INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1962-63

1964

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ANNUAL REPORT FOR THE FINANCIAL YEAR 1962-63

ADMINISTRATIVE AND GENERAL

General — The Institute pursued its research and other activities as programmed, although on a restricted scale due to acute shortage of staff.

A notable event during the year under report was a visit to this Institute by Dr. Ram Subhag Singh, Honourable Minister for Agriculture, Government of India. During his visit, the Minister suggested the establishment of a sticklac processing unit in the Institute, as an additional activity of our Production Unit. The scheme formulated for this purpose has been approved by the Government of India, and its implementation has been taken on hand.

Among the results of research in the Institute worthy of special mention is a composition based on dewaxed shellac in conjunction with a synthetic resin which produces a French polish of outstanding heat- and water-resistance. The synthetic resin is butylated urea-formaldehyde and is used to the extent of 40 per cent on the weight of lac. On the developments side, the shellac-based single-pack wash primer has shown progress, and the experiments in co-operation with the Railways and State Road Transport Authorities have been successful. The firm producing the material on a commercial scale is reported to have sold over 6,000 litres during the year, including to some important large-scale consumers, and more, it was learnt, could not be sold due to difficulties about availability of one of the solvents. Again, at the request of the Central Water & Power Research Station, about 1·5 tonnes of two shellac compositions for use as bed material for hydraulic models were got prepared in a plastic processing factory in Calcutta, and supplied. The material is under service tests at the Research Station.

Visitors — As usual, the Institute continued to attract numerous visitors including students and trainees from colleges and other institutions, important officials andfor eign dignitaries among whom were:

1. Shri Ananthasayanam Iyengar, Governor of Bihar.
2. Dr. Ram Subhag Singh, Minister of Agriculture, Government of India.
3. Prof. S. N. Bose, National Professor.
4. Mr. William R. Jockson, United States of American Consulate, Calcutta.
5. Mr. Stefen I. Rogov, Consulate General of U.S.S.R.
6. Dr. R. N. Mathur, Additional Agricultural Commissioner, I.C.A.R., Government of India.
7. Prof. Dhal, United States of America.
8. Dr. Kalkhof Rose of M/s Ernst Kalkhoff & Co., West Germany.
9. Dr. S. Pradhan, Head of the Division of Entomology, I.A.R.I., New Delhi.

Roads and Buildings — No annual repairs to roads and buildings of the Institute were carried out during the period.

The construction of one block of two 'B' type residential quarters and another block of four 'C' type residential quarters was completed by the C.P.W.D.

Water supply — The replacement of the existing water distribution pipe-line to staff quarters, laboratory, etc., by a new one has been taken up, and is expected to be completed by the end of May 1963. It is also understood that tenders have been invited for the construction of a new R.C.C. overhead tank to replace the existing mild steel tank which is leaking badly.

Library — The number of bound volumes of periodicals and books accessioned during the year was 220. In addition, miscellaneous reports and scientific publications numbering 45 were also received.

The printing of the Monograph on Lac has nearly been completed. The publication is expected to be out by the end of May 1963.

The 'press ready' manuscript of the book 'Chemistry of Lac' has been sent to the press. It is expected that its printing will be completed by the end of July 1963.

Training — Fifty-nine candidates, deputed by various States, were trained in 'Lac Cultivation' in two batches of 29 and 30 trainees, respectively, from 1st April to 30th September and 1st October to 31st March. Three officers, one each from Maharastra, Bihar and U.P., also received a short course of training of one month's duration.

Two trainees deputed by Director of Industries, Government of West Bengal completed their training of six months in 'Industrial Uses of Lac'. Three trainees deputed by the trade obtained short courses of training in the processing and analysis of Lac.

Exhibitions — Apart from sending samples to interested enquiries, the Institute did not take part in any major exhibition in the country as a measure of economy due to the National Emergency.

Staff — Dr. M. S. Muthana, Director, resigned from the services of the Institute with effect from the 30th September 1962 to join as Deputy Director, Indian Institute of Technology, Kanpur. Shri Y. Sankaranarayanan, Organic Chemist, was appointed to look after the work of the Director and continued in that capacity for the rest of the year under report.

Dr. T. P. S. Teotia joined the Institute as Entomologist on 18th October 1962.

Sri S. C. Sen Gupta, M.Sc., Senior Scientific Officer, left for the United Kingdom for higher training under Colombo Plan, at St. Andrews University for one year.

The staff position in the Chemistry Division is extremely acute. Out of a total of 25 posts of Research Assistants in the Division, 16 posts are vacant.

Further details regarding the staff will be found in Appendix G.

Meeting of Entomology Research Sub-committee — In pursuance of a recommendation made by the Advisory Board of the Indian Lac Cess Committee in its meeting held in March 1962, and later accepted by the Governing Body, the *Ad-hoc* Entomology Research Sub-committee, which was constituted to review the present work of the Entomology Division and the membership of which was subsequently modified at a meeting of the Advisory Board held on 21st and 22nd December 1962, met on the 26th and 27th of March 1963 at the Indian Lac Research Institute, Namkum, with all the members being present, except Dr. P. N. Chatterjee, Forest Entomologist, who could not attend the meeting but had sent his observations which were considered by the Sub-committee. The Sub-committee reviewed the present programme of work and progress so far made against each item and recorded its observations. The Sub-committee also drew out a programme of research work to be continued and indicated priorities.

Staff Club — The Staff Club continued its activities as usual.

A swing and a rocking chair were added to the Childrens' Park through the munificence of a donation by Dr. S. V. Puntambekar, ex-Director of this Institute.

ENTOMOLOGY DIVISION

(Dr. T. P. S. Teotia, 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. Work on physiological studies was intensified in the later part of the year.

55 kg. of *Moghania macrophylla* seeds were collected from plantation and distributed to various Institutions and State Forest Departments for further propagation.

Staff — Sri R. Vishwanathan joined as Insect Physiologist in February 1963. Two Senior Research Assistants, two Research Assistants and three Laboratory Assistants joined during the period under report. Four existing Research Assistants were promoted as Senior Research Assistants.

Season — The weather conditions for all the four crops during the year were favourable. As anticipated, *Baisakhi* 1961-62 was a bumper crop, which in turn produced a good *Katki* 1962 crop. *Baisakhi* crop 1962-63 is expected to be below average because of low prices of sticklac and hence lack of incentive to the cultivators to inoculate the trees. *Jethwi* 1962 crop was satisfactory and *Aghani* 1962-63 crop was also a good one.

The predator infestation was rather severe in *Katki* 1962 and *Aghani* 1962-63 crops.

IIA—RESEARCH AND INVESTIGATIONS

1. Lac Cultivation Studies on *Palas* (*Butea monosperma*)

(i) *Data on large-scale lac cultivation on* palas

The experiment was continued at Kundri with nearly 20,000 trees. Details of operations and itemwise cost are given in Table I (Appendix A). It will be observed that against a total expenditure of Rs. 4,129·61 nP., a revenue of Rs. 3,089·90 nP., was obtained. The loss, despite a total yield of sticklac amounting to 8,492·75 kg., is attributed to a large fall in the prices of lac and also to the fact that the sale of broodlac, which fetches a better price than scraped lac, could not be made, there being no demand for it.

(ii) *Evolution of a suitable cultivation practice for* palas *at Kundri*

(a) *Critical experiment* — The experiment was continued for the fourth year in succession on 2,500 trees with the following 5 treatments having 100 trees in each treatment (the 5th treatment having been added in October 1961).

A — Heavy inoculation in October/November followed by complete harvesting in April (next year).

B — Heavy inoculation in October/November, partial cropping in April (as *ari*) and complete harvesting (after one year) in October/November.

C — Medium light inoculation in October/November, partial harvesting in June/July and complete harvesting in October/November (after one year).

D — Light inoculation in October/November and complete harvesting in October/November next year.

E — Light inoculation in October/November after partial defoliation and complete harvesting in October/November (after one year).

Per-tree average yield of broodlac from C and D was 2·40 kg. each, from E 2·29 kg. and from B 1·75 kg. The ratio of brood used to brood yield was 1: 20·5 (D), 1: 19·6 (E), 1: 10·2 (C), and 1: 3·7 (B).

Yield of scraped lac could be arranged in the descending order as follows: D, C, E, B and A. However, since trees under A could yield another crop if, for instance, they were inoculated again in October/November 1962 and harvested in April 1963, A may theoretically be considered as the best treatment.

Details are shown in Table II (App. A).

A sixth treatment, namely, very light inoculation in October/November and complete harvesting in October/November next year with no operation in between (Treatment F) has been introduced on 100 trees with 5 replications.

(b) *Large-scale trials* — 1,000 trees under each of the treatments A and D, as described above, were inoculated in October/November 1961. The former resulted in yield of 0·655 kg. and the later in 0·976 kg. per tree. Ratio of brood used to brood yield of treatment D was found to be 1: 13·8.

2. Lac Cultivation Studies on *Ber* (*Zizyphus mauritiana*)

(i) *Proper time of harvesting and determination of optimum density of larval settlement for* ber *in* Baisakhi *crop*

The experiment was initiated in 1960-61 and continued for the third season with the following 9 treatments:

A — *Ari*-cutting in April with ½ N brood rate.
B — ,, ,, ,, N ,,
C — ,, ,, ,, 2 N ,,
D — ,, May ,, ½ N ,,
E — ,, ,, ,, N ,,
F — ,, ,, ,, 2 N ,,
G — Harvesting at maturity with ½ N brood rate
H — ,, ,, ,, N ,,
I — ,, ,, ,, 2 N ,,

The normal brood rate was arbitrarily fixed as 1 ft. of healthy brood for 25 ft. of infectable shoots. There were 4 replications with 1 tree under each treatment, and a total of 36 trees. Inoculation for *Baisakhi* 1961-62 was affected in October 1961 and *phunki* removed in November 1961. [Results of *Baisakhi* 1961-62 are presented in Table III (App. A)].

Results indicate that from April harvesting, maximum scraped lac yield was obtained from 2 N brood rate followed by N and ½ N; for May harvesting the order was N, ½ N and 2 N and for harvesting at maturity N, 2 N and ½ N. Maximum brood yield was obtained from N brood rate (Treatment H). According to scraped lac yield data, the treatments could be arranged in the following descending order:

H, E, D, I, F, C, G, B, A.

Inoculation for *Baisakhi* 1962-63 was carried out in October 1962 and *phunki* was removed in November 1962.

(ii) *Optimum density of larval settlement for* ber *in* Katki *crop*

The experiment was started in the Namkum Plantation from *Katki* 1961 season, using 3 brood rates, namely, ½ N (Treatment A), N (normal) (Treatment B), and 2 N (Treatment C), replicated 12 times with 1 tree per treatment, i.e. on a total of 36 trees.

Inoculation was carried out in June 1962 and the crop harvested in October 1962. The crop data for *Katki* 1962 are given in Table IV (App. A). The maximum brood was obtained from Normal brood rate, followed by 2 N and ½ N, with little difference in these two in brood yield. But the brood to brood ratio and brood to yield (scraped lac) ratio for ½ N, N and 2 N were found to be in the descending order, indicating the superiority for ½ N brood rate over others.

(iii) *Studies on pruning time for* ber *for* Katki *crop*

The experiment is being continued since 1960. *Ber* was pruned in February, May, October and December (A, B, C and D treatments respectively), with 1 tree under each treatment replicated 10 times. The layout is based on randomized block design. Inoculation for *Katki* 1962 was carried out in July 1962 and the crop was harvested in October 1962.

Data on shoot measurement at the time of inoculation and yield of *Katki* 1962 crop are recorded in Tables V and VI (App. A).

It will be seen that pruning in May (Treatment B) gave the best results in respect of the growth of primaries and secondaries, yield and brood to yield ratio.

3. Lac Cultivation Studies on *Kusum* (*Schleichera oleosa*)

Evolution of a cultivation practice for kusum

The experiment was started in June-July 1961 with the following treatments:

A_1 Rest for 1 year — Inoculation in June-July, allowed self-inoculation in January-February, complete harvesting in June-July (2-coupé system).

A_2 Rest for 1 year — Inoculation in January-February, allowed self-inoculation in June-July, complete harvesting in January-February (2-coupé system).

B_1 Rest for 2 years — Inoculation in June-July, allowed self-inoculation in January-February, complete harvesting in June-July (3-coupé system).

B_2 Rest for 2 years — Inoculation in January-February, allowed self-inoculation in June-July, complete harvesting in January-February (3-coupé system).

C (Control) Rest for $1\frac{1}{2}$ years — Complete harvesting six months after inoculation (4-coupé system).

There were in all 14 coupés, 4 for A (2×2, i.e. A_1 & A_2), 6 for B (3×2, i.e. B_1 & B_2), and 4 for C. The brood used was: 1 ft. of brood for $12\frac{1}{2}$ ft. of inoculable length for C and 1 ft. of brood for 30 ft. of inoculable length for A and B.

Each coupé contained 15 trees.

Coupés A_1 I, B_1 I and C I were inoculated in July 1961; C I was harvested in February 1962; while A_1 I and B_1 I were left for self-inoculation in February 1962 and harvested in July 1962.

Coupés A_2 I, B_2 I and C II were inoculated in February 1962; C II was harvested in July 1962; while A_2 I and B_2 I were left for self-inoculation in July 1962 and harvested in February 1963.

Results are shown in Table VII (App. A).

The maximum ratio of brood to yield of scraped lac was obtained from B treatment in *Jethwi* 1962 crop and from A treatment in *Aghani* 1962-63 crop.

Coupés A_1 II, B_1 II and C II were inoculated in July 1962; C III was harvested in February 1963; while A_1 II and B_1 II were left for self-inoculation in February 1963 and will be harvested in July 1963.

Coupés A_2 II, B_2 II and C IV were inoculated in February 1963.

4. Growing of Lac Hosts Under Bush Conditions

(i) *Albizzia lucida* — Twenty trained bushes carrying 1½ year old shoots were inoculated in January, for *Jethwi* 1962 crop with a total of 12·400 kg. *kusmi* broodlac (scraped weight 5·100 kg.). The crop yield was found to be poor (4·650 kg.) due to high initial mortality, giving 1: 0·91 ratio of brood to yield (scraped lac).

Forty bushes were inoculated with 10 kg. *kusmi* brood for *Jethwi* 1963 crop. Mortality is estimated about 40-50 per cent.

(ii) *Ber* (*Zizyphus mauritiana*) — Forty trained bushes of this species were inoculated for *Baisakhi* 1961-62 crop with 7·00 kg. *rangeeni* (*ber*) broodlac (scraped weight 1 kg.). The crop was harvested *ari* in May 1962 and a yield of 4·400 kg. was obtained, giving 1: 4·4 ratio of brood to yield (scraped lac).

Forty bushes were inoculated with 7·600 kg. *ber* broodlac for *Baisakhi* 1962-63 crop. The crop is progressing satisfactorily.

(iii) *Moghania macrophylla*

(a) *Spacing trials on* Moghania macrophylla

Three spacings, namely, 6′×6′, 6′×4′ and 4′×4′ (A, B & C respectively), are being tried since 1960-61. The layout is in randomized block design with 8 replications. There were 3×8 = 24 plots with 5 bushes in each under observation. Each plot measured 36′×36′ with 288, 432 and 648 bushes, respectively, in each of the cases.

Developmental data of the plants at the time of inoculation in February 1963 for *Jethwi* 1963 crop are given in Table VIII (App. A).

Treatments B and C have shown similar results in respect of height of the plants and number and length of shoots but taking all the plants into consideration, C appears to be the best.

(b) *Plantation technique of raising* M. macrophylla

This experiment is in progress since 1961.

The following treatments are being tried:

A — Direct sowing in May with 2 seeds per pit.
B — ,, ,, ,, ,, 3 ,, ,,
C — ,, ,, June ,, 2 ,, ,,
D — ,, ,, ,, ,, 3 ,, ,,
E — Transplanting 1 plant (per pit) of March seedlings.
F — ,, 2 plants ,, ,, ,,
G — ,, 1 plant ,, April ,,
H — ,, 2 plants ,, ,, ,,
I — ,, 1 plant ,, ,, ,,
J — ,, 2 plants ,, ,, ,,

Each treatment is being replicated 4 times; that is, there are 10×4 = 40 plots, each 20′×18′ in size having 15 pits. The experiment has been laid out in randomized block design. All transplantations were carried out in July 1961. Inoculation was done in July 1962.

Data on shoot measurement at the time of inoculation and crop yield for *Aghani* 1962-63 are recorded in Tables IX and X (App. A).

It will be seen that treatment F is the most promising, followed by G and H.

(c) *Effect of nitrogen, phosphorus and potassium on the yield of lac on* M. macrophylla

The experiment was laid out in 1962 on 640 bushes with a view to increase the yield of lac by applying different fertilizers individually and in combination.

The following 8 treatments, with 20 bushes in each treatment, are being replicated 4 times in randomized block design layout.

A — No fertilizer (control)	E — N + P
B — Nitrogen (N) alone	F — N + K
C — Phosphorus (P) alone	G — P + K
D — Potassium (K) alone	H — N + P + K

In treatments B to H, ammonium sulphate (for nitrogen) and muriate of potash (for potassium) were each applied at the rate of 15 gm. per bush, i.e. 27 kg. per acre and super phosphate (for phosphorus) at the rate of 30 gm. per bush, i.e. 54 kg. per acre.

The inoculation was carried out in July 1962 on one year old bushes. Fertilizers were applied in a ring round the bushes at the time of *phunki* removal. 20-25 per cent predator damage was estimated during August-October 1962. Spurious emergence was observed on some of the plants irrespective of the treatments.

The crop data and chemical analysis for *Aghani* 1962-63 are given in Table XI (App. A).

Combination of all the three fertilizers (Treatment H) has shown the best result in respect of per-tree yield of scraped lac (130 gm.) and brood to yield ratio (1 : 4·0).

(d) *Effect of different levels of nitrogen on the growth of* M. macrophylla *bushes*

The experiment was laid out in randomized block design in 1962 on 640 bushes with the following 5 treatments replicated 8 times, and with 16 bushes in each treatment:

A — No ammonium sulphate (control)
B — 10 kg. ammonium sulphate per acre
C — 20 kg. „ „ „
D — 30 kg. „ „ „
E — 40 kg. „ „ „

The nursery raised seedlings were transplanted in pits in July 1962 and ammonium sulphate applied after transplantation.

Results of shoot study are recorded in Table XII (App. A).

Application of 40 kg. ammonium sulphate per acre (Treatment E) has shown the best results in respect of average height of plants, average number of shoots and total length of shoots.

5. Finding out Alternative Hosts for the *Kusmi* Strain of Lac Insect and Conducting Cultivation Experiments on Them

Trials are being conducted on *A. lucida*, *O. oojeinensis* (Syn. *O. dalbergioides*) and *Ficus cunia* by inoculating them with *kusmi* broodlac and alternating the resultant crops between *kusum* trees and the hosts under trial.

A. lucida and *O. oojeinensis* were inoculated with K (Prog. K×A.l.) brood and *kusmi* brood respectively, for *Jethwi* 1962 crop. In the following *Aghani* 1962-63 crop, *kusum* trees were inoculated with the resultant progeny, namely, A.l. (Prog. K×A.l.×K) brood and *O. oojeinensis*. (Prog. K) brood. The crop data are shown in Table XIII (App. A). The results on *A. lucida* are in conformity with those of the last year.

The resultant broods from *Aghani* 1962-63 have been inoculated on *A. lucida* and *O. oojeinensis*, respectively, for *Jethwi* 1963, besides inoculating *Ficus cunia* with *kusmi* brood.

6. Survey of Lac Insect Enemies and Their Parasites

Agathis sp., reported last year as a new internal parasite of *Holcocera pulverea*, was identified at the British Museum (N.H.), London, as *Agathis coryphe* Nixon (Braconidae). No new enemies and their parasites were encountered during the year

7. Biological Control of Lac Insect Enemies

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

(a) *Apanteles fakhrulhajiae* Mahd.

Nine cages were started which gave 10 males and 3 females. Progeny of these insects and those collected from the field consisted mostly of males and hence further breeding could not be done.

At crop maturity, the field parasitization of this insect varied from 11-19 per cent. Higher parasitization was found in *Aghani* and *Katki* crops than in *Jethwi* and *Baisakhi* crops.

(b) *Brachymeria tachardiae* Cam.

Biology and life-history of this pupal parasite of *E. amabilis* and *H. pulverea* have been completed. The studies were made on the alternative host *Corcyra cephalonica* Staint under laboratory conditions.

The egg to adult stage was completed, on an average, in 16·3 days (variation 14-19 days) at mean average laboratory temperature 25·5°C. and in 11·6 days (variation 10-13 days) at controlled temperature 27°C. The data are given in Table XIV (App. A).

Studies on longevity of the adult parasites showed that, on an average, females lived for 38·2 days (variation 8-115 days) and males for 27·2 days (variation 2-68 days) on moist raisins. The data are recorded in Table XV (App. A).

(c) *Elasmus claripennis* (cam.)

The biology and life-history studies of this external parasite of *E. amabilis* were re-started during 1962 and the parasite could be bred for seven generations continuously.

The present technique involves the following operations. Healthy host larvae are selected and provided with crushed lac, which is used up in spinning a cocoon. These cocoons are offered to the field collected adult parasites (which are kept in 50 mm. Petri-dishes and fed on moistened and opened raisins) and allowed one day's contact between the host and the parasite. The parasitized hosts are then collected and stocked for development of the parasites.

Seven generations could be bred in the laboratory during the period September 1962 to April 1963. Females and males took almost equal time to develop into adults from egg. The duration increased as the atmospheric temperatures lowered. The average duration of life-cycle and its range during the seven generations were, 19·7 days and 11-34 days for females and 19·5 days and 11-33 days for male, respectively. The data are recorded in Table XVI (App. A).

(d) *Mass-rearing of* Bracon greeni Ashm.

A small culture was maintained depending on the availability of the hosts, both natural and alternate.

Work suffered due to unavailability of the larvae of alternate host, *Etiella zinckenella*, at all times.

(e) *Mass-rearing of* Apanteles tachardiae

Work suffered due to breakdown of the air-conditioning machine for long periods.

Thirteen generations (XXX-XLII) were bred in 113 cages by offering 2,01,700 host larvae to 1,894 gravid females which had been mated with 2,141 males. The average parasitization was 55·1 per cent. A total of 1,14,435 parasites (70,821 males and 43,614 females) emerged, of which 9,200 parasites (4,600 males and 4,600 females) were released in *Aghani* 1962-63 crop in September 1962.

Though the total figures of the parasites reared during the year were quite high, the day-to-day emergence of adult parasites was not much and quite a large number of them

were dead soon after emergence, so that sufficient numbers were not available at the time of periodical releases.

(ii) *Large-scale liberation of* Apanteles tachardiae

Jethwi 1962 and *Aghani* 1962-63 crops were raised in the Biological Control Field areas. As stated above 4,600 males and an equal number of females were released. Estimation of parasitization is under study.

(iii) *Incidence of predators* (E. amabilis *and* H. pulverea) *on* Kusmi *strain of lac grown on* M. macrophylla

Till December 1962, the experiment was being conducted on the following lines:

Two sets of *Moghania* bushes — Set Nos. I and II having 360 and 600 bushes respectively — were inoculated with *Kusmi* brood. Set No. I with 360 bushes was divided into 4 blocks of 90 bushes each. Set No. II with 600 bushes were divided into 5 blocks of 120 bushes each, which were further divided into 8 plots of 15 bushes.

In set No. I, predators were collected every 10 days from all the 360 bushes between August-December 1962. In set No. II, collection was made from each of the 8 plots with 15 bushes in rotation with an interval of 15 days between August-November 1962. The data on predator collection are recorded in Table XVII (App. A).

From February 1963, the experiment has been started afresh on 1,200 bushes by inoculating for *Jethwi* 1963 crop. Twenty-five samples are being collected every fortnight and examined for the presence of predators and the extent of damage done by them.

8. Chemical Control of Lac Insect Enemies

Effect of insecticidal spray residues on the longevity and oviposition of Eublemma amabilis *and* Holcocera pulverea

Freshly emerged adult predators from both *rangeeni* and *kusmi* crops were liberated in pairs in 4″×4″ battery jars, with a 7·5 cm. long lac stick with developing lac insects, which had been sprayed with 100 c.c. each of 0·25 and 0·5 per cent sprays of dieldrin and aldrin, so as to give a residue deposit of 0·0032 gm. and 0·0016 gm. of dieldrin per sq. cm. and 0·0018 gm. and 0·0009 gm. of aldrin per sq. cm. Maximum reduction in longevity and fecundity of the predators was obtained with the use of 0·5 per cent dieldrin spray. Data are given in Table XVIII (App. A).

9. Physiological Studies

(i) *Relation of host plant to the fecundity and resin secretion efficiency of the* rangeeni *and* kusmi *strains of the lac insect*

(a) *Rangeeni strain* — The study was started in *Katki* 1962. Isolated mature female cells from *ber* (*Zizyphus mauritiana*), *ghont* (*Z. xylopyra*), *khair* (*Acacia catechu*), *palas* (*Butea monosperma*), *Acacia farnesiana* and *Moghania macrophylla* were collected and kept for larval emergence. Data of larval emergence are shown in Table XIX (App. A). Maximum average larvae emerged from lac females from *A. catechu* and minimum from *A. farnesiana*.

The cells are being studied for resin secretion.

Fourteen hosts have been inoculated for *Baisakhi* 1962-63 crop.

