portion to separate out. Only one temperature (0°-5°C.) was used. The resin was thus separated into two fractions, viz. soft resin which was retained in solution, and pure resin that separated out. The advantages of separating complex mixtures like lac resin into as simple and homogeneous fractions as possible before subjecting them to chemical or other degradation are well recognized.

Temperature phase separation from acetone solution has been adopted for the purpose using arbitrarily fixed temperatures of 30°, 5° and —10°C. A 10 per cent solution of dewaxed decolorized shellac in boiling acetone was allowed to stand at 30°C. for 20 hrs. and the fraction that precipitated out was separated from the mother liquor by decantation and washing with fresh acetone at the same temperature. The combined mother liquor and washings were cooled to 5°C. and —10°C. successively and the fractions that separated similarly collected. What was retained in solution at —10°C. was reclaimed by distilling off the solvent.

It was found (Appendix B, Table V) that there was a progressive fall in the melting points and rise in the acid and saponification values of the successive fractions, perhaps indicating decreasing molecular size (weight). It was further found that the acetone should be dry for successful fractionation of lac by this method.

The first fraction (obtained at 30°C.) was further purified by redissolving in boiling acetone (to form a 10 per cent solution) and allowing to separate at 30°C. This process was repeated thrice for complete removal of all soluble fraction at this temperature. It was found that as more and more soluble fraction was removed, the residue became more and more insoluble even in boiling acetone. Ultimately the residue was extracted at boiling temperature in an extractor for four hours. The insoluble portion left was about 22 per cent on total lac and had a softening point 105°-108°C., melting point 118°-120°C. and acid value 52·8. It is worthy of note that no fraction of lac has so far been reported with such high softening and melting points.

Paper chromatography of the saponification products of the above fractions shows that the first three have more or less the same constituents whereas the fourth is somewhat different and has concentrated in it at least one constituent acid which is either absent or only faintly present in the other fractions.

3.1.6 *Fractionation of* palas *seedlac* — Although the above preliminary investigation was carried out on dewaxed decolorized lac, it was considered that future work should be based on a more dependable starting material. It was therefore decided to use only the seedlac obtained from *palas* sticklac by washing with water only, as *palas* lac constituted by far the major proportion of lac cultivated in this country.

Conditions were therefore re-determined for the fractionation of a representative sample of *palas* seedlac.

It was found that a concentration of 50 gm. of resin in 400 gm. of the solution was the most convenient and a minimum of 12 hours' keeping at the respective temperatures was necessary for complete separation of the fractions.

The yields and physical contents of the different fractions obtained under the above conditions are reproduced in Appendix B, Table VI.

In order to confirm that the above fractionation has only been a physical one and that no chemical damage has been caused to the constituents, lac was reconstituted from the above fractions by merely mixing or melting them together in their respective proportions and its film properties studied. It was found that the reconstituted lac, either by mere mixing or melting had film properties identical with those of the parent lac, confirming the absence of any change, chemical or otherwise by the fractionation. The work is being continued.

3.1.7 *Paper chromatography of seedlac* — Paper chromatographic studies were also carried out on the hydrolysed products of *kusmi*, *palas*, *ber*, *jalari*, *arhar* and *ghont* seedlacs. The chromatograms were all alike and showed at least seven distinct spots indicating that they were all more or less similarly constituted.

3.1.8 *Fractionation of lac by urea complexes from acetone* — The use of urea as an accelarator for lac is well known. It has already been pointed out that lac can be fractionated into three solid complexes with urea from boiling acetone solution (*I.L.R.I. Annual Report*, 1957-58, p. 15; ibid. 1958-59).

The properties of those different complexes, the whole shellac-urea complex as well as of lac resin fractions regenerated from these by removal of the urea with repeated boiling with water have now been determined (Appendix B, Table VII).

It was found that complex I, on standing showed a tendency to gradually become insoluble in butyl alcohol indicating some sort of progressive polymerization. Complex II and the whole lac-urea complex, on the other hand remained unchanged.

3.2 *Physico-chemical studies*

3.2.1 *Changes in the carbonyl value of lac during saponification* — Kamath and Mainkar [*J. sci. industr. Res.*, **14B** (1955), 560] reported that during saponification of shellac with 0·5*N* alcoholic alkali at room temperature, the carbonyl value gradually increases at first and then decreases. This observation was confirmed in respect of *kusmi* seedlac and shellac. It was found that the carbonyl value increased rapidly during the first half hour, and then slowly reaching a maximum of 55·4 for seedlac and 51·6 for shellac in 4 hours. Thereafter the values decreased steadily but slowly to 31·3 and 24·9 respectively in 48 hours. This would indicate that the carbonyl in lac is partly free and partly in the combined state, most probably as acylal. The reasons for the later decrease in the value are yet to be investigated.

3.2.2 *Infra-red spectra of lac* — The complete infra-red spectra* of dewaxed lemon shellac, dewaxed decolorized lac and dewaxed bleached lac were recorded over the range 2·5 to 15μ. The three spectra were almost alike. No evidence of chlorine was noticeable in the (chemically) bleached lac presumably because chlorine-containing materials show only weak absorption bands. The assignments that could be made out are primary and secondary hydroxyl, methyl, methylene, carboxyl, carbonyl unsaturation, chains of more than four methylene groups and substituted aromatic rings.

3.2.3 *Changes of carbonyl value during thermal polymerization* — It has been reported by Kamath and Mainkar [*J. sci. industr. Res.* (1955), **14B**, 272] that whereas fresh lac has a definite carbonyl value, the carbonyl value of lac polymerized by heat or ageing is nil. If this be so, carbonyl value may provide an easy way to determine the age of any lac. Experiments were undertaken to determine the rate of change of carbonyl value during thermal polymerization by measuring this constant for lac polymerized at specific temperatures

*These spectra were recorded during the visit of one of our officers to the Paint Researh Station, Teddington, England and functional groups assigned with the help of Dr. A. Biswas, Asst. Director, National Chemical Laboratory, Poona, to both of whom our thanks are due.

of 125°C., 150°C., and so on for specific periods such as 10, 20, 30 minutes till the rubbery stage.

It was found that the usual sodium sulphite method was not satisfactory in the case of polymerized lac as the end-points could not be perceived sharply either by use of an indicator or by a *p*H meter (*I.L.R.I. Annual Report*, 1958-59). The hydroxylamine hydrochloride method (*Analyst Chem.*, 22, No. 6, 1950, 750-755) was tried. The carbonyl value by this method was found to be within 70-80 which is much higher than the value obtained by other methods.

3.3 *Kinetics of thermal polymerization of lac* — The study of the kinetics of thermal polymerization of lac was continued. The samples of dewaxed lac (*I.L.R.I. Annual Report*, 1958-59) prepared by heating at different temperatures for different periods were dissolved in alcohol (94-95 per cent) to produce solutions containing 2 gm. of the resin per 100 c.c. solvent. These were then filtered and their viscosities determined at 35 ± 0·05°C. by means of an Ostwald capillary viscometer. From the data obtained (Appendix B, Table VIII) specific viscosities were calculated using the formula:

$$\eta_{sp} = \frac{t_2}{t_1} - 1$$

where t_2 is the time of flow of solution and t_1 that of the solvent.

It will be seen from the values of specific viscosities that polymerization of lac takes place progressively on continued heating and that the speed or rate of polymerization increases sharply when the sample approaches the completely 'cured' or rubbery stage. These observations are in general conformity with earlier findings.

4. Utilization of Lac

4.1 *Aqueous lac varnishes — Water-soluble lac* — The preparation of a water-soluble lac (by exposure of lac flakes to vapour of liquor ammonia) suitable for use as aqueous varnishes for earthenware has been described already (*I.L.R.I. Annual Report*, 1958-59). The keeping qualities of this lac were examined during the year under report. It was found that a sample sealed in an alkathene bag and stored in the laboratory has retained its solubility for nearly 1½ years so far. An identical sample kept exposed in an open vessel started becoming gradually insoluble within a month.

All the above experiments were carried out on dewaxed lac. Ordinary shellac and autoclave shellac were also tried. Whereas ordinary shellac gave dull films, autoclave shellac was found to be quite comparable with dewaxed lac and incidentally is also cheaper.

The work having been completed, production of water-soluble lac for sale to the public has been taken over by our newly set up Production Unit.

A paper entitled "Water-soluble lac and its use in aqueous varnishes for earthenware" has been communicated for publication.

4.2 *Shellac wash primers* — Shellac-based wash primers, both single pack and double pack, suitable for use on light metal surfaces were formulated and fully tested (including weatherometer tests) at the Paint Research Station, Teddington. The single-pack system was further examined for natural weathering by exposure of coated aluminium panels on a stand over the roof of our laboratory. The results, reported in the previous Annual Report, also proving satisfactory, a service test was arranged in co-operation with the authorities of the Carriage Workshops of the S.E. Railway at Kharagpur. One side of an aluminium coach was coated with a shellac wash primer (prepared and supplied from here) and the other side with a commercial two-pack primer (presumably based on P.V.B.) of a prominent manufacturer. After 24 hours, both the surfaces were painted on according to the Railways, usual schedule. It was reported that within a month of the coach being sent for service, the paints flaked off on both the surfaces. Our primer tested here,

however, had behaved quite normally. The possible reason for the failure is therefore either faulty application or the effect of the paint system applied over the primers. This is being looked into. Meanwhile Railway authorities have also been requested for facilities for a second experiment to which they have agreed.

[Shellac wash primer was simultaneously under test at the Hindustan Air Craft Factory, Bangalore and the Integral Coach Factory, Madras. The former reported after one year's trial that the sample satisfied all their tests except can-stability which is being looked into. The Integral coach factory reported that exposure trials were going on since May 1959 and that the results so far are satisfactory. Their tests would be completed within the next few months when they would send us a consolidated report.]

4.2.1 *Storage of wash primers* — For all the experiments so far, shellac wash primers were stored in glass bottles. As this is not a practical proposition for general purposes, the storage of these primers in metal containers was investigated. Samples were prepared and stored in (a) glass and (b) bright plate (tin) containers, in (c) tins coated in side by slushing with a catalysed cold-curing expoxy resin. The film properties such as drying and scratch hardness of these stored primers were examined at intervals of one month. There has so far (after three months) been no deterioration in any of the samples. The observations are continued.

4.2.2 *Accelerating hard drying time of the wash primer* — During the tests in the carriage Workshop of the S.E.Rly., it was reported that the primer was not drying hard enough in 24 hours for the further painting over. This was examined and it was found that the primer film reached its maximum hardness in 48 hours although the maximum hardness (1800 gm.) was not much higher than the hardness (1600 gm.) of the film after 24 hours' air-drying. Attempts were made to accelerate the hard drying by increasing the phosphoric acid content from 30 to 35 and 40 per cent, but without success.

4.2.3 *Shellac wash primer — two-pack system* — It was observed during the investigation at Teddington that shellac wash primer (two-pack system) based on zinc tetroxy chromate was distinctly superior to the single-pack composition in its general performance and weather resistance. Samples of zinc tetroxy chromate were received from two parties and these were experimented with for the two-pack primers. The results were inconsistent.

4.3 *Modification of shellac esters with polycarboxylic acids* — Shellac has been known to be capable of being modified with polycarboxylic acid or anhydride such as phthalic anhydride to yield hard brittle resins of high acid value. Due to progressive polymerization of the lac the reaction, however, cannot be continued long enough to reduce the acid value. Shellac esters show much less tendency to polymerize and are also soluble in hydrocarbon solvents, e.g. xylene, so that modification by these anhydrides may be carried out to a much larger extent. The products are also likely to be flexible and elastic. Accordingly butyl ester of lac (5 gm.) was treated with the calculated amount of phthalic anhydride (8 gm.) at 180° $\pm$ 5°C. in the presence of xylene (15 gm.) and in a stream of carbon dioxide. In the course of 3 hours, the acid value dropped from 109·6 to 38·10. The product was soluble in toluene and benzene but insoluble in alcohol. Further work is in progress.

4.4 *Storage of French polish in metal containers* — French polish (shellac varnish) is not generally packed in tin containers due to the corrosive action of lac on the metal (pin holes) and consequent darkening. Remedies to eliminate the difficulty have been suggested which are: (a) removing the more acidic portion of lac by alkali extraction, (b) neutralization of the acidity by modification with metallic oxides, (c) protecting the metal surface by waxes or lead coating or, (d) adding inhibitors like oxalic acid, triethyl ammonium phosphate, etc., to the varnish. The last has been found to adversely affect the film properties of the varnish.

(a) Portions of the more acidic (soft resin) portion of dewaxed lac were removed (i) by extraction in the cold of the very finely ground material with aqueous soda (0·1,

0·2, 0·4, 0·8 and 1·2 gm. per 100 gm. of the lac) and (ii) by dissolving the lac in dry acetone and cooling the (25 per cent) solution to −11°C. when the soft resin remains in solution and the rest of the lac gets precipitated. 25 per cent solutions of the resulting lacs in alcohol were stored in glass bottles (as control), in tins, and in a flask with an iron nail as an accelerated test. All the varnishes except those in glass bottles darkened within 2 to 2½ months.

(b) The acidity of a shellac varnish was reduced by refluxing with 0·5, 1·0, 1·5, 2·0 and 2·5 per cent magnesium oxide (*London Shellac Research Bureau Tech. Note*, No. 22). Magnesium oxide was chosen as this gave varnishes of the lowest viscosity. The treated varnishes were stored in tin containers but were also found to darken within two months.

(c) In view of the attempts being made to popularize the use of ready-made french polish and the consequent need of light, cheap and convenient containers for the purpose, several leading paint and varnish manufacturers were contacted for a convenient coating protection for the metal container which would resist shellac and the solvent alcohol. Epoxy resin, either baked or catalysed cold cured, was invariably suggested. Samples were received and tins were coated by slushing with a catalysed cold-curing enamel. After eight days' curing the tins were used for packing french polish, samples of which were also preserved side by side in untreated tins and in glass bottles for comparison. Whereas the polish in untreated tin darkened within a month, that stored in the expoxy-coated container has kept unchanged so far for about eight months.

A prominent firm of metal container manufacturers suggested that tin containers manufactured by them could be used for storage of french polish without any protective treatment. As our experience was otherwise, one gallon of a ready-made french polish has been supplied to them at their request for their experiments. Their report is awaited.

4.5 *Hydrolysed lac* — Hydrolysed lac (also sometimes referred to as saponified lac) by which is meant the water-insoluble portion of the resinous mixture obtained by hydrolysis of lac, has been found useful as a plasticizer for shellac for use in paper varnishes. The yield reported generally varies from only 60 to 70 per cent on the weight of lac used. The conditions of preparation of the same were therefore, standardized, attempting at the same time to recover the missing portion also. Under optimum conditions (described in Appendix G) the yield was 66-70 per cent, the material possessing the same acid and saponification values (205-206) indicating complete saponification. Evaporation of the mother liquor on the water bath resulted in the gradual separation of a pale resinous material which was collected, washed with a very small amount of water and dried by heating in an open pan to 120°C. The yield was about 30 per cent. Acid value of the material was 219·7, saponification value 277·5 and hydroxyl value 266·1.

After removing the separated resinous material, the remaining aqueous liquor was evaporated to dryness and then extracted with absolute alcohol. On evaporation of the alcoholic extract, only a small amount of a resinous material was left behind.

4.6 *Water 'soluble' hydrolysed lac* — The resinous material collected during evaporation of the aqueous mother liquor from lac saponification known as water-soluble hydrolysed lac, is a product quite different in properties from the water-insoluble hydrolysed lac. (*I.L.R.I. Annual Report*, 1952-53, p. 37). It is a hard, brittle and rather hygroscopic product, gradually thickening on heating, into a permanently fusible material, never turning into a rubbery stage. A 10 gm. sample was therefore heated in an oil bath at 150°C. and the acid-hydroxyl and saponification values determined at intervals up to 10 hours (Appendix B, Table IX). It was found that the acid and hydroxyl values fell rapidly during the first two hours and after this period, when incidentally the A.V. and H.V. were the same, further drop was very slow. Saponification value, however, remained

practically constant throughout. The product after 10 hours' heating was a hard brittle resin completely soluble in alcohol.

5. *Ad hoc* Investigations

5.1 *Shellac composition for prevention of loosening of bolts and nuts* — The use of shellac for the prevention of loosening of nuts from bolts particularly in vibrating equipments is well known. A suggestion was received from the Shellac Export Promotion Council that experimental data be obtained in support of this performance of shellac. Enquiries revealed that the Machine Tool Prototype Factory at Ambernath had the necessary equipment (An Amsler's Hammer Impact Testing Machine). Six samples of shellac varnish differing only in the type of shellac and solvent used, formulated on the basis of a composition suggested by the Development Wing of the Ministry of Commerce and Industry, Govt. of India, were prepared and submitted to the Machine Tool Factory for the tests. As a result of five tests on each of the samples, it has been reported that (i) the composition dewaxed lac 60 gm., methylated spirit 200 gm., castor oil 2·5 gm. gave the most satisfactory result. (ii) Ordinary shellac in place of dewaxed lac in the above composition was not satisfactory. (iii) The alcohol may be rectified or methylated spirit. (iv) The belt has to be dipped into the varnish and the nut fitted while the varnish is still wet. (v) If the nut is fitted after the varnish dries, the shellac is ineffective. A nut fitted on a bolt dipped in the above-mentioned compostion could withstand without loosening $2{\cdot}5 \times 16^6$ blows from a hammer with the strength of blows varying from 7 to 40 kg. cm. (0·5 to 2·9 ft. lb.) at the rate of 600 blows per minute.

The complete report is reproduced in Appendix H.

5.2 *Shellac for use in hydraulic models* — An enquiry was received from the Central Water and Power Commission Research Station for shellac samples for use in their hydraulic models. The requirements were that the particles must be free flowing, inert, of uniform specific gravity of 1·10 to 1·20 and not affected by continued or periodical immersion in water and must not block by exposure to the sun either directly or under water. Samples of button lac and *kiri* crushed to appropriate size and hot-mixed with barytes for adjustment of specific gravity were supplied. After testing it was reported that button lac crushed to the proper size behaved reasonably well except for slight swelling during immersion and blocking by exposure to the sun. Modified samples using calcium stearate as water repellent and urea as accelerator were supplied as also old infusible garnet lac. These are under test and their report is awaited.

If successful, the requirement, it is reported, is quite considerable.

5.3 *No-rub polishes* — It was reported during an Advisory Board meeting of the Indian Lac Cess Committee that there is a large demand for no-rub polishes in this country and that work should be taken up to determine conditions for the manufacture of suitable compositions based on shellac. It may be pointed out that "no-rub" or "dry bright" polishes is one of the most important uses of lac in foreign countries, particularly the U.S.A. The necessary literature was collected and samples were prepared according to various formulations based on dewaxed lac and carnauba wax in aqueous emulsion. Simultaneously a new foreign commercial synthetic wax, claimed to be suitable for dry bright polishes, was also examined in place of carnauba wax. These polishes were compared with an American ready-made polish which had been obtained earlier. Films were made on glass and wood and examined. It was found that all these polishes produced matt films on application by brush or cloth pad. After ageing for seven days scratch hardness and water-resistance were determined. The scratch hardness varied from 50 gm. to 300 gm. and all of them on immersion in water blushed badly within a few minutes. But when the shellac was replaced by water-soluble lac described earlier and no triethanol amine oleate was used for dissolving the lac in water, the films with varying proportions of the synthetic wax did not show any blush during 24 hours' water immersion. The gloss, however, was still poor. Further work is continuing.

6. Publicity and Propaganda

6.1 *Lac dye* — Having worked out an economic method for the recovery and refining of lac dye of a technical grade (70 per cent purity), steps were taken to popularize this among dyers of silk and wool. Samples of this technical grade together with a note on how to use it with different mordants to produce different shades on wool and silk and shade cards of wool and silk thus dyed were sent to about 25 wool weavers' co-operative societies. Reports received from them confirmed that the quality was quite suitable. A 10 lb. sample has been sent to the Weavers Service Centre, All-India Handloom Board, Madras, for trial. Their report is awaited. Meanwhile, at our request the Small Industries Service Institute, Bombay, has undertaken a market survey to assess the marketing possibility of the dye. In this connection samples of the dye have been supplied to about forty woolen and silk mills in Bombay for their trial and report. The process of dyeing wool with this dye was demonstrated to a group of wool dyers and carpet manufacturers in Mirzapur. One of them prepared a 8′ by 6′ carpet using wool dyed with lac dye and this was displayed in our stall in the Indian Council of Agricultural Research pavilion in the recent World Agricultural Fair in New Delhi. It was widely appreciated.

6.2 *Dry-mounting tissues* — As mentioned in the 1958-59 Annual Report, the Institute had worked out a detailed process for the manufacture of dry-mounting tissues for photographic purposes and a patent had been applied for to cover the process. One firm in Ranchi was granted royalty-free rights to manufacture the material according to our process and they commenced production in 1958-59. A second firm in Mirzapur was also granted similar rights and they were given full technical assistance in fabricating, erecting and commencing production in their factory. They commenced production in July last. Steps are being taken to see if imports of this material can be restricted as the combined output of these two factories is more than the estimated consumption of the material in India, and the quality is also entirely satisfactory, and comparable with the best imported stuff.

6.3 *Bleached lac* — The demand for bleached lac has been slowly but steadily going up. Samples were supplied to the S.E.Rly. for the inside finishing of their upper class coaches. The results were reported to be very satisfactory. They have, therefore, purchased a lot of 100 lb. for finishing a few more coaches. The Central Food Technological Institute, Mysore has been supplied with 5 lb. for experiments on preservation of fruits. Here again they have purchased a larger consignment (25 lb.) for large-scale use.

Apart from our Production Unit, it is understood bleached lac is now being manufactured by two parties, one in Calcutta and the other in Delhi.

6.4 *Shellac coating on earthenware* (*Water-soluble lac*) — Contact has been established with the Village Pottery Section of the All India Khadi and Village Industries Commission for the popularization of water-soluble lac for coating earthenware. Samples together with details of use were sent to all Community Projects and Block Development Officers of Andhra Pradesh and Extension Centres of the Village Pottery Section of the Khadi and Village Industries Commission throughout the country, arrangements have been made to distribute water-soluble lac to consumers through their regional training centres. Coating of earthenware using water-soluble lac was demonstrated to potters during a seminar of pottery workers of Southern Region held at Khanapur.

6.5 *Hydrolysed lac* — There were enquiries from three parties for the supply of hydrolysed lac, presumably for use in paper varnishes. Two firms in Calcutta were contacted and one of them has undertaken the manufacture and supply according to demand. They were supplied full technical details for the manufacture.

6.6 *Furniture Repolishing Publicity Centre* — The maximum consumption of lac in India today is in furniture polishing. Most of the furniture in this country seldom gets a second polishing in its lifetime. If only the habit of periodically repolishing furniture can be developed, the additional consumption of lac can be substantial. In order to create and

popularize this habit a publicity cum demonstration centre has been established in Delhi. The centre commenced its activities in November last. The present staff consists of one Manager cum canvasser-in-charge of the centre and its activities, and a team of polishers.

One firm, the Oriental Building and Furnishing Co. Pvt. Ltd. with whose co-operation the scheme is being implemented, is manufacturing and marketing handy 'do-it-yourself' 'all-in-one' furniture repolishing kits. The team of polishers go from house to house and demonstrates to the householders how easily old furniture can be given a new and pleasing look by simple repolishing. The demonstration, it is understood, is becoming popular. The demand for ready-made french polish is thus being slowly created. Side by side, publicity *re*: furniture repolishing is also being carried on through cinema slides, newspapers, etc.

Demonstration of furniture repolishing was also carried on in our lac stall throughout the period of the World Agricultural Fair.

7. Technical Assistance to Shellac Manufacturers and Consumers

7.1 *General* — Constant contact is being maintained with manufacturers of seedlac and shellac. Short notices in Hindi and English were sent to over 150 manufacturers about the newly developed improved methods of seedlac washing. The working of the sand-separating machine was demonstrated to some of the factories in Gondia and Dhamtari. The precipitation and recovery of lac dye from wash water were demonstrated to a number of factories.

As usual, a number of technical enquiries were answered regarding manufacture of seedlac, shellac, autoclave shellac and bleached lac as well as utilization of these and their modifications.

One cwt. of polymerized lac received from a paint factory at Kanpur was depolymerized by autoclaving and returned to the party for use.

7.2 *Regional Analytical laboratories — At Gondia* — The Regional Analytical laboratory at Gondia functioned throughout the year. The analyses carried out were mostly for 'impurities' and bleach index. There were slack periods when very few samples were received and busy seasons as well. All told 237 samples were received for analysis for 302 tests. Although manufacturers appeared to be satisfied with the results of the analysis, they were not making as much use of the laboratory as was expected or hoped. It was learnt that the reason for this was two-fold, viz. (i) that the results of this laboratory were not 'recognized' for trade purposes in Calcutta and (ii) the charges levied for analysis were considered too high. *Re*: (i) it is emphasized that the main object of the laboratory is to assist the manufacturers of the Region improve the quality of their products. *Re*: (ii) the Indian Lac Cess Committee has already decided to reduce the charges per sample to a nominal fee of Re. 0·50 nP. and this has been given effect to from 1st April 1960. It is hoped manufacturers will make greater use of the laboratory from now on.

7.2.1 *At Jhalda* — The laboratory started functioning from November 1959 and the use so far made of the laboratory by manufacturers of the region has been disappointing. Up to the end of March 1960, only 22 samples were received which were promptly analysed and reports sent. Owing to the very limited amount of work, the staff at present in the laboratory comprise only one Research Assistant (Analyst) and one Durwan.

8. Compilation of Literature

(a) The compilation of the *Chemistry of Lac* was finally edited and is being retyped for final printing.

(b) The book *Uses of Lac* was revised and reprinted.

(c) The *Shellac Patents Index* was revised and brought up-to-date and sent to the Press for printing.

9. Production Unit

With a view to pupularizing the newer products developed at the Institute and make them readily available in required quantities to interested consumers as also to demonstrate the feasibility of commercial manufacture of these products and develop a market, a Production Unit was established in the Institute. It started functioning in September 1959. The staff so far appointed are only one Manager, one Senior Clerk and one Peon. Because of the fact that the Unit is still in its early stages, no new equipment was purchased and only the equipment already available in the factory is being utilized. The Unit started producing three types of refined lac, each in two grades. The types produced, the quantities sold up to 31-3-60 and their sale value are shown in the table below:

TABLE

Materials	Grade	Details of sale	
		Quantity lb. oz.*	Value Rs.
1. Water-soluble lac (dewaxed)	DL	109 14	338·14
2. Water-soluble lac from autoclave shellac	AL	134 10	326·56
3. Bleached lac without wax	BRF	336 14	1479·19
4. Bleached lac with wax	BR	261 10	1020·90
5. Autoclave shellac	ASK	290 10	465·02
6. do	ASB	34 10	48·58
		Total	3678·39

*The Production Unit will be changing over to the Metric System from the 1st April 1961.

It may be pointed out that although the Unit was formerly established on 1st September 1959, it really got going only in December after the first advertisement appeared in newspapers. The demand for some of the products particularly bleached lac is seen to be developing. It is, however, too early to draw any specific conclusions.