(b) *Kusmi strain* — 1,000 isolated mature female lac cells each from *kusum*, *Albizzia lucida* and *M. macrophylla* from *Jethwi* 1962 crop were collected and dissolved in alcohol for resin estimation. The quantity of resin obtained from the cells collected from the three hosts was 28·29 gm., 18·53 gm., and 10·90 gm. respectively. 100 mature female cells each from the three hosts were also kept for fecundity studies. The data of larval emergence are given in Table XX (App. A).

Hundred isolated mature female cells each from *ber, khair, kusum* and *M. macrophylla* from *Aghani* 1962-63 crop have been collected. Further studies are in progress.

(ii) *Studies on the honeydew of the lac insect*

A number of single dimensional ascending chromatograms of honeydew were run using the solvent systems, *n*-butanol: acetic acid: water = 4: 1: 5 and 25: 6: 25. No proper separation of the amino acids was observed.

Some separation of amino acids could be obtained by using the solvent system, phenol: water = 3: 1. Six amino acid spots could be observed when the strips were sprayed with 0·3 per cent ninhydrin in 95 per cent ethanol.

Chromatograms were run with *n*-butanol: ethanol: acetone: water = 5: 4: 3: 2, *n*-butanol: acetic acid: water = 4: 1: 5 and phenol: water = 3: 1 for finding out sugar component of honeydew. The chromatograms were sprayed with aniline hydrogen phthalate reagent for the detection of aldoses but no separation was observed. Some of the chromatograms were sprayed with 2,4-dinitrophenyl hydrazine for the detection of ketoses. Brown streak was observed after keeping the chromatograms for a few days.

The above-mentioned technique was improved by treating the paper strips with 2 N hydrochloric acid and running single-dimensional chromatograms with honeydew, using the above-mentioned solvent systems for amino acids and sugars. Only some separation of amino acids was obtained.

Honeydew treated for removal of protein and fatty material before running the chromatograms did not show any improved separation with the above-mentioned solvent systems.

(iii) *Comparative study of the components of plant sap of major and minor hosts*

Single-dimensional ascending chromatograms were run with fresh *palas* sap using phenol: water = 3: 1 solvent system. Spray of aniline hydrogen phthalate for the detection of sugars and ninhydrin for amino acids gave only partial success.

Chromatograms were also run with *n*-butanol: acetic acid: water = 25: 6: 25 and *n*-butanol: ethanol: acetone: water = 5: 4: 3: 2 solvent systems, which also did not give good separation.

(iv) *Comparative study on the effect of major nutrients applied to* M. macrophylla *plants on the development of lac insect*

Moghania macrophylla plants raised during March-April 1962 were transplanted in flower pots in July 1962 after leaving only one main shoot. The plants were inoculated in October 1962 for *Baisakhi* 1962-63 with single-mature female lac insects from the same brood stock for all the plants. The plants were kept covered with 80 mesh brass wire net for protection against enemy infestation. The progeny was thinned soon after settlement.

Ammonium sulphate, superphosphate, calcium chloride, muriate of potash and magnesium chloride applied @ 5 gm., 10 gm., 1·5 gm., 5 gm., and 1·5 gm. per plant, respectively, are being tried separately and in combination. The following 12 treatments are being tried and replicated 3 times with 1 plant under each treatment.

A — No nutrient used — Control.
B — Ammonium sulphate for nitrogen (N).
C — Superphosphate for phosphorus (P).
D — Muriate of potash for potassium (K).
E — Magnesium chloride for magnesium (Mg).
F — Calcium chloride for calcium (Ca).
G — P + K + Mg + Ca.

H — N + K + Mg + Ca.
I — N + P + Mg + Ca.
J — N + P + K + Mg.
K — N + P + K + Ca.
L — N + P + K + Mg + Ca.

The nutrient solutions were applied round the plants a week before inoculation.

The observations on sex ratio taken at the time of male emergence in February-March 1963 are recorded in Table XXI (App. A).

It was found that the use of Ca (Treatment F), P + K + Mg + Ca (Treatment G), N + K + Mg + Ca (Treatment H), and N + P + Mg + Ca (Treatment I) increased the percentage of males and N (Treatment B) and N + P + K + Ca (Treatment K) increased the percentage of females.

10. Genetical Studies on Lac Insect

(i) *Mode of reproduction in lac insects*

The lac insects were reared in family lines on potted *Moghania macrophylla* plants under cover of 80 mesh wire net sleeve cages. Lac larvae of a family selected for study were isolated by removing the neighbouring ones. All the male cells were removed from each family as soon as sex differentiation was evident. At the time of sexual maturity, some of the females of a family were impregnated with outside males and the rest developed as virgins. In some cases, all the females of a family were developed virgins.

114 virgin and 119 impregnated female lac insects in 5 families and 245 virgins in 10 families in *Katki* 1962 crop and 30 virgins and 40 impregnated female lac insects in *Aghani* 1962-63 crop were studied. The impregnated females of *Katki* 1962 produced their progeny during October 1962 and of *Aghani* 1962-63 in March 1963. The virgins were observed to be smaller in size, lived comparatively longer than their impregnated counterparts and died without producing any progeny.

The studies undertaken so far indicate the absence of effective parthenogenesis in the two strains of the lac insect, which is contrary to the earlier findings (*vide I.L.R.I. Annual Reports*, 1928-29 to 1941-42).

104 virgins and 102 impregnated females in 10 families in *Baisakhi* 1962-63 and 450 females in 9 families in *Jethwi* 1963 are under study.

(ii) *Interbreeding experiments*

Technique, as described under the previous experiment, was adopted.

Crosses between rangeeni *and* kusmi *strains* — 10 females of *Katki* 1962 were crossed with males from *Aghani* 1962-63 and *vice versa*. The F_1 generation of both is under study.

The results indicate that the two strains can interbreed.

Crosses between Crimson (ordinary) and yellow forms — Four yellow females of *Katki* 1962 were crossed with the crimson males of the same crop. Similarly, 2 crimson females were crossed with yellow males, 3 yellow females with yellow males and 5 yellow females were developed virgins.

Both the male and female offsprings of F_1 generation of crimson and yellow insects were found to be crimson; those of yellow parents were yellow and the yellow virgins did not produce any progeny.

From the results, therefore, it appears that the yellow variety of lac insect also does not probably reproduce parthenogenetically, and that the colour may be an inherited character with crimson showing dominance over yellow.

(iii) *Evolution of a better resin yielding strain of the lac insect by selection*

Five ' bold ' and five ' small ' mature female insects were selected from *Baisakhi* 1961-62 crop and their progeny raised in family lines on potted *Moghania macrophylla* plants under cover of 80 mesh wire net sleeve cages. Some insects only in each family were selected for study, which were isolated from others. In the families of bold mother cells, only the bold male cells were allowed to live and the rest were eliminated.

From the measurements it was observed that the bold female cells measuring 4·56 mm. in length and 4·62 mm. in width, on an average, produced female progeny measuring 2·99 mm. in length and 2·9 mm. in width, on an average. Similarly, small females measuring 2·33 mm. in length and 2·30 mm. in width produced female progeny measuring 2·81 mm. in length and 2·72 mm. in width, on an average.

From the data it will be seen that there is very little difference in the size of the progeny of the two types of females and there is not much of an indication that a better resin yielding strain can be evolved through selective breeding.

At the time of crop maturity of *Katki* 1962, the boldest mother cells in each of the five families in the line of *Baisakhi* 1961-62 bold mothers were selected for raising the next generation in *Baisakhi* 1962-63, which is under study.

(iv) *Studies on the yellow variety of lac insect in relation to host specificity*

The study was taken up in July 1962 by inoculating yellow lac insects, collected from *Ficus* sp. from Delhi, on potted plants of *Albizzia lucida, Acacia farnesiana* and *ber*. The yellow larvae, soon after settlement, started changing their colour to crimson. Complete larval mortality occurred on *A. lucida*, whereas on *ber* and *A. farnesiana* 29·5 and 12·7 per cent respectively, of the larvae survived after the first moult. Of the surviving larvae, 35 per cent insects on *ber* and 55 per cent insects on *A. farnesiana* retained their yellow colour till maturity. All cells turning crimson in colour were removed at intervals, thus allowing the yellow coloured insects only to reach maturity.

The individual mature yellow cells collected from the above hosts in October-November 1962 have, respectively, been inoculated again on potted plants of *ber* and *A. farnesiana*. The *Baisakhi* 1962-63 crop is developing satisfactorily. Both unmated and mated insects are under study. During *Katki* 1962, the unmated females had failed to give any progeny.

(v) *Chromosomal cytology of the two strains and yellow variety of lac insect*

The chromosome number of the females of both the *kusmi* and *rangeeni* strains and of the males of the *rangeeni* strain has been investigated. In all cases, a diploid chromosome number of 18 was found. In the studies on the *kusmi* strain, the usual methods of fixation and staining were slightly modified by transferring the material to a stain fixative mixture, Aceto-orcein, maintained at 60°C. for varying periods up to 12 minutes. The method was further modified for the *rangeeni* insects by treating the ovarioles with chemicals, such as, resorcinol, phloroglucinol, guiacol and hydroxyquinoline of known concentrations, for periods ranging from 2-24 hours at a constant temperature, before transferring them to the stain fixative mixture, aceto-orcein/N. Hcl (9: 1 parts) at 60°C. for about 10 minutes. The pretreatment of ovarioles with chemicals, particularly phloroglucinol, helped in getting a good spreading of the individual cells. Chromosomal cytology of the yellow variety of lac insects is under investigation.

(vi) *Oogenensis and spermatogenesis of the two strains and yellow variety of lac insect*

Studies on the pattern of sperm formation or spermiogenesis and on meiosis in the males of the *rangeeni* strain have been completed. Oogenetic studies of the *rangeeni* females have been taken up. For this, the female insects have been collected at regular intervals and fixed in various fixatives for varying lengths of time.

X-ray irradiation of *kusmi* broodlac was also done in June 1962 to determine its effect on the chromosomes. The broodlac was exposed to 40-80 kilowatt units for periods ranging from 10 to 25 seconds. The exposed brood was inoculated on potted plants and on host trees in the plantation. When the insects reached sexual maturity, the male cells were examined and their sperms did not show any abnormality. The female cells also behaved normally by giving rise to an average number of larvae. These larvae were allowed to self-inoculate the host plants. Later, the insects (adults) died on all plants and hence the studies had to be discontinued.

11. Ecological Studies on Lac Insect

Determination of optimum environmental conditions for storing the broodlac to delay emergence of larvae

This experiment was started during February 1963.

1·6 kg. *kusum* brood in 4-5 day stage of ovules from *Aghani* 1962-63 crop was stored in the laboratory at 17·5°C. mean temperature on 5th February 1963. 17·00 kg. of *kusum* brood from the same lot was also stored at controlled temperature 14·5°C. $\pm$ 1.

Larval emergence from the brood at laboratory temperature was observed on 7.2.1963 when 1·00 kg. brood from this stock and 1·00 kg. from controlled temperature stock were used to inoculate 10 *Moghania macrophylla* bushes in each case. Thereafter, brood from controlled temperature stock only was used to inoculate 10 bushes every day for 15 days, till 21.2.1963. The *Jethwi* 1963 crop is progressing satisfactorily.

12. Pests of Lac Host Trees

(i) Holotrichia serrata (*Coleoptera: Melolonthidae*)

The life-history studies of this important pest of *palas* were continued. The data based on observations on 12 females in the laboratory are recorded in Table XXII (App. A).

In the laboratory, the adults started emerging from mid March till early July, and laid eggs from April to August. The grubs hatching therefrom developed into adults from October onwards till January of the following year. Thus the insect passed through only one life-cycle in a year.

In the field, the adults made first appearance from their hidings towards the end of January and were found in largest numbers during May and June. From the weekly soil survey to a depth of 9 inches in the plantation, it was found that the eggs were available from February to July, grubs in various stages throughout the year, pupae from September to February and adults from January to September. Data are given in Table XXIII (App. A).

The apparent variation in the time of emergence of adults in the laboratory and in the field may be due to climatic factors resulting in a prolongation of the pupal stage in the field during winter months. The study is in progress.

Adults in the field appear after sunset, and start mating soon after and thereafter feed till dawn, when they again disappear. They feed from the periphery of the tender leaves towards the mid-rib leaving the veins, which are also consumed during severe attack. The peak period of damage was observed during May to July. The grubs feed on tender roots and humus in the soil around the host.

Eggs from the cells, prepared by the adults, were collected in batches of 3-5. The freshly laid egg is oblong, but gradually becomes round as the development progresses.

(ii) Thiacidas postica Walker (*Hairy caterpillar on* ber)

Observations on the incidence, nature of damage and life-history were continued. The larval stages were found in the field from June to September 1962 — July and August

being their peak period of activity. Three generations could be reared in the laboratory from the larvae collected from field in August 1961. Details of the life-cycle are shown in Table XXIV (App. A).

Total life-cycle period was found to vary from 37 to 215 days. Pre-oviposition and oviposition periods were found to be 2 and 4-5 days, respectively. Fecundity was found to be 708, 452 and 318 in the parent, 1st and 2nd generations, respectively.

(iii) *Hairy caterpillar on* ghont (No. 2)

The pest appeared in the field in the larval stage in July and August 1962, when they were found in batches of up to 100 on the under side of the leaves. The larvae feed on the whole blade of the leaf starting from the periphery. Early instar larvae feed on the tender leaves while the later stages eat the older leaves as well. As the pest was collected in larval stage, the exact number of larval instars could not be ascertained but they have pupated after passing through 8 instars in the laboratory.

(iv) Pagyda traducalis Zell. (*Leaf-roller on* ghont)

The larvae were found from July to September 1962 generally on the growing tips of the shoots where they roll tender leaves individually. They eat the green matter of the leaf. The larvae collected from field moulted 2-4 times before pupation. The laboratory bred female moths failed to lay eggs.

(v) Hypena iconicalis Walker (*Caterpillar on* M. macrophylla)

The larvae were found during July to October 1962 — peak period of their activity being August and September. The larvae made perforations on the lamina of the leaf. Larvae collected from field in July emerged as adults in August.

(vi) Hemithea sp. (*Looper on* M. macrophylla)

Larvae were collected during September to November 1962. They feed on soft portion of the lamina of the leaf, leaving the veins. Larvae collected on 1.9.1962 completed 4 generations by March 1963. Pre-oviposition period, oviposition period and fecundity were found to be 2-5 days, 2-11 days and 19-307 eggs, respectively. Other details are recorded in Table XXV (App. A).

(vii) *Hairy caterpillar-on* ghont (No. 6)

Larval stages of this pest were found in the plantation during October-November 1962. Young larvae feed on the green matter of tender leaves but the grown ups feed on the whole leaf, starting from the margin.

Three caterpillars collected on 2.10.1962 could be reared in the laboratory up to 2nd generation and the 3rd generation is progressing. Pre-oviposition period, oviposition period and fecundity were found to be 1-2½ days, 1-3 days and 37-154 eggs per female, respectively. Details of the life-history are recorded in Table XXVI (App. A).

(viii) Nephopteryx leucophaella Zell (*Leaf-binder on* M. macrophylla).

The larvae of this pest consume the soft material of the leaf leaving the veins, which are then woven together into a nest.

Ten larvae in various stages, collected during October 1962, have completed two generations and the third generation is in progress.

Eggs are generally laid singly and sometimes in batches on the ventral surface of the leaf. The pre-oviposition period, oviposition period and fecundity were found to be 2-6 days, 2-9 days and 42-335 eggs per female, respectively. Details of life-cycle are recorded in Table XXVII (App. A).

IIB—REGIONAL FIELD RESEARCH STATIONS

1. JHALDA (WEST BENGAL)

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

The following mixed and cross-inoculations were tried on *kusum* as before with the object of finding out the causes of untimely early emergence of lac larvae and to isolate such early emerging strain of the insects, if possible.

Treatment

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

For *Jethwi* 1962 crop, 4 trees of treatment D and 1 tree of treatment E were inoculated with the harvested brood of their respective treatments and the rest were inoculated with *kusum* brood only, as *rangeeni* broods were not available at that time. The crop did not show early emergence.

Treatment D gave a brood to yield ratio of 1: 3·10, treatment E 1: 3·50 and the rest of the trees an overall ratio of 1: 2·13. The crop data are recorded in Table XXVIII (App. A).

Inoculation was done for *Aghani* 1962-63 and *Jethwi* 1963 crops, partially by harvested broods and partially by purchased brood. Mild spurious emergence was observed in *Aghani* 1962-63 crop from trees inoculated with *kusum* brood (Treatment A).

(ii) (a) *Alternative lac hosts for* kusmi *strain*

Trials were continued on *Protium serratum, Dalbergia latifolia, Ficus arnottiana, palas* and *ber* with *kusum* brood. The resulting broods were either raised continuously on these hosts or alternated with *kusum* trees to see their performance as *kusmi* hosts and the effect of cross-inoculations.

The results of stick examination and crop data are recorded in Tables XXIX and XXX (App. A).

Ber showed the best results both in *Jethwi* 1962 and *Aghani* 1962-63 crops in respect of brood to yield ratio.

(b) *Introduction of exotic hosts*

Only 50 *M. macrophylla* plants out of 200 transplanted last year are growing well. The rest died.

(iii) *Relative importance of enemy and friendly insects*

No new insects were collected.

2. DAMOH (MADHYA PRADESH)

(i) *Response of* ghont *to pruning*

The experiment was continued with a view to evolve suitable pruning methods both for *Katki* and *Baisakhi* crops. The experimental details are as follows:

Treatments for Katki *crop*

A — Pruning in 1st week of December
B — Pruning in 2nd week of February
} Exploited every year

C — Pruning in 2nd week of May
D — Pruning in 2nd week of May } Exploited in alternate years

Treatment for Baisakhi *crop*

A — Pruning in 2nd week of April.

B — Pruning in 3rd week of May.

Under *Katki* crop, pruning in December (Treatment A) was replaced in 1961 by pruning in November at the time of harvesting and under *Baisakhi* crop, pruning in November has been added in 1962 as treatment C. The modification has been introduced with a view to minimize expenditure on account of pruning as a separate operation.

Shoot measurement studies and crop data indicate that treatment A under *Baisakhi* crop and treatment D under *Katki* crop showed better results than the other treatments.

Table XXXI (App. A) records the results of shoot measurements made at the time of crop inoculation of three crops and Table XXXII (App. A) records the crop data of two crops.

(ii) *Determination of the optimum amount of brood requirement for* ghont

The experiment was continued with the object of finding out the effect of different densities of larval settlement on crop production as well as brood preservation in both *Baisakhi* and *Katki* crops.

Half-normal (A), normal (B) and double-normal (C) treatments are under trial.

In *Baisakhi* crop, there is no significant difference in larval and adult mortalities between the treatments, though normal brood rate has given higher brood to yield ratio than the other two treatments.

In *Katki* crop, there is no significant difference in the larval mortality in the three treatments, though double-normal brood rate has shown minimum adult mortality and maximum brood to yield ratio.

The results of stick examination and crop data are recorded in Tables XXXIII and XXXIV (App. A).

Baisakhi 1962-63 crop is progressing satisfactorily.

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

The experiment was continued with the object of obtaining *ari* lac and broodlac and reducing the cost of operation.

Under this experiment, 500 trees have been divided into 5 coupés. There are 3 treatments, with 10 trees in each treatment and 10 replications.

Treatment

A — Inoculation in October-November with 125 gm. brood per tree, no harvesting in June-July and complete harvesting in October-November next year.
There are 2 coupés under this treatment, with 100 trees in each, to be used in alternate years.

B — Inoculation in October-November with 250 gm. brood per tree. Dead lac and excess brood to be removed in June-July and complete harvesting to be done in October-November next year.
There are 2 coupés, with 100 trees in each, to be used in alternate years.

C — Inoculation in October-November with 600 gm. brood per tree and *ari*-cutting in April.
There is one coupé only under this treatment, with 100 trees, to be used every year by harvesting in April, which will also serve as pruning.

Baisakhi 1962-63 crop (first inoculation done in November 1962 after fresh layout) is progressing satisfactorily.

(iv) *Trials on regional and exotic hosts to find out their suitability to fortify lac cultivation on* ghont

(a) *Trials on regional hosts.*

Palas, *ber*, *airma* (*Acacia donaldi* Haines), *renja* (*Acacia leucophloea* Willd), *dhobein* (*Dalbergia paniculata* Roxb.), and *bansa* (*Albizzia odoratissima* Benth.) were tried for lac cultivation to determine their performance both as brood preserver in the *Baisakhi* crop and brood producer in *Katki* crop. The few available trees of these species found in the experimental field area were inoculated in both the seasons after being duly pruned. Regular observations on initial larval mortality, sex-ratio, pest attack and heat mortality were made during the progress of the crop. *Palas* is indicative of better brood preservation in *Baisakhi* 1961-62 and *ghont* in *Katki* 1962, though *ghont* has shown better results than *palas* regarding yield.

Data are recorded in Table XXXV (App. A).

Baisakhi 1962-63 is progressing satisfactorily on *palas* and *khair* and failed on other hosts before male emergence.

(b) *Introduction of exotic hosts*

50 *M. macrophylla*, 40 *Samanea saman* (Rain tree), 10 *A. lucida*, and 3 *O. oojeinensis* plants are developing satisfactorily.

(v) *Relative importance of enemy and friendly insects*

Some new insects emerged from *Baisakhi* 1962-63 crop on *ghont*; these will be identified.

Data on caging is recorded in Table XXXVI (App. A). It will be seen that enemies emerged four months after inoculation in *Baisakhi* crop and two months after in *Katki* crop, *Tetrastichus purpureus* emerged more from immature lac than from mature lac and more insects emerged from mature lac than immature lac.

3. MIRZAPUR (U.P.)

(i) *Studies on the pruning of* ghont

This experiment is being conducted on the same lines as at Damoh.

April-pruning (Treatment A) has given better brood to yield ratio (scraped lac) in *Baisakhi* 1961-62 crop and February-pruning (Treatment B) in *Katki* 1962 crop. Crop data are given in Table XXXVII (App. A).

(ii) *Determination of the optimum amount of brood requirement for* ghont *and* palas

This experiment is also being conducted on the same lines as at Damoh.

The crop data of *Baisakhi* 1961-62 and *Katki* 1962 crops are recorded in Table XXXVIII (App. A).

Brood was obtained from *palas* in both the crops. No definite conclusions can be drawn from the results obtained so far.

Heavy larval mortality on *ghont* and *palas* was observed at *phunki* removal from *Baisakhi* 1962-63 crop. The percentage mortality observed for A, B and C treatments was, respectively, 89·00, 92·28 and 93·51 in *ghont* and 78·01, 84·65 and 89·03 in *palas*.

(iii) *Evolution of a suitable cultivation practice to be followed for* ghont *and* palas.

This experiment is also being conducted on the same lines as at Damoh.

Higher larval mortality in the three treatments was observed on *ghont* (93·26%, 93·94% and 90·61%, respectively) than on *palas* (73·41%, 62·52% and 38·35%, respectively) in *Baisakhi* 1962-63 crop at *phunki* removal.

(iv) *Trials on regional and exotic hosts to find out their suitability to fortify lac cultivation on* ghont

(a) *Trials on regional hosts*

Ber in *Baisakhi* 1961-62 crop and *khair* in *Katki* 1962 crop gave the highest brood to yield ratio of scraped lac, though the yield was insignificant. Some brood was obtained only from *khair* in *Katki* 1962 crop.

The data are recorded in Table XXXIX (App. A).

No *Baisakhi* 1961-62 crop was obtained from *sidh, ail* (*Mimosa himalayana*) and *rev* (*Acacia leucopheloea*) and no *Katki* 1962 crop from *kuchai, khair, rev, katmauhuli, katar, sidh* and *siris* (*Albizzia lebbek*).

(b) *Relative importance of enemy and friendly insects*

Data on caging are recorded in Table XL (App. A). More enemies emerged from brood collected from outstations than from our own field area.

4. UMARIA (M.P.)

(i) *Evolution of a cultivation practice for* kusum

The experiment was continued on 210 trees with the following 3 treatments:

A — One-year rest between pruning and inoculation, i.e. 2-coupé system. There are 4 coupés under this treatment with 15 trees in each coupé. Two coupés will be used in alternate years for inoculation in January-February, followed by self-inoculation in June-July and harvesting in January-February next year.

The other two coupés will be used in alternate years for inoculation in June-July, followed by self-inoculation in January-February and harvesting in June-July next year.

B — Two-year rest between pruning and inoculation, i.e. 3-coupé system. There are 6 coupés under this treatment with 15 trees in each coupé. Three coupés will be used in turn each year, as in treatment A.

C — One and a half-year rest between pruning and inoculation, i.e. the usual 4-coupé system. There are 15 trees in each coupé. Each coupé will be used as usual for one crop every season, without leaving for self-inoculation.

Harvesting in all the above-mentioned treatments will also serve as pruning.

Coupés A_1 I, B_1 I and C I were inoculated in February 1962 for *Jethwi* 1962 crop. The crop was harvested from coupé C I in July 1962 and coupé C II inoculated for *Aghani* 1962-63 crop, while coupés A_1 I and B_1 I were left for self-inoculation in July 1962. *Aghani* 1962-63 was harvested in February 1963 from A_1 I, B_1 I and C II.

The ratio of brood to yield (scraped lac) obtained from coupés A_1 I, B_1 I and C I + C II (since two combined crops were obtained each from A_1 I and B_1 I coupés and two separate crops from C I and C II coupés in one year) was found in descending order.

The crop data are recorded in Table XLI (App. A).

Inoculation was carried out in July 1962 in coupés A_2 I and B_2 I and in February 1963 in A_1 II, B_1 II and C III.

The crops are progressing satisfactorily.

(ii) *Trials on regional and exotic hosts to find out their suitability to fortify lac cultivation on* kusum.

(a) *Trials on regional hosts*

Dhaba, kaima, kakai, khair (*Acacia catechu*) and *rev* (*A. lencophloea*) were tried for *Jethwi* 1962 crop but none gave any yield.

(b) *Introduction of exotic hosts*

M. macrophylla seedlings, raised in nursery beds in March 1962 and by direct sowing in pits in July 1962, are developing satisfactorily.

(iii) *Relative importance of enemy and friendly insects*

Agathis coryphe Nixon (Braconidae), a new internal parasite of *H. pulverea*, was collected. Two new Ichneumonids were also collected, which will be identified.

Enemy and friendly insects started emerging three months after inoculation in *Jethwi* crop and two months after inoculation in *Aghani* crop. Some unidentified insects emerged from *Aghani* 1962-63 crop. Data on caging are recorded in Table XLII (App. A).

III—PLANTATION AT NAMKUM

General upkeep of the plantation was maintained. Hoeing and weeding were carried out to keep down the weeds.

Large-scale raising of *Moghania macrophylla* seedlings was done by sowing seeds in April and May. Transplanting of seedlings was done in previously prepared pits and in earthen flower pots in the month of July for extensive cultivation of lac on this bush and for collection of seeds for distribution to outside parties.

Seedlings of various lac hosts were raised for replacing the dead and diseased ones in the plantation, and for potting for experimental studies in the laboratory.

Periodical spraying of insecticides was continued for extermination of insect pests infesting the plantation.

IV—TRAINING AND ADVISORY SERVICE

Two six-month regular courses in improved methods of lac cultivation were conducted during the year, namely, from 1st April to 30th September and 1st October to 31st March, with 29 and 30 trainees, respectively.

In all 59 candidates (17 from West Bengal, 13 from Bihar, 10 each from Madhya Pradesh and Uttar Pradesh, 7 from Development Wing of I.L.C.C., and one each from Mysore and Tripura) were trained during the year.

Two short courses of training, each of one month's duration, were organized during the year in June-July and October-November and three officers, one each from Maharastra, Bihar and Uttar Pradesh, received the training. One Forest Utilization Officer from Madras received a fortnight's *ad hoc* training.

Lectures on improved methods of lac cultivation were delivered at Forest Guards' Training Schools at Mahilong and Betla and at Foresters' Training School at Chaibasa.

CHEMISTRY DIVISION

I—GRADING AND ANALYSIS

1. Bleach Index/Bleachability

On the basis of the recommendation of the ISO/TC-50 Lac, the possibility of using a photoelectric colorimeter for the determination of the bleach index/bleachability of lac by the 'Indian' method (developed by this Institute) was investigated. Details of the modified method including a method for calibrating the instrument on the basis of standard iodine solution were communicated to the Indian Standards Institution at the Secretariat of the ISO/TC-50. It was learnt that these details have been communicated to member countries.

Samples are now awaited from the U.S.A. for the proposed new series of Round Robin tests both by this method as well as by the currently used U.S.S.I.A. method, slightly modified in respect of particle size of the sample to be tested as agreed to in the last ISO meeting.

2. Determination of the 'Age' of Lac

Determination of the 'age' (i.e. the state of storage polymerization) of lac has been a problem baffling the lac industry. Several attempts had been made by earlier workers to correlate the physical and chemical constants such as life, flow, percentage of insolubles and rate of filtration as well as acid, saponification, hydroxyl and carbonyl values with the 'age' of the sample without any significant success.

It has now been found that specific heat — a physical constant easily determinable with great accuracy — shows promise of being useful for this purpose.

Specific heat of lac at various temperatures has been determined by Bhattacharya (*Indian Lac Res. Inst.*, Bull. No. 36) and Srivastava [*Indian J. Phys.*, **32** (1958), 443]. The latter has reported that the specific heat of fresh *kusmi* shellac at 70-75°C. is 0·71 and that the specific heat of heat polymerized sample at the same temperature is 0·53. It was considered likely that the specific heat of seedlac also under the same conditions might show similar significant difference.

The specific heats of fresh *kusmi* seedlac were, therefore, determined at various temperatures from 30° to 72°C. making use of the apparatus described by Shrivastava. The results are brought out in Table I (App. B). It was found that the sample had the highest specific heat at 70°C. It was also found that both *palas* and *ber* seedlacs, when fresh, had almost the same specific heat at this temperature.

Specific heats of a few samples of seedlacs of known ages were then determined (*see* Table II, App. B). It was found that the specific heat at 70°C. declined rapidly with age from 0·68 when fresh to about 0·60 after one year, 0·53 after two years, 0·39 after 3 years and so on up to 0·32 for a sample 13 years old.

Attempts are being made to procure more samples of known 'age' in order to confirm how far this change in specific heat could be made use of to assess the 'age' of the samples.

3. Determination of Insoluble Lac Resin in Old Samples

It is well known that when lac is stored for a long time, especially in unfavourable weather conditions, it deteriorates and gradually becomes insoluble. It is also known that when insoluble lac is boiled under reflux in alcohol in the presence of a mineral acid, the lac goes back into solution. Advantage was taken of the latter to determine the per cent of insoluble lac in samples of old lac.

For these experiments, sulphuric acid was preferred as it does not volatilize during the refluxing. The optimum amount of the acid required to dissolve 5 gm. of the sample in 125 c.c. of alcohol, was found to be 0·6 c.c. or about 1 gm. of concentrated sulphuric acid diluted with an equal amount of water.

Method

One set of extraction cartridges was prepared in the usual manner, i.e. extracted with alcohol, dried and weighed to constant weight. Another set was first treated with the alcohol containing the same amount of sulphuric acid as mentioned above and then extracted, dried and weighed in the usual manner.

First, the hot alcohol insolubles of the sample was determined in the usual manner using the first set of cartridges. The experiment was then repeated using alcohol (125 c.c. containing 0·6 c.c. of 1 : 1 dilute sulphuric acid) as mentioned above for the initial dissolution of the lac and carrying out the filtration in the cartridges already washed with acidulated alcohol.

If W_1 is the result of determination of hot alcohol insolubles using plain alcohol and W_2 the same using acidulated alcohol, W_2 represents the amount of non-lac impurities in the sample and $W_1—W_2$ the amount of insoluble lac. A few typical data for fresh and old seedlacs are brought out in Table III (App. B).

4. Correlation of Quality of Lac, Especially Colour, with Climatic Conditions of the Area of Cultivation

Experiments were continued during the year under report to determine the correlation, if any, between the quality, especially colour of lac and the climatic conditions of the area in which it is cultivated. A total of twenty-two samples had already been examined for the qualities of the seedlac and shellac produced from them and reported in the previous Annual Reports [*vide Annual Report* (1960-61), 14 and (1961-62), 14].

Twenty more samples were obtained from the various regions of the country during the year and examined. The results obtained are brought out in Table IV (App. B). Differences are noticeable in the quality of the lac obtained from the same species of hosts in different regions. How far these are related to the different climates can be assessed only after some more observations.

II — IMPROVEMENTS IN THE MANUFACTURE OF SEEDLAC, SHELLAC, BLEACHED LAC, ETC.

1. Improved Method of Lac Washing

The advantages of using potassium permanganate as a 'washing aid' for the washing of sticklac into seedlac have already been described in the earlier Annual Reports (*Annual Report*, 1960-61, 1961-62). The experiments which had so far been confined to the tub method were extended to barrel washing during the year. Sticklac (beuli — 80 kg.) was charged into an experimental lac washing barrel and given the usual preliminary washing for one hour before the permanganate was added. After rubbing for 20 minutes with permanganate the washing was continued for further 40 minutes. The material was then discharged through the manhole. The final acid treatment was carried out in the cement vat below, and the lac finally washed free from the mineral acid in baskets. It was confirmed that in barrel washing also, as in tub washing, use of permanganate results in the same quality of seedlac as with soda washing and that the yield of seedlac is about 5 per cent higher.

It has already been reported that the use of borax and caustic soda in place of washing soda reduces the bleach index of the seedlac produced by about 10 units with the yield of

seedlac lower by 4 to 5 per cent. These chemicals also were, therefore, investigated in the washing barrel, as early experiments were mostly carried out in tub washing. It was found that the quantity of these chemicals required for use in the barrel, is only 0·25 per cent of borax and 0·05 per cent of caustic soda, on the weight of beuli, i.e. roughly 50 per cent of the quantity required when the washing is carried out in vats. Consequently the yield of seedlac was also only 1·5 to 2 per cent less than when washing soda was used. Barrel washing using these chemicals also resulted in the same lowering of bleach index as in tub washing, i.e. by about 10 units.

2. Use of Centrifuge for the Drying of Washed Lac

In the indigenous process of washing sticklac into seedlac, in the barrel or in the tubs, the washed lac is kept in a basket to drain off the water as much as possible and the lac then dried by spreading in thin layers in an open or covered courtyard. The drying may take from about an hour to several hours or even days depending upon the weather.

When the drying process is mechanized to eliminate this dependance upon weather, it will be economical to drain the water as effectively as possible before subjecting the lac to any drying process. The extent to which a (basket-type) centrifuge would be useful for this purpose was investigated.

Washed lac drained in the conventional way was found to contain 36·40 per cent of water/moisture. This was centrifuged in a perforated basket-type centrifuge at 1,170 r.p.m. and the water/moisture content of the sample after 10, 20, 30, . . . 180 minutes determined (*vide* Table V, App. B). It was seen that the adhering water/moisture dropped from 36·40 to 11·30 per cent within ten minutes and that thereafter, the drop was comparatively slower. It would appear, therefore, that centrifuging for about ten minutes will introduce considerable economy in the further drying of the lac by any mechanical means.

The possibility of using a rotary type of dryer for the further drying is to be investigated.

3. Preparation of Shellac by Alkali Extraction Method

Conditions for the production of shellac from seedlac by extraction with aqueous alkalies have been described already in the 1961-62 *Annual Report* of this Institute. It has been shown that when seedlac is extracted with a solution containing sodium carbonate and sodium sulphite and the extract treated for a short while with a dilute solution of sodium hydrosulphite and the lac then reclaimed by acidification, etc., under the usual conditions, the shellac produced has a colour index and hue very nearly the same as those of shellac produced from the same starting materials by the *bhatta* method [cf. *I.L.R.I. Annual Report*, (1961-62), 15-16].

The storage stability of the products was examined. Shellac prepared by this method had been stored under the usual laboratory conditions and tested for its keeping quality from time to time (*vide* Table VI, App. B). It is found that even after 18 months' storage (so far), the material is easily soluble and that its life and flow are only slightly inferior than when fresh. The storage stability obviously is very satisfactory.

Film properties

The shellac produced by the above method, however, was found to contain 1·05 to 1·25 per cent of combined sulphur. As this might have some influence on the properties of the films obtained from them, these were examined (*vide* Table VII, App. B). The film properties were almost identical.

4. Dewaxing of Lac Using Aqueous Alkalies

The possibility of dewaxing lac in the course of the alkali extraction described above was investigated. Boiling of the alkali extract and allowing it to cool undisturbed resulted

in a portion of the wax rising up to the surface and forming a crust at the top, which could be easily removed. A certain amount of wax still remained suspended in a fine condition at the upper half of the extract column. Methods of removing this wax also either by filtration through a cloth bag after mixing with paper pulp as filter-aid or by extraction with white spirit have already been described (*vide Annual Reports* (1960-61), 17 and (1961-62), 17]. It has now been found that if the extract is boiled with a small amount of barytes powder, the suspended wax easily settles along with the barytes to the bottom of the container. The quantity of barytes required was about 80 per cent on the weight of lac content of the extract. The settling was rapid and the remaining solution could be strained through cloth easily. Lac reclaimed from this dewaxed extract was found to have wax content of only 0·04 per cent. Its solution in alcohol was clear. It has also been found that the same lot of barytes could be used at least twice for this wax separation.

5. Making of Shellac Using Soft Coke in Place of Charcoal

The possibility of using soft coke in place of charcoal for converting seedlac into shellac by the conventional *bhatta* process was investigated as the former is comparatively much cheaper. For this purpose, the conventional *bhatta* (oven) had to be slightly modified in order to provide for passage of air through the coke, for its complete and proper burning. After a series of experiments, the process was standardized. The properties of shellac obtained from the same seedlacs using either fuels are brought out in Table VIII (App. B).

It will be seen that soft coke can be successfully used for this purpose thus effecting an economy of about Rs. 5.40 per quintal of seedlac, i.e. Rs. 2.00 per maund.

6. Economic Utilization of the By-Products

(a) *Recovery of lac from* molamma

The technique of alkali extraction using sodium carbonate, sodium sulphite, sodium hydrosulphite was used for the extraction of the lac resin from different samples of *molamma* produced in our experimental lac factory, as well as from samples obtained from outside. The yield of lac resin was 85 to 90 per cent of the hot alcohol solubles in the samples. The colour index of the extracted resin was in the range of 26 to 32.

(b) *Recovery of wax lost during the processing of sticklac into seedlac.*

Lac wax is a valuable product lost in substantial quantities during the washing of sticklac into seedlac. The possibility of recovering as much of this wax as possible was investigated. As a first step, the wax contents of the materials obtained during the processing of sticklac into seedlac were determined. The results are indicated in Table IX (App. B).

It will be seen that whereas sticklac originally contained 4·67 per cent of wax, seedlac obtained from it in an yield of about 70 per cent had 4·78 per cent and *molamma* and other by-products (yield 7%) 8·04 per cent wax. These would account for about 3·91 per cent of the wax in sticklac. Approximately 0·76 per cent of lac wax is thus being lost during the processing of sticklac into seedlac which means about 325 tonnes from this country's annual estimated output of 43,000 tonnes of sticklac. Attempts are, therefore, very much worthwhile to recover as much of this wax, as possible.

It has already been shown [*vide I.L.R.I. Annual Report* (1959-60), 51] that the crude material obtained by the precipitation of lac factory wash water with dilute sulphuric acid contains about 10 to 12 per cent of wax on dry weight. Experiments were, therefore, taken up to extract this wax by the usual solvent, hexane. Extraction was carried out in a soxhlet apparatus. Practically all the wax contained in the sample could be extracted. Alternately, the wax could also be extracted with the use of white spirit (mineral turpentine) at a temperature of about 90°C. The yield was 80 to 85 per cent of the wax content of the sample. The wax obtained was fairly hard and brittle and had a melting point of 85°C. The product obtained with mineral turpentine was comparatively darker. Both could be further hardened

by ' oxidation ', that is by maintaining in a thin layer at 120°C. for 24 hours. Large-scale collection of the crude dye as well as extraction of wax therefrom are being attempted.

If this could be organized, it is estimated that it would be possible to recover at the rate of 6 kg. of wax per tonne of sticklac washed or about 258,000 kg. from the 43,000 tonnes of sticklac processed in this country annually valued at about 12·9 lakhs of rupees @ Rs. 5 per kg.

Attempts were also made to extract the wax by the solvent extraction of *molamma*. It was found that at the temperature of extraction, the lac resin in *molamma* softened and formed a lump so that extraction of wax was incomplete. When, however, the *molamma* was mixed with an equal weight of the precipitated crude dye, the wax of both could be extracted to the extent of about 90 per cent.

7. Bleached Lac

(i) *Chemistry of bleaching*

(a) Mention was made in the last *Annual Report* of the action of bleach liquor (sodium hypochlorite) on aleuritic acid, the chief constituent acid of lac. Continuing the study, the action of bleach liquor on the aldehydic acid, another major acid present in lac, under conditions identical with those of bleaching of lac was investigated. The aldehydic acid was prepared according to the method described by Sengupta [*J. sci. industr. Res.*, **14B** (1955), 86]. The acid, on dissolving in sodium carbonate and precipitating with mineral (sulphuric) acid, was found to separate into two fractions, the insoluble and the soluble, the latter having higher acid and hydroxyl values. The same behaviour was noticed on treatment with bleach liquor, except that the proportion of the fraction remaining in the solution was higher. A certain amount of chlorine was found to have been taken up by the acid and the iodine value was a little lower (*vide* Table X, App. B). This drop in iodine value, however, does not account for all the chlorine entering. It may, therefore, be inferred that the rest of the chlorine enters through substitution. Carbonyl value of the resin practically disappeared on dissolution in sodium carbonate and precipitation.

A surprising observation was that the aldehydic acid prepared gave a very low carbonyl value. The aldehydic acid, prepared according to the procedure recommended by Kamath (XIVth International Congress of Pure & Applied Chem., Zurich, 1955), also gave a carbonyl value of only 17·0. A pure sample of the aldehydic acid should have a carbonyl value of about 200, the same as its acid value. On this basis, the purity of the prepared acid works out to be only 8·5 per cent. The 2: 4 dinitrophenyl hydrazone of the acid was also obtained in a yield corresponding to only about 8 per cent aldehydic acid, thus confirming the figure for purity worked out through carbonyl value.

(b) The action of bleach liquor on erythrolaccin, the water-insoluble colouring matter present in lac, would also be of interest in the study of the chemistry of bleaching. Attempts were, therefore, made to isolate the dye by the process employed by Tschirch and Farner (*Arch. d. Pharm.*, **35,** 1899 and *Diss. Bern*, 1899). The dye, however, could not be obtained in a crystalline form and a certain amount of resin was always found admixed with it.

Attempts to isolate the dye using other methods were therefore tried. It has been claimed by Wright [*Paint Manuf.*, **19** (1949), 153] that erythrolaccin crystallizes out when the ether extract of lac is allowed to stand for a sufficiently long time. However, no crystals were noticed even when the extract was kept for 4 months. The study is being continued.

(ii) *Stabilizers for bleached lac*

Lead thiosulphate was found to work as an efficient stabilizer for bleached lac [cf. *Annual Report* (1961-62), 17]. The suitability of organo-tin salts as stabilizers for bleached lac similar to their use in polyvinyl chloride, was next investigated. The three salts examined were dibutyl-tin-maleate, dibutyl-tin-dinonyl-maleate and dibutyl-tin-dilaurate. These salts were mixed with bleached lac washed free from acid, in different proportions, from

0·25 to 2 per cent, by grinding in a ball-mill for half an hour. Some improvement in life under heat was noticed (cf. Table XI, App. B). However, these tin salts were no better than lead thiosulphate except that they are free from lead.

(iii) *Preparation of chlorine-free bleached lac*

It is well known that it is the chlorine that enters the lac resin molecule when bleached with sodium hypochlorite and brings about the deterioration in some of the desirable properties of the bleached lac. Attempts were, therefore, made to prepare chlorine-free bleached lac by using chlorine-less oxidizing agents. Gaseous oxygen was bubbled through a solution of lac or hydrolysed lac in alcohol or sodium carbonate under different *p*H and temperature and in the presence of various catalysts. No bleaching was observed under any condition. Other oxidizing agents investigated were hydrogen peroxide (with or without catalyst), benzoyl peroxide, sodium perborate and nitric acid. The bleaching was negligible in all cases except with nitric acid which produced a somewhat less coloured sticky material.

(iv) *Rapid method of bleaching of lac*

An alternative method of bleaching of lac resin was described in the previous *Annual Report,* in which the lac was bleached with sodium hypochlorite while in the form of a fine suspension obtained by treating a sodium carbonate extract of the resin with sodium chloride. It was shown that bleached lac thus produced compared favourably with bleached lac obtained by the conventional method in respect of colour and was superior to the latter being free flowing and of better texture and lower chlorine content [*vide I.L.R.I. Annual Report* (1961-62) 18].

Samples prepared had been stored under the laboratory conditions for the determination of their storage stability. They, after 12 months so far, still retain their free flowing condition and texture, have not changed in colour and are still soluble in alcohol. They are apparently somewhat superior to conventional bleached lac in these respects.

The film properties of these bleached lacs were also compared with those of the conventional bleached lac. It was seen that there was hardly any difference between the film properties of the two varieties except, perhaps, for a slight inferiority in respect of blush-resistance, in the case of the rapidly bleached sample.

Bleached lac pilot plant

Experiments on the pilot plant were continued. After making some modifications in the plant and in the process of manufacture, it was possible to use the plant to produce bleached lac of good colour and desirable keeping qualities. Several batches of bleached lacs both by the ordinary as well as by the ' rapid ' method, were prepared. The following modifications were made in the plant for better and smooth working:

(a) The size of the rotary strainer was increased to 1·5 times the original. This is now found to work very satisfactorily. The present dimensions of the strainer are 65·0 cm. (26 inches) long and 40·0 cm. (16 inches) in diameter. The strainer moves at a speed of 20 r.p.m.

(b) The stainless steel manhole cover of the rotary washer was replaced by a long zip fastener fitted to the cloth. This has not only made the operation of opening and closing the washer simpler but also saves a lot of time and trouble during discharge of the materials from the washer.

The following improvements are still necessary in our plant:

1. The stainless steel body of the seedlac extractor often gives way at the welded joint even while working with steam almost at atmospheric pressure. This is being checked.

2. The epoxy lining of the bleaching tank has chipped off at several places. While some have been repaired, new ones are continually appearing. Epoxy lining is perhaps not entirely satisfactory for steel for this purpose.

Experiments are being continued to investigate the possibility of using alternate materials of construction for the bleaching and precipitation tanks.

III—FUNDAMENTAL RESEARCH

1. Constitutional Studies — Separation and Study of the Components of Fraction V

The separation of lac into five fractions by temperature phase separation from dry acetone solution and the preliminary studies of Fraction V, the fraction left in acetone solution at —11°C., had already been reported [*vide I.L.R.I. Annual Report* (1961-62), 18-19]. It was shown that this fraction is only partly soluble in ether and that a non-acidic fraction could be isolated from its ether extract. This neutral fraction was further studied.

This product was completely soluble in alcohols, ketones, acids and ether and partly in toluene, benzene and petroleum ether. The acid value was 3·4, saponification value 160, hydroxyl value 162, iodine value 3·9, and molecular weight (by Rast's method in camphor) 338. On ultimate analysis, carbon content was found to be 74·8 per cent and hydrogen 10·9 per cent; oxygen, by difference, was 14·3 per cent. The empirical formula works out to $C_{21}H_{37}O_3$ which also would appear to be the molecular formula because of the excellent agreement with the observed data as indicated below:

Chemical constants of neutral fraction

	Mol.wt.	C%	H%	A.V.	S.V.	Hydroxyl value	I.V.
Determined	338	74·8	10·9	3·4	160	162	3·9
As per formula $C_{21}H_{37}O_3$	337	74·78	10·91	0·0	164 for one ester group	164 for one hydroxyl	

The saponification and hydroxyl values would indicate the presence of only one ester and one free hydroxyl group in the molecule (of molecular weight 337). Consequently the product is likely to be a lactone with one free hydroxyl group.

The study is being continued to elucidate its constitution and confirm it by synthesis.

2. Differential Thermal Analysis

The object of this method is to study the structural changes occurring in shellac and its constituent acids when heated. The main principle of this technique is to measure the heat changes in consequence to any physical or chemical changes like dehydration, transition from one crystalline stage to another, etc.

During the assembly of the apparatus, several difficulties were encountered; the temperature of the cell could not be measured by Potentiometer through Pt.-Pt. Rh. 10 per cent thermocouple as a low-resistance galvanometer of about 30-40 ohms resistance to measure the changes in e.m.f. was not available. A microammeter was tried but this also did not work satisfactorily because, slight difference in millivolts on the lower side were always observed when compared with the standard voltage-temperature chart in (Pt.-Pt. Rh. 10%) thermocouple systems. Hence, the cell was modified slightly like Bourchardt's and temperature measured by ordinary thermometer. The cell is being calibrated in terms of known heat of reaction of $CuSO_4$, $5H_2O$.

IV—MODIFICATIONS AND USES

1. Modification of Lac with Diisocyanates

In the *Annual Report* for 1961-62 (*vide* page 27-28), it was reported that dewaxed lemon shellac was treated with varying amounts (1 to 6%) of toluene diisocyanate (Suprasec C).

It was also reported that the lac modified with up to 5 per cent Suprasec C was Soluble in alcohol, whereas with 6 per cent of the reagent, only partial solubility was observed. The physical and chemical constants of the modified lac, have now been determined.

(a) *Physical properties and chemical constants*

The softening and melting points of these modified lacs were found to increase gradually with increase in diisocyanate proportion. It was observed that whereas the parent lac had softening and melting points of 73° and 79°C., in the lac treated with 5 per cent diisocyanate these had been raised to 88° and 95°C. and that in the lac with 6 per cent, to 93° and 102°C. respectively. The acid, saponification and hydroxyl values of these resins were also determined. There was a slight drop in the acid value from 76·99 to 65·63 whereas the saponification value was more or less unchanged at about 230. However, there was a gradual drop in the hydroxyl value from 250·6 for the parent lac, to 204·3 for the sample treated with 6 per cent diisocyanate. The significant increase in softening and melting points and the drop in hydroxyl value are conclusive evidence that the isocyanate had reacted with the hydroxyl groups of lac forming urethane type compounds.

The physical and chemical constants of the various modifications are brought out in Table XII (App. B).

(b) *Film properties*

To study the film properties, varnishes were prepared by reacting dewaxed lac in dry acetone solution with 3, 4 and 5 per cent diisocyanate respectively and dissolving the resulting mass, after allowing to stand overnight, in methylated spirit to produce 20 per cent solution. These varnishes were used to produce films on glass and tin pannels by flowing. The varnished panels were dried at 20° ± 1°C. and aged for 7 days before testing.