METEOROLOGICAL REPORT FOR THE YEAR 1959-60

The average meteorological data for each month during the year 1959-60 *are given*:

Month & year	Barometric pressure (in.)	Mean wind speed (miles/hr.)	Mean max. temp. (°F.)	Mean min. temp. (°F.)	Mean dry bulb temp. (°F.)	Mean humidity	Mean sunshine (hr./day)	Total rainfall (in.)	Highest max. temp. (°F.)	Lowest min. (°F.)
April 1959	27·725	7·680	97·46	61·86	88·68	31·80	8·98	1·38	105·0	58
May 1959	27·587	7·524	102·64	75·39	93·58	36·61	9·68	2·26	107·5	66
June 1959	27·520	1·400	91·93	74·06	83·46	73·53	6·53	12·03	99·0	67
July 1959	27·490	0·374	84·77	73·45	80·16	82·97	3·71	14·21	90·0	70
August 1959	27·484	0·198	85·19	73·00	78·74	86·51	3·60	11·63	90·0	71
September 1959	27·597	0·493	84·36	72·00	78·33	83·73	4·53	15·78	89·0	70
October 1959	27·765	1·420	83·61	66·42	77·55	74·13	7·11	11·72	88·0	59
November 1959	27·905	0·900	78·50	51·43	71·66	49·06	9·92	nil	84·0	45
December 1959	27·959	0·096	74·39	45·66	64·90	45·74	10·06	nil	80·0	40
January 1960	27·972	0·735	73·84	47·71	62·97	54·10	7·95	0·02	79·0	39
February 1960	27·907	1·294	83·76	52·65	73·50	40·30	9·80	nil	91·0	43
March 1960	27·839	2·217	86·06	59·26	75·19	44·87	8·48	0·08	99·0	53

The highest maximum temperature recorded was 107·5°F. on the 14th and 16th May 1959 whereas the lowest recorded was 39°F. on the 25th January 1960. The total rainfall during the year amounted to 69·11 inches of which the monsoon rainfall was 53·65 inches. There were several hailstorms of moderate intensity, twice on 1st April 1959, i.e. at 4 p.m. and 9·25 p.m. and again on the 1st and 2nd March 1960 at 3 p.m. A heavy cyclone swept on the 1st October 1959 and continued up to the 2nd instant uprooting a large number of trees and dislocating all the electrical transmission lines, etc. On these two days the wind speeds were 242 miles/day and 150 miles/day and rainfalls recorded were 3·10″ and 4·25″ respectively; for the first day the minimum, the dry bulb, and the wet bulb temperatures registered nearly the same figure, namely 68°C., 69°C. and 69°C. with a humidity of 100 per cent. Many big trees, to say nothing of the small ones, were uprooted in the Institute and nearby areas, and the supply of electricity was suspended for 3-4 days owing to dislocation of electric transmission wires.

28th June 1960

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Offg. Director
Indian Lac Research Institute
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APPENDIX A

(Tables : Entomology Division)

TABLE I — DETAILS OF LARGE-SCALE LAC CULTIVATION AT KUNDRI

Season of operation	Particulars of operation	No. of trees	Yield of lac if any			Quantity of brood used for inoculation	Cost of the operation	Remarks
			Lac sticks	Scraped lac	Broodlac			
April 1959	Pruning	18224	—	—	—	—	595.40 nP.	
	Ari collection	do	27204·21 kg. (60409 lb.)	—	—	—	5104.70 nP.	
	Scraping	do	—	5248·80 kg. (11664 lb.)	—	—	705.91 nP.	
July 1959	Partial cropping (Group II) and selection of brood	4978	6764·40 kg. (15032 lb.) rejected	—	740·70 kg. (1646 lb.)	—	181.20 nP.	The scraped lac obtained was 1067·17 kg. (or 2372 lb.)
	Inoculation	407	—	—	—	469 kg. (1040 lb.)	27.09 nP.	
	Scraping	—	—	—	—	—	112.84 nP.	194·45 kg. (432 lb.) *phunki* lac sticks recovered were scraped and yielded 56·86 kg. (126 lb.) scraped lac
	Phunki removal	407	—	—	—	—	4.85 nP.	
	Scraping	—	—	—	—	—	12.52 nP.	
October 1959	Full cropping G 1 G 2	9755	4925·75 kg. (10941 lb.) rejected	—	9772·90 kg. (21715 lb.)	—	236.49 nP.	3393 kg. (7519 lb.) *phunki* lac sticks yielded on scraping 1389 kg. of scraped lac
	*Scraping	—	—	—	—	—	80.40 nP.	
	Inoculation	17145	—	—	—	9666 kg. (21422 lb.)	695.51 nP.	
	Phunki removal	do	—	—	—	—	220.38 nP.	
	Scraping	—	—	—	—	—	180.24 nP.	
February 1960	Pruning	776	—	—	—	—	29.22 nP.	
							3636.46 nP.	

TABLE II — EFFECT OF PARTIAL DEFOLIATION OF *PALAS* ON BROOD PRESERVATION

Treatment (50 trees each)	Inoculation		Yield in terms of lac sticks			Yield in terms of scraped lac			Ratio of brood used to brood yield	Percentage of brood on yield
	Wt. of broodlac	Wt. of scraped lac	Wt. of broodlac	Wt. of rejected lac	Total yield	Wt. of broodlac	Wt. of rejected lac	Total yield		
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.		
1. Defoliated	22·95	54·49	18·64	74·75	93·39	3·47	7·70	11·17	1 : 0·63	31·16
2. Control	32·63	6·16	15·97	121·53	137·50	3·05	17·48	20·53	1 : 0·50	14·86

I. Analysis of variance (Data on percentage of selected brood)

Sources of variance	D.F.	S.S.	M.S.	F.	If significant or not
Blocks	9	1216·97	135·22	1·945	—
Treatments	1	357·35	357·35	5·142	Yes
Errors	9	625·37	69·49	—	—
Total	19	2199·69			

II. Analysis of co-variance (Data on yield of broodlac)

Due to	D.F.	Sums of squares & products			Reduced	D.F.	M.S.S.	F.	If significant or not
		Sx^2	Sxy	Sy^2	Y^2				
Blocks	9	54080·2	7908·8	12255·2	—	—	—	—	—
Treatments	1	112800·2	7810·4	540·8	—	—	—	—	—
Errors	9	93777·8	19706·6	8951.2	4810·0	8	601·25	—	—
Total	19	260658·2	19804·8	21747·2					
Treatment — Error	10	206578·0	11896·2	9492·0	8806·9	9	—	—	—
Treatment (adjusted)					3996·9	1	3996·9	6·647	Yes

TABLE III — RESULTS OF STICK EXAMINATION FOR HEAT MORTALITY UNDER THE EXPERIMENT ON THE DEFOLIATION OF *PALAS* FOR BROOD PRESERVATION

Treatment	No. of twigs examined	Total length	Total No. of female insects parasite	No. of twigs	Percentage survived
1. Defoliated	100	144′4″	635110	8707	13·70
2. Control	100	164′	168310	3615	2·14

TABLE IV—COMPARATIVE CROP DATA OF THE 5 PLANS OF CULTIVATION PRACTICES

Plan No.	Inoculation		Yield of crop from harvest					Total brood-lac in all seasons	Total scraped lac in all seasons	Remarks	
	Wt. of brood used for inoculation	Wt. of *phunki* scraped lac	April Scraped *ari* lac	July Brood-lac	Total scraped lac	Oct.-Nov. Brood-lac	Oct.-Nov. Total scraped lac			Brood to brood ratio	Scraped to scraped ratio
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.		
I	373	42·2	226·22	—	226·22	96·45	35·45	96·45	261·67	1 : 0·25	1 : 6·1
II	373	26·67	—	102	225·22	402·00	121·44	504·00	346·65	1 : 1·35	1 : 12·9
III	112	7·19	—	—	—	949·45	143·45	949·45	143·45	1 : 8·47	1 : 19·9
IV	187	16·00	—	—	—	284·00	169·78	284·00	169·78	1 : 1·51	1 : 10·6
V	187	18·19	—	56	36·45	324·00	146·00	380·00	182·45	1 : 2·00	1 : 10·0

TABLE V — CROP DATA ON THE ECONOMICS OF UTILIZING *PALAS* FOR *BAISAKHI* CROP AND *BER* FOR *KATKI* CROP

Host	No. of trees	Lac sticks				Scraped lac			
		Brood used	Brood yield	Total yield	Ratio of brood to brood yield	Brood used	Brood yield	Total yield	Ratio of brood to total yield
		kg.	kg.	kg.		kg.	kg.	kg.	
		***Baisakhi* crop 1958-59**							
Palas	10	8·28	18·37	36·42	1 : 2·22	2·04	3·20	6·32	1 : 3·09
Ber	10	4·65	4·99	32·21	1 : 1·07	1·13	0·96	4·48	1 : 3·95
		***Katki* crop 1959**							
Palas	10	7·94	2·61	20·75	1 : 2·61	2·32	0·43	2·58	1 : 1·11
Ber	10	16·26	25·63	107·73	1 : 6·63	4·71	4·71	18·09	1 : 3·84

TABLE VI — PRESERVATION OF BROODLAC ON *BER* BY PARTIAL PRUNING BEFORE AND AFTER INFECTION

Particulars	Treatments		
	A kg.	B kg.	C kg.
Brood used for infection	5·22	4·99	6·01
Scraped lac from brood used	1·28	1·30	1·47
Broodlac obtained	5·33	4·42	3·74
Total yield of lac sticks	31·75	24·01	33·57
Total yield of scraped lac	2·55	2·30	4·14
Brood to yield ratio: (i) Lac stick	1: 6·08	1: 4·81	1: 5·58
(ii) Scraped lac	1: 2·00	1: 1·76	1: 2·80
Percentage of selected broodlac	16·78	18·53	11·84

TABLE VII — PROPER TIME OF HARVESTING FOR MAXIMIZING YIELD-CROP DATA

Date of cropping	Treatments (50 trees under each)	Lac stick			Scraped lac			Percentage of driage on scraped lac	Ratio of brood to yield (scraped lac) after driage
		Brood used	Yield	Brood to yield ratio	Brood used	Yield	Brood to yield ratio		
		kg.	kg.		kg.	kg.			
25-4-60	I	37·2	164·65	1: 4·4	6·01	38·32	1: 6·3	24·2	1: 4·8
26-5-60	II	37·2	148·78	1: 4·0	5·21	30·61	1: 5·8	18·0	1: 4·8
12-7-60	III	37·2	145·20	1: 3·9	5·07	21·65	1: 4·2	6·8	1: 3·6
12-7-60	IV	27·9	86·66	1: 3·1	2·55	8·84	1: 3·4	6·25	1: 1·9

TABLE VIII — OPTIMUM DENSITY OF LARVAL SETTLEMENT: *PALAS-KATKI* (1959)

Experimental details

Treatments		Replication		No. of trees per plot		Total No. of trees
3	×	10	×	1	=	30

Crop data

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio
	kg.	kg.		kg.	kg.		kg.	kg.	
Lac sticks	3·40	20·58	1: 6·05	6·80	35·75	1: 5·23	13·61	41·62	1: 3·06
Scraped lac	0·79	1·93	1: 2·43	1·28	3·80	1: 3·00	2·58	4·79	1: 1·85

Analysis of variance (Data on yield as sticklac)

Due to	D.F.	S.S.	M.S.	F.	If significant or not
Blocks	9	720·30	80·30	2·414	
Treatments	2	526·07	263·03	7·936	Yes
Errors	18	596·60	33·14	—	
Total	29	1842·97			

TABLE IX — RESULTS OF STICK EXAMINATION OF EXPERIMENT ON DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT (*PALAS-KATKI* 1959)

Treatment	After 4 weeks		At male emergence	At crop maturity		
	Density of settlement	Percentage mortality	Percentage of males	No. of living cells per inch	Per cent mature mortality	Per cent parasitized
A	118	50·5	20·8	6	11·0	28·1
B	174	44·1	23·8	11	14·5	15·4
C	269	31·5	30·4	17	7·7	17·3

TABLE X — *KUSUM-JETHWI* (1959) CROP

Experimental details

Treatments		Replication		No. of trees per plot		Total No. of trees
3	×	10	×	1	=	30

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio
	kg.	kg.		kg.	kg.		kg.	kg.	
Lac sticks	24·49	76·32	1 : 3·11	48·99	105·29	1 : 2·15	97·98	168·00	1 : 1·71
Scraped lac	11·68	18·37	1 : 1·57	23·08	21·21	1 : 0·22	45·30	45·39	1 : 1·00

Analysis of variance (Data on yield as sticklac)

Due to	D.F.	S.S.	M.S.S.	F.	If significant or not
Blocks	9	50630·03	5625·56	2·1198	
Treatments	2	54860·60	27430·30	10·3360	Yes
Errors	18	47768·07	2653·78	—	
Total	29	153258·70			

TABLE XI — RESULTS OF STICK EXAMINATION OF EXPERIMENT ON DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT (*KUSUM-JETHWI* 1959)

Treatment	After 4 weeks		At male emergence	At crop maturity	
	Density of settlement	Percentage mortality	Percentage of males	No. of living cells per inch	Per cent natural mortality
A	123	40·3	11·4	18·4	35·7
B	180	38·8	10·9	21·6	40·5
C	293	32·3	16·6	34·5	23·1

TABLE XII — CROP DATA AND EXPERIMENTAL DETAILS FOR *KUSUM-AGHANI* (1959-60), *KUSUM-AGHANI* (1959-60) SEASON

Experimental details

Treatments		Replication		No. of trees per plot		Total No. of trees
3	×	10	×	1	=	30

Crop data

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio
	kg.	kg.		kg.	kg.		kg.	kg.	
Lac sticks	19·96	167·61	1 : 8·39	39·92	277·49	1 : 6·95	79·83	360·22	1 : 4·51
Scraped lac	7·99	57·92	1 : 7·24	17·01	97·16	1 : 5·71	30·19	119·92	1 : 3·98

Analysis of variance (Data on yield as scraped lac)

Due to	D.F.	S.S.	M.S.	F.	If significant or not
Blocks	9	748320·00	83146·66	3·960	
Treatments	2	244774·47	122387·23	5·345	Yes
Errors	18	377936·20	20996·46	—	
Total	29	1371030·67			

TABLE XIII — RESULTS OF STICK EXAMINATION OF EXPERIMENT ON DETERMINATION OF OPTIMUM LARVAL SETTLEMENT (*KUSUM-AGHANI* 1959-60)

Treatment	After 4 weeks		At male emergence	At crop maturity	
	Density of settlement	Percentage mortality	Percentage of males	No. of living cells per inch	Percentage of natural mortality
A	241	43·5	13·4	15·4	40·3
B	336	36·6	18·6	29·4	36·8
C	469	32·2	16·9	40·0	33·3

TABLE XIV—EXPERIMENT ON THE DIFFERENT BROOD RATES AND DIFFERENT TIMES OF HARVEST

Treatments		Lac sticks			Yield particulars Scraped lac		
Time of harvest	Brood rate used	Brood used	Yield obtained	Brood to yield ratio	Brood used	Yield obtained	Brood to yield ratio
		kg.	kg.		kg.	kg.	
Ari cutting April	Half normal	0·91	4·88	1 : 5·36	0·28	0·51	1 : 1·82
do	Normal	1·81	6·92	1 : 3·82	0·45	1·02	1 : 2·26
do	Double normal	3·63	9·75	1 : 2·68	0·88	1·56	1 : 1·77
Ari cutting May	Half normal	0·91	4·65	1 : 5·109	0·23	0·79	1 : 3·43
do	Normal	1·81	7·26	1 : 4·01	0·43	1·36	1 : 3·16
do	Double normal	3·23	8·90	1 : 2·76	0·96	1·98	1 : 2·06
Cropping at maturity	Half normal	0·91	7·26	1 : 7·97	0·23	0·91	1 : 3·95
do	Normal	1·81	9·64	1 : 5·32	0·45	1·30	1 : 2·88
do	Double normal	3·23	13·27	1 : 4·108	0·91	1·96	1 : 2·15