When the glass panels were kept dipped in water at room temperature, faint blush was noticed in the film after 1½ hours immersion in the case of isocyanate treated lacs, whereas the parent lac film blushed in about ½ hour. All the treated lac films recovered completely when removed after 24 hours immersion, but the recovery of the parent lac film was not so complete.

Scratch hardness was found to increase with increasing amounts of the isocyanate. The control lac film had a hardness of about 600 gm. and the 5 per cent isocyanate treated lac film a hardness of more than 2,000 gm. There was thus considerable improvement in the hardness of the film by modification of lac with diisocyanate.

Elasticity, on the other hand, was poorer in the case of the films of treated lacs.

Weather resistance of these films was studied by exposing a set of wooden panels polished with these varnishes and aged for 7 days, on a stand on the roof of the laboratory. Their gloss was measured after about 4 months' exposure. The control panel had lost all its gloss by that time and appeared as if the complete film itself had been washed out. The gloss was only about 8·6 per cent of the original, whereas 3 and 5 per cent diisocyanate treated lacs showed 27·8 and 15·7 per cent gloss respectively. The 4 per cent treated varnish had retained gloss to the extent of 44·35 per cent. All these treated varnish films, however, showed fine cracks indicating brittleness. To eliminate this, plasticizers are being investigated.

2. Shellac (Single-pack) Etch Primer

Shellac-based wash primer had been tested extensively for its suitability on light metal surfaces and the results reported in the previous *Annual Report* [*vide I.L.R.I. Annual Report* (1961-62), 20-22]. The study was continued.

(a) *Modification of the primer*

It had already been reported that modification of the primer was tried with different proportions of saponified lac, phenol and cresols. Even though these modifications gave

fairly satisfactory results, they were not superior to the primer containing 3 per cent urea and 10 per cent dibutyl phthalate.

The effect of incorporation of synthetic resins into the primer composition was also investigated. Different proportions of phenolic resins obtained from a few reputed firms, were incorporated into the formulation up to 30 per cent of the phenolic on the weight of lac. Even though these modifications gave satisfactory results when freshly made, they were found to thicken and gel on storage in about 4 months. Only the primer with 10 per cent phenolic possessed a fair storage stability (*vide* Table XIII, App. B).

It was also found that incorporation of phenolic resin improved the adhesion of shellac wash primer to steel even when without urea and dibutyl phthalate. The study is being continued.

(b) *Natural and Dynamic weathering*

It was reported in the *Annual Report* 1961-62 that a few aluminium panels and a part of a Railway coach had been coated in November 1960, with shellac wash primer, with and without modification with urea and dibutyl phthalate. These panels were subjected to natural weathering on the roof of the laboratory and to dynamic weathering in the Institute's jeep car. The panels had been exposed for about 27 months so far. It is found that there is no deterioration of any sort in the panels fixed to the jeep car. In the panels exposed for natural weathering, no further deterioration was observed. The adhesion between the primer and metal, and between the primer and the immediate top coat, continues to be quite satisfactory.

Results of service trials of shellac etch primer on railway coaches and bus bodies are described under the head ' Utilization, Publicity and Propaganda '.

(c) *Storage stability*

It has been observed that some batches of shellac etch primer thickened very much on storage in about six months. It would appear that the water content of the spirit used is very critical, as the water content of other ingredients of the primer were found to be negligible. To study this aspect, shellac etch primers were made using 98, 95, 92·5, 90, 87·5, 85, 82·5 and 80 per cent strength rectified spirit. These samples were stored in tin containers and kept at 20° ± 1°C. Periodically, the consistancies of the above primers were measured in a B4 Ford cup. When freshly made, the viscosities were 28·5, 24·5, 23·3, 22·2, 21·8, 23·8, 31·85 and 39·5 seconds respectively. In about three months' storage, the primers made with 80 to 87·5 per cent strength spirit had thickened very much, whereas with others, the viscosities were found to have increased only slightly. After six months' storage, the viscosities of the primer made with 98, 95, 92·5 and 90 per cent strength spirit, were found to be 35·9, 28·6, 29·5 and 28·1 seconds respectively (*vide* Table XIV, App. B).

The film properties of the above primers after six months' storage were studied. Primer made with 98 and 95 per cent spirit, gave softer films after 24 hours air-drying, whereas primers made with 92·5 and 90 per cent spirit gave quite satisfactory film properties, i.e. in respect of adhesion and flexibility. The pigment had settled but could be easily redispersed without difficulty.

(d) *Shellac etch primer as a primer for steel*

Shellac etch primer was tried as an anticorrosive primer for steel and the details of method of preparation of panels and testing were described in the *Annual Report* of 1961-62 (page 21). It was observed that the primer made with pigment zinc chrome washed with boiling water gave satisfactory results, i.e. no rust spots developed after 15 days exposure in the humidity cabinet. The studies were continued. The results with washed zinc chrome, however, were not reproducible. The primer also thickened considerably on storage and the settled pigment could not be redispersed to the original state. Other modified primers mentioned earlier in this report are being tried.

(e) *Shellac etch primer for refrigerator finishes*

An enquiry was received about the suitability of shellac etch primer on steel for use in refrigerators. The method of test suggested was that steel panels with one coat each of the primer, surfacer and enamel, baked at 120-125°C. for 30 minutes, should withstand, without corrosion, immersion in distilled water at 37·5°C. for eight weeks.

Shellac wash primer of the standard composition as well as with various modifications were tried but all of them started blistering on immersion only after three days. The work is being continued.

3. Hydrolysed Lac

Lac is a solid solution of inter- and intra-esters of hydroxy carboxylic acids. Products of hydrolysis of lac will, therefore, essentially be a mixture of these hydoxy fatty acids. It has been shown that if the total products of hydrolysis of lac are heated together, they recombine to form a new ' reconstituted ' lac of very desirable properties, particularly flexibility. There are a number of other uses also claimed for hydrolysed lac, viz. as a plasticizer for shellac in paper varnishes, in improved adhesives, for finishes of outstanding low temperature flexibility, etc. Hydrolysed lac can thus be an important starting material for a variety of products. Economic methods for the hydrolysis of lac will therefore be of considerable practical interest.

Hydrolysed lac is generally prepared by boiling the resin under reflux with excess of aqueous alkali (NaOH) and treating the reaction mixture with mineral acid. Possibility of hydrolysing lac by heating under pressure without the use of alkali or acid, and with and without catalysts was investigated.

Lac together with three parts of its weight of water, and catalysts where used, was heated under pressure in an autoclave at various temperatures for different periods and the acid, saponification and carbonyl values of the resulting products determined (*see* Table XV, App. B). It was found (*vide* Table XV, App. B) that in the absence of any catalyst, the extent of hydrolysis was not appreciable even after prolonged heating (up to 16 hours). With catalysts, the hydrolysis was more, but for it to go to completion, the catalyst used (sodium carbonate) had to be equivalent to the saponification value of the sample. Other catalysts have to be investigated.

It is of interest to note that the carbonyl value of the resin drops rapidly during autoclaving from about 18 in the original to 2·1 in 3 hours, and to almost zero in about 10 hours. At the same time, from the aqueous layer is obtained a product having a high carbonyl value of about 100.

Optimum conditions for hydrolysis of lac under ordinary pressures were also investigated. In common practice, lac is boiled with excess of alkali for several hours and the saponified product treated with excess of mineral acid. The optimum conditions for this process such as the concentration and excess of alkali required, temperature and duration of the process, etc., have not been determined. These were studied during the year under report.

The first step was to investigate the course of the reaction in presence of just the requisite amount of aqueous alkali (equal to the saponification value) at different concentrations, viz. 0·25, 0·5, 0·75, 1·0, 1·5 and 2 N respectively. The procedure was as follows:

The requisite volume of caustic soda* solution equivalent to the saponification value of lac, was taken in a 500 c.c. jena beaker and 25 gm. of powdered (dewaxed lemon) shellac added. This was then briskly stirred with the help of an electric stirrer till complete dissolution, which took about one hour. The whole of the solution was then carefully transferred to a jena glass stoppered measuring cylinder and placed in a thermostat at 30° ± 0·1°C. and the volume noted. At the end of 1, 2, 3, 4, 5, 6, 24 and 48 hours, 5 c.c. of the solution

*Kamath and Co-workers preferred caustic soda to caustic potash for the hydrolysis of lac.

were transferred by means of a pipette to a titrating flask containing 20 c.c. of cold water. The excess of alkali was then immediately back titrated against standard dilute hydrochloric acid (0·1 N) using thymol blue as external indicator. The determinations were carried out using 0·25, 0·5, 0·75, 1·0, 1·5 and 2 N aqueous caustic soda. It was found that, whereas with 0·25, 0·5, 0·75 and 1·0 N solutions, the dissolution was smooth, with 1·5 and 2·0 N caustic soda solutions, lumps were formed which would not go into solutions easily at this temperature.

The titration values gave the amounts of alkali left unconsumed in 5 c.c. of the solution. The amounts of alkali and lac originally present in 5 c.c. of the solution (before the commencement of hydrolysis at that temperature) was calculated from the total volume of the original solution. From these data, the amount of acidity liberated due to hydrolysis was computed. The acid and saponification values of the lac were also determined separately by the usual methods (74·73 and 221·9 respectively), to calculate the ester-value. From the *liberated* acidity in each case (total acidity less the acid value of lac) and ester-value of lac, the percentage of hydrolysis was calculated. The results are included in Table XVI (App. B). It will be seen that the hydrolysis never reached completion even up to 48 hours and, it would appear, is not likely to do so either for a considerable period.

The effect of temperature was next examined. Temperatures of 20°, 50°C. and boiling water temperature (99°C.) were studied. It was found, as expected that hydrolysis was faster at higher temperature (*vide* Table XVII, App. B) and that alkalies of higher concentrations could be used at the higher temperatures due to lower viscosity of the reaction mixture. However, even at boiling water temperature, the hydrolysis did not reach completion indicating that some excess of alkali is unavoidable for complete hydrolysis.

The progress of hydrolysis with known excesses of alkali of different concentrations was then investigated. It has been found that, for any concentration, the maximum hydrolysis takes place when the excess alkali present over the saponification equivalent is about 40 per cent. It was also found that saponification is almost complete when the reaction is carried out with 1·0 N alkali at boiling water temperature for 3·25 hours with about 40 per cent excess alkali.

When, however, stronger alkali was used in very large excess, the alkali consumed amounted to even more than the saponification value of the sample. Apparently other (side) reactions take place as had already been observed by Kamath and Co-workers [*J. sci. industr. Res.*, Vol. **14B** (1955), pp. 555-62].

4. Reconstituted Shellac

(a) *Improving water-resistance*

Mention was made in the last *Annual Report* [*vide I.L.R.I. Annual Report* (1961-62), 22-23] that by heating a mixture of water-soluble and water-insoluble hydrolysed lacs in the proportions in which they are obtained from lac, a modified lac is obtained, which gives films of outstanding hardness and adhesion and unusual flexibility. It was also reported that these properties could be considerably enhanced by baking. However, these films were deficient in blush-resistance. Attempts were made during the year under report to improve this property.

Incorporation of a variety of spirit-soluble synthetic resins such as phenol-formaldehyde, urea-formaldehyde, etc., were examined. Of these, urea-formaldehyde, butylated urea-formaldehyde and melamine-formaldehyde to an extent of from 20 to 40 per cent of the composition, were found to be quite effective in rendering the baked films water-resistant, showing no blush on continued immersion in water for 7 days.

(b) *Reducing acid value*

It may be recalled that the reconstituted shellac prepared had acid values in the region of 100 to 105. As this acidity is excessive, attempts were made to reduce it as much as

possible. With this end in view, reconstituting was carried out both at lower and higher temperatures, with and without catalysts as well as in the presence of alcohols. At lower temperatures, the reconstitution was comparatively very slow (*see* Table XVIII, App. B), but the product showed a tendency to gel when the A.V. was much higher (about 142). At temperatures higher than 150°C., the reaction was very rapid and the gelling time very low.

The cooking of the total hydrolysed lac was then carried out in the presence of alcohol (ethylene glycol) added either at the start or after partial condensation. In either case, the acid value (*vide* Table XIX, App. B) could be brought down to only 36. The product was sticky and non-drying. By the use of 0·5 per cent of *p*-toluene sulphonic acid as catalyst, the acid value (*vide* Table XX, App. B) came down to about 13 but the product, which continued to be alcohol-soluble, possessed very poor film properties.

(c) *Bleaching of reconstituted lac*

Reconstituted lac, as prepared from seedlac or dewaxed shellac, is rather dark in colour, which naturally would limit its scope of application. Attempts were, therefore, made to bleach it under the same conditions as lac is bleached, i.e. with a solution of sodium hypochlorite containing $3 \pm 0{\cdot}05$ per cent available chlorine. It was observed that better yields of the bleached product could be obtained by using the 'rapid' method of bleaching [cf. *I.L.R.I. Annual Report* (1961-62), 18]. The product obtained was somewhat sticky, and had to be dried by heating to 120°C. The resulting product gave very pale varnishes which could be pigmented with titanium dioxide and other pigments to give glossy, hard films of pastel shades.

As the composition dried under the usual conditions of metal lacquering and the films produced had adequate hardness, gloss and flexibility, a sample has been sent to two reputed firms of tinplate container manufacturers for assessing its suitability under their conditions of manufacture. Their reports are awaited.

An Indian patent has been applied for to cover the process of manufacture of reconstituted shellac.

5. Modification of Shellac with Synthetic Resins

The modification of lac with phenol and cresols with a view to improve its heat- and water-resistance has already been described in the previous *Annual Report* [*vide Annual Report* (1961-62), 24-26]. It was shown that these phenols behave more or less as solvent plasticizers for the lac and that there is deterioration in respect of blush-resistance with no improvement in heat-resistance.

The modification of lac with spirit-soluble synthetic resins such as phenolics and amino resins were therefore studied.

(a) *With phenolic resins*

25 per cent solutions of dewaxed lac and spirit-soluble phenol-formaldehyde resins were prepared separately and mixed in appropriate proportions to produce varnishes containing 10, 20, 30, 40 and 50 per cent of the synthetic on the weight of lac. Films were made on glass plates and tin panels by flowing and were tested after air-drying for seven days. It was found (*vide* Table XXI, App. B) that there was some improvement in the film properties of air-dried films, although not to the desired degree. It was found that all the compositions gave hard, smooth and glossy films on air-drying and as well as on baking. Incorporation of phenolic resin up to 50 per cent on the weight of shellac resulted only in moderate improvement in regard to heat- and water-resistance of the air-dried film. There was also wide variation in the properties from sample to sample. The best when used to the extent of 50 per cent on the weight of lac, produced air-dried films which did not blush in water up to 16 hours and also did not stick to a beaker containing water at 95°C., up to two minutes. However, all these films possessed poor flexibility.

Baked films (100°C. for 1 hour) of shellac modified with phenol-formaldehyde resin on the other hand, gave remarkable properties. In this case, incorporation of as little as 10 per cent of the resin on the weight of shellac produced films which were completely resistant to water and heat. These films did not blush in water for weeks together and also did not stick to any object up to 100°C. These films were, however, found to possess insufficient flexibility. They cracked when bent round a 3 mm. (1/8 inch) mandrel.

Shellac varnishes modified with phenol-formaldehyde resin have a tendency to darken on storage.

Some of the phenolic resins used for these experiments were obtained from different parties and a few were also prepared in the laboratory. It was noticed that acid catalysed resins dissolved in alcohol and mixed well with shellac varnish in all proportions.

Modification of lac with phenol and formalin treated *in situ*, is proposed to be investigated.

(b) *With urea-formaldehyde resins*

In the case of urea-formaldehyde resins similarly tested, there was no noticeable improvement in the properties of air-dried films in the case of practically all samples obtained from the market. One resin, a butylated urea-formaldehyde resin, prepared in the laboratory, however, gave remarkable results. This resin was prepared by boiling under reflux, urea, formalin and *n*-butyl alcohol at a *p*H of 5-7 for two hours, distilling off most of the solvent and water with a Dean and Stark separator and dissolving the residue in alcohol to produce a 25 per cent solution.

This resin was compatible with shellac in all proportions giving homogeneous clear films. Different proportions of the resin were mixed with shellac varnish and the film properties of the different mixtures studied. All the varnishes gave hard, smooth and glossy films on air-drying and as well as on baking. The varnish containing 40 per cent resin on the weight of shellac gave the best performance. Air-dried films prepared on glass slides and aged for 7 days did not blush when immersed in water up to 24 hours. French polished surfaces (on wooden panels) did not show any tendency to stick or disfigure when a beaker containing water kept boiling by an immersion heater was placed over them for two minutes. These surfaces did not also blush or soften or even deteriorate in gloss when alcohol up to 40 per cent strength was splashed over and left over night (*vide* Tables XXII & XXIII, App. B).

Dewaxed lac varnish containing 40 per cent butylated urea-formaldehyde resin thus proved very satisfactory as a heat- and blush-proof French polish. It did not cause any irritation when applied by hand during polishing.

All the four familiar types of lac, viz. commercial dewaxed lemon, platina and bleached lac as well as dewaxed lac obtained by filtering an alcoholic solution of seedlac, were modified with the above resin and their film properties studied. It was noted that all the varieties of lac behaved almost alike.

It would be of interest to note that the above butylated urea resin alone produced dull and tacky films which did not dry for weeks together. It would, therefore, appear that some sort of reaction takes place between shellac and the resin when the two solutions are mixed together resulting in the improvement of film properties. In fact, it has since been observed that these improvements take place only if the films are made *at least* two days after the urea resin and shellac varnishes are mixed together. If the films are prepared earlier, no improvements are noticeable.

Baking of these films resulted in further improvement of their properties. In the case of baked films, incorporation of as little as 10 per cent of the resin on the weight of shellac gave better properties than by the incorporation of even 40 per cent resin in the case of air-dried films (*vide* Table XXIV, App. B).

Further experiments on ageing qualities and the chemistry of this modified shellac are under progress.

(c) *With melamine-formaldehyde resin*

Spirit-soluble melamine-formaldehyde resins behaved in much the same way as the butylated urea-formaldehyde resin described earlier except that the performance was somewhat better in all respects (*vide* Table XXV, App. B).

Air-dried films containing 40 per cent of the melamine resin on the weight of lac did not blush under water on continued immersion for 20 days. All commercial samples, and samples produced in the laboratory behaved alike.

(d) *Modified shellac varnish for use as tin plate lacquers*

Mention has already been made of the improved properties and particularly elasticity of baked shellac films containing urea resins. These were, therefore, studied in greater detail.

The improvements were noticed with all commercial samples of urea resin with only slight variation from sample to sample. The optimum hardness and elasticity were noticed when the composition contained 20 per cent urea resin on the weight of lac and the baking schedule was 1 hour at 100°C. or 10-15 minutes at 150°C. The elasticity persisted even after the films had been baked continuously at 150°C. for 12 hours (*vide* Table XXVI, App. B).

A sample has been sent to two metal plate container manufacturers for assessment of its suitability for metal plate lacquering.

6. Aqueous Shellac-Drying Oil Varnishes

Water thinned organic coatings are becoming increasingly popular in modern days and a great deal of interest is being shown in this field. These finishes have special advantages over the conventional solvent based compositions. Apart from economic considerations, viz. cheapness and ready availability, water thinned varnishes are non-inflammable and non-toxic and, therefore, the risk of fire and pollution of atmosphere are completely eliminated.

The use of shellac varnish in aqueous medium is well known. Shellac, because of the presence of carboxylic group in the molecule, reacts with alkalies to give soluble products. Of all the alkalies used to dissolve lac, ammonia is particularly attractive because of its practically complete removal when the films are baked, leaving the film more heat- and water-resistant.

Tung oil, which is a drying oil, was made water-soluble by maleinization, i.e. by reacting with appropriate quantity of maleic anhydride at 165°C. for one hour. The product so obtained was cooled, washed thoroughly with water and then dissolved in ammonia to give a clear solution.

Water-soluble lac (25% solution) and water-soluble *tung* oil (25% solution) were mixed together in different proportions. Clear varnishes were obtained. Films were prepared on tin and glass panels by flowing and baking at 150°C. for not less than 30 minutes. These films containing up to 50 per cent *tung* oil were hard, smooth and glossy. On bending round a 3 mm. mandrel, the film did not show any crack and the scratch hardness on tin plate was 1·2 kg. The films also showed excellent resistance to water. They did not blush when under water for 20 days. Immersion in boiling water up to 15 minutes also did not cause any damage to the film, i.e. the film did not blush or dissolve. The film was also found to be resistant to 5 per cent solutions of mineral or organic acids, viz. hydrochloric, nitric, sulphuric, citric, acetic and tartaric acids (*vide* Table XXVII, App. B).

These varnishes can be diluted with water to any desired extent and can be applied by dipping, flowing, brushing, etc. The used equipment and implements can also be cleaned with water. Immersion in oils and white spirit did not cause any damage to the film in respect of gloss or hardness. In view of its excellent resistance to heat, water, chemicals, oil, etc., the suitability of this varnish for metal plate lacquers and other applications are

being investigated. Other drying oils such as linseed and tobacco seed oils are also to be studied.

Further experiments on the keeping quality and effect of the percentage of the oil on the film properties are under progress.

7. Lac — Drying Oil Insulating Varnish

Mention was made in the previous *Annual Report* (page 26-27) about the preparation of a lac-linseed oil varnish by combining shellac, linseed oil, glycerine and phthalic anhydride for use as baking type clear oil insulating varnishes, for the impregnation of coils, etc., and for the manufacture of yellow varnished insulating cloth, tape, etc. As a result of a series of experiments, the following optimum proportions of the constituents and conditions were determined which would give a varnish partially conforming to the requirements of standard specifications for the product (*vide* I.S. Specification No. 350-1952).

Alkali refined linseed oil was heated with 20 per cent of its weight of glycerine, in an inert atmosphere, using 0·2 per cent lead oxide as alcoholysis catalyst. It required 3 to 4 hours heating at 250°C. to get complete solubility of 1 part of reacted product in 10 parts of ethyl alcohol. 100 gm. of this reaction mixture was heated to 180°C., and 50 gm. of powdered lac added gradually in about ten minutes. The temperature was then raised to 240°C. and maintained for 30 minutes. The melt was then allowed to cool to 180°C. and 20 gm. of phthalic anhydride was added and the product maintained at 180°C., for another twenty minutes. It was then cooled to 150°C. and thinned with white spirit to a non-volatile content of about 60 per cent. A typical composition had the following characteristic:

1. Drying time	...	5 hours
2. Finish on drying	...	Satisfactory
3. Consistency	...	Normal
4. *p*H of film	...	4·9
5. Viscosity at 30°C.	...	6 stokes
6. Effect of oil	...	Satisfactory
7. Test for ageing	...	Passes
8. Thinning property	...	Suitable for thinning with white spirit

Electrical properties could not be tested for want of facilities.

Two litres of the varnish, prepared as above, has been sent to the Government Test House, Alipore, Calcutta for their tests and report.

8. Modified Shellac for Moulding Compositions

During experiments on the modification of lac with phenolic resins to improve the film properties of the varnish, it was noted that when lac and phenolic resins are mixed together in powdered form and subjected to heat at 150°C., the resulting mass becomes hard and infusible within 2 minutes. Further, it was noted that this could happen with the addition of as little as 10 per cent of the phenolic resin on the weight of lac.

Investigations on the preparation of moulding compositions by incorporation of the optimum quantity of the phenolic resins are to be taken up.

9. Shellac Composition for Use as Bed Material for Hydraulic Models

Co-operative experiments have been going on between the I.L.R.I. and the Central Water & Power Research Station, Poona, investigating the possibility of using shellac compositions as bed material for hydraulic models. As a result of investigations carried out during the past two years, two compositions based on shellac, urea, coal-dust or barytes

and calcium stearate were found satisfactory (*vide* Appendix C) and a request was received from the Research station for the supply of about 1·5 tonnes of the material for large-scale field trials [*vide I.L.R.I. Annual Report* (1961-62), 23].

As the production of this quantity of the materials was beyond the capacity of this Institute because of want of equipment, they were got prepared in a plastics processing factory in Calcutta and sent to Poona, where they are under field trials. The results are awaited.

If found suitable, it is understood, the requirement of the Station would be about 400 tonnes of the compositions in the first year and another 100 tonnes during subsequent years.

10. Technical Preparation of Aleuritic Acid

Aleuritic acid is the major constituent of shellac and is believed to be present in it to the extent of nearly 50 per cent, if not more. It is a colourless crystalline compound with one carboxyl and three hydroxyl groups in its molecule of molecular weight 304. As such, it has been shown to be a valuable starting material for synthetic products particularly in the perfumary trade where price is not of much consequence. Demand for the product is therefore gradually increasing.

The present method of production, based on the original method developed by Nagel and co-workers, involves keeping lac dissolved in 5 N caustic soda for a few days, filtering off the precipitated sodium aleuritate and reclaiming the acid from the residue by treatment with mineral acid followed by recrystallization from boiling water using animal charcoal. The chief difficulty in the operation is the filtration of the sodium aleuritate for which two procedures have been suggested, viz. (i) diluting the solution before filtration with 20 per cent salt solution and (ii) by carrying out the saponification in alcoholic alkali. While the former has not eliminated the difficulty appreciably, the latter is a process covered by patent, involving centrifuge, etc. However, information regarding the optimum conditions required for the process is lacking and the yields reported are only in the region of about 20 per cent on the weight of lac as against about 50 per cent reported to be present in the resin.

A systematic study was, therefore, undertaken with a view to simplifying the process and improving the yield, if possible.