Analysis of variance (Data on yield as sticklac)

Due to	D.F.	S.S.	M.S.	F.	If significant or not
Times of harvest	2	312·67	156·33	42·596	Yes
Brood rates	2	2250·66	1125·33	306·629	Yes
Errors	4	14·69	3·67	—	—
Total	8	2578·02			

TABLE XV—RESULTS OF STICK EXAMINATION OF EXPERIMENT ON DIFFERENT BROOD RATES AND DIFFERENT TIMES OF HARVEST (*BAISAKHI* 1958-59)

Brood rates	After 4 weeks		At male emergence Percentage of males	At the end of May before crop maturity	
	Density of settlement	Percentage mortality		No. of living cells per inch	Percentage of natural mortality
Half normal	132	52·6	20·8	26	22·0
Normal	202	43·9	24·7	38	16·3
Double normal	298	40·3	30·5	35	13·5

TABLE XVI — GROWING OF LAC ON *MOGHANIA MACROPHYLLA* UNDER BUSH CONDITION

Crop	No. of plants	Brood used		Total yield		Ratio of brood to yield	
		Lac sticks	Scraped lac	Lac sticks	Scraped lac	Lac sticks	Scraped lac
		kg.	kg.	kg.	kg.		
Baisakhi (1958-59)	100	7·26	1·42	36·29	4·39	1 : 5·00	1 : 3·10
Katki (1959)	75	15·65	2·58	49·61	5·93	1 : 3·17	1 : 2·30
Jethwi (1959)	40	6·35	3·03	7·94	1·02	1 : 1·25	1 : 0·34
Aghani (1959-60)	200	24·38	9·98	39·24	10·94	1 : 1·61	1 : 1·09

TABLE XVII — GROWING OF LAC ON *ALBIZZIA LUCIDA* UNDER BUSH CONDITION

Crop	No. of plants	Brood used		Total yield		Ratio of brood to yield	
		Lac sticks	Scraped lac	Lac sticks	Scraped lac	Lac sticks	Scraped lac
Baisakhi (1958-59)	8	1·81	0·45	8·85	1·42	1 : 4·87	1 : 3·12
Jethwi (1959)	12	2·27	1·25	11·34	1·93	1 : 5·00	1 : 1·55

TABLE XVIII — EMERGENCE OF INSECTS FROM LAC SAMPLES, TREATED WITH INSECTICIDES AND FUMIGANTS, AND UNTREATED CONTROL — *PALAS-BAISAKHI* (1958-1959)

Lac samples and quantity caged	Insecticides and fumigation treatment	Emergence of insects		
		Enemies		Beneficial insects
		Predators	Parasites	
Lac sticks				
4·5360 kg.	Aldrex 2% dust	32	452	—
4·5360 kg.	Aldrex 5% dust	7	385	—
4·5360 kg.	Dieldrex 1·5% dust	95	809	1
4·5360 kg.	Endrex 1% dust	6	147	2
4·5360 kg.	Ekatox 2% dust	3	41	1
4·5360 kg.	Aldrex 40% W.P. spray 0·1%	74	416	—
4·5360 kg.	Dieldrex 50% W.P. spray 0·1%	29	231	—
4·5360 kg.	Ekatox 20% W.P. spray 0·1%	19	40	1
4·5360 kg.	Endrex 20% E.C. spray 0·1%	76	348	1
4·5360 kg.	Fumigated with E.D.B.	—	4	—
4·5360 kg.	Fumigated with Trichlorethylene	—	87	2
4·5360 kg.	Control	1095	686	20

Contd.

TABLE XVIII — EMERGENCE OF INSECTS FROM LAC SAMPLES, TREATED WITH INSECTICIDES AND FUMIGANTS, AND UNTREATED CONTROL — *PALAS-BAISAKHI* (1958-1959) — *Contd.*

Lac samples and quantity caged	Insecticides and fumigation treatment	Emergence of insects		
		Enemies		Beneficial insects
		Predators	Parasites	
Lac scraped				
1·7004 kg.	Aldrex 2% dust	24	413	—
1·7004 kg.	Aldrex 5% dust	1	251	—
1·7004 kg.	Dieldrex 1·5% dust	35	604	1
1·7004 kg.	Endrex 1% dust	1	116	2
1·7004 kg.	Ekatox 2% dust	2	15	—
1·7004 kg.	Aldrex 40% W.P. spray 0·1%	14	89	—
1·7004 kg.	Dieldrex 50% W.P. spray 0·1%	—	22	—
1·7004 kg.	Ekatox 20% W.P. spray 0·1%	9	—	—
1·7004 kg.	Endrex 20% E.C. spray 0·1%	8	9	—
1·7004 kg.	Fumigated with E.D.B.	—	—	—
1·7004 kg.	Fumigated with Trichlorethylene	—	5	—
1·7004 kg.	Control	377	383	4

TABLE XIX — LABORATORY BREEDING OF *APANTELES FAKHRULHAJIAE*

Month	Period of development in days	% of females bred
December 1959	26	42·0
January 1960	18	40·6
February 1960	17	35·4
March 1960	16	19·1

TABLE XX — CROP DATA OF THE BIOLOGICAL CONTROL EXPERIMENT

Treatments (Release of parasites)	No. of trees	Lac sticks			Scraped lac		
		Brood used	Yield	Ratio of brood to yield	Brood used	Yield	Ratio of brood to yield
		kg.	kg.		kg.	kg.	
		***Jethwi* crop 1959**					
A — *A. tachardiae*	30	86·60	687·30	1 : 7·93	32·90	266·03	1 : 8·08
B* — B. *greeni*	30	81·80	584·40	1 : 7·14	28·50	238·20	1 : 8·35
C* — Both A & B above	30	81·10	604·90	1 : 7·45	26·70	216·02	1 : 8·09
B — Control (no release)	30	92·70	752·80	1 : 8·12	31·80	303·30	1 : 9·50
		***Aghani* crop 1959-60**					
A — *A. tachardiae*	30	164·59	981·36	1 : 5·96	66·04	331·99	1 : 5·02
B* — *B. greeni*	30	157·23	734·17	1 : 4·66	57·43	238·35	1 : 4·15
C* — Both A & B	30	136·13	700·30	1 : 5·14	50·98	222·54	1 : 4·36
D — Control (no release)	30	137·87	792·09	1 : 5·74	71·87	270·98	1 : 3·77

*Only *A. tachardiae* was released and *B. greeni* could not be released.

TABLE XXI — CROP DATA FOR *JETHWI* 1959

Host	No. of trees	Kind of brood	Lac sticks			Scraped lac		
			Brood used	Total yield	Ratio of brood to yield	Brood used	Total yield	Ratio of brood to yield
			kg.	kg.		kg.	kg.	
(i) *B. serrata*	16	*kusum* purchased	20·22	36·94	1 : 1·82	5·01	8·82	1 : 1·76
do	1	*kusum* × *B. serrata*	4·05	0·22	1 : 2·02	1·86	2·05	1 : 1·10
(ii) *B. latifolia*	4	*kusum* purchased	11·88	0·80	1 : 0·06	3·96	0·25	1 : 0·06
do	—	*kusum* × *sissoo*	3·37	9·14	1 : 2·71	1·86	4·54	1 : 2·44
Kusum general	1	*kusum* × *sissoo*	3·37	3·80	1 : 1·12	1·86	1·71	1 : 0·96
(iii) *F. infectoria*	1	*kusum* purchased	3·31	—	1 : 0·00	1·10	nil	1 : 0·00
do	1	*kusum* × *pakur*	5·34	0·22	1 : 0·04	2·31	0·05	1 : 0·02
Kusum general	1	*kusum* × *pakur*	5·37	7·77	1 : 1·44	2·34	3·09	1 : 1·32
(iv) *Palas*	10	*kusum* purchased	3·65	—	1 : 0·00	1·21	nil	1 : 0·00
(v) *Ber*	6	*kusum* × *ber*	3·31	—	1 : 0·00	0·65	nil	1 : 0·00
Kusum general	4	*kusum* × *ber*	3·37	0·22	1 : 0·06	1·32	0·05	1 : 0·03

TABLE XXII — CROP DATA FOR *AGHANI* 1959-60

Host	No. of trees	Kind of brood	Lac sticks			Scraped lac		
			Brood used	Total yield	Ratio of brood to yield	Brood used	Total yield	Ratio of brood to yield
			kg.	kg.		kg.	kg.	
(i) *B. serrata*	13	*Kusum* brood	29·94	70·68	1 : 2·36	11·81	19·89	1 : 1·59
do	3	*K.* × *B. serrata*	12·68	23·42	1 : 1·84	2·73	7·02	1 : 1·40
do	1	*K.* × *B. serrata* × *B. serrata*	3·88	4·34	1 : 1·11	0·91	1·13	1 : 1·24
Kusum	5	*K.* × *B. serrata*	22·28	55·37	1 : 2·48	5·09	13·31	1 : 2·61
(ii) *D. latifolia*	8	*Kusum*	30·97	57·94	1 : 1·87	9·53	26·48	1 : 2·77
do	1	*K.* × *sissoo* × *sissoo*	7·20	5·12	1 : 0·71	2·71	2·51	1 : 0·92
do	1	*Kusum* × *sissoo* × *kusum*	2·40	0·80	1 : 0·33	0·88	0·40	1 : 0·45
(iii) *F. infectoria*	5	*Kusum*	10·97	27·37	1 : 2·49	3·75	11·02	1 : 2·93
do	1	*K.* × *Pakur* × *K.*	5·94	9·71	1 : 1·63	2·28	4·11	1 : 1·80
(iv) *Palas*	9	*Kusum*	22·28	66·11	1 : 2·96	9·13	21·07	1 : 2·32
(v) *Ber*	9	*Kusum*	7·14	10·54	1 : 1·47	1·31	1·77	1 : 1·32

TABLE XXIII — RESPONSE TO PRUNING

Treatment	Time of pruning	Shoots	Average No. per tree	Mean length of shoots in inches	Ratio of brood to yield (lac on sticks)
		***Katki* crop 1959**			
A	Dec. 1958	Primaries	25	33·30	1 : 0·05
		Secondaries	187	13·50	
B	Feb. 1959	Primaries	32	33·80	1 : 0·07
		Secondaries	226	14·60	
C	May 1958	Primaries	45	47·00	1 : 0·05
		Secondaries	327	12·15	
		***Baisakhi* crop 1958-59**			
A	April 1958	Primaries	21	28·20	1 : 2·49
		Secondaries	109	12·15	
B	May 1958	Primaries	18	40·00	1 : 1·12
		Secondaries	172	12·53	

APPENDIX B

(Tables : Chemistry Division)

TABLE I — RAPID METHOD FOR THE DETERMINATION OF HOT ALCOHOL INSOLUBLES (IMPURITIES) IN LAC-COMPARATIVE RESULTS OF RAPID METHOD AND CURRENT METHOD (METHOD 'A' OF UNITED STATES SHELLAC IMPORTERS' ASSOCIATION)

Sl. No.	Result by rapid method (average of two)	Result by method 'A' (average of two)	Difference
1	4·470	4·500	+0·030
2	3·400	3·360	—0·040
3	1·470	1·460	—0·010
4	4·080	3·990	—0·090
5	2·626	2·644	+0·018
6	4·410	4·390	—0·020
7	0·638	0·634	—0·004
8	1·560	1·590	+0·030
9	4·310	4·270	—0·040
10	1·476	1·460	—0·016
11	0·147	0·135	—0·012
12	2·744	2·626	—0·118
13	3·850	3·650	—0·200
14	4·210	4·040	—0·170
15	4·380	4·330	—0·050
16	4·210	4·280	+0·070
17	4·044	4·084	+0·040

TABLE I — RAPID METHOD FOR THE DETERMINATION OF HOT ALCOHOL INSOLUBLES (IMPURITIES) IN LAC-COMPARATIVE RESULTS OF RAPID METHOD AND CURRENT METHOD (METHOD 'A' OF UNITED STATES SHELLAC IMPORTERS' ASSOCIATION) — *Contd.*

Sl. No.	Result by rapid method (average of two)	Result by method 'A' (average of two)	Difference
18	4·402	4·450	+0·048
19	2·010	1·920	−0·090
20	4·460	4·120	−0·340
21	4·180	3·886	−0·294
22	4·390	4·360	−0·030
23	6·930	7·070	+0·140
24	3·330	3·370	+0·040
25	1·840	1·684	−0·156
26	4·920	4·990	+0·070
27	4·070	3·970	−0·100
28	2·830	2·860	+0·030
29	3·150	3·130	−0·020
30	7·230	7·160	−0·070
31	2·890	2·890	nil
32	2·780	2·850	+0·070
33	1·051	1·053	+0·002
34	7·845	7·790	−0·005
35	2·120	2·110	−0·010
36	4·120	4·000	−0·120
37	24·500	24·570	+0·070
38	5·370	5·300	−0·070
39	2·040	2·140	+0·100
40	4·720	4·760	+0·040
41	1·800	1·660	−0·140
42	2·870	2·816	−0·054
43	6·570	6·420	−0·150
44	5·410	5·300	−0·110
45	1·670	1·600	−0·070
46	12·300	12·560	+0·260
47	1·190	1·180	−0·010
48	5·270	5·060	−0·210
49	4·305	4·328	−0·023
50	6·430	6·420	−0·010
51	5·188	5·164	−0·024
52	0·403	0·400	−0·003
53	5·046	5·216	+0·170
54	0·250	0·252	+0·002

TABLE II—COMPARATIVE RESULTS OF IMPROVED METHODS OF SEEDLAC WASHING

18 kg. (20 srs.) of *beuli* washed with	Partial size of *beuli*	Experiment	Properties of seedlac obtained				Reduction of bleach index by improved washing over the conventional soda washing
			Yield of seedlac (per cent on *beuli*)	Impurities per cent	Bleach index I	Bleach index II	
100 gm. borax +20 gm. Caustic soda	8-10 mesh	1	60·63	3·75	86·0	82·0	
		2	60·95	3·27	88·0	85·0	
		3	60·95	4·97	101·0	95·0	5 c.c.
		4	61·25	4·28	89·0	88·0	
		5	60·63	3·86	90·0	95·0	
					91·0	89·0	
Soda 58 gm.	8-10 mesh	1	60·37	3·34	95·0		
		2	60·39	3·39	95·0		
		3	60·40	4·75	95·0	—	
		4	60·37	3·96	94·0		
		5	60·37	4·15	95·0		
					95·0		
Ammonium oxalate 30 gm.	8-10 mesh	1	61·25	4·01	88·5		
		2	61·25	4·21	91·0		
		3	61·35	4·74	89·5	—	5 c.c.
		4	61·37	4·27	90·5		
		5	61·25	—	89·5		
					90·0		
Ammonium oxalate 30 gm.	14-16 mesh	1	61·25	5·30*	96·5*		
		2	60·95	5·35	94·0		
		3	61·10	6·76	93·0	—	Hardly any change
		4	60·63	4·54	95·0		
		5	60·95	—	—		
					94·6		

*Higher values because it is very difficult to remove *pathi* and *molamma* satisfactorily.

TABLE III — KEEPING QUALITIES OF BLEACHED LAC ON DIFFERENT TREATMENTS

Sample No.	Mode of treatment	Life at 150°C. min.	Flow	Filtration rate
BLP 8	Bleached in daylight	10	Does not flow 5 inches	Filtration slow after 10 months
BLP 9	Bleached in the dark	11	do	Filtration slow after 10 months
BLP 10	Sodium carbonate used for extraction 7%	11	do	Filtration slow after 8 months
BLP 11	Sodium carbonate used for extraction 8·5%	11	do	Filtration slow after 8 months
BLP 13	Sodium carbonate used for extraction 10%	12	do	Filtration slow after 10 months
BLP 12	Sodium carbonate used for extraction 15%	13	do	Filtration slow after 10 months
BLP 15 (a)	Precipitated with 60 per cent of required acid (H_2SO_4)	—	do	Filtration slow after 10 months

TABLE III — KEEPING QUALITIES OF BLEACHED LAC ON DIFFERENT TREATMENTS — *Contd.*

Sample No.	Mode of treament	Life at 15°C. min.	Flow	Filtration rate
	(b) Precipitated with 40 per cent of required (H_2SO_4)	—	Does not flow 5 inches	Filtration good even after 15 months
BLP 16	Bleached lac allowed to stand in 0·1% $NaHCO_3$, solution overnight, washed and dried	12	do	Filtration slow after 9 months
BLP 17	Bleached lac allowed to stand in 0·3% $NaHCO_3$, solution overnight, washed and dried	12	do	Filtration slow after 9 months
BLP 18	Bleached lac allowed to stand in 0·5% $NaHCO_3$, solution overnight, washed and dried	13	do	Filtration slow after 1 year
BLP 19	Control, no treatment	11	do	Filtration slow after 9 months
BLP 20	After bleaching was complete, added 5 gm. NaOH to the 1,000 c.c. of bleached solution (containing 10%). Allowed to stand for 1 hour at room temperature, precipitated, washed and dried	24	8 min. 15 sec.	Sample blocked on standing Filtration slow after 6 months
BLP 21	After bleaching was complete, added 2 gm. NaOH to the bleached solution containing 10% solution of 100 gm. seedlac in 10 gm. soda. Heated gently (70°C.) for ½ hour. Cooled, precipitated, washed and dried	19	10 min. 10 sec.	Filtration slow after 9 months
BLP 22	After bleaching was complete, heated gently (70°C.) for ½ hour. Cooled, precipitated, washed and dried	13	Does not flow 5 inches	Filtration slow after 1 year
BLP 23	Control, no treatment	11	do	Filtration slow after 10 months

TABLE IV — PERCENTAGE OF DIFFERENT FRACTIONS AND THEIR CHEMICAL CONSTANTS OBTAINED FROM REFINED BLEACHED LAC

Fraction	Temp. of separation °C.	Acid value	Yield %	Sap. value (apparent)	Sap. value corrected (corrected for chlorine)	Chlorine %
Refined bleached lac	—	68·73	—	256·80	238·89	1·14
Fraction I	30	53·95	34	236·20	219·73	1·05
Fraction II	5	60·98	27	248·00	233·44	0·92
Fraction III	10	65·77	8	253·90	239·62	0·91
Fraction IV	Retained in solution	100·00	31	268·60	245·64	1·46

TABLE V— FRACTIONATION OF DEWAXED DECOLORIZED LAC (100 gm.) FROM A SOLUTION IN DRY ACETONE (1,000 c.c.)

Fraction	Temp. of separation °C.	Percentage on the weight of total lac	Melting point °C.	A.V.	S.V.
1	30	36	105	57·0	219
2	5	26	85	59·6	226
3	—10	8	72	68·3	248
4	Retained in solution at —10°C.	30	Soft	103·0	—

TABLE VI — FRACTIONATION OF FRESH *PALAS* SEEDLAC FROM 10 TO 12·5 PER CENT SOLUTION IN DRY ACETONE

No.	Temp. of separation °C.	Yield (% on lac resin)	Acid value	Saponification value	Hydroxyl value
1	30	20	53·6	200·4	267·9
2	16	24	57·3	214·6	270·0
3	5	9	57·8	215·7	272·1
4	—10	10	63·6	215·6	275·9
5	Retained in solution at —10°C.	32	93·4	214·1	217·6

TABLE VII—PROPERTIES OF SHELLAC-UREA COMPLEXES AND UREA-FREE PRODUCTS

Products	M.P. °C.	Acid value	Carbonyl value	Nitrogen %	Urea %
Complex I	Does not melt up to 200	58-60	Nil	1·33	2·8
Complex II	185 with decomp.	65·50	Nil	1·67	3·5
Complex III	85	101·20	Nil	1·52	3·2
Whole complex	—	70·10	Nil	1·48	3·1
Complex I, urea-free	118-119	60·50	17·2	Nil	—
Complex II, urea-free	96-96	64·40	28·4	Nil	—
Complex III, urea-free	Soft	109·40	20·8	Nil	—
Whole complex, urea-free	79-80	78·00	17·5	Nil	—
Original shellac	78-79	74·20	18·6	0·08	—

TABLE VIII — SPECIFIC VISCOSITIES OF SHELLAC POLYMERIZED AT DIFFERENT TEMPERATURES

Sample No.	Temp.	Polymtn. interval min.	Sp. viscosity
1	125°C.	10	0·274
2	125°C.	20	0·280
3	125°C.	30	0·289
4	125°C.	40	0·282*
5	125°C.	50	0·285
6	125°C.	60	0·296
7	125°C.	70	0·284
1	135°C.	5	0·271
2	135°C.	10	0·273
3	135°C.	15	0·273
4	135°C.	20	0·277
5	135°C.	25	0·294
6	135°C.	30	0·310
7	135°C.	35	0·357
1	150°C.	5	0·295
2	150°C.	10	0·276
3	150°C.	15	0·290
4	150°C.	20	0·295
5	150°C.	25	0·343
6	150°C.	30	0·373
1	175°C.	3	0·257
2	175°C.	6	0·283
3	175°C.	9	0·234
4	175°C.	12	0·347

*The values underlined need checking which is presently undertaken.

TABLE IX — ACTION OF HEAT (150°C.) ON WATER-SOLUBLE HYDROLYSED LAC

Duration of heating	A.V.	S.V.	H.V.
0 hr.	225·3	270·5	268·42
½ hr.	192·3	275·4	248·40
1 hr.	172·0	284·0	209·37
2 hrs.	154·9	272·5	154·90
0 hr. (separate sample)	219·7	277·5	266·10
2 hrs.	157·1	287·9	157·10
4 hrs.	150·4	288·6	150·40
10 hrs.	143·1	293·9	143·10
17 hrs.	134·2	—	—

APPENDIX C

Method for the Determination of Seedlac Yield from Sticklac

100 gm. of a representative sample of the sticklac is taken and sieved through a B.S. 40-mesh sieve, and the dust passing through is weighed (A). The residue is now ground and passed through the 40-mesh sieve. The portion that is not easily ground and consists mainly of woody matter, etc., is weighed (B).

The portion which has been ground and passed through is properly mixed by rolling 20 times on a sheet of paper. 10 gm. of this is accurately weighed and transfered into a glass stoppered conical flask containing 100 c.c. of neutral alcohol. After shaking a minute it is warmed in a water bath maintained at 45° ± 1°C. for 5 minutes, and then with occasional shaking at intervals of 5 minutes for another 40 minutes. After this, the flask is allowed to stand at room temperature for 10 minutes whereby the insoluble materials settle to the bottom. In some cases some lighter particles may also float on to the surface. 5 c.c. of the clear solution is then pipetted out into a beaker containing 50 c.c. of neutral alcohol and the diluted solution titrated against $N/10$ alcoholic potassium hydroxide solution using thymol blue as external indicator.

The yield of seedlac obtainable from the sticklac examined is calculated from the following formula:

$$P = [\,100-(A+B)\,]\,[\,V\times 0{\cdot}1318\,]$$

where P = percentage of seedlac available from the sample of sticklac,

A, the weight of dust,

B, the weight of woody and other matter and

V, the volume in c.c. of the alcohol potash required to neutralize the diluted solution.

To convert this percentage into seers per maund, multiply by 0·4.

APPENDIX D

Rapid Method for the Determination of 'Impurities' (Matter Insoluble in Hot Alcohol) in Lac

Apparatus:

1. Beaker without spout 600 c.c.
2. Wire gauze funnel to fit lightly in the above.
3. Whatman folded filter paper No. 13, 15 cm. or equivalent.
4. Glass stoppered weighing bottles 90 ± 1 mm. in height and 40 ± 1 mm. in diameter.
5. A hot extraction apparatus (The one used for method A of U.S.S.I.A. for this determination can be used).

Procedure:

Dry two filter papers after marking them A and B in an oven at 105°C. for twenty minutes; transfer to two weighing bottles, allow to cool in a desiccator and weigh by counterpoise. Fit A into the conical wire gauze fitted at the mouth of the beaker containing

about 50 c.c. of alcohol. Weigh accurately about 5 gm. of the sample and transfer to the filter paper. Wet the lac with a fine stream of cold alcohol from a wash bottle. After 10 minutes, place the beaker on a hot plate and raise the alcohol to gentle boiling. Dissolve the remaining portion of lac on the filter paper with a fine stream of hot alcohol, giving at least two washings with 20 c.c. each. Allow the vapours of the boiling alcohol in the beaker to extract as much lac from the filter paper as possible. The operation on the hot plate takes about 20 minutes.

Remove the wire gauze funnel from the beaker and allow the filter paper to dry, fold it and then wrap the other filter paper marked 'B' round it, by means of a piece of thread. Extract this packet for one hour in the hot extraction apparatus. Remove, transfer it in a funnel and wash it with two successive amounts of 5 c.c. sulphuric ether. Separate and allow the filter papers to dry on a 15 cm. watch glass in the air for a few minutes and then for one hour at 105°C. Cool for 20 minutes in a desiccator, before weighing them again in their respective weighing bottles.

Calculations:

$$\text{Hot alcohol insolubles per cent} = \frac{w}{W} \times 100$$

where w = increase in the differences in weight between the weighing bottles by the determination, and W = weight of lac.

APPENDIX E

Recovery and Refining of Lac Dye

RECOVERY

Small factories — Lac wash water from the first three washings from 35 kg. (1 md.) of *beuli* (72 to 90 litres or 16-20 gallons) is taken in a washing vat and concentrated sulphuric acid (0·45 kg.) added slowly with continuous stirring with a wooden rod till precipitation is complete. Sudden curdling of the solution indicates the completion of precipitation. The acidified suspension is allowed to stand for 30 min., when the dye settles down. If sodium carbonate is used for washing sticklac, the precipitate floats on to the surface due to the presence of carbon dioxide gas, but on vigorous stirring it settles down. The coloured supernatant liquid is removed without disturbing the settled precipitate. The bottom layer is then filtered through cloth. For complete draining of water the cloth with the precipitate is hung on poles. The precipitate is then spread on a cemented floor in the sun for drying, and powdered.

In factories not provided with washing vats, cement lined cisterns (capacity, 15,000 litres; height, 1 m.) can be used. To drain out the supernatant liquid and the settled mass, the cistern should be provided with two openings, one 7·5 cm. above the inside floor level, and the other flush with the bottom.

Big factories — In big factories, washing of seedlac is usually done in barrels (capacity 800 kg.) and the rate of flow of effluent is 70-90 cu. ft. per min. The effluent from the barrels is allowed to pass through a succession of cisterns, the overflow being from the top of one cistern to the bottom of the next so that the suspended particles of lac get enough time to settle down. The effluent from the last cistern is taken into another cistern 1 m. deep and of such a size that it gets filled to the overflowing level in 30 min.

A sample of the effluent is taken from near the inlet and its dye content determined. The quantity of sulphuric acid required for complete precipitation of the dye is calculated and added to the cistern during a period of 25 min. The liquor overflowing from the cistern is allowed to pass into another cistern of equal size where the remaining precipitate settles down. The effluent from the second cistern is allowed to flow out. The precipitated dye settling at the bottom of the cisterns is allowed to stand for one hour and then the supernatant liquid drained out through an opening provided at a height of 7·5 cm. from bottom. The precipitate is finally filtered through a filter press, dried in the sun and powdered.

REFINING

Crushing — Crude lac dye as obtained from lac manufacturers will be in the form of hard cakes. These are to be first crushed to 30-40 mesh in a mechanical disintegrator. It takes about one hour to crush one maund of crude dye in a 17″ C & N disintegrator fitted with a 7·5 H.P. motor and one attendant. The crushed lac dye is less in weight than the crude by about 10 per cent due to driage, mechanical losses, etc.