When shellac is dissolved in 5 N caustic soda and allowed to stand at laboratory temperature, precipitation of sodium aleuritate starts on standing overnight but there is no information as to when it is complete, so that the maximum yield of aleuritic acid may be obtained. This was, therefore, first investigated. Aleuritic acid was isolated after allowing the saponification to proceed for 1, 2, 3, . . . 10 days. It was seen that the yield of aleuritic acid increased gradually from 14·5 per cent after hydrolysis for one day to 19·8 per cent after 10 days' hydrolysis (*vide* Table XXVIII, App. B). Moreover there was a substantial amount of resinous matter associated with the sodium aleuritate filtered after up to two to three days standing. Further work is in progress.

V — UTILIZATION OF LAC IN INDIA — PUBLICITY AND PROPAGANDA

1. Varnishes and Lacquers

(a) *Shellac Picture Varnish*

Attempts were continued to popularize shellac picture varnish. The Director of Handicrafts, All India Handicrafts Board, was supplied necessary publicity and propaganda literature and requested to issue instructions to handicrafts centres of all States for using shellac picture varnish. Samples of the varnish, including one of twenty litres, were supplied to 15 parties including Shri Aurobindo Ashram, Pondicherry and Government Industrial School, Hoshiarpur for trial on wooden articles, toys and works of arts and crafts.

(b) *Shellac spirit varnish*

A scheme for manufacturing French polish was supplied to an interested party.

Notes on the method of preparation and use of different types of varnishes based on shellac were supplied for (i) lacquering of dolls, (ii) varnishing rubber goods, (iii) making leak-proof containers for hydrocarbon oils, and (iv) investigation for use as insulating varnishes.

2. Water-soluble Lac

Samples of water-soluble lac were supplied to:

(a) the Punjab Khadi and Village Industries Board and two Panchayat Samities and one 'Kumbhar' Co-operative Society for demonstration of varnishing earthenware and (b) a firm each in Brazil and Coimbatore for experimenting on the preparation of emulsion paints.

A composition based on water-soluble lac was supplied to the Director of Industries, Orissa, for use in the finishing of leather goods. Water-soluble lac was also tried for photo-engraving in collaboration with Indian School of Printing Technology, Calcutta. It was found to be better than fish glue used at present.

3. Adhesives and Cements

A mica-shellac adhesion tester, as designed by British Standard Institution, was fabricated and supplied together with the procedure of the tentative method of test to the India Mica & Micanite Industries, Kodarma.

Details about the manufacture of gasket shellac compound, bulb capping cement, shellac moulding powder and insulating tape were supplied to a few enquirers together with appropriate samples.

Central Salt & Marine Chemical Research Institute, Bhavnagar, was recommended a shellac composition, which will not be hydrophobic, for fixing inorganic powder on to paper and textile fabric.

4. Sealing Wax

Schemes for the manufacture and marketing of sealing wax were supplied to several firms. Details of different compositions for preparing sealing wax of different varieties and colours were supplied to the Industrial Centre for Lac, Government of West Bengal, Balarampur. Samples received from two parties were tested and methods for improving their qualities suggested. Notes on the method of manufacture of sealing wax were supplied to the Director, Small Industries Service Institute, Bangalore for distribution to interested parties.

A party requested for a composition and its method of preparation for fixing diamonds for polishing, which was supplied.

5. Lac Wax

Government Lac Utilization Centre, Pendra, was supplied details of the method of extraction of lac wax from sludge (Crude Lac Dye) obtained from lac factory effluent.

6. Bleached Lac

Director of Biological Science, Botanical Institute, U.S.S.R., was supplied details of the method of preparing bleached lac as requested.

Details of the method of dewaxing lac in sodium carbonate solution for preparing dewaxed bleached lac were supplied to a firm in Sydney, Australia.

7. Shellac Etch (Wash) Primer

In November 1961, Prof. Ross, Curator of Insects, Science Museum of the California Academy of Science, visited this Institute during his world tour for collection of insects. With his concurrence, the aluminium body of his unpainted Van in which he and his party were travelling, was painted with our shellac wash primer (by brush) which, after overnight drying, was finished with a commercial (green) synthetic enamel. As the Professor's stay was short, only one coat of finish coat could be applied.

The Van has since toured the whole of India, Burma, Malaya, Australia and Japan, and is back in the United States, a distance of over 55,000 kilometres (34,000 miles) during the last one and a half years. The Professor now reports that the paint had thus received a ' rugged test ' and that it is still in such a condition that there will be no need to repaint the surfaces for further use.

An extract from his report is reproduced in Appendix D.

Reports about the performance of the primer on aluminium bodies of buses of State Road Transport Corporations and railway coaches also continued to be satisfactory. On one coach in the South Eastern Railway, the painting system was found to be in such a condition when the coach returned to the workshop after twenty months' service that only a finish coat had to be applied. The adhesion of the primer to the aluminium base and to the paint system above was very satisfactory.

A direct mail folder on shellac etch primer was brought out and distributed to potential consumers both in India and abroad. A prominent firm of shellac bleachers in New York was supplied details of the method of preparations of shellac etch primer.

Samples of the primer were supplied to the Central and Western Railways, and to the Chief Engineer, General and Irrigation, Government of Kerala for service trials. Their reports are awaited.

Director, Central Electrochemical Research Institute, Karaikudi, has been supplied technical literature on the primer for their research on paints as protective agents against corrosion of light gauge structures and pre-treatments before painting.

8. Technical Assistance to Manufacturers and Consumers

(i) *Manufacturers*

Fullest cooperation and technical assistance were provided to manufacturers of seedlac and to the State Trading Corporation in the operation of the latter's scheme of seedlac purchases. Technical assistance was also provided to (a) The Forest Utilization Officer, Madras, to select and purchase a sticklac washing barrel for mechanizing their lac factory at Cumbum and (b) The Superintendent, Industrial Centre for Lac, Government of West Bengal, to design a godown for storing 950 tonnes (25,000 mds.) of sticklac.

A scheme was submitted, as desired, to the Chief Conservator of Forests, Madhya Pradesh for revival of their Umaria Lac Factory.

(ii) *Consumers*

Several enquiries regarding the possibility of using shellae and shellac derivaties for various purposes were attended to. A few typical ones are described below.

Water-soluble lac and a hot dip composition containing shellac and hydrolysed lac (50: 50) were supplied to the Indian Institute of Sugarcane Research, Lucknow, for their experiments on the prevention of escape of moisture from sugarcane cuttings. The compositions were reported as satisfactory for the purpose.

A composition of high melting point based on shellac and urea was recommended to a party for preparing paper capacitors.

A shellac-based composition for use as binder for mineral wool and details about its application for the manufacture of mineral wool boards for use in industrial and acoustic insulation were supplied to a firm. Samples of mineral wool board were prepared at the Institute from the mineral wool manufactured by the party and supplied to the firm. These were reported to be satisfactory.

130 kg. of seedlac supplied by a firm were processed to autoclave shellac in our pilot plant and sent to them to explore the marketing possibilities of the material within the country and abroad. 245 kg. of old polymerized shellac sent by another firm were reconditioned in our autoclave plant and returned.

9. Regional Testing Laboratories

Besides the three laboratories that were functioning at the beginning, two more were started during the year under report, one in February 1963 at Bilaspur and the other in May 1963 at Namkum.

The charge for testing lac samples in our laboratories, which was 0·50 nP. per test, was enhanced to Rs. 2.

During 1962-63, the number of samples analysed in the different laboratories were as under:

(i)	Gondia (Maharashtra)	2,658
(ii)	Balarampur (West Bengal)	2,661
(iii)	Daltonganj (Bihar)	878
(iv)	Bilaspur (Madhya Pradesh)	157 (for about six weeks only)
(v)	Namkum (Bihar)	1,217

10. Exhibition and Exhibits

During the period, the Institute did not participate in any Exhibition due to the National Emergency.

Exhibits of lac and lac products were, however, prepared and sent to the Shellac Export Promotion Council for display in their Stall in the 15th Technical Exhibition of the Oil and Colour Chemists' Association in London in March 1963 and to the Ministry of Food & Agriculture, New Delhi for the Indian Exhibition to be held in Moscow in July 1963.

VI—PILOT PRODUCTION UNIT

The Pilot Production Unit continued to function throughout the year. Five grades of special shellacs, viz. two grades of bleached lacs — refined and regular, two grades of water-soluble lacs (DL and AL), and one grade of autoclave shellac (ASK) were manufactured and sold to the public. Apart from these, very small quantities of hydrolysed lac and different types of shellac varnishes were also manufactured and sold to interested parties.

Some bleached lac manufacturers visited the Institute to see the working of our bleached lac pilot plant. Training was also imparted to some of their deputees. A local manufacturing concern of bleached lac had our active assistance and guidance throughout the year. Manufacture of bleached lac by the newly developed ' rapid ' method (using 60% of required bleach liquor) was demonstrated to them on a semi-large scale, both in our own factory as well as in theirs. They were also assisted, at their request, by converting some quantity of their seedlac into bleached lac, using chemicals supplied by them in order to enable them to develop their market for bleached lac, till they set up their own plant. 238 kg. of their seedlac were processed to bleached lac for which they were charged our actual processing cost, viz. 0·66 nP. per kg. of seedlac.

Sales

During the period under report, this unit sold 2,674·35 kg. of special shellacs for Rs. 12,574·54 nP. apart from other miscellaneous articles like hydrolysed lac, shellac varnishes, etc., at a sale value of Rs. 871·28 nP. The total sale figure, therefore, amounted to Rs. 13,445·82 nP. The gross profit made during the year was Rs. 5,069·61 nP.

It may be pointed out that the total quantity of bleached lac sold during the year under report increased from about 400 kg. in the previous year to about 900 kg. in spite of the fact that four small manufacturers have started production of the material and are meeting at least part of the requirements of their respective areas. South Eastern Railway is one of the major buyers and users of our bleached lac. The sale of autoclave shellac has also increased from 225 kg. to over 1,300 kg. The progress of the Unit during the three years of its existence so far has been brought out in Table XXIX (App. B).

Advertisement and publicity

Publicity was given to our products through circular letters and through the Directorate of Advertisements and Visual Publicity, New Delhi, in the shape of periodical advertisement in the principal English and vernacular dailies and periodicals of different regions.

Free samples (20 gm. each) together with price list, methods of use and business terms, were also sent, on request, to about 225 parties during the period under report. Larger quantities were also sent out to bigger consumers.

Sticklac processing unit

As desired by Dr. Ram Subhag Singh, Minister of Agriculture, Government of India, a scheme was submitted for setting up of a sticklac processing unit for processing annually about 5,000 quintals (about 15,000 maunds) of sticklac into seedlac. Approval for this has been received from the government and steps are being taken to implement the scheme.

METEOROLOGICAL REPORT FOR THE YEAR 1962-63

The average meteorological data for each month during the year 1962-63 *are given*:

Month & Year	Mean 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. temp. (°F.)
April 1962	27·70	1·549	88·21	69·67	87·60	50·03	7·58	1·06	98·0	61·5
May 1962	27·58	2·270	93·61	74·64	92·22	57·83	8·00	1·34	110·0	66·0
June 1962	27·47	1·509	93·63	75·90	86·22	62·88	5·07	10·50	106·0	71·0
July 1962	27·46	1·188	87·84	74·90	81·79	79·00	4·61	11·20	95·0	72·0
August 1962	27·56	1·035	85·71	74·10	80·03	81·90	4·11	9·41	90·0	72·0
September 1962	27·61	1·539	86·53	72·97	80·92	76·43	5·76	8·66	91·0	68·0
October 1962	27·79	0·956	83·41	63·77	77·35	69·05	7·60	1·20	89·0	57·0
November 1962	27·90	0·690	81·60	53·73	75·46	30·20	9·21	Nil	87·0	48·0
December 1962	27·94	0·556	74·81	50·81	66·35	50·65	7·45	1·01	87·0	42·0
January 1963	27·95	0·481	74·36	45·97	64·52	40·81	9·07	Traces	83·0	40·0
February 1963	27·91	0·977	83·07	55·21	73·29	38·89	8·16	0·86	90·0	46·0
March 1963	27·82	1·760	88·23	60·87	79·41	30·56	8·61	0·83	98·0	56·0

The highest maximum temperature recorded was 110·0°F. on 30th May 1962, whereas the lowest recorded was 40·0°F. on 1st, 5th and 21st January 1963. The total rainfall during the year amounted to 46·07 inches of which the monsoon rainfall (June-September) was 39·77 inches. The rainfall during the year was much below normal as compared to 1961-62, the total rainfall being 75·45 inches of which the monsoon rainfall was 58·72 inches. The highest wind speed recorded was 142·6 miles on 23rd September 1962 whereas the lowest recorded wind speed was 1·0 mile on 6th December 1962 for 24 hours.

Dated, 8th July 1963

Y. SANKARANARAYANAN
Officiating Director
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APPENDIX A

(Tables: Entomology Division)

TABLE I — DETAILS OF LARGE-SCALE LAC CULTIVATION ON *PALAS* AT KUNDRI WITH REVENUE AND EXPENDITURE

Season of operation	Particulars of operation	No. of trees	Yield of lac			Broodlac used for inoculation (kg.)	Cost of the operation (Rs. nP.)	Revenue			
			Lac sticks (kg.)	Scraped lac (kg.)	Brood-lac (kg.)			By sale of surplus broodlac			By sale
								Quantity (kg.)	Rate (Rs. nP.)	Amount (Rs. nP.)	Quantity (kg.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
April 1962	Pruning and *Ari* collection	21301 —	— 29084·0	— —	— —	— —	525·17 686·32	— —	— —	— —	— —
	Scraping	—	—	5018·0	—	—	720·00	—	—	—	8212·53
July 1962	Partial harvesting and selection of broodlac	3513	1954·0 (Rejected)	—	447·84	—	185·41	—	—	—	—
	Scraping	—	—	561·50	—	—	68·71	—	—	—	—
	Inoculation	1065	—	—	—	447·84	22·74	—	—	—	—
	Miscellaneous	—	—	—	—	—	80·88	—	—	—	—
August 1962	*Phunki* removal	1065	—	—	—	—	4·50	—	—	—	—
	,, scraping	—	—	38·75	—	—	4·86	—	—	—	—
	Miscellaneous	—	—	—	—	—	1·25	—	—	—	—
Oct.-Nov. 1962	Complete harvesting	6191	—	—	—	—	199·12	—	—	—	—
	Collection and selection of brood	—	8112·0 (Rejected)	—	11052·0	—	603·70	—	—	—	—
	Inoculation and	10080	—	—	—	2391·0	269·50	—	—	—	—
	Chope collection	—	—	—	—	—	91·87	—	—	—	—
	Scraping	—	16773·0	2651·50	—	—	288·90	—	—	—	—
	Miscellaneous	—	—	—	—	—	181·69	—	—	—	—
Dec. 1962	*Phunki* removal	10080	632·0	—	—	—	108·57	—	—	—	—
	,, scraping	—	—	223·0	—	—	27·87	—	—	—	3232·90
	Miscellaneous	—	—	—	—	—	48·30	—	—	—	—
Feb. 1963	Pruning	200	—	—	—	—	10·25	—	—	—	—
	TOTAL	—	56555·0	8492·75	11499·84	2838·84	4129·61	—	—	—	11445·43

STATEMENT (APRIL 1962 TO MARCH 1963)

of scraped lac		Total revenue	Remarks
Rate (Rs. nP.)	Amount (Rs. nP.)	(Rs. nP.)	
(13)	(14)	(15)	(16)
—	—	—	—
—	—	—	—
10·25	2256·80	2256·80	This includes 3194·63 kg. scraped lac not sold during December 1961, costing Rs. 873·05 nP.
—	—	—	—
—	—	51·25	186·04 kg. brought to the Institute
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	—	—	—
—	781·85	781·85	By auction sale of 321·0 kg. scraped lac
—	—	—	—
—	—	—	—
—	—	3089·90	Total revenue includes Rs. 873·05 nP. on account of sale of 3194·63 kg. scraped lac of 1961.

TABLE II — EVOLUTION OF A CULTIVATION PRACTICE FOR *PALAS*

Crop data (1961-62)

(a) *Critical Experiment*

Treatment	No. of trees	Lac sticks				Scraped lac			
		Brood used kg.	Brood obtained kg.	Yield obtained kg.	Brood to brood ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Yield of lac per plant kg.
A	500	232·25	—	1568·0	—	44·817	271·77	1 : 6·063	0·543
B	500	232·25	874·0	2525·0	1 : 3·76	42·694	405·42	1 : 9·495	0·810
C	500	116·60	1199·0	2094·0	1 : 10·273	21·926	457·10	1 : 20·845	0·914
D	500	58·30	1200·0	2112·0	1 : 20·583	14·422	488·50	1 : 33·9	0·976
E	500	58·30	1146·0	1989·0	1 : 19·66	13·137	444·50	1 : 33·835	0·890
(b) *Large-scale trials*									
	1000	464·50	—	3200·0	—	69·15	655·80	1 : 9·4	0·655
	1000	116·62	1612·0	3743·0	1 : 13·8	16·09	976·50	1 : 60·6	0·976

TABLE III — PROPER TIME OF HARVESTING AND DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT FOR *BER* IN *BAISAKHI* CROP

Experimental details

Treatment		Replications		No. of trees per plot		Total No. of trees
9	×	4	×	1	=	36

Crop data (*Baisakhi* 1961-62)

Date of harvesting	Treatment	Lac sticks					Scraped lac		
		Brood used kg.	Brood yield kg.	Total yield kg.	Brood to brood ratio	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio
26-4-1962	A	1·15	—	10·30	—	1 : 8·95	0·22	1·27	1 : 5·77
26-4-1962	B	2·30	—	12·90	—	1 : 5·61	0·51	2·01	1 : 3·74
26-4-1962	C	4·60	—	13·70	—	1 : 2·71	0·93	2·60	1 : 2·79
26-5-1962	D	1·15	—	12·10	—	1 : 10·52	0·22	3·24	1 : 14·73
26-5-1962	E	2·30	—	14·19	—	1 : 6·48	0·48	3·60	1 : 7·50
26-5-1962	F	4·60	—	10·90	—	1 : 2·37	0·91	2·92	1 : 3·21
11-7-1962	G	1·15	2·69	8·54	1 : 2·34	1 : 7·43	0·23	2·37	1 : 10·30
11-7-1962	H	2·30	3·93	13·83	1 : 1·71	1 : 6·01	0·47	4·00	1 : 8·51
11-7-1962	I	4·60	2·90	12·75	1 : 0·63	1 : 2·77	0·83	3·22	1 : 3·88

TABLE IV — OPTIMUM DENSITY OF LARVAL SETTLEMENT FOR *BER* IN *KATKI* CROP

Experimental details

Treatment		Replication		No. of trees per plot		Total No. of trees
3	×	12	×	1	=	36

Crop data (*Katki* 1962)

Treatment	Lac sticks					Scraped lac		
	Brood used kg.	Brood yield kg.	Total yield kg.	Brood to brood ratio	Brood to yield ratio	Brood used kg.	Total yield obtained kg.	Brood to yield ratio
A	4·20	16·95	43·81	1 : 4·04	1 : 10·43	1·29	7·58	1 : 5·88
B	8·40	21·24	57·45	1 : 2·53	1 : 6·84	2·57	8·58	1 : 3·34
C	16·80	17·20	65·20	1 : 1·02	1 : 3·88	4·95	11·10	1 : 2·24

TABLE V — PRUNING TIME FOR *BER* FOR *KATKI* CROP

Data on shoot measurement (*Katki* 1962)

Treatment	Primaries				Secondaries		
	Per-centage of buds developed into shoots	Average No. of shoots per tree	Total length of shoots cm.	Average length per shoot	Average No. of shoots per tree	Total length of shoots cm.	Average length per shoot cm.
A	82·1	40·0	1798·0	44·9	69·0	1770·4	25·6
B	83·7	57·2	5293·6	92·5	145·6	5000·2	34·3
C	71·0	61·0	2676·4	43·8	96·0	2179·2	22·7
D	78·3	66·0	3014·6	45·6	117·0	2691·2	23·0

TABLE VI — PRUNING TIME FOR *BER* FOR *KATKI* CROP

Experimental details

Treatment		Replication		No. of trees per plot		Total No. of trees
4	×	10	×	1	=	40

Crop data (*Katki* 1962)

Treatment	Lac sticks				Scraped lac			
	Brood used kg.	Brood yield kg.	Total yield kg.	Brood to yield ratio	Brood used kg.	Total yield kg.	Brood to yield ratio	Yield of lac per tree gm.
A	3·150	2·600	12·430	1 : 3·9	0·990	3·130	1 : 3·2	313
B	7·650	14·970	44·490	1 : 5·8	2·120	10·760	1 : 5·1	1076
C	3·600	0·700	6·130	1 : 1·7	1·100	1·140	1 : 1·04	110
D	3·250	1·120	4·340	1 : 1·3	0·960	0·910	1 : 0·94	91

TABLE VII — EVOLUTION OF A CULTIVATION PRACTICE FOR *KUSUM*

Experimental details

Coupé		No. of trees per coupé		Total No. of trees
14	×	15	=	210

Crop data (*Jethwi* 1962)

Coupé	Lac sticks					Scraped lac		
	Brood used kg.	Brood yield kg.	Total yield kg.	Brood to brood ratio	Brood to yield ratio	Brood used kg.	Total yield kg.	Brood to yield ratio
A_1I	61·30	56·20	183·50	1 : 0·92	1 : 2·99	22·87	53·72	1 : 2·35
B_1I	70·75	79·85	280·93	1 : 1·13	1 : 3·97	25·92	88·25	1 : 3·40
CII	112·71	69·50	211·75	1 : 0·62	1 : 1·88	53·21	57·81	1 : 1·12
Crop data (*Aghani* 1962-63)								
A_2I	50·11	135·26	398·52	1 : 2·70	1 : 7·95	19·57	116·98	1 : 5·98
B_2I	53·19	52·22	361·31	1 : 0·98	1 : 6·92	22·33	106·50	1 : 4·77
CIII	115·75	94·10	420·00	1 : 0·81	1 : 3·63	41·77	150·29	1 : 3·60

TABLE VIII — SPACING TRIALS ON *M. MACROPHYLLA*

Data on shoot measurement (*Jethwi* 1963)

Treatment	No. of plants	Average height per plant cm.	Average No. of shoots per tree	Average total length	
				Shoots cm.	Larval settlement cm.
A	288	147·6	13·9	919·5	352·9
B	432	180·5	18·8	1419·7	604·9
C	648	182·2	17·9	1396·1	463·2

TABLE IX — PLANTATION TECHNIQUE OF RAISING *M. MACROPHYLLA*

Treatment	Percentage germination of seeds	Average height of seedlings at transplantation cm.	Percentage survival of seedlings at inoculation	At inoculation (for 12 pits)		
				Average height of plants cm.	Average No. of shoots on plant(s) per pit	Average total length of shoots on plant(s) per pit cm.
A	87·5	—	49·3	122·1	22·8	1291·6
B	85·6	—	59·2	90·6	22·5	1026·8
C	80·8	—	80·6	70·2	12·2	566·0
D	72·2	—	67·7	78·3	15·6	683·2
E	—	48·6	95·0	147·1	27·6	1339·7
F	—	49·3	96·5	166·0	44·2	2082·8
G	—	16·1	95·0	159·0	32·2	1690·0
H	—	15·3	96·2	152·6	39·3	1953·1
I	—	5·4	70·2	123·9	14·9	814·4
J	—	6·1	58·3	124·9	22·3	989·5

TABLE X — PLANTATION TECHNIQUE OF RAISING *M. MACROPHYLLA*

Crop data (*Aghani* 1962-63)

Treatment	No. of pits observed	Lac sticks				Scraped lac			
		Brood used kg.	Brood yield kg.	Total yield kg.	Brood to yield ratio	Brood used kg.	Total yield kg.	Brood to yield ratio	Yield of lac per pit gm.
A	12	1·420	0·740	1·950	1 : 1·37	0·250	0·450	1 : 1·8	37·5
B	12	1·900	0·720	1·840	1 : 0·97	0·200	0·250	1 : 1·25	20·8
C	12	0·790	0·420	1·320	1 : 1·67	0·180	0·270	1 : 1·50	22·5
D	12	1·350	1·190	2·790	1 : 2·07	0·200	0·420	1 : 2·10	35·0
E	12	2·050	0·800	2·600	1 : 1·26	0·350	0·540	1 : 1·54	45·0
F	12	2·650	2·160	6·310	1 : 2·38	0·490	1·130	1 : 2·40	94·2
G	12	2·600	1·500	4·100	1 : 1·56	0·440	0·880	1 : 2·00	73·3
H	12	2·670	1·390	4·840	1 : 1·81	0·480	0·770	1 : 1·60	64·2
I	12	0·690	0·450	1·250	1 : 1·80	0·148	0·320	1 : 2·16	26·7
J	12	1·630	1·100	2·350	1 : 1·44	0·240	0·460	1 : 1·82	38·3

TABLE XI — EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE YIELD OF LAC ON *M. MACROPHYLLA*

Crop data (*Aghani* 1962-63)

Treatment	No. of plants	Lac sticks				Scraped lac				Chemical analysis		
		Brood lac used kg.	Brood lac yield kg.	Total yield kg.	Brood to yield ratio	Brood lac used kg.	Total yield kg.	Brood to yield ratio	Yield of lac per plant gm.	Seed-lac yield %	Bleach index	Colour index (seedlac)
A	80	6·900	11·500	32·000	1 : 4·63	3·050	7·300	1 : 2·38	91	62·5	70	14
B	80	6·700	10·100	32·100	1 : 4·78	2·750	7·700	1 : 2·43	96	66·7	65	15
C	80	6·500	7·700	30·200	1 : 4·64	2·450	7·500	1 : 3·06	94	65·0	86	13
D	80	6·550	9·200	26·200	1 : 4·00	2·600	6·500	1 : 2·50	81	62·8	75	15
E	80	6·500	8·300	28·800	1 : 4·43	2·350	6·850	1 : 2·90	86	62·5	86	16
F	80	6·550	13·700	44·200	1 : 7·51	2·650	9·700	1 : 3·60	121	62·5	74	15
G	80	7·150	13·700	31·700	1 : 4·80	2·750	8·300	1 : 3·00	104	69·0	76	14
H	80	6·700	14·200	44·900	1 : 6·70	2·600	10·400	1 : 4·00	130	66·7	78	15

TABLE XII — EFFECT OF DIFFERENT LEVELS OF NITROGEN ON THE GROWTH OF *M. MACROPHYLLA*

Data on shoot measurement

Treatment	Average height of plants at transplanting cm.	Measurement at the end of March 1963		
		Average height cm.	Average No. of shoots cm.	Total length of shoots cm.
A	50·2	79·8	7·0	265·2
B	46·5	89·7	7·4	289·0
C	45·2	93·3	8·9	350·3
D	44·8	82·6	7·4	320·6
E	50·4	104·3	10·6	484·1

TABLE XIII — FINDING OUT ALTERNATIVE HOSTS FOR *KUSMI* STRAIN

Crop data

Crop	Brood history	Lac sticks				Scraped lac		
		Brood used kg.	Brood yield kg.	Total yield kg.	Brood to yield ratio	Brood used kg.	Total yield kg.	Brood to yield ratio
Jethwi 1962	K (Prog. K. × A.l.) × A.l.	11·500	13·000	31·500	1 : 2·74	4·870	6·550	1 : 1·34
	K × O. ooj.	3·000	5·000	11·000	1 : 3·67	1·400	3·550	1 : 2·53
Aghani 1962-63	A.l. (Prog. K. × A.l. × K) × K.	13·000	9·000	29·000	1 : 2·23	3·800	8·900	1 : 2·34
	O. ooj. (Prog. K) × K	5·000	2·000	17·000	1 : 3·4	2·250	2·800	1 : 1·25

TABLE XIV — *BRACHYMERIA TACHARDIAE* CAM. — LIFE-HISTORY (THREE FEMALES AND THREE MALES)

Stage	Laboratory temperature 25·5°C. (Mean average)	Controlled temperature 27°C.
Incubation	18-24 hrs.	18-24 hrs.
Larval	7-10 days	4-7 days
Prepupal	1 day	1 day
Pupal	6-8 days	4-7 days
Egg to adult — Average	16·3 days	11·6 days
Variation	14-19 days	10-13 days

TABLE XV — *BRACHYMERIA TACHARDIAE* CAM. — LONGEVITY

With raisin as food and *Corcyra cephalonica* as host

Month	Males			Females			Temperature °C.	Relative humidity %
	No. under observation	Average days	Range days	No. under observation	Average days	Range days		
July 1961	9	30·0	9-46	9	28·1	8-46	26·6	68
August 1961	4	18·7	14-23	12	28·8	22-38	27·2	89
October 1961	2	54·5	49-60	4	48·6	45-61	25·0	76
November 1961	2	58·5	49-68	2	102·5	90-115	21·1	61
January 1962	4	35·0	6-64	×	×	×	16·1	51
February 1962	×	×	×	2	29·0	28-30	18·8	53
March 1962	3	25·3	2-42	4	40·2	37-44	25·5	38
April 1962	2	11·0	10-12	4	46·0	31-69	31·0	75
May 1962	4	21·0	4-37	7	35·5	27-62	36·0	83
June 1962	4	18·5	12-25	4	24·0	21-28	32·0	82

TABLE XVI — *ELASMUS CLARIPENNIS* (CAM.)