Dewaxing — The crushed crude dye contains 10 to 12 per cent wax. For extracting this wax, hexane may be used. By hot soxhleting with hexane for 30 minutes (15 to 20 cycles) the wax content is reduced to 1·2 per cent. By cold soxhleting for two hours the wax content is reduced to 3·4 per cent. By recirculation of the same solvent (300 c.c.) through the same material (50 gm.) 15 to 20 times in the cold, the wax content is reduced to 4·5 per cent. It has previously been noted, that if the wax content is 5 per cent or less the crude can be conveniently processed for further purification. 1,000 gm. of crushed crude dye, when packed lightly, occupies a volume of about 2,000 c.c. In our equipment we used 12,000 c.c. of solvent for extraction of 2,000 gm. of crude dye. The amount of hexane retained by the residue from 2,000 gm. of crude dye was about 2,000 c.c. This should be recoverable in a solvent recovery plant.

Dye extraction — The dewaxed dye is now extracted with 1 per cent borax solution. For 4,000 gm. of dewaxed dye 80 litres of 1 per cent borax solution, i.e. 800 gm. of borax ($Na_2B_4O_7$, 10 H_2O) in 80 litres of water is required. The extraction is carried out at room temperature by stirring the dewaxed crude in the borax solution in a stainless steel vat by a mechanical stirrer for one hour. For borax having composition $Na_2B_4O_7$, 10 H_2O the quantity required is 800 gm. If the water content of borax is less the quantity required will also be proportionately reduced. The quantity of anhydrous borax ($Na_2B_4O_7$) required is 422 gm. For extraction of the dye with borax solution, wooden vats may also be used instead of the stainless steel vessel.

Precipitation and isolation — After extraction for one hour, 10 c.c. of glacial acetic acid is added with stirring and then allowed to settle for two hours whereby the albuminous matter and other insolubles settle down. The top solution is decanted and acidified with 1 lb. of commercial sulphuric acid diluted to 50 per cent strength. The precipitated dye settles within two hours and then the top liquor is decanted out and the bottom sludge filtered through cloth and dried in a steam heated S.S. pan. The dry material is cooled and finally powdered to 100-mesh.

The crude dye contains 10 to 15 per cent of lac dye and the material refined as above 65 to 70 per cent.

APPENDIX F

Dyeing of Wool and Silk with Refined or Technical-Grade of Lac Dye

The following percentage of the dye on the weight of the material is recommended for obtaining light, medium and heavy shades on wool and silk:

Shade	Lac dye per cent required on the weight of the material.
Light	0·0-0·5
Medium	0·5-2·0
Heavy	2·0-6·0

A one per cent solution of the dye is first prepared by dissolving 1 part of dye in 100 parts of water, containing 1 part of borax (commercial) and filtered through a cloth.

Wool or silk is scoured before dyeing. The vat to be used for dyeing should be made of any metal other than iron, like stainless steel, enamelled iron, or copper, etc. 50-60 parts of iron-free water on the weight of material to be dyed is taken in the dye bath. Common salt (15 per cent on the weight of the material to be dyed) is added and dissolved. The required amount of dye solution prepared as above, according to the depth of shade required, is now added, at room temperature.

The dye bath is then made just acidic to litmus with acetic acid and the material is dipped in the bath and stirred continuously. The bath is then gradually heated to boiling in 15 minutes and then kept at boiling temperature for one hour. If the concentration of dye is more than 4 per cent on the weight of material, it is advisable to add the dye solution in three lots for level dyeing.

For mordanting — After the dyeing is complete, a solution of any of the following mordants is added to the residual solution in the same bath which may or may not contain very small amounts of the dye.

1. Tin chloride — oxalic acid (maximum of 4 per cent each on the weight of material)
2. Alum (maximum of 6 per cent on the weight of the material)
3. Ferrous sulphate (maximum of 6 per cent on the weight of the material)
4. Potassium dichromate and Sulphuric acid (maximum of 4 and 1·0 per cent respectively on the weight of material)
5. Potassium dichromate and Cream of tartar (maximum of 4 per cent each on the weight of the material)

The actual amount of mordant to be used will depend upon the amount of the dye used and shade required. After adding the mordant the bath is maintained at boiling temperature for another hour. Mordanting may be done before the dyeing also.

APPENDIX G

Preparation of Hydrolysed Lac (Saponified Lac) from Shellac

125 gm. of sodium hydroxide is dissolved in 200 c.c. of water, cooled and the total volume measured. 5 c.c. is pipetted into a 100 c.c. measuring flask and the volume made up. The remaining solution is taken in a 2-litre flask. 500 gm. of shellac powder is added. The whole is mixed together and boiled under reflux for five to six hours.

The refluxed material is allowed to cool down over-night and dissolved in about 2 litres of water and filtered into a 4-litre beaker, and the wax thus separated. The clear filtrate is diluted to 3 litres and precipitated with the calculated quantity of 10 per cent sulphuric acid, as determined by titration of the made-up NaOH solution against the acid. The acidified solution is allowed to stand for an hour and the supernatant liquid decanted. The sticky mass left behind is washed with hot water, till free from mineral acid. It is then transfered to an evaporating basin and heated up to 120°C. with constant stirring to remove moisture. The hot melt is filtered through muslin cloth.

Yield 60-70 per cent.

APPENDIX H

Test Report on the Prevention of Loosening of Bolts and Nuts by Shellac

Sample:	Shellac varnish.
Mark:	O/C1, O/C2, O/C3, O/C4, and O/C5.
Sample sent by:	The Indian Lac Research Institute, P.O. Namkum, Ranchi, Bihar.
Reference:	Indian Lac Research Institute, Letter No. LR-IU/14/59/3631, dated 26th May 1959.
Equipment used:	AMSLER'S Hammer Impact Testing Machine.

1. The arrangement of the test is to fit up a tensile test piece having double ended threads, one end of which is fitted with a nut and fixed under a lock-nut and a solid block threaded up to the top of the nut. The other end of the nut which passes through the central hole of the hammer is tightened with the bottom nut and locked with a lock-nut to prevent loosening. The hammer shoulder knocks the collar of the nut imparting 600 blows per minute with strength of the blows varying from 7 to 40 kg. cm. (0·5 to 2·9 ft. lb.)

2. In testing the varnish samples, the bottom end of the test piece was dipped in varnish and the nut tightened. The lock-nut was not used, to study the effect of the varnishes in preventing the loosening of the nut.

The results obtained are as under:

Specimen tested in Hammer machine — $\frac{3}{8}$" B.S.G. (Double ended threads)

Stage No. 1: Nut fitted to the bolt without application of varnish.

Stage No. 2: Bolt dipped in varnish and nut tightened after the varnish had dried up.

Stage No. 3: Bolt dipped in varnish and nut tightened before the varnish gets dried up.

Stage No. 1 — Free nut

1. *0·10 × 10^6 blows
2. *0·16 × 10^6 blows
3. *0·33 × 10^6 blows

*Nut opened out.

Stage No. 3

Nut fitted to the bolt dipped in varnish and tightened before the varnish gets dried up:

O/C1	O/C2	O/C3	O/C4	O/C5
‡$2{\cdot}5\times10^6$	*$0{\cdot}267\times10^6$		†$0{\cdot}80\times10^6$	$0{\cdot}115\times10^6$
	*$0{\cdot}415\times10^6$	*$2{\cdot}4\times10^6$	*$1{\cdot}60\times10^6$	$0{\cdot}219\times10^6$*
	*$0{\cdot}219\times10^6$			$0{\cdot}180\times10^6$*

3. All the samples of varnishes at Stage No. 2 did not show any better results than the nut free from varnishes, because it was observed that when the varnish was allowed to dry up completely, the entire matter comes out clean from the threads when the nut is fitted to the bolt.

4. The varnish samples have to be applied to the bolt and nut and the nut has to be tightened before the varnish gets dried up. The vibration has to be started after the varnish inside the threads gets completely dried up which generally takes two to three hours.

4. On a comparative study of the samples forwarded, it was found that varnish marked O/C1 and O/C3 gave very good results and there was no looseness even at $2{\cdot}5\times10^6$ blows. The nut had to be taken out with considerable force. Amongst the other three O/C4 is comparatively better, though not quite satisfactory.

*Nut opened out.
†Tendency to open out but continued in position for some more time.
‡Nut still in position firmly fixed.

APPENDIX J

Tabulated Statement of Progress of Investigations

ENTOMOLOGY DIVISION

Item	Date commenced	Progress	Remarks/Future work
IIA — Research and Investigations			
1. Improving crop production on *palas* by partial defoliation			
(i) Large-scale defoliation experiments at Kundri	1948-49	Severity of summer (1959) was responsible for 90 per cent mortality of lac insects. Against a total expenditure of 3,636.46 nP., a revenue of Rs. 5,927.62 nP. was obtained.	To be continued
(ii) Effect of partial defoliation of *palas* on brood preservation	1948-49	Conducted on sound statistical lines for the 2nd year, ratios of brood yield to brood used were 1 : 0·63 and 1 : 0·50 respectively for the defoliated and the control group. Survival rates (from summer heat) for lac insects were 13·7 per cent and 2·14 per cent respectively for the defoliated and the control groups.	To be continued
2. Preliminary trials on the evolution of cultivation practices	1959	Five plans of operations were adopted: (1) Heavy inoculation, no defoliation, partial *ari* cutting in April, complete cropping in Oct.-Nov. (2) Same as (1) except that partial cropping was done in July. (3) Light inoculation, no defoliation, allowed self-inoculation in July and complete cropping in Oct.-Nov. (4) Same as (3) except that medium light inoculation was adopted. (5) Medium light inoculation following partial defoliation, partial cropping in July, and complete cropping in Oct.-Nov. Maximum crop was obtained from plan (2) and maximum brood from (3).	A combination of (2) and (3) is to be evolved
3. Economics of utilizing *palas* for the *Baisakhi* and *ber* for *Katki* crop only	Before 1953	In the *Baisakhi* season, *ber* produced more crop but less broodlac than *palas*. In the *Katki* season, *ber* proved better than *palas* in either respect.	To be continued
4. Comparative preservation of broodlac on *ber* by partial pruning before and after inoculation	1954-55	Brood yields were either very poor or nil. Pruning treatments, however, appeared to be slightly more effective: Statistical analysis was not possible.	To be continued
5. Finding of, and trial as, brood preservers on lac hosts for *Baisakhi* crop including certain *Ficus* and *Albizzia* sp. and also trials on hosts similar to those in Thailand	1945-46	*A. lebbek*, *A. stipulata*, *F. glomerata* and *F. glabella* were tried. Initial (larval) good settlement was followed by almost complete mortality.	To be continued

APPENDIX J (*Contd.*)

ITEM	DATE COMMENCED	PROGRESS	REMARKS/FUTURE WORK
6. Proper time of harvesting for maximizing yield	1955-56	Experiment was done on *palas* subjected to four treatments: (1) heavy inoculation and *ari* cutting in April, (2) Ditto, *ari* cutting in May. (3) Ditto, and cropping at maturity (June-July). (4) Light inoculation after partial defoliation, and cropping at maturity. *Ari* cutting in April and May [(1) and (2)] gave much higher yields: this confirms previous findings.	To be continued
7. Determination of the optimum density of larval settlement	1953	Experiments were conducted with both *palas* and *kusum*, three treatments being adopted, namely (A) Half the normal, (B) Full normal and (C) Double the normal requirement of brood. Statistical analysis indicated the following: For *palas*, (C) was better than either (A) or (B). For *kusum*, (C) is found to differ significantly from either (A) or (B), these two not differing significantly between themselves. As in past years decreased larval mortality and increased occurrence of males were found, to go with denser settlement.	To be continued
8. Determination of optimum density of larval settlement and proper time of harvesting for maximizing yield on *palas* in the *Baisakhi* season	1957-58	This is a combination of items 6 and 7. Times of harvesting and brood rates were varied together. All the times of harvest and brood rates differed significantly among themselves.	To be continued
9. Growing of lac under crop and bush conditions			
(i) Under crop conditions	1952-53	*Kusum* brood on *arhar* was tried. Initial larval settlement good. But plants died out during the summer in spite of irrigation. The *Aghani* crop was destroyed completely by predators and parasites.	To be continued
(ii) Under bush condition	1952-53	Experiments with *Moghania macrophylla* were continued. Shoots were found to grow in March and September. Bushes are ready with infectable shoots one year after previous harvesting. *Rangeeni* strain fared well, but *Aghani* (*kusmi*) suffered due to insect attack, and *Jethwi* from initial larval mortality. *Kusum* progeny raised on *M. macrophylla* could be successfully used to inoculate *kusum*, *Albizzia lucida* carried both *Baisakhi* (*rangeeni*) and *Jethwi* (*kusmi*) crops successfully.	To be continued
10. Control of enemies of lac during storage by use of insecticides	1954	*Baisakhi* crop was experimented upon on the same line as in past year. Insecticides were effective particularly	To be continued

APPENDIX J (*Contd.*)

Item	Date commenced	Progress	Remarks/Future work
		against predators. Ekadox 2 per cent, Endrex 1 per cent and Aldrex 5 per cent dust being the most effective. Two fumigants (Ethylene dibromide and trichlorethylene) proved quite effective in controlling enemy insects during storage.	
11. Survey of lac enemies and their parasites		(a) *Caging study*: Samples of lac sticks from various field areas were caged: 4 species of insects, probably *new*, could be recorded. (b) *Non-insect enemies*: Four plots in 4 blocks were under observation: 53·6 per cent of the length of brood sticks was found damaged due to birds and rodents.	To be continued
12. Biological control of insect enemies	1942		
(a) Life-history studies and developing breeding techniques	1959	Life-history studies of *Apanteles fakhrulhajiae* were started. Laboratory breeding going on at 26-27°C. and 70-80 per cent R.H.; the parasites were made to accept as food *Corcyra cephalonica*.	To be continued
(b) Mass-breeding of *B. greeni* and *A. tachardiae*	1959	Technique developed in the past having failed, attempts are being made to find out new technique. Of the various foods offered, honeydew excreted by lac insects appeared to work.	To be continued
(c) Large-scale liberation of *A. tachardiae* and *B. greeni* in the fields and estimation of effect of liberation		The two parasites separately as also together, were released in certain selected plots, the experiment being laid on statistical lines. No significant effect could be observed.	To be continued
13. Rearing lac insects through artificial feeding	1957	Larvae settled on severed barks and fed on sap for *ca* 3 weeks. Other substrates did not succeed, in particular, due to yeast fermentation of sap. Salicylic acid proved most effective in checking fermentation. One fact could be established, namely that insects can feed independently of the living plant.	To be continued
14. Genetical studies on the lac insects	1959		
(i) Irradiation studies on the lac insect		*Kusum* sapling, potted *palas* plants and broodlac sticks were exposed to radiation from Cobalt 60, the dosage being varied from 100*r* to 5,000*r*. Doses up to 500*r* did not affect the larvae: in certain cases, 1,166*r* completely killed all the insects. Progeny from irradiated stock has been used to inoculate plants.	To be continued
(ii) Cross-breeding of *rangeeni* and *kusmi* strains	1959	Experiments just started. Crossed females on *palas* are developing normally.	To be continued

APPENDIX J (*Contd.*)

ITEM	DATE COMMENCED	PROGRESS	REMARKS/FUTURE WORK
IIB — REGIONAL FIELD RESEARCH STATIONS			
1. Jhalda (West Bengal)			
(ii) Research			
(a) Spurious emergence of larvae	1959	To study the cause of observed spurious (early) emergence of lac larvae, *kusum* trees were inoculated with (A) pure *kusum* brood, (B) *ber* brood, (C) *palas* brood, (D) mixed (*ber* and *kusum*) brood and (E) mixed (*palas* and *kusum*) brood. No spurious emergence occurred in *Aghani* 1958-59 season. In *Aghani* 1959-60 season, larvae mostly died out in case of mixed inoculation. In 4th week of October, spurious emergence occurred on *all* the trees, showing that this was due to weather factors, and not to mixed inoculation. Progeny from spurious emergence, used to inoculate hosts, gave mature crop in April.	To be continued
(b) Alternative lac hosts for the *kusmi* strain	1959	In one set of experiments, *Bursea serrata*, *Dalbergia latifolia* (also *palas* and *ber*) as well as *kusum* were alternated and in another set *kusum* progeny was tried continuously on new hosts. Ratio of brood used to yield in terms of scraped lac varied from 1:0·45 (*D. latifolia*) to 1:2·93 (*F. infectoria*).	To be continued
2. Madhya Pradesh			
(i) Research			
(a) Response of *ghont* (*Z. xylopyra*) to pruning	1959	For *Kathi* (1959), pruning times (trial) were first week of December; 2nd week of February, and 2nd week of May in alternate years. For *Baisakhi* (1958-59), the pruning times were 2nd week of April and 3rd week of May. Trees pruned in April gave better yield ratio.	To be continued
(b) Trials of regional hosts to fortify lac cultivation on *ghont*	1959	*Ber*, *palas*, *airma* (*Acacia* sp.), *renja* (*A. leucophloea*) were tried: pruning and inoculation were done and hosts were kept under observation.	
(c) Investigation on preservation of broodlac	1959	Experiments designed on statistical basis. Pruning and inoculation have been done.	To be continued
(d) Evolution of cultivation practice to be followed for *ghont*	1959	A new experiment with 500 trees undertaken: only one crop (*Katki*) as a result of self-inoculation in June-July is to be taken.	To be continued
(e) Comparison of performance of trees situated in open tracts and those in shaded areas along tank bunds		Three brood rates, normal, medium and light, were used for inoculation. Better *Baisakhi* crop was obtained from the shaded areas. No dependable conclusion could be drawn for the *Katki* crop.	

APPENDIX J (*Contd.*)

Item	Date commenced	Progress	Remarks/Future work
(ii) Introduction of new hosts for brood preservation: Raising of exotic hosts	1959	Along with *A. lucida* and *O. dalbergioides*, *M. macrophylla* and *Samania saman* were raised in nurseries.	
3. Mirzapur (U.P.)			
(ii) Research (a) Response of *ghont* to pruning	1959	400 *ghont* trees divided into 3 coupés: coupes I & III with 100 trees each for *Baisakhi* crop and coupé II with 200 trees for *Katki* crop. For *Baisakhi* coupés I & II pruning will be done in April and May respectively. For *Katki* coupé, pruning will be done each year in December (A), in February (B); in alternate years in May (C & D).	
(b) Optimum density of larval settlement	1959	Division in coupés has been done.	
III. Plantation at Namkum		Maintained. *M. macrophylla* was planted. *C. saltiana* was raised continuously.	
IV. Training and Advisory Services			
(1) Training		No trainees joined the Division. Lectures on lac cultivation were given in Forest Guards Training School and Forester Training Schools.	
(2) Advisory Service		As usual, technical advice was given.	
(3) Exhibitions		The Division took part in, as well as sent exhibits to, several exhibitions.	

CHEMISTRY DIVISION

1. Grading and Analysis			
1.1 Assay of sticklac for resin content	1958-59	A method based on determination of the acid value has been successfully formulated for the determination of resin content of, and seedlac yield from sticklac.	Concluded (Details in App. C)
1.2 Determination of impurities or hot alcohol insoluble matter in lac	1959-60	The existing (U.S.S.I.A.) method requires 2-3 days. A new method has been worked out which reduces the period of determination to *ca* 4 hrs., besides not requiring special thimbles. 54 determinations have been made by the method and the results statistically analysed.	Further samples have to be tested
1.3 Bleach Index/Bleachability of lac (Round robin test)	1957	The Indian Lac Research Institute method was tried in different laboratories in U.S.A., U.K., France and India. While results obtained in different laboratories in India were concordant, those obtained in laboratories abroad showed wide varia-	To be continued

APPENDIX J (*Contd.*)

ITEM	DATE COMMENCED	PROGRESS	REMARKS/FUTURE WORK
		tions. The discrepancies were attributed to *visual* colour determination (in a Dubosq colorimeter), hence a photoelectric colorimeter is being tried.	
2. Refining and manufacture			
2.1 Improved method of lac washing	1959-60	Lac was washed using (i) soda (the usual process), (ii) caustic soda and borax (a new Institute process) and (iii) ammonium oxalate (Shellac Export Promotion Council method); while yield is practically the same, (ii) & (iii) reduce the bleach index by *ca* 5 c.c. more than the soda process. However, whereas (ii) does not give consistent results, (iii) does.	To be continued
2.2 Bleaching of lac	1953/57	Conducting bleaching at 15° and 8° was a very slow process (43 hrs. and 109½ hrs. respectively), besides effecting little or no saving in bleach liquor as compared with bleaching at 25°C.	To be continued
2.2.1 Improving keeping quality of bleached lac	1958-59		
2.2.2 Life and flow		The usually poor life and flow of bleached lac could not be appreciably improved by changing conditions of preparation, e.g. using varied amounts of soda for the extraction of the seedlac, portion-wise precipitation of bleached lac, use of antichlors (washing soda or caustic soda), bleaching in absence of light, etc., etc.	To be continued
2.2.3 Pilot plant for lac bleaching	1957	Some of the units of the plant were received and the centrifuge and the dryer were given trials. Their operation conditions are being standardized.	To be continued
2.2.4 Mechanism of bleaching	1959	Contrary to the view held in certain quarters, it was found that bleaching of lac is not related to chlorine intake by the resin, bleaching and chlorination being two independent reactions; chlorination appears to be an unavoidable side reaction only.	Chlorine-free bleached lac would have better keeping qualities and investigations towards the end will continue
2.2.5 Fractionation of bleached lac	1959	Bleached lac was fractionated using low temperature technique with acetone as solvent. All the fractions contained chlorine, and were present in much the same proportions as in the case of dewaxed decolorized lac.	Completed
2.3 Recovery of by-product			
2.3.1 Lac dye	1957	The process was improved: Soxhleting with white spirit instead of hot extraction in an open pan meant saving in white spirit. Replacing white	To be continued

APPENDIX J (*Contd.*)

Item	Date commenced	Progress	Remarks/Future work
		spirit by *n*-hexane yielded still better results.	
2.3.2 Dyeing with lac dye		The process of dyeing wool and silk with our technical grade was standardized. The dye also proved suitable for dyeing jute.	
3. Fundamental Researches			
3.1 Constitution studies			
3.1.1 Isolation of shellolic acid		The process for obtaining shellolic acid from dimethyl shellolate was standardized. Colourless crystals of shellolic acid were obtained (m.p. 204°-205°C. with decomposition).	Suspended
3.1.2 Aldehydic acid		Some progress was made in obtaining the acid in a purer form than before. The product, however, cannot yet be obtained in a crystalline form.	do
3.1.3. Fractionation of aleuritic acid		Aleuritic acid could be fractionated into two fractions. These on oxidizing with pot. permanganate under boiling water temperature, gave two dibasic acids which on paper chromatography were found to be azelaic and pimelic acids: the original fractions were therefore geometrical isomers.	do
3.1.4. Butolic acid	1949	Butolic acid was first obtained from hydrolysis products of lac. It has now been obtained without hydrolysis by repeated extraction of a 30 per cent alcoholic solution of lac with excess of petroleum ether: the new method of isolation has shown that a major portion of butolic acid is present in lac in the free state.	do
3.1.5. Fractionation of lac resin	1959	The technique of temp. phase separation was applied to lac resin, the solvent being dry acetone. Four fractions with gradually decreasing m.p. (highest m.p. 105°C.) and increasing A.V. and S.V. were obtained. Paper chromatography shows the first three fractions to be alike, but the 4th one is different.	To be continued
3.1.5.1. Fractionation of *palas* seedlac	1959	Similar experiments as in 3.1.5 were done with much the same results. Using an additional intermediate temperature a total of five fractions was obtained.	do
3.1.6. Paper chromatography of seedlac	1957	Chromatography of various hydrolysed seedlacs (*kusmi*, *rangeeni*) gave 7 distinct spots in each case, showing they were all similarly constituted.	
3.1.7. Fractionation of lac-urea complexes from acetone	1957	Three solid complexes with urea for boiling acetone solution were obtained, of which I, on standing, under-	Suspended

APPENDIX J (*Contd.*)

Item	Date commenced	Progress	Remarks/Future work
		went gradual polymerization: the other two remained unchanged (on standing).	
3.2 Physico-chemical studies			
3.2.1 Changes in the carbonyl value of lac during saponification	1957	Kamath and Mainkar's finding that during saponification, the carbonyl value of lac first gradually increases and then slowly decreases could be verified. The nature of progressive change suggests that the carbonyl occurs in lac partly free and partly in a combined state.	To be continued
3.2.2 Infra-red spectra of lac	1959	Complete infra-red spectra of dewaxed shellac, dewaxed decolorized lac and dewaxed bleached lac were recorded over the range 2·5 to 15μ. The spectra were alike. Absorption bands are assigned to secondary — OH, methyl, methylene, carbonyl, carboxyl, chains of more than 4 methylene groups, and substituted aromatic rings, Cl could not be detected in bleached lac, presumably due to its weak absorption.	
3.2.3 Changes of carbonyl value during thermal polymerization	1959	Carbonyl value on heat- or age-polymerization gradually changes to nil. Preliminary experiments suggest that the method of determination requires closer study.	To be continued
3.3 Kinetics of thermal polymerization of lac	1959	Viscosities were determined of alcoholic solutions of lac heated for different periods. Polymerization was found to be progressive, and occurring at a very much increased rate as the sample approaches the fully 'cured' or rubbery stage.	To be continued
4. Uses of lac			
4.1 Aqueous lac varnishes	1952	Ammonia-exposed (water-soluble) lac stored in alkathene bags has retained water solubility for 1½ years so far but samples kept exposed in an open vessel started becoming insoluble within a month.	Completed
4.2 Shellac wash primer (single-pack)	1957	A commercial two-pack primer and the Institute's single-pack wash primer were tried respectively on two samples of an aluminium coach of S.E.Ry. Paints flaked off both the surfaces after a month.	To be continued
4.2.1 Storage of wash primer	1957	The primer was stored in glass, bright plate (tin) containers and tins slushed inside with a catalysed cold cured epoxy resin. No deterioration was noted in any of these after three months.	To be continued

APPENDIX J (*Contd.*)

Item	Date commenced	Progress	Remarks/Future work
4.2.2 Accelerating hard drying time of the wash primer	1959	Maximum hardness was attained after 48 hours' air-drying: attempts to reduce the period to 24 hours by increasing the phosphoric acid content did not succeed.	To be continued
4.2.3 Shellac wash primer: two-pack system	1959	A two-pack system based on zinc tetroxy chromate did not give consistent results.	To be continued
4.3 Modification of shellac esters with polycarboxylic acids	1959	Butyl ester of lac was treated with phthalic anhydride at 188°±5°C. in presence of xylene and in a stream of CO_2: the A.V. came down from 109·6 to 38·10. The product was soluble in toluene and benzene, but insoluble in alcohol.	To be continued
4.4 Storage of french polish in metal containers	1959	Addition of inhibitors, or reduction of acidity of the varnish did not improve the keeping quality. Containers with their inside slushed with a catalysed cold curing epoxy resin proved satisfactory, no deterioration after eight months' storage having been observed.	To be continued
4.5.1 Hydrolysed lac (water-insoluble)	1959	In view of its possible use as a plasticizer, preparation of the water-insoluble portion of the resinous mixture obtained by the hydrolysis of lac was standardized.	To be continued
4.5.2 Water-soluble hydrolysed lac	1959	Properties were studied.	
5. *Ad hoc* Investigations			
5.1 Shellac composition for prevention of loosening of bolts and nuts	1959	A few shellac-based compositions prepared according to suggestions of the Ministry of Commerce & Industry were prepared and tested and conditions for successful working determined.	Completed
5.2 Shellac for use in hydraulic bed models	1959	After some preliminary trials, button-lac and *kiri* mixed with barytes for adjustment of sp. gr. with addition of a stearate as water-repellent and urea as accelerator, and crushed to appropriate particle size were supplied to the Central Water and Power Commission Research Station, Poona for tests.	Reports received subsequently show that the composition has shown promise and enquiry has been received for possibilities of a bulk supply.
5.3 No-rub polishes	1959	Some published formulations based on dewaxed lac and carnauba wax were tried: the films had poor water-resistance. Replacing shellac by water-soluble lac (ammoniated lac) and carrying out other modifications gave films with good water-resistance, but poor gloss.	To be continued
6. Publicity and propaganda		(1) Lac dye for dyeing wool and silk has evoked considerable interest in many quarters.	