Total duration egg to adult stage

Month	Generation	Female		Male		Total No. of adults emerged
		Average days	Range days	Average days	Range days	
September-October 1962	First	13·0	12-14	11·8	11-13	21
October-November 1962	Second	16·0	12-19	16·1	14-19	81
November-December 1962	Third	20·5	14-31	20·3	14-31	91
December 1962 to January 1963	Fourth	27·6	22-31	26·6	22-30	35
January-February 1963	Fifth	32·0	27-34	32·6	31-33	111
February-March 1963	Sixth	16·0	14-20	15·6	14-18	254
March-April 1963	Seventh	13·3	11-15	13·4	11-15	94

TABLE XVII — INCIDENCE OF PREDATORS ON *KUSMI* LAC ON *M. MACROPHYLLA*

Set No. I

Experimental details

Block		No. of bushes per block		Total No. of bushes
4	×	90	=	360

Month	*E. amabilis*		*H. pulverea*	
	Larvae No.	Pupae No.	Larvae No.	Pupae No.
August 1962	234	3	11	2
September 1962	4,078	568	1,883	15
October 1962	—	—	672	164
November 1962	—	—	416	4
December 1962	13	—	336	7

(*Continued*)

TABLE XVII — INCIDENCE OF PREDATORS ON *KUSMI* LAC ON *M. MACROPHYLLA* — *Contd.*

Set No. II

Experimental details

Block		Plot		No. of bushes per plot		Total No. of bushes
5	×	8	×	15	=	600

Month	*E. amabilis*		*H. pulverea*	
	Larvae No.	Pupae No.	Larvae No.	Pupae No.
August 1962	44	3	71	—
September 1962	129	7	645	31
October 1962	1	3	326	107
November 1962	—	—	247	24

TABLE XVIII — EFFECT OF INSECTICIDAL SPRAY RESIDUES ON THE LONGEVITY AND FECUNDITY OF *E. AMABILIS* AND *H. PULVEREA*

	E. amabilis						*H. pulverea*					
	Longevity in days		No. of eggs laid periodically in hours				Longevity in days		No. of eggs laid periodically in hours			
	Female	Male	24	48	72	96	Female	Male	24	48	72	96
Dieldrin, 0·25%	1·80	1·37	13·20	2·36	—	—	1·81	1·45	6·32	2·42	0·30	—
Dieldrin, 0·5%	1·37	0·83	13·20	1·51	—	—	1·71	1·42	4·52	1·32	0·20	—
Aldrin, 0·25%	1·71	1·37	17·37	2·67	—	—	1·84	1·49	10·60	1·59	—	—
Aldrin, 0·5×	1·47	1·42	19·20	3·22	—	—	1·76	1·36	7·45	1·80	0·33	—
No insecticide (control)	4·07	3·29	57·11	10·37	4·80	1·70	4·33	3·17	30·71	5·65	1·08	0·96

TABLE XIX — RELATION OF HOST PLANT TO THE FECUNDITY AND RESIN SECRETION EFFICIENCY OF THE *RANGEENI* STRAIN OF LAC INSECT — *Katki* 1962

Host plant	No. of females under observation	No. of cells from which only larvae emerged	No. of cells from which no larvae or parasite emerged	No. of cells from which only parasites emerged	No. of cells from which both larvae and parasites emerged	Larval emergence from non-parasitized female cells	
						Average	Maximum
A. catechu	50	36	5	5	4	426·0	602
A. farnesiana	20	12	2	6	—	242·6	463
B. monosperma	50	38	9	3	—	313·2	620
M. macrophylla	50	47	0	2	1	278·9	425
Z. mauritiana	50	39	6	0	5	358·1	675
Z. xylopyra	50	36	5	6	3	273·9	619

TABLE XX — RELATION OF HOST PLANT TO THE FECUNDITY AND RESIN SECRETION EFFICIENCY OF THE *KUSMI* STRAIN OF LAC INSECT — *Jethwi* 1962

Host plant	No. of females under observation	No. of cells from which only larvae emerged	No. of cells from which no larvae or parasite emerged	No. of cells from which only parasites emerged	No. of cells from which both larvae and parasites emerged	Larval emergence from non-parasitized female cells	
						Average	Maximum
S. oleosa	100	53	10	33	4	342·2	785
A. lucida	100	53	12	28	7	281·4	743
M. macrophylla	100	62	14	15	9	266·2	594

TABLE XXI — COMPARATIVE STUDY ON THE EFFECT OF MAJOR NUTRIENTS APPLIED TO *M. MACROPHYLLA* PLANTS ON THE DEVELOPMENT OF LAC INSECT

Treatment	Element supplied	Sex ratio Male-Female
A	Control	1:1·12
B	N	1:2·76
C	P	1:1·13
D	K	1:1·13
E	Mg	1:1·50
F	Ca	1:0·98
G	P+K+Mg+Ca	1:0·68
H	N+K+Mg+Ca	1:0· 5
I	N+P+Mg+Ca	1:0·89
J	N+P+K+Mg	1:1·24
K	N+P+K+Ca	1:2·12
L	N+P+K+Mg+Ca	1:1·83

TABLE XXII — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF *HOLOTRICHIA SERRATA* (FAB.)

Showing average of 12 individuals with variation in parenthesis

Preoviposition period days	Oviposition period days	Fecundity per female eggs	Incubation period days	Larval Instars			Pupal stage days	Total duration egg to adult days
				First days	Second days	Third days		
30·5 (14-56)	21·4 (17-31)	28·6 (26-30)	10·0 (6-15)	29·9 (22-38)	34·8 (28-39)	75·8 (62-92	10·0 (8-13)	162·4 (139-183)

TABLE XXIII — RESULTS OF SOIL SURVEY FOR POPULATION OF *HOLOTRICHIA SERRATA* (FAB.)

Average number per collection — 4 collections a month

Month	Egg	Grub	Pupa	Adult
January 1962	—	4·3	29·8	2·8
February 1962	1·6	1·3	10·6	4·6
March 1962	3·2	2·9	—	10·3
April 1962	5·6	4·7	—	18·5
May 1962	12·2	8·9	—	29·3
June 1962	27·6	162·3	—	38·6
July 1962	24·3	189·6	—	36·4
August 1962	—	127·6	—	10·3
September 1962	—	96·7	12·3	3·6
October 1962	—	37·4	16·8	—
November 1962	—	12·6	20·6	—
December 1962	—	4·3	31·8	—

TABLE XXIV — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF *THIACIDAS POSTICA* WALKER

In days

Generation	Date of egg laying	Egg stage	1st larval instar	2nd larval instar	3rd larval instar	4th larval instar	5th larval instar	6th larval instar	7th larval instar	8th larval instar	Pre-pupal stage	Pupal stage	Date of emergence of adult	Number observed	Total duration egg to adult
First	30-9-61	6·0	2·0	2·0	2·0	2·0	2·0	2·0	9·6 (6-13)	—	24·1 (20-34)	—	20-27 11-61	6	52·5 (51-58)
Second	24-11-61	13·0	8·0	6·5 (6-7)	8·4 (8-9)	7·4 (6-8)	8·3 (6-13)	7·8 (8-19)	—	—	28·4 (6-136)	22·0 (13-39)	3-3-62 to 6-6-62	22	114·6 (99-215)
Third	15-3-62	6·0	3·0	2·0	2·2 (2-4)	2·2 (2-3)	2·3 (2-3)	3·0 (2-4)	5·6 (4-8)	4·0	5·7 (4-7)	14·1 (9-25)	21-25 4-63	8	45 (37-61)

TABLE XXV — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF *HEMITHEA* SP.

In days

Generation	Date of egg laying	Egg stage	1st larval instar	2nd larval instar	3rd larval instar	4th larval instar	5th larval instar	Pre-pupal stage	Pupal stage	Date of emergence of adult	Number observed	Total duration egg to adult
First	4-10-62	2·0	2·3 (2-3)	2·0 (2-2)	2·6 (2-3)	2·0 (2-2)	8·0 (7-10)	2·0 (2-2)	9·3 (9-10)	2-6 Nov.	3	30·3 (29-33)
	5-10-62	2·3	2·4 (2-3)	2·4 (2-3)	2·5 (2-3)	3·2 (2-5)	7·2 (6-12)	2·1 (2-3)	9·3 (7-11)	1-11 Oct.	9	31·4 (29-38)
	11-10-62	2·3	3·0	2·1 (2-3)	2·4 (2-3)	2·2 (2-3)	6·7 (4-7)	2·0	10·2 (9-11)	9-12 Nov.	7	30·5 (29-32)
Second	9-11-62	4·0	3·2 (3-4)	5·0	3·0	4·0	8·7 (8-9)	2·5 (2-3)	19·5 (18-21)	27-12-62 to 1-1-63	4	50·0 (48-53)
	10-11-62	4·5	3·3 (3-4)	4·3 (4-5)	3·6 (3-9)	6·3 (5-7)	11·6 (11-12)	4·3 (4-5)	17·6 (17-18)	3-6 Jan.	3	56·6 (55-57)
	12-11-62	4·0	4·0	3·5 (3-6)	3·5 (3-5)	5·8 (4-8)	9·7 (6-13)	3·0 (2-4)	17·4 (16-21)	30-12-62 to 8-1-63	7	50·7 (45-57)
	16-11-62	7·0	3·0	3·2 (3-4)	6·7 (5-8)	5·2 (4-6)	6·7 (6-8)	3·2 (2-4)	13·5 (12-16)	31-12-62 to 9-1-63	4	48·7 (45-54)
Third	10-1-63	6·0	6·8 (5-9)	5·6 (4-8)	5·0 (3-6)	5·0 (3-6)	6·5 (5-8)	2·8 (2-3)	10·3 (10-11)	24-2-63 to 2-3-63	13	49·6 (45-51)
Fourth	3-3-63	4·0	3·0	4·5 (4-5)	3·2 (3-4)	5·8 (5-7)	—	2·0	7·8 (7-9)	Continued	—	—

TABLE XXVI — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF DEFOLIATOR ON *GHONT* (No. 6)

In days

Genera-tion	Date of egg laying	Egg stage	1st larval instar	2nd larval instar	3rd larval instar	4th larval instar	5th larval instar	6th larval instar	7th larval instar	Pre-pupal stage	Pupal stage	Date of emergence of adult	Number observed	Total duration egg to adult
First	19-10-62	7·0	6·0	4·8 (4-5)	5·0	6·2 (6-7)	7·7 (7-9)	8·2 (8-10)	12·5 (11-14)	3·4 (3-4)	19·1 (18-20)	3-11 Jan. 63	7	80·2 (79-84)
	20-10-62	7·2 (7-8)	4·6 (4-5)	5·2 (4-6)	4·7 (4-7)	6·0 (5-8)	6·2 (7-9)	6·4 (7-13)	9·2 (4-15)	3·1 (2-6)	21·6 (14-29)	24-12-62 to 18-1-63	13	78·3 (65-90)
Second	8-1-63	13·0	10·2 (10-11)	8·4 (7-10)	5·7 (5-7)	5·7 (5-6)	5·7 (5-6)	7·8 (5-13)	7·0	2·5 (2-3)	12·2 (11-14)	18-25 March 63	14	58·9 (56-63)

TABLE XXVII — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF *NEPHOPTERYX LEUCOPHAELLA* ZELL.

Gene-ration	Date of egg laying	Egg stage	1st larval instar	2nd larval instar	3rd larval instar	4th larval instar	5th larval instar	6th larval instar	Pre-pupal period	Pupal period	Date of emergence of adult	Number observed	Total duration egg to adult
First	6-11-62	4·0	4·5 (4-5)	4·1 (3-6)	5·0 (4-6)	4·7 (3-5)	8·4 (6-16)	—	3·1 (3-4)	22·6 (20-30)	6-19 Dec. 1962	10	56·4 (50-6)
	16-11-62	6·0	5·0 (3-7)	4·6 (4-5)	6·1 (6-7)	7·8 (7-8)	5·1 (5-6)	—	2·0	30·0 (24-33)	19-23 Jan. 1962	6	66·8 (65-68)
	17-11-62	6·0	3·4 (3-4)	4·0	5·4 (5-6)	5·4 (5-6)	8·0 (7-8)	8·0	4·0 (3-5)	32·8 (30-34)	24-26 Jan. 1962	5	69·0 (68-71)
Second	30-12-62	12·0	4·0	10·2 (7-11)	11·2 (7-13)	9·2 (7-11)	5·4 (4-6)	6·0 (5-7)	3·0	12·4 (11-14)	12-14 Mar. 1963	5	71·4 (71-73)

TABLE XXVIII — INVESTIGATIONS ON SPURIOUS EMERGENCE OF LAC LARVAE (JHALDA)

Experimental details

Treatment		Replication		No. of trees per plot		Total No. of trees
5	×	8	×	1	=	40

Crop data (*Jethwi* 1962)

Treatment	No. of trees	Brood used kg.	Progeny of brood	Yield		Brood to yield ratio
				Brood kg.	Total kg.	
A	8	198·15	*kusum*	157·98	423·13	1 : 2·13
B	8					
C	8					
D	4					
E	7					
D	4	10·80	*kusum* (Prog. *ber* + *kusum*)	23·52	33·52	1 : 3·10
E	1	3·72	*kusum* (Prog. *palas* + *kusum*)	6·84	13·04	1 : 3·50

TABLE XXIX — ALTERNATIVE *KUSMI* HOSTS (JHALDA)

Results of stick examination

Host	After 4 weeks Percentage of larval mortality	At male emergence Percentage of males	At crop maturity Percentage of adult mortality
	***Jethwi* 1962**		
Protium serratum (Syn. *Bursera serrata*) and *kusum*	45·73	21·14	48·23
Dalbergia latifolia	40·89	19·23	35·90
Ficus arnottiana	48·30	20·40	100·00
Palas	54·85	17·24	100·00
Ber and *kusum*	21·21	19·79	66·32
	***Aghani* 1962-63**		
P. serratum	46·9	22·22	56·00
D. latifolia	51·7	25·00	46·00
F. arnottiana	30·6	28·57	45·00
Palas	52·8	28·57	62·00
Ber	20·63	28·91	40·38

TABLE XXX — CROP DATA OF ALTERNATIVE *KUSMI* HOSTS (JHALDA)

Host	No. of trees	Brood used kg.	Yield obtained kg.	Brood to yield ratio
		***Jethwi* 1962**		
P. serratum	17	33·54	23·82	1 : 0·71
D. latifolia	6	11·40	2·60	1 : 0·22
Ber	10	14·755	24·160	1 : 1·63
		***Aghani* 1962-63**		
P. serratum	17	32·70	26·83	1 : 0·82
D. latifolia	7	21·00	4·57	1 : 0·21
F. arnottiana	5	14·88	16·78	1 : 1·12
Ber	10	18·84	51·08	1 : 2·71

TABLE XXXI — RESPONSE OF *GHONT* TO PRUNING

Data on shoot measurement (Damoh)

Treatment	Date of pruning	Date of first appearance of bud	Primaries						Date of first appearance of bud	Secondaries				
			At inoculation			At harvesting				At inoculation			At harves	
			Average Nos.		Average length cm.	Average Nos.		Average length cm.		Average Nos.		Average length cm.	Average Nos.	
			Total	Living		Total	Living			Total	Living		Total	Living
									***Baisakhi* 1961-62**					
A	13-4-61	20-5-61	52	35	57·6	58·0	29·6	65·4	20-5-61	330	277·8	36·3	404·0	198·3
B	19-5-61	18-6-61	38	29	48·6	39·0	18·3	59·5	17-6-61	210	185·0	38·1	259·0	133·3
C	20-11-62	28-12-62	19	19	7·7	—	—	—	7-3-62	28	28·0	4·7	—	—
									***Katki* 1962**					
A	2-11-61	17-11-61	22	20	48·6	21·8	19·5	64·2	6-2-62	144	137·0	31·3	152·6	142·1
B	13-2-62	2-3-62	40	34	53·1	60·3	31·0	71·0	19-3-62	256	229·0	32·5	282·3	241·8
C	19-5-61	16-6-61	40	22	129·9	40·0	22·6	144·0	16-6-61	413	265·0	46·5	450·0	271·3
									***Baisakhi* 1962-63**					
A	10-4-62	18-4-62	89	70	92·2	—	—	—	4-5-62	695	605·0	46·5	—	—
B	19-5-62	23-5-62	32	30	78·2	—	—	—	11-6-62	267	257·0	42·3	—	—

ting		Tertiaries Nos.		Remarks
	Average length cm.	At inoculation	At harvesting	
	34·7	406·1	407·8	—
	36·7	304·3	308·6	—
	—	Nil	—	Till the period under report. To be utilized for *Baisakhi* 1963-64 crop with other treatments of this coupé.
	40·8	55·0	248·3	—
	41·2	109·0	346·5	—
	51·6	538·0	671·3	—
	—	504·0	—	—
	—	215·0	—	—

TABLE XXXII — RESPONSE OF *GHONT* TO PRUNING (DAMOH)

Experimental details

Treatment			No. of trees per plot		Replication		Total
Katki	4	×	5	×	10	=	200
Baisakhi	2	×	5	×	10	=	100

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio
				***Baisakhi* 1961-62**					
Lac sticks	11·8	42·9	1 : 3·6	11·8	38·7	1 : 3·2	—	—	—
Scraped lac	2·2	5·28	1 : 2·4	2·3	4·72	1 : 2·0	—	—	—
				***Katki* 1962**					
Lac sticks	33·4	5·8	1 : 0·17	33·4	9·1	1 : 0·27	33·4	13·1	1 : 0·39
Scraped lac	5·5	0·35	1 : 0·06	4·6	0·73	1 : 0·15	5·1	1·03	1 : 0·20

TABLE XXXIII — OPTIMUM AMOUNT OF BROOD REQUIREMENT FOR *GHONT* (DAMOH)

Results of stick examination

Treatment	After 4 weeks		At male emergence		At crop maturity	
	Density of larval settlement per 2·5 cm.	Percentage of larval mortality	No. of living insects per 2·5 cm.	Percentage of males	No. of living cells per 2·5 cm.	Percentage of adult mortality
			***Baisakhi* 1961-62**			
A	53·0	97·38	110	34·81	3·0	80·64
B	81·0	97·13	60	43·24	6·6	74·04
C	103·0	96·78	88	39·85	10·5	75·10
			***Katki* 1962**			
A	147·0	78·28	16	28·32	5	60·85
B	186·0	74·14	22	23·26	4	60·68
C	276·0	77·33	28	34·36	5	45·91

TABLE XXXIV — OPTIMUM AMOUNT OF BROOD REQUIREMENT FOR *GHONT* (DAMOH)

Experimental details

Treatment		Replication		No. of trees per plot		Total No. of trees
3	×	10	×	5	=	150

Crop data

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio
				***Baisakhi* 1961-62**					
Lac sticks	8·0	16·0	1 : 2·0	16·0	66·90	1 : 4·1	32·0	78·50	1 : 2·4
Scraped lac	1·43	0·86	1 : 0·6	2·41	4·54	1 : 1·8	4·32	4·34	1 : 1·0
				***Katki* 1962**					
Lac sticks	5·5	1·5	1 : 0·27	11·0	1·1	1 : 0·10	22·0	2·8	1 : 0·12
Scraped lac	1·05	0·05	1 : 0·04	1·7	0·07	1 : 0·04	3·5	1·0	1 : 0·28

TABLE XXXV — TRIALS ON REGIONAL HOSTS (DAMOH)

Host	No. of trees	Lac sticks					Scraped lac			
		Brood used kg.	Kind of brood	Brood obtained kg.	Total yield kg.	Brood to yield ratio	Brood used kg.	Brood obtained kg.	Total yield kg.	Brood to yield ratio
					***Baisakhi* 1961-62**					
Ber	5	5·40	*Ghont* (Prog. *palas* × *ghont*)	—	1·70	1 : 0·31	0·60	—	0·03	1 : 0·05
Ghont	5	2·30	*Palas*	2·10	8·10	1 : 3·5	0·30	0·10	0·50	1 : 1·6
Palas	1	3·10	*Ghont* (Prog. *palas*)	11·00	11·0	1 : 3·5	1·30	0·90	0·90	1 : 0·69
					***Katki* 1962**					
Ghont	5	3·30	*Palas*	1·70	1·70	1 : 0·56	0·50	0·16	0·16	1 : 0·3
Ghont	2	5·00	*Palas* (Prog. *palas* × *ghont*)	5·80	5·80	1 : 1·16	0·40	0·74	0·74	1 : 1·8
Ghont	1	2·10	*Ghont* (Prog. *palas*)	0·40	0·40	1 : 0·19	0·10	0·08	0·08	1 : 0·8
Palas	2	6·00	*Palas* (Prog. *palas* × *ghont*)	0·40	4·80	1 : 0·8	0·50	0·03	0·33	1 : 0·62

TABLE XXXVI — RELATIVE IMPORTANCE OF ENEMY AND FRIENDLY INSECTS (DAMOH)

Particulars of caging			No. of insects emerged									
Lac caged	Locality	Month	Tetra-stichus purpureus	Eupelmus tachar-diae	Tachar-diae-phagus tachar-diae	Eurytoma palidis-capus	Bracon greeni	Apanteles tachar-diae	Pristo-merus sulci	Eublema amabilis	Holco-cera pulverea	Chrysopa sp.
					***Baishakhi* 1961-62**							
Monthly caging 1962												
Ghont	Field area	January	—	—	—	—	—	—	—	—	—	—
,,	,,	February	126	—	—	—	—	—	—	3	7	—
,,	,,	March	55	—	1	—	—	5	—	—	2	—
,,	,,	April	11	—	1	—	—	2	—	—	1	—
,,	,,	May	—	—	—	—	—	—	—	—	—	—
,,	,,	June	—	—	—	—	—	—	—	—	—	—
,,	,,	July	59	18	398	—	—	14	26	1	157	—
Routine caging of mature lac 1962												
Ghont	Indrana	July	—	4	19	—	—	—	—	19	9	—
					***Katki* 1962**							
Fortnightly caging 1962												
Ghont	Field area	August	—	—	—	—	—	—	—	—	—	—
,,	,,	September	110	2	—	—	—	—	3	—	72	—
,,	,,	October	11	—	—	—	—	—	—	—	39	—
,,	,,	November	50	—	5	—	—	2	3	27	373	—
Routine caging of mature lac 1962												
Ghont	Katangi	November	55	2	17	1	1	13	—	24	419	—
Palas	Rajnagar	,,	12	—	6	—	—	4	—	9	15	—