APPENDIX J (*Contd.*)

ITEM	DATE COMMENCED	PROGRESS	REMARKS/FUTURE WORK
		(2) Dry mounting (photo) tissue paper is in commercial production, and possibility of restricting imports is being considered.	
		(3) Bleached lac, being made in the Production Unit, is slowly gaining in popularity. Private firms in Calcutta and Delhi also have started production.	
		(4) Water-soluble lac is being popularized through the Khadi & Village Industries Commission, and Extension Centres.	
		(5) One firm in Calcutta has undertaken manufacture and supply of hydrolysed lac, (presumably for use in paper varnishes).	
		(6) Furniture Repolishing Publicity Centre started functioning at Delhi. One private firm is marketing a handy " Do it yourself " " all in one " kits, and demand for ready-made french polish is on the increase. A batch of demonstrators is also carrying on house-to-house propaganda cum demonstration work.	
7. Regional Analytical laboratories			
7.1 At Gondia	1959	237 samples for 302 tests were received and tested. To make the manufacturers more interested in analysis, charges for analysis per sample have been reduced to 0·50 nP.	
7.2 At Jhalda		During the five months it has functioned, it received and analysed 22 samples.	
8. Compilation of literature		(1) *Uses of lac* was revised and reprinted.	
		(2) *Chemistry of lac* was finally edited.	
		(3) *Shellac Patents Index* revised and brought up-to-date and sent to to the Press for printing.	
9. Production Unit	1959	The Unit is making water-soluble and bleached lac, as also autoclave shellac of several grades. Total sales during 9 months amounted to Rs. 3,678.39.	

APPENDIX K

List of Publications from the Institute during 1959-60

1. Fractionation of shellac: Part I — Shellac-urea complexes, by S. C. SEN GUPTA (*J. sci. industr. Res.*, **18A**, No. 5, 1959, pp. 221-24).
2. Separation and Identification of Hydroxy Acids in shellac, Part I — Chromatographic separation and identification, by S. C. SEN GUPTA (*J. sci. industr. Res.*, **18B**, No. 5, 1959, pp. 210-212).
3. *I.L.R.I. Bulletin No.* 97 — Lac cultivation in Assam with notes on the use of *Arhar* (*Cajanus cajan*) and other species as lac host, by S. KRISHNASWAMI & D. R. SAIKIA, (*Ind. Forester*, Vol. **85**, No. 5, 1959, pp. 294-300).
4. *I.L.R.I. Bulletin No.* 96 — A simple method of hygienic disposal of lac factory wastes, by T. BHOWMIK & A. K. GHOSE.
5. Annual Report of the Indian Lac Research Institute, 1957-58.
6. Uses of lac, by H. K. SEN & S. R. RANGANATHAN — revised edition, by Y. SANKARANARAYANAN, 1959.
7. Carbonyl value of shellac, by S. C. SEN GUPTA & S. K. MANI TRIPATHI (*J. sci. industr. Res.*, Vol. **18B**, No. 12, 1959, pp. 535-537).
8. *Moghania macrophylla* (willd) O. ktze (Syn. *Flemingia congesta* Roxb. *Var Semialata* Bak.) as a new lac host for growing the *Kusmi* strain of the lac insect, by S. KRISHNASWAMI, B. K. PURKAYASTHA & N. S. CHAUHAN (*Current Science*, Vol. **28**, No. 10, 1959, pp. 419-420).
9. Shellac-dimethylol urea moulding compositions, by P. K. GHOSH & S. C. SEN GUPTA (*J. sci. industr. Res.*, **18A**, 1959, 318).
10. Separation and Identification of dicarboxylic acid by paper chromatography, by S. C. SEN GUPTA, *Proc. Indian Sci. Congr. Assoc.*, Part III, 1960, 193.
11. Water-soluble lac and its use in aqueous varnishes for earthenware, by V. S. RAO & Y. SANKARANARAYANAN (Communicated for publication).

APPENDIX L

Statistics of Sticklac Production in Tonnes* (Metric) during the Years 1957-58 to 1959-60

Years	*Baisakhi*	*Jethwi*	*Katki*	*Aghani*	*Total*
1959-60	24,261	1,306	12,877	4,815	43,259
1958-59	22,392	1,120	9,405	1,698	34,615
1957-58	31,340	1,008	8,660	1,511	42,528

*1 tonne = 1,000 kg. = 26·79 maunds.

APPENDIX M

Appointments, Resignations, etc., during 1959-60

(a) APPOINTMENTS

Administrative Section

1. Sri Harihar Singh Munda	Junior Clerk	24th September 1959
2. Sri S. K. Banerjee	Junior Clerk	14th November 1959
3. Sri I. Joy	Junior Clerk	14th November 1959
4. Sri Rajeshwari Prasad Singh	Junior Clerk	18th November 1959
5. Sri Jatru Munda	Plantation Chaukidar	4th April 1959
6. Sri Deolal Singh Yadav	Plantation Chaukidar	4th April 1959
7. Sri Mohan Bahadur Chatri	Durwan	2nd May 1959
8. Sri Joakim Ekka	Chaukidar	22nd April 1959

Chemistry Division

1. Sri P. K. Ghose	Manager, Production Unit	22nd October 1959
2. Sri R. P. Gupta	Research Assistant	7th April 1959
3. Sri O. P. Ratra	Exhibition Assistant	6th November 1959
4. Sri B. I. Nemade	Research Assistant	5th December 1959
5. Sri Azizur Rahaman	Junior Research Assistant	24th September 1959
6. Sri P. Kunhunny	Junior Research Assistant	13th January 1960
7. Sri M. Mukherjee	Junior Research Assistant	14th January 1960
8. Sri A. K. Sen Gupta	Junior Research Assistant	1st March 1960
9. Sri Mahadeo Mahato	Peon	4th April 1959
10. Sri K. P. Chakraborty	Laboratory Attendant	7th April 1959
11. Sri P. B. Sen	Laboratory Attendant	9th April 1959
12. Sri Sibcharan Gope	Peon	23rd July 1959
13. Sri Md. Ghasheet	Laboratory Attendant	24th July 1959
14. Sri Sukra Oraon	Melter	15th September 1959
15. Bhandoo Mahto	(in Leave vacancy)	28th September 1959
16. Sri Saroj Kumar Deogharia	Laboratory Attendant	1st November 1959
17. Sri Chinmoy Sen Gupta	Laboratory Attendant	28th November 1959

Entomology Division

1. Sri U. N. Prasad	Arboricultural Officer	29th January 1960
2. Sri C. P. Malhotra	Instructor	22nd October 1959
3. Sri K. G. K. Murthy	Research Assistant	9th November 1959
4. Sri Syed A. H. Naqvi	Research Assistant	14th November 1959
5. Sri Md. K. Rahaman Noamani	Research Assistant	16th November 1959
6. Sri Md. Shakil	Research Assistant	28th November 1959
7. Sri H. D. Sharma	Research Assistant	27th January 1960
8. Sri N. B. Rai	Research Assistant	2nd February 1960
9. Miss Sati Guha Roy	Museum Assistant	1st May 1959
10. Miss Chitra Chatterjee	Lab. Assit.-cum-insect setter	21st May 1959
11. Sri S. K. Chatterjee	Fieldman	1st July 1959

12. Miss Aleyamma T. Verghese	Steno-typist	7th July 1959
13. Sri D. P. Karmakar	Fieldman	19th August 1959
14. Sri R. K. Paul	Fieldman	28th August 1959
15. Sri A. K. Saha	Steno-typist	27th October 1959
16. Sri R. C. Misra	Research Assistant	10th November 1959
17. Sri K. C. Jain	Fieldman	10th November 1959
18. Sri H. L. Ravidas	Laboratory Assistant	20th November 1959
19. Sri M. C. Pandey	Junior Research Assistant	24th December 1959
20. Sri Baldeo Mirdha	Chaukidar	1st February 1960
21. Sri Md Sharif	Laboratory Attendant	4th April 1959
22. Sri Prayag Mahto	Chaukidar	4th April 1959
23. Sri Yakub Tirkey	Laboratory Attendant	4th April 1959
24. Sri K. P. Keshri	Laboratory Assistant	7th April 1959
25. Sri Kamla Prasad	Laboratory Attendant	7th April 1959
26. Sri Jiwanlal	Durwan	7th April 1959
27. Sri Badri Prasad	Chaukidar	7th April 1959
28. Sri K. K. Chakraborty	Laboratory Assistant	7th April 1959

(b) PROMOTIONS DURING 1959-60

Administrative Section

1. Sri Md. Sharfuddin	Store-keeper	1st April 1959
2. Sri Md. Saheb Ali	Estate Caretaker	1st April 1959
3. Sri K. B. Thappa	Laboratory Supervisor	1st April 1959
4. Sri K. N. Sinha	Chief Mechanic	1st January 1960

Entomology Division

1. Sri C. P. Malhotra	Selection Grade	12th May 1959
2. Sri C. P. Malhotra	Instructor	22nd October 1959
3. Sri B. K. Purakayastha	Selection Grade	12th May 1959
4. Sri N. S. Chauhan	Research Assistant (Selection Grade)	22nd January 1960
5. Sri G. Lakra	Field Plantation and Store Assistant	1st April 1959
6. Sri B. B. Banerjee	Junior Research Assistant	11th August 1959
7. Sri Md. Ali Ansari	Insect Collector Tender	1st April 1959
8. Sri R. S. Maliya	Fieldman	30th September 1959

Chemistry Division

1. Sri Y. Sankaranarayanan	Organic Chemist	22nd May 1959
2. Dr. T. Bhowmik	Shellac Utilization Officer	20th July 1959
3. Sri P. K. Ghose	Manager, Production Unit	22nd October 1959
4. Sri S. C. Sen Gupta	Factory Officer	13th October 1959
5. Sri P. K. Ghose	Research Assistant (Selection Grade)	12th May 1959
6. Sri P. K. Choudhury	Senior Clerk	2nd September 1959

(c) TRANSFERS DURING 1959-60

1. Sri Jagarnath Bhatia	Lac Supervisor under L.E.O. to I.L.R.I. as Fieldman (Ento. Sec.)	31st August 1959
2. Sri Sant Kumar	Fieldman from Damoh to Namkum (Ento. Sec.)	15th October 1959
3. Sri P. C. Ghose	Research Assistant as T.A. to S.U.O. (Chem. Sec.)	20th October 1959
4. Sri M. A. Hassan	Junior Research Assistant from Namkum to Jhalda (Chem. Sec.)	3rd November 1959
5. Sri A. Banerjee	Exh. Assistant as Junior Research Assistant (Chem. Sec.)	8th November 1959
6. Sri R. K. Paul	Fieldman from Namkum to Mirzapur (Ento. Sec.)	3rd February 1960
7. Sri S. K. M. Tripathi	Junior Research Assistant from Namkum to Jhalda (Chem. Sec.)	10th February 1960
8. Sri S. K. Mukherjee	Junior Research Assistant from Namkum to Gondia (Chem. Sec.)	16th February 1960
9. Sri R. C. Maurya	Junior Research Assistant from Namkum to Mirzapur (Ento. Sec.)	12th March 1960
10. Sri R. C. Misra	Research Assistant from Namkum to Mirzapur (Ento. Sec.)	12th March 1960
11. Sri S. K. Mukherjee	Junior Research Assistant from Gondia to Namkum (Chem. Sec.)	20th March 1960
12. Sri Mahadeo Mahato	Peon from Chem. to Admin. (Admin. Sec.)	6th May 1959
13. Sri Birsa Oraon	Peon from Admin. to Chem. (Chem. Sec.)	6th May 1960
14. Sri Dhadoo Mahato	Laboratory Attendant as Peon (Chem. Sec.)	15th September 1959

(d) RESIGNATIONS DURING 1959-60

1. Sri G. C. Agarwala	Research Assistant (Chem. Sec.)	1st April 1959
2. Sri Amresh Gupta	Junior Research Assistant (Chem Sec.)	9th April 1959
3. Sri Joakim Ekka	Chaukidar (Admin. Sec.)	25th April 1959
4. Sri K. N. Prasad	Research Assistant (Chem. Sec.)	4th June 1959
5. Sri N. V. Rao	Research Assistant (Chem. Sec.)	30th June 1959
6. Sri Jwala Prasad	Research Assistant (Ento. Sec.)	6th July 1959

7. Sri Mosso Oraon	Melter (Chem. Sec.)	3rd August 1959
8. Miss A. T. Varghese	Steno-typist (Ento. Sec.)	7th August 1959
9. Sri A. V. Subharao	Research Assistant (Chem. Sec.)	15th August 1959
10. Sri G. S. Arora	Research Assistant (Ento. Sec.)	1st September 1959
11. Sri A. Mukherjee	Junior Clerk (Chem. Sec.)	6th November 1959
12. Sri S. V. Kamath	Research Assistant (Chem. Sec.)	23rd November 1959
13. Sri N. Gopal Krishnan	Junior Research Assistant (Chem. Sec.)	1st December 1959
14. Sri B. B. Banerjee	Junior Research Assistant (Ento. Sec.)	21st December 1959
15. Sri R. L. Singh	Artist & Photographer (Ento. Sec.)	21st December 1959
16. Sri T. S. Krishnan	Junior Research Assistant (Chem. Sec.)	17th January 1960
17. Sri M. A. Hassan	Junior Research Assistant (Chem. Sec.)	23rd January 1960
18. Sri A. Banerjee	Junior Research Assistant (Chem. Sec.)	20th January 1960
19. Sri Sukhdeo Mirdha	Chaukidar (Ento. Sec.)	1st February 1960
20. Sri Md. Shakil	Research Assistant (Ento. Sec.)	16th February 1960
21. Sri R. P. Gupta	Research Assistant (Chem. Sec.)	16th February 1960
22. Sri Shivajee Sahu	Junior Clerk (Ento. Sec.)	16th March 1960

(d) TERMINATION OF SERVICES DURING 1959-60

1. Sri Benedict Kachhap	Peon (on leave vacancy) (Chem. Sec.)	14th August 1959
2. Sri Bhandoo Mahato	Laboratory Attendant (on leave vacancy) (Chem. Sec.)	23rd February 1960

(e) RETIREMENTS DURING 1959-60

1. Sri Dr. S. V. Puntambekar	Director	29th July 1959
2. Sri J. N. Singh	Junior Research Assistant (Ento. Sec.)	29th June 1959
3. Sri Ram Prasad	Fieldman (Ento. Sec.)	20th August 1959
4. Sri K. C. Guha Roy	Chief Mechanic (Admin. Sec.)	1st January 1960
5. Sri K. C. Chatterjee	Junior Research Assistant (Ento. Sec.)	16th February 1960

(f) DEATH DURING 1959-60

1. Sri K. P. Chakravarty	Laboratory Attendant (Chem. Sec.)	20th May 1959

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