TABLE XXXVII — RESPONSE OF *GHONT* TO PRUNING (MIRZAPUR)

Experimental details

	Treatment		No. of trees per plot		Replication		Total No. of trees
Katki	4	×	5	×	10	=	200
Baisakhi	2	×	5	×	10	=	100

Crop data

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio
				***Baisakhi* 1961-62**					
Lac sticks	25·000	84·825	1 : 3·39	25·000	83·372	1 : 3·33	—	—	—
Sticklac	4·725	1·899	1 : 0·40	4·184	1·524	1 : 0·36	—	—	—
				***Katki* 1962**					
Lac sticks	15·300	1·990	1 : 0·130	15·300	2·200	1 : 0·143	50·00	1·020	1 : 0·020
Sticklac	4·533	0·007	1 : 0·001	4·157	0·010	1 : 0·002	12·072	0·007	1 : 0·001

TABLE XXXVIII — OPTIMUM AMOUNT OF BROOD REQUIREMENT (MIRZAPUR)

Experimental details

Treatment		Replication		No. of trees per plot		Total No. of trees
3	×	10	×	5	=	150

Crop data

Yield particulars	Treatment A			Treatment B			Treatment C		
	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio	Brood used kg.	Yield obtained kg.	Brood to yield ratio
				***Baisakhi* 1961-62**					
Ghont									
Lac sticks	12·50	80·730	1 : 6·45	25·0	96·460	1 : 3·85	50·0	136·400	1 : 2·72
Scraped lac	2·849	2·026	1 : 0·70	4·215	3·075	1 : 0·62	9·641	6·913	1 : 0·71
				***Katki* 1962**					
Palas									
Lac sticks	14·0	110·40	1 : 7·88	28·0	161·80	1 : 5·77	55·20	205·25	1 : 3·71
Scraped lac	2·773	10·396	1 : 1·374	5·444	19·379	1 : 3·55	11·423	26·577	1 : 2·32
Ghont									
Lac sticks	8·0	1·593	1 : 0·199	16·0	1·071	1 : 0·066	32·0	6·860	1 : 0·021
Scraped lac	2·183	0·013	1 : 0·005	4·509	0·006	1 : 0·001	8·738	0·068	1 : 0·007
Palas									
Lac sticks	15·60	7·80	1 : 0·500	31·20	10·40	1 : 0·333	62·40	28·60	1 : 0·445
Scraped lac	2·183	0·249	1 : 0·075	3·292	0·312	1 : 0·004	11·872	0·827	1 : 0·166

TABLE XXXIX — TRIALS ON REGIONAL HO

Host	No. of trees	Lac sticks: Brood used kg.	Kind of brood	Brood obtained kg.	Total yield kg.	Brood to yield ratio
					***Baisakhi* 1961-62**	
Ber	5	5·00	*Palas*	—	11·582	1 : 2·3
Ghont	5	4·00	*Palas*	—	2·770	1 : 0·69
Khair	5	3·00	*Palas*	—	7·05	1 : 2·3
Khair	4	0·960	*Ber*	—	0·570	1 : 1·06
Kuchai	4	2·00	*Palas*	—	11·60	1 : 5·8
Rev (*Acacia leucophloea*)	2	3·00	*Palas*	—	1·950	1 : 0·65
					***Katki* 1962**	
Ber	5	2·500	*Palas*	—	2·585	1 : 1·03
Khair	5	2·00	*Palas*	0·55	2·750	1 : 1·87
Khair	5	1·500	*Ber*	0·350	1·250	1 : 0·83

TABLE XL — RELATIVE IMPORTANCE OF ENEMY AND FRIEN

Particulars of caging: Lac caged	Locality	Month	No. of i: Tetrastichus purpureus	Eupelmus tachardiae	Parechthrodryinus clavicornis	Encyrtus dewitzi	Tachardiaephagus tachardiae	T. somervilli	Elasmus claripennis	Eyrutoma palidiscapus	Brachymeria tachardiae
									***Baisakhi* 1961-62**		
Routine caging of mature lac 1962											
Palas	Field area	July	15	3	1	15	9	—	—	—	—
,,	Zaidpur	,,	53	6	21	6	—	—	—	—	—
,,	Chuppepur	,,	15	14	—	6	1	—	—	—	—
									***Katki* 1962**		
Routine caging of mature lac 1962											
Palas	Field area	November	9	2	—	1	4	—	—	—	—
,,	Kirwil	,,	219	4	3	9	37	1	4	—	1
,,	Madhira	,,	220	10	3	13	52	—	5	1	3

OSTS (MIRZAPUR)

Scraped lac			
Brood used kg.	Brood obtained kg.	Total yield kg.	Brood to yield ratio
0·620	—	1·174	1 : 1·90
0·706	—	0·025	1 : 0·03
0·500	—	0·156	1 : 0·31
0·042	—	0·005	1 : 0·12
0·438	—	0·311	1 : 0·71
0·492	—	0·085	1 : 0·17
0·610	—	0·003	1 : 0·005
0·0469	0·044	0·048	1 : 0·10
0·421	0·007	0·008	1 : 0·01

NDLY INSECTS (MIRZAPUR)

nsects emerged								
Bracon greeni	Apanteles tachar-diae	Chelonella sp.	Agathis coryphe	Pristo-merus sulci	Peri-sierola pulveriae	Eublemma amabilis	Holcocera pulverea	Miscella-neous
—	—	10	—	1	—	—	—	41
—	4	5	—	1	—	—	18	44
—	2	8	—	1	—	—	31	197
—	18	25	1	22	—	21	115	30
9	4	6	—	24	3	23	87	4
13	7	11	—	45	4	40	94	2

TABLE XLI — EVOLUTION OF A CULTIVATION PRACTICE FOR *KUSUM* (UMARIA)

Experimental details

Treatment	No. of coupé		No. of trees per coupé		Total No. of trees
A	4	×	15	=	60
B	6	×	15	=	90
C	4	×	15	=	60

Treatment and coupé number	Date of inoculation	Brood used kg.	Scraped *phunki* brood kg.	Date of harvesting	Lac sticks			Scraped			Ratio of brood used to yield	
					Total yield kg.	Brood kg.	Rejected kg.	Total yield kg.	*Phunki* brood kg.	Rejected kg.	Lac sticks	Scraped
A_1I	3-2-62	51·00	22·80	14-2-63	200·70	21·29	179·41	35·18	6·26	28·92	1 : 3·93	1 : 1·54
B_1I	4-2-62	44·00	17·20	15-2-63	82·00	8·40	73·60	13·22	2·80	10·42	1 : 1·86	1 : 0·77
CI	4-2-62	55·00	26·10	16-7-62	102·07	47·00	55·07	27·05	11·85	15·20	1 : 1·86	1 : 1·03
CII	15-18 July 62	46·50	20·45	16-2-63	11·78	Nil	11·78	0·74	Nil	0·74	1 : 0·25	1 : 0·03
CI + CII	—	101·50	46·55	—	113·85	47·00	66·85	27·79	11·85	15·94	1 : 1·12	1 : 0·59

TABLE XLII — RELATIVE IMPORTANCE OF ENEMY AND FRIENDLY INSECT (UMARIA)

Particulars of caging			No. of insects emerged													
Lac caged	Locality	Month	Tetrastichus purpureus	Eupelmus tachardiae	Parechthrodryinus clavicornis	Erencyrtus dewitzi	Tachardiaephagus tachardiae	Coccophagus tschirchii	Tachardiae phagus somervilli	Eurytoma palidiscapus	Brachymeria tachardiae	Bracon greeni	Apanteles fakhrulhajiae	Apanteles tachardiae	Chelonella sp.	Pristo meru sulc
											***Jethwi* 1962**					
Monthly caging, 1962																
Kusum	Field area	April	—	—	—	—	—	—	—	—	—	—	—	—	—	—
,,	,,	May	14	—	—	10	5	13	—	—	—	—	—	—	—	2
,,	,,	June	5	—	—	—	2	—	—	—	—	—	—	—	—	—
,,	,,	July	1374	86	91	615	6448	36	—	1	4	—	80	54	5	176
											***Aghani* 1962-63**					
,,	,,	August	—	—	—	—	—	—	—	—	—	—	—	—	—	—
,,	,,	September	22	—	—	—	—	—	—	—	—	—	3	2	—	—
,,	,,	October	25	—	—	—	—	—	—	—	—	—	5	13	—	4
,,	,,	November	—	10	—	—	6	—	—	—	—	—	14	9	—	—
,,	,,	December	4	—	—	—	—	—	—	—	—	4	—	—	—	13
Monthly caging, 1963																
,,	,,	January	3	—	—	—	15	—	—	—	—	—	—	—	—	10
,,	,,	February	2	—	—	—	—	—	20	—	—	1	—	—	—	13

Peri-sierola pulveriae	Eublemma amabilis	Holcocera pulverea	Un-identified parasites	Miscella-neous	Chrysopa sp.
—	—	—	—	—	—
—	1	2	—	1	—
—	6	5	—	2	2
35	457	1464	65	—	—
—	—	—	—	—	—
—	—	5	—	—	—
10	50	—	—	—	—
—	—	3	—	—	—
—	26	66	—	—	—
—	23	46	2	—	—
1	10	32	3	—	—

APPENDIX B

Tables: Chemistry Division

TABLE I — SPECIFIC HEAT OF FRESH SEEDLAC AT DIFFERENT TEMPERATURE

Sl. No.	Seedlac	Temperature °C	Specific heat Replication	Average
1	*Kusum*	30	0·372 0·361 0·373	0·368
		35	0·410 0·424 0·432	0·422
		40	0·461 0·487 0·480	0·476
		70	0·695 0·674 0·686	0·685
		72	0·650 0·669 0·652	0·657
2	*Palas*	30	0·348 0·362 0·367	0·359
		35	0·420 0·416 0·436	0·424
		70	0·671 0·680 0·689	0·680
		72	0·654 0·665 0·642	0·652
3	*Ber*	30	0·355 0·360 0·365	0·360
		35	0·414 0·420 0·420	0·418
		70	0·682 0·683 0·681	0·681
		72	0·650 0·666 0·661	0·659

TABLE II — SPECIFIC HEAT AT 70°C. OF *KUSMI* SEEDLAC OF DIFFERENT AGES

Sl. No.	Approximate age in years	Specific heat at 70°C. replications	Average
1	0	0·69 0·67 0·68	0·68
2	1	0·61 0·60 0·60	0·60
3	2	0·52 0·53 0·54	0·53
4	3	0·39 0·40 0·38	0·39
5	12	0·36 0·36 0·37	0·36
6	13	0·33 0·32 0·32	0·32

TABLE III — INSOLUBLES IN OLD LACS

Sl. No.	Sample	Age of the sample (year)	H.A.I. in neutral alcohol (percent) W_1	H.A.I. in acidic alcohol (percent) W_2	Percentage of insoluble $W_1—W_2$
1	*Kusmi* Seedlac	Fresh	2·89	2·92	Difference within the limits of experimental error
2	*Ber* Seedlac	Fresh	2·76	2·76	
3	*Palas* Seedlac	Fresh	4·14	4·14	
4		13	19·75	6·79	12·96
5		13	20·16	5·06	15·10
6		12	30·11	3·76	26·35
7		10	18·74	3·20	15·54
8		14	26·16	4·29	21·87
9		14	14·90	4·94	9·96
10		13	28·34	4·40	23·94

TABLE IV — CORRELATION OF QUALITY (ESPECIALLY COLOUR) OF LAC WITH THE CLIMATE OF THE REGION, WHERE IT IS CULTIVATED

Sl. No.	State	District	Place	Summary of climatic conditions during growth				Host	Crop	Whether *Ari* or *Phunki*	Driage % on dry sticklac	Quality of seedlac				Quality of shellac		
				Rainfall (mm.)	Average R.H. %	Average max. temp. °C.	Average min. temp. °C.					Yield from dry sticklac %	Impurities %	Bleach index	Colour index	Flow 12·5 cm. (sec.)	Life at 150°C. (min.)	Colo ind
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19
1	Bihar	Palamau	Chandwa	18	65·6	26·4	11·8	*Palas*	*Baisakhi*	*Ari*	7·7	55·7	9·63	140	21	77	40	20
2	,,	Palamau	Chandewi	18	65·6	26·4	11·8	*Palas*	*Baisakhi*	*Phunki*	—	65·3	5·86	116	17	90	40	15
3	,,	Palamau	Chainpur	125	71·4	34·3	21·7	*Palas*	*Katki*	*Phunki*	12·5	64·7	5·62	151	14	72	39	12
4	,,	Hazaribagh	Paini	22	57·1	25·4	11·4	*Palas*	*Baisakhi*	*Ari*	12·8	63·9	6·54	132	20	107	34	18
5	,,	Gaya	Malickak	19	65·6	26·4	11·8	*Palas*	*Baisakhi*	*Ari*	12·5	55·3	8·46	117	18	113	39	19
6	,,	Gaya	Piperghati	103	79·2	32·2	25·4	*Palas*	*Katki*	*Ari*	22·5	63·5	4·33	163	12	85	60	12
7	,,	Monghyr	Simultaka	72	73·0	33·3	23·0	*Palas*	*Katki*	*Ari*	20·0	66·7	5·48	126	11	126	42	10
8	,,	Dhanbad	Chas	111	72·0	34·0	23·5	*Palas*	*Katki*	*Ari*	50·0	64·0	5·28	152	12	117	44	9
9	,,	S. Pargana	Basantpur	111	73·0	33·3	23·0	*Palas*	*Katki*	*Ari*	8·75	66·4	4·47	130	17	9 (min.)	24	13
10	,,	Singhbhum	Pilaki	110	77·0	33·0	25·4	*Palas*	*Katki*	*Ari*	43·6	53·5	6·75	180	13	85	43	11
11	Delhi	Delhi	I.A.R.I.	Period not known				*Ficus*	—	—	—	53·6	7·00	162	14	60	40	12
12	M.P.	Shahdol	Umaria	110	85·5	32·1	24·6	*Palas*	*Katki*	*Ari*	15·0	60·0	8·02	180	30	240	41	28
13	,,	Shahdol	Umaria	110	85·5	32·1	24·6	*Palas*	*Katki*	*Phunki*	—	66·0	5·25	118	17	101	59	16
14	,,	Shahdol	Umaria	76	66·7	35·3	15·7	*Palas*	*Katki*	*Phunki*	3·75	67·1	5·23	108	12	70	42	10
15	M.P.	Bilaspur	Padakar	76	74·1	32·2	22·7	*Palas*	*Katki*	*Phunki*	2·4	61·24	4·38	119	11	160	44	9
16	,,	Bilaspur	Chandrapur	76	74·1	32·2	22·7	*Palas*	*Katki*	*Phunki*	3·1	71·5	5·51	116	12	170	37	10
17	Maharastra	Bhandara	Sonder	93	55·8	34·3	19·6	*Palas*	*Baisakhi*	*Phunki*	12·5	69·5	6·74	126	17	250	43	16
18	,,	Bhandara	Sonder	110	72·2	32·2	22·7	*Palas*	*Katki*	*Phunki*	12·5	58·89	4·44	122	10	86	40	10
19	Orissa	Kalahandi	Jayapatra	105	71·5	26·6	18·8	*Kusum*	*Aghani*	*Ari*	7·5	73·25	2·22	62	11	65	47	7
20	W. Bengal	Bankura	Chhatna	108	75·0	36·0	23·0	*Palas*	*Katki*	*Phunki*	—	50·0	8·78	126	13	113	45	12

TABLE V — WATER/MOISTURE REMOVAL FROM WASHED LAC ON CENTRIFUGING (AT 1170 r.p.m.) FOR VARIOUS PERIODS

Expt. No.	Time of centrifuging min.	Time required for centrifuged sample to dry to constant weight at 42°±1°C. (hours)	Moisture lost on drying to constant weight at 42°±1°C. (%)	Moisture constant of dried sample by standard method (%)	Total moisture percent in the centrifuged sample (%)
1	0	7	34·25	1·15	36·40
2	10	6	9·71	1·50	11·30
3	20	4·5	9·10	1·54	10·64
4	30	4	9·08	1·15	10·23
5	60	3	5·06	1·09	6·15
6	90	2·5	3·21	1·42	4·63
7	120	2	2·65	1·15	3·80
8	180	—	1·48	1·48	1·48

TABLE VI — STORAGE STABILITY OF SHELLAC PRODUCED BY ALKALI EXTRACTION METHOD

Sl. No.	Starting material for the shellac	Duration of storage (month)	Properties of the shellac		
			Life at 150°C. (min.)	Flow (sec.)	Hot alcohol insolubles (%)
1	Seedlac	0	28	600	1·02
2	,,	6	26	650	1·02
3	,,	12	22	705	1·02
4	,,	18	22	720	1·02
1	*Molamma*	0	22	600 for 5 cm.	1·85
2	,,	6	20	610	1·85
3	,,	12	19	650	1·85
4	,,	18	16	660 for 5 cm.	1·85

TABLE VII — COMPARATIVE FILM PROPERTIES OF SHELLAC MADE BY *BHATTA* AND ALKALI EXTRACTION METHOD

Material	Scratch hardness— Load on 1 mm. steel ball gm.	Water-resistance — Blushing time on immersion in water (hours)
Shellac made by *bhatta* process	1000	4
Shellac made by alkali extraction	1000	4

TABLE VIII — COMPARATIVE RESULTS OF MELTING SEEDLAC USING CHARCOAL AND SOFT COKE

20 kg. of seedlac was used in each experiment

Sl. No.	Seed-lac	Fuel used	Quan-tity of fuel con-sumed kg.	Time taken for the melting hr.	Yield of shellac %	Yield of *kiri* %	Lac sticking to cloth bag (bunch) %	Loss %	Properties of the shellac obtained			
									At 150°C. life (min.)	Flow (sec.)	Hot alcohol in-solubles %	Colour index
1a	*Kusum*	Charcoal	10·5	4	88·5	7·5	2·25	1·75	68	51	0·376	8·5
1b	do	Soft coke	12*	4	88·25	7·5	2·25	2·00	67	54	0·372	8·5
2a	*Ber*	Charcoal	12	4·5	85·5	9·5	3·25	1·75	52	64	0·456	12
2b	do	Soft coke	13*	4·5	85·5	10·0	3·00	1·50	52	64	0·461	12
3a	*Palas*	Charcoal	13	5	81·5	12·5	5·00	1·00	50	69	0·482	13·5
3b	do	Soft coke	15*	5	81·5	12·5	5·00	1·00	51	68	0·478	13·5

*In addition to these quantities of soft coke, 2 kg. of charcoal was necessary to light the soft coke. The soft coke for these experiments was obtained from the Central Fuel Research Institute, Jealgora, Dhanbad, from their coke oven plant. The experiments were repeated with coke, obtained from our Institute gas plant also with the same result.

TABLE IX — DISTRIBUTION OF WAX IN THE PRODUCTS OBTAINED DURING PROCESSING OF STICKLAC INTO SEEDLAC

Material	Yield of product per cent on sticklac	Wax content	
		Per cent on product	Per cent on the weight of sticklac used
Sticklac	100	4·67	4·67
Seedlac	70	4·78	3·346
Molamma and other by-products	7	8·04	0·563
		Total of seedlac and *Molamma*, etc.	3·909
		∴ Wax lost during processing (per cent)	0·761

TABLE X — ACTION OF BLEACH LIQUOR ON ALDEHYDIC ACID

Treatment	Yield %	M.P. °C.	Acid value	Chlorine content	Sap. value	Hydroxyl value	Carbonyl value	Iodine value
I. Aldehydic acid	—	85·88	199·4	—	335·2	177·5	5·8	7·2
II. Precipitated form sodium carbonate solution without addition of bleach								
(a) Material obtained as precipitated mass	68	—	165·2	—	236·1	168·0	0·0	7·8
(b) Material left in solution	30	—	203·2	—	256·1	229·2	0·6	7·5
III. Sodium carbonate solution of acid, treated with bleach liquor, precipitated, washed and dried								
(a) Material obtained as precipitated mass	65	92·95	186·1	1·25	279·6	148·2	0·2	6·0
(b) Material left in solution	33	Sticky mass	192·1	1·1	—	296·8	0·0	6·5

TABLE XI — PROPERTIES OF BLEACHED LAC STABILIZED WITH TIN SALTS

Tin salt used	Amount per cent on the weight of dry bleached lac	Life of the stabilized bleached lac at 150°C. min.
Dibutyl-tin-maleate	0·25	13
	0·5	15
	1·0	15
	2·0	15
Dibutyl-tin-dinonyl maleate	1·0	10
	2·0	14
Dibutyl-tin-dilaurate	1·0	15
	2·0	14
Control	—	10

TABLE XII — PROPERTIES OF LAC TREATED WITH TOLUENE DI-ISOCYANATE

Sl. No.	Lac	Di-isocyanate per cent on the weight of lac	Properties of the modified resin			
			Solubility in alcohol	Softening point °C.	Melting point °C.	Nitrogen content %
1	Dewaxed lemon shellac	0 (untreated)	Soluble	69	76	0·0554
2	do	0 (dissolved and reclaimed from solvent)	do	73	79	0·1163
3	do	1	do	76	82	0·2119
4	do	2	do	79	85	0·3265
5	do	3	do	81	89	0·4843
6	do	4	do	85	92	0·5954
7	do	5	Soluble with difficulty	88	95	0·8034
8	do	6	Partially soluble	93	102	0·9084

TABLE XIII — FILM PROPERTIES OF MODIFIED SHELLAC ETCH PRIMER

Sl. No.	Modification	Freshly made			After 4 months' storage		
		Scratch hardness after 24 hours air-drying on		Flexibility after 24 hrs. air-drying on Al-panel	Scratch hardness after 24 hrs air-drying on		Flexibility after 24 hrs. air-drying on Al-panel
		Aluminium gm.	Steel gm.		Aluminium gm.	Steel gm.	
1	10% Phenolic resin (Firm-A) 3% Urea 10% Dibutyl phthalate	800-1000	1300-1400	Poor	1000	1000	Poor
2	20% Phenolic Resin (Firm-A) 3% Urea 10% Dibutyl phthalate	1400	1500	Between poor and fair	600-700	1000-1200	Between poor and fair
3	30% Phenolic resin (Firm-A) 3% Urea 10% Dibutyl phthalate	1300	1100	Poor	1000	700-800	Poor
4	10% Biolac (Firm-B) 3% Urea 10% Dibutyl phthalate	1000	1600	Poor	800-1000	800-900	Poor
5	20% Biolac (Firm-B) 3% Urea 10% Dibutyl phthalate	1000-1200	1400-1600	Poor	Very much thickened. Film properties could not be tested		
6	30% Biolac (Firm-B) 3% Urea 10% Dibutyl phthalate	800-1000	1400	Poor	do		
7	10% Phenolic resin (Firm-C) 3% Urea 10% Dibutyl phthalate	600-800	1500-1800	Fair	do		
8	20% Phenolic resin (Firm-C) 3% Urea 10% Dibutyl phthalate	200	900-1200	Poor	do		
9	30% Phenolic resin (Firm-C) 3% Urea 10% Dibutyl phthalate	Less than 200	1000-1200	Poor	do		
10	10% Phenolic resin (Firm-C)	1200-1400	1500-1700	Fair	Yet to be studied		
11	20% Phenolic resin (Firm-C)	1500-1700	1400-1700	Good			
12	20% Phenolic resin (Firm-C)	1000-1100	1500-1800	Good			

Phenolic resins for these experiments were kindly supplied free of cost by (i) Shalimar Paint, Colour Varnish Co., (ii) M/s Hardcastle Wand & Co., and (iii) M/s Godlass Wall & Co. to whom our thanks are due.

TABLE XIV — VISCOSITIES OF DIFFERENT SHELLAC ETCH PRIMER ON STORAGE

Sl. No.	Strength of ethyl alcohol used in the primer composition-alcohol %	Viscosities measured in B4 Ford cup, at 20°±1°C. (second)		
		Freshly made	After 3 months' storage	After 6 months' storage
1	98	28·5	37·9	35·9
2	95	24·5	28·8	28·6
3	92·5	23·3	25·0	29·5
4	90·0	22·2	23·7	28·1
5	87·5	21·8	Thickened	Thickened
6	85·0	23·8	do	do
7	82·5	31·85	do	do
8	80·0	39·5	do	do

TABLE XV — CHEMICAL CONSTANTS OF THE REACTION PRODUCTS OBTAINED BY HEATING DEWAXED LEMON SHELLAC UNDER PRESSURE WITH WATER IN AN AUTOCLAVE UNDER VARIOUS CONDITIONS

Heating		Catalysts used		Constants of the resinous products		Material left in aqueous phase	
Temperature °C.±3°C.	Duration (hours)	Catalysts	Amount used per cent on lac	Acid value	Carbonyl value	Acid value	Carbonyl value
180	2·5	nil	—	80·0	11·0	—	—
180	5	nil	—	86·0	7·8	—	—
190	3·5	nil	—	97·2	6·4	216·0	100·0
200	3	nil	—	123·5	2·1	238·7	98·4
200	5	nil	—	127·1	1·9	207·6	110·0
200	10	nil	—	128·8	nil	218·4	104·0
200	16	nil	—	127·5	nil	220·0	105·0
200	3	Sodium carbonate	6	122·8	—	—	—
200	3	Sodium carbonate and sodium sulphite	6 each	152·2	—	—	—
200	4	Sodium carbonate	32	227·2	—	—	—

TABLE XVI — HYDROLYSIS OF LAC WITH JUST THE REQUISITE AMOUNT OF AQUEOUS CAUSTIC SODA OF VARIOUS CONCENTRATIONS

Experiment No.	Duration of hydrolysis (hours)	Hydrolysis per cent with alkali concentration of					
		0·25 N	0·5 N	0·75 N	1·0 N	1·5 N	2·0 N
1	1	—	—	50·59	54·45	Could not be determined as the resin formed lumps and would not go into solution	
2	1·5	24·51	47·26	—	—		
3	3	—	58·75	65·87	63·68		
4	3·5	42·58	—	—	—		
5	4	45·23	63·56	—	71·14	do	
6	5	47·80	66·25	70·58	73·77	do	
7	24	—	80·65	82·60	84·64	do	
8	48	72·43	85·39	87·30	89·87	do	

TABLE XVII — HYDROLYSIS OF LAC WITH JUST THE REQUISITE AMOUNT OF AQUEOUS CAUSTIC SODA AT VARIOUS TEMPERATURE

Duration of hydrolysis hours	Hydrolysis, percentage													
	20°C.			30°C.				50°C.			Boiling water temperature (99°C.)		
	0·5 N	0·75 N	1·0 N	0·25 N	0·5 N	0·75 N	1·0 N	0·5 N	0·75 N	1·0 N	0·5 N	0·75 N	1·0 N
1·0	32·86	—	—	—	—	50·59	54·45	—	47·30	—	75·54	78·81	81·27
1·5	—	—	55·76	24·51	47·26	—	—	42·37	—	63·00	—		
2·0	—	33·37	—	—	—	—	—	—	—	—	—	—	—
2·5	—	—	—	—	—	—	—	—	—	—	—	—	—
3·0	47·19	57·25	61·63	—	58·75	65·75	63·68	—	69·20	73·43	83·83	87·10	89·13
3·5	—	—	—	42·48	—	—	—	65·95	—	—	—	—	—
4·0	50·66	59·09	63·56	45·23	63·56	—	71·14	—	—	76·49	85·21	88·20	91·24
4·5	—	—	—	—	—	—	—	67·50	73·16	—	—		
5·0	54·12	—	65·06	47·80	66·23	70·58	73·77	69·76	74·59	78·40	85·80	89·28	92·39
24·0	69·15	73·37	76·30	—	80·65	82·60	82·64	83·62	85·88	88·84	—	—	—
48·0	74·68	78·20	81·20	72·43	85·39	87·30	89·87	86·70	90·28	91·58	—	—	—

TABLE XVIII — EFFECT OF HEAT ON TOTAL HYDROLYSED LAC KEPT WITHOUT STIRRING IN AN OVEN MAINTAINED AT 100°C.

Sl. No.	Duration of heating (hours)	Acid value of the reaction mixture
1	0	221
2	24	182
3	48	168
4	72	159
5	96	152
6	120	147
7	144	142

TABLE XIX — REACTION OF TOTAL HYDROLYSED LAC WITH 30% ETHYLENE GLYCOL AT 190-195°C. WITHOUT CATALYST

Sl. No.	Time of heating under reflux (hours)	Acid value
1	0	220
2	10	71
3	17	65
4	24	54
5	31	48
6	38	45
7	45	40
8	52	38·6
9	57	38·1
10	64	36·6
11	71	35·5
12	78	35·4

TABLE XX — REACTION OF TOTAL HYDROLYSED LAC WITH 30 PER CENT ETHYLENE GLYCOL AT 190-195°C. IN THE PRESENCE OF 0·5 PER CENT *p*-TOLUENE SULPHONIC ACID AS CATALYST

Sl. No.	Time of heating under reflux (hours)	Acid value
1	0	220
2	6	59
3	13	48
4	19	44
5	25	37
6	31	30
7	37	27
8	44	17
9	50	14
10	56	13

TABLE XXI — FILM PROPERTIES OF SHELLAC VARNISHES MODIFIED WITH PHENOLIC RESIN. AIR-DRIED FILMS WERE TESTED AFTER DRYING FOR SEVEN DAYS. BAKED FILMS (BAKED AT 100°C. FOR ONE HOUR) WERE TESTED AFTER 24 HOURS AFTER BAKING

Sl. No.	Phenolic resin	Per cent of resin on wt. of lac	Scratch hardness, load on 1 mm. steel ball, gm.		Flexibility-panel bent round 3 mm. mandrel		Water-resistance (samples immersed in water)		Resistance to heat	
			Air-dried films	Baked films	Air-dried films	Baked films	Air-dried films time of initial blush hours	Baked films after immersion for 15 days	Air-dried films minimum temp. at which no sticking takes place (°C.)	Baked films boiling water beaker placed over the film for 2 min.
1	I	0	700	800	FC	C	1	BB	70	ST
2	I	10	800	900	FC	C	2	NB	72	NS
3	I	20	700	900	FC	C	5	NB	82	NS
4	I	30	900	900	C	C	6	NB	82	NS
5	I	40	800	800	C	C	14	NB	90	NS
6	I	50	900	1000	C	C	16	NB	95	NS
7	II	50	800	900	FC	C	6	NB	88	NS
8	III	50	900	700	C	C	4	NB	82	NS
9	IV	50	800	800	C	C	10	NB	92	NS
10	V	50	900	1000	FC	C	4	NB	82	NS
11	VI	50	1000	1200	FC	C	6	NB	90	NS
12	VII	50	900	900	C	C	5	NB	84	NS

Sample Nos. V, VI & VII were acid-catalysed phenolics prepared in the laboratory.
FC = Fine cracks; BB = Blush; ST = Sticking with faint mark; C = Cracks; NB = No blush; NS = No sticking no mark; NC = No cracks.

TABLE XXII — PROPERTIES OF AIR-DRIED FILMS OF SHELLAC VARNISHES MODIFIED WITH BUTYLATED UREA FORMALDEHYDE RESIN

Sl. No.	Percentage of the resin on wt. of lac	Flexibility-film bent round a 3 mm. mandrel	Gloss of the film measured by glossmeter per cent of standard black glass	Scratch hardness load over 1 mm. steel ball gm.	Water-resistance (immersed in water for 24 hrs.)	Heat-resistance-beaker containing water kept boiling by immersion heater placed over the film for 2 min.
1	10	NC	54	900	FB	SM
2	20	NC	72	700	FB	SM
3	30	NC	50	900	VB	ST
4	40	NC	62	900	NB	NS
5	50	NC	63	800	NB	NS

NC = No cracks; NB = No blush; FB = Faint blush; VB = Very faint blush; SM = Sticks and makes mark; ST = Sticks and makes very faint mark; NS = No sticking no mark.

TABLEX XXIII — FILM PROPERTIES OF HEAT- AND WATER-PROOF SHELLAC VARNISH (FRENCH POLISH)

(Shellac varnish containing 40 per cent amino resin either butylated melamine or urea resin)

1.	Appearance of the varnish	Clear homogeneous varnish
2.	Solid content — per cent	25
	PROPERTIES OF AIR-DRIED FILMS —	
3.	Appearance	Smooth, hard and glossy
4.	Flexibility (film bent round a 3 mm. mandrel)	No cracks
5.	Scratch hardness, load on 1 mm. ball in gm.	800-1000
6.	Water-resistance, films on glass slides immersed in water	No blush up to 24 hrs. with urea resin and up to 15 days with melamine resin
7.	Heat-resistance — Beaker containing boiling water put over the film for 2 minutes	No sticking, no mark
8.	Resistance to alcohol — 40 per cent alcohol splashed over the film over wooden surface and left over night	No deterioration of gloss
9.	Gloss measured by glossmeter — per cent of standard black glass	60-65

TABLE XXIV — PROPERTIES OF BAKED FILMS OF SHELLAC VARNISHES MODIFIED WITH UREA RESIN

Sl. No.	Urea resin	Percentage of urea resin on the weight of shellac	Baking		Flexibility-panel bent round a 3 mm. mandrel	Scratch hardness, load on 1 mm. ball gm.	Water-resistance film immersed in water for 7 days
			Temperature °C.	Time (min.)			
1	I	0	150	10	C	800	BB
2	II	10	150	10	C	700	NB
3	III	20	150	10	NC	800	NB
4	IV	30	150	10	NC	1200	NB
5	V	40	150	10	C	800	NB
6	VI	50	150	10	C	600	NB
7	Ia	0	150	20	C	800	BB
8	IIa	10	150	20	C	1000	NB
9	IIIa	20	150	20	NC	1200	NB
10	IVa	30	150	20	NC	900	NB
11	Va	40	150	20	C	800	NB
12	VIa	50	150	20	C	700	NB
13	Ib	0	150	30	C	1000	BB
14	IIb	20	150	30	C	600	NB
15	IIIb	20	150	30	NC	600	NB
16	IVb	30	150	30	NC	800	NB
17	Vb	40	150	30	C	1100	NB
18	VIb	50	150	30	C	1000	NB
19	Ic	0	150	60	C	900	BB
20	IIc	10	150	60	NC	800	NB
21	IIIc	20	150	60	NC	1000	NB
22	IVc	30	150	60	NC	800	NB
23	Vc	40	150	60	C	700	NB
24	VIc	50	150	60	C	700	NB
25	Id	20	150	2 hrs.	NC	900	NB
26	IId	20	150	4 ,,	NC	1000	NB
27	IIId	20	150	6 ,,	NC	1000	NB
28	IVd	20	150	8 ,,	NC	1100	NB
29	Vd	20	150	10 ,,	NC	1000	NB
30	VId	20	150	12 ,,	NC	1200	NB

C = Cracks; NC = No cracks; BB = Bad blush; NB = No blush.

TABLE XXV — FILM PROPERTIES OF SHELLAC-MELAMINE RESIN VARNISHES

Air-dried films were tested after drying for seven days. Baked films (baked at 100°C./1 hour) were tested after 24 hours of baking

Sl. No.	Percentage of resin on wt. of lac	Scratch hardness load over 1 mm. ball, gm.		Flexibility-panel bent over 3 mm. mandrel		Water-resistance Air-dried films immersed for			Baked films immersed for 15 days	Heat-resistance	
		Air-dried film	Baked film	Air-dried film	Baked film	24 hrs.	7 days	15 days		Air-dried films boiling water beaker placed over the film on wooden panel for 2 min.	Baked film boiling water beaker placed over the film on tin panel for 2 min.
1	0	700	800	C	C	B	BB	BB	B	SM	ST
2	10	800	1000	NC	NC	FB	B	B	NB	SM	NT
3	20	800	800	NC	NC	NB	FB	B	NB	SM	NT
4	30	900	900	NC	NC	NB	FB	B	NB	ST	NT
5	40	800	1000	NC	NC	NB	NB	NB	NB	NT	NT
6	50	900	900	NC	NC	NB	NB	NB	NB	NT	NT

NB = No blush; ST = Slight sticking with mark; NT = No sticking no mark; SM = Sticking with mark; FB = Faint blush; BB = Bad blush; C = Film cracks; NC = No cracks

TABLE XXVI — FILM PROPERTIES OF METAL PLATE LACQUER — SHELLAC VARNISH CONTAINING 20 PER CENT UREA RESIN

1.	Appearance of the varnish	Clear homogeneous lacquer
2.	Solid content — per cent	25
3.	Baking time — minutes	10-15
4.	Baking temperature °C.	150
	PROPERTIES OF BAKED FILM —	
5.	Appearance.	Smooth, hard and glossy
6.	Flexibility (panel bent round 3 mm. mandrel)	No cracks
7.	Scratch hardness — load on 1 mm. steel ball in gm.	1,200
8.	Water-resistance of the film on glass slides (Immersed in water for one month)	No blushing or lifting of the film
9.	Boiling water-resistance on glass slides	No blushing or softening when immersed in boiling water for 5 minutes
10.	Heat-resistance (Beaker containing boiling water placed over the film for 5 min.)	No sticking and no mark
11.	Resistance to acids (Immersed in solutions for 24 hours)	No blushing and no lifting
	(a) 5 per cent Hydrochloric acid	do
	(b) 5 per cent Nitric acid	do
	(c) 5 per cent Sulphuric acid	do
	(d) 5 per cent Acetic acid	do
	(e) 5 per cent Citric acid	do
	(f) 5 per cent Tartaric acid	do
12.	Resistance to lubricating oil (Film immersed for 7 days)	No loss of gloss or sticking or softening of the film
13.	Resistance to white spirit (Film immersed for 7 days)	do
14.	Resistance to grease and vaseline	do

TABLE XXVII — FILM PROPERTIES OF AQUEOUS LAC-*TUNG* OIL VARNISHES

		Dewaxed lac and *Tung* oil ratio 1:1	2:1
1.	Appearance of the varnish	Clear homogeneous solution	Clear homogeneous solution
2.	Solid content	25%	25%
3.	Baking time (optimum)	30 minutes	30 minutes
4.	Baking temperature	150°C.	150°C.
	PROPERTIES OF THE BAKED FILM —		
5.	Appearance	Smooth, hard and glossy	Smooth, hard and glossy
6.	Flexibility (Panel bent round 3 mm. mandrel)	No crack	No crack
7.	Scratch hardness — load on 1·0 mm. ball on tin plates — kg.	1·3	1·5
8.	Water-resistance of the films on glass slides (Immersed in water for 7 days)	No blush or lifting	No blush or lifting
9.	Boiling water-resistance on glass slides (Immersed in boiling water for 2 min.)	No blushing or softening of the film	No blushing or softening of the film
10.	Resistance to alcohol-glass slides immersed in 40 per cent alcohol solution for 2 hours	No blushing or removal of the film	No blushing or removal of the film
11.	Resistance to acids — films immersed in the respective solutions for 7 days		
	(a) 5% Nitric acid	No blushing	No blushing
	(b) 5% Hydrochloric acid	do	do
	(c) 5% Acetic acid	do	do
	(d) 5% Sulphuric acid	do	do
	(e) 5% Tartaric acid	do	do
	(f) 5% Citric acid	do	do
	(g) 3% Sodium hydroxide	do	do
12.	Resistance to lubricating oils and grease (samples immersed for 7 days)		
	(a) Lubricating oil	No effect	No effect
	(b) White spirit	No effect	No effect
14.	Resistance to grease (grease applied over the films and kept for 7 days)	No effect	No effect

TABLE XXVIII — YIELD OF ALEURITIC ACID WITH VARYING PERIODS OF HYDROLYSIS OF LAC

Period of hydrolysis, days	Yield of aleuritic acid from dewaxed lac %	Remarks
1	14·5	Some resinous material was found mixed with sodium aleuritate on filtration.
2	16·8	
3	17·0	
4	17·2	
5	17·3	
6	17·2	
7	17·5	
8	17·5	
9	18·3	
10	19·8	

TABLE XXIX — PROGRESS OF PILOT PRODUCTION UNIT SALES DURING THE THREE YEARS OF ITS EXISTANCE

Material produced and sold	Distinguished mark	In 1960-61		In 1961-62		In 1962-63	
		Quantity kg.	Value Rs.	Quantity kg.	Value Rs.	Quantity kg.	Value Rs.
Bleached lac — refined (wax free)	BRF	364·24	3,488·01	303·27	2,763·83	645·50	4,617·58
Bleached lac — regular	BR	438·60	3,695·13	98·65	806·21	278·60	1,717·45
Water-soluble shellac (dewaxed)	DL	107·72	747·21	101·75	701·84	298·80	1,876·86
Autoclave shellac	ASK	265·01	1,009·70	225·60	847·28	1,307·70	3,591·67
Water-soluble shellac (autoclave)	AL	220·30	1,253·34	143·98	818·44	138·75	730·98
TOTAL		1,395·87	10,193·39	873·25	5,937·60	2,669·35	12,534·54

APPENDIX C

Studies on Bed Material for Hydraulic Models

Carried out at the Central Water & Power Research Station, Poona

In continuation of last year's work, further study of bed material was carried out to find out a suitable bed material having specific gravity between 1·1 to 1·5 for use in hydraulic models. Following types of material have been investigated.

(i) Lac mixed with Barytes.

(ii) Lac mixed with coal-dust.

Samples of garnet lac and shellac mixed with barytes and coal-dust were obtained from the Lac Research Institute. Various amount of calcium stearate, 2 per cent of urea and 5 per cent of paraformaldehyde were also added to the lac samples during hot rolling with barytes or coal-dust.

The average density of the particles, the variation in the density of the particles and other physical characteristics such as swelling and adhesion of particles under sun rays have been studied and the results are presented in Table 1.

The results show:

(i) That the average density lies between 1·12 to 1·56, that barytes mixtures have comparatively higher densities than coal-dust mixtures.

(ii) That more than 90 per cent of the particles in a sample lie between $x \pm \cdot 1$ density.

(iii) That swelling of the samples is not appreciable even without calcium stearate addition (sample Nos. 38 & 40).

(iv) That slight colour comes to solution from sample Nos. 13, 31, 35 to 40.

(v) That garnet lac with barytes but without urea formed lumps at 34°C. under sun rays.

(vi) That 5 per cent formaldehyde treatment has not prevented fungus growth in the samples when kept under water.

Discussion:

The present study shows that with regards to the uniformity in the density of the particles both barytes and coal-dust can be used. Former will give a density of 1·45 with 60 per cent addition whereas with coal-dust the density obtained will be of the order of 1·22 with addition of 100 per cent of coal-dust. The results also show that addition of 2 per cent urea is essential for preventing lump formation. There is no advantage in adding calcium stearate for prevention of swelling as swelling is not appreciable, however, small amount of calcium stearate is necessary for uniform mixing during hot rolling.

As regards addition of paraformaldehyde to prevent fungus growth, the results show that it is not effective. It may, however, be pointed out though some fungus growth is observed in samples when kept under water in the laboratory, it may not be a problem in actual models where water will not stagnate.

It is suggested that field trial with samples of following composition may be given to finally decide about the suitability of the lac samples as a bed material.

(1) a) Shellac or garnet lac	100	(2) a) Shellac or garnet lac	100
b) Urea	2	b) Urea	2
c) Calcium stearate	1	c) Calcium stearate	1
d) Coal-dust	100	d) Barytes	60

TABLE I (App. C) — SHOWING DIFFERENT DENSITY FRACTIONS SWELLING PERCENTAGE, ETC., OF THE SAMPLES

Sl. No.	Material		Average density	Percentage of density fractions and density of each						Swelling %	Action under sun	Action under water
				1·1	1·1-1·2	1·2-1·3	1·3-1·4	1·4-1·5	1·5-1·6			
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
13	Garnet lac	100	1·47	—	—	—	5·0	89·8	5·4	3	Particles remain separate up to 42°C.	Faint yellow colour coming in the solution. Fungus growth is observed.
	Ca stearate	3										
	Urea	2										
	Barytes	60										
31	Garnet lac	100	1·12	27·8 d=1·07	72·1 d=1·15	—	—	—	—	3	do	Reddish yellow colour coming in the solution. Fungus growth is observed.
	Ca stearate	3										
	Urea	2										
	Barytes	—										
35	Shellac	100	1·45	—	—	—	10·8	89·2	—	3	do	Faint violet colour coming in the solution. Slight fungus growth is observed.
	Ca stearate	3										
	Urea	2										
	Barytes	60										
36	Shellac	100	1·45	—	—	—	15·9 d=1·39	84·0 d=1·46	—	1·5	do	do
	Ca stearate	2										
	Urea	2										
	Barytes	60										
37	Shellac	100	1·44	—	—	—	23·0 d=1·38	76·8 d=1·47	—	1·3	do	do
	Ca stearate	1										
	Urea	2										
	Barytes	60										
38	Shellac	100	1·47	—	—	—	0·5	99·4	—	nil	do	do
	Ca stearate	—										
	Urea	3										
	Barytes	60										
39	Shellac	100	1·23	2·0	75·0 d=1·20	21·6 d=1·26	—	—	—	1·7	do	Slight violet colour is coming in the solution. Fungus growth is observed.
	Ca stearate	3										
	Urea	2										
	Coal-dust	100										
40	Shellac	100	1·18	3·0	92·0	5·0	—	—	—	1·8	do	Slight violet colour is coming in the solution. Slight fungus growth is observed.
	Ca stearate	3										
	Urea	2										
	Coal-dust	60										
41	Garnet lac mixed with barytes		1·56	—	—	—	—	—	100·0	0·6	Formed lumps at 34°C.	Brown colour of the material is faded. Fungus growth is observed
46	Shellac	100	1·19	3·9	92·9 d=1·17	2·0	0·3	—	—	4·0	No effect up to 35°C.	Solution clear. Fungus growth is observed.
	Ca stearate	1										
	Urea	2										
	Coal-dust	60										
	Paraform-aldehyde	5										
47	Shellac	100	1·21	9·4 d=1·08	76·9 d=1·18	10·6 d=1·25	2·4	—	—	3·9	do	do
	Ca stearate	Nil										
	Urea	2										
	Coal-dust	60										
	Paraform-aldehyde	5										
48	Garnet lac	100	1·20	0·2	88·0 d=1·17	8·7 d=1·24	3·0	—	—	4·0	do	do
	Ca stearate	11										
	Urea	2										
	Coal-dust	60										
	Paraform-aldehyde	5										
49	Shellac	100	1·22	0·1	83·6 d=1·18	16·5 d=1·23	0·2	—	—	3·9	do	do
	Ca stearate	1										
	Urea	2										
	Coal-dust	100										
	Paraform-aldehyde	5										
	Composition same as 46 sheets		1·19	3·5	83·1 d=1·17	8·3 d=1·26	4·4	—	—	1·9	do	do

APPENDIX D

Extract from letter No. nil, dated 19th June 1963 from Prof. E. S. Ross, Curator of Insects, The Science Museum, California, Academy of Science, addressed to Y. Sankaranarayanan, Indian Lac Research Institute, Namkum, Ranchi, Bihar, India.

" I enclose three of these showing the nature of our vehicle and some scenes of operation. I also enclose route maps which will indicate the great extent of our travels and the long exposure of the truck's paint to a wide variety of climates. In addition, I have included a few Kodachromes which might be of interest. The family group picture should be passed on to the appropriate staff member.

" If we had painted two surfaces of the truck with different types of Etch Primer we could have had a controlled experiment to test relative effectiveness or durability under similar conditions. Without this all I can report is that the paint held up very well over the 34,000 mile route. At times the shade temperature rose to 120°F. in Australia so the sun heat exposure must have been exceedingly severe. Frequently, we drove cross-country through shrubs which brushed the paint surface. In other words, the paint received a rugged test.

" We still possess the truck and will use it on some future expedition and there will be no need to repaint the surfaces which you covered. It appears that you have produced a very good paint base and I am sorry that I did not have the opportunity to compare it with products available for the same purpose. I am confident that it would have been as good or better.

" I wish that there was more to report but I think that this should be sufficient for your needs. When my National Geographic article appears, pictures of the truck will be published and this can be further reference to the extensive exposure of your product."

APPENDIX E

List of Publications from the Institute during the Year 1962-63

1. A rapid method for the determination of impurities in lac, by S. S. Chopra and Y. Sankaranarayanan [*Journal of Scientific & Industrial Research*, Vol. **21D**, No. 6 (1962), pp. 201-2].
2. Calibration of photoelectric colorimeter for the determination of bleach index of lac, by S. S. Chopra and Y. Sankaranarayanan [*Journal of Scientific & Industrial Research*, Vol. **21D**, No. 9 (1962), pp. 341-2].
3. Dewaxing of bleached lac, by B. B. Khanna and Y. Sankaranarayanan [*Research & Industry*, Vol. **7**, No. 11 (1962), pp. 373-4].
4. Preliminary trials on *Moghania chapparan* unrecorded shrub with *kusmi* strain of the lac insect, by B. K. Purkayastha and U. N. Prasad [*Science & Culture*, Vol. **28**, Nov. (1962), pp. 541-2].
5. Chromsome number of *Laccifer lacca* (Kerr) (*kusmi* strain) *Homoptera-coccodea*, by S. Dikshith [*Current Science*, **31** (Sept. 1962), 383-4].
6. Notes on some arboreal type of Cockroaches feeding on *Laccifer lacca* Kerr, by N. Majumdar [*Current Science*, **31** (Aug. 1962), 340-1].
7. Correlation coefficient between the major chalcid parasites attacking *Laccifer lacca* Kerr, by N. Majumdar, A. Bhattacharya and A. C. Chatterjee [*Science & Culture*, Vol. **28** (Aug. 1962), pp. 393-4].

8. Lac cultivation in India: an article in Kannada, by S. Dikshith (Samyukta Karnatak, Banglore, 10th Sept. 1961).
9. Shellac etch primer: an outstanding one pack wash primer, by V. S. Rao and Y. Sankaranarayanan [*Journal of the Colour Society*, Vol. **1**, No. 3 (1962), pp. 26-30].
10. Lead thiosulphate as a stabilizer for bleached lac, by B. B. Khanna and Y. Sankaranarayanan [*Journal of Scientific & Industrial Research*, Vol. **21D**, No. 9 (1962), pp. 342-3].
11. Effect of artificial partial defoliation of *palas* (*Butea monosperma*) on broodlac preservation in the *Baisakhi* crop, by S. Krishnaswami and C. P. Malhotra (*Indian Forester*, Vol. **88**, No. 11, pp. 866-72).
12. Proper time of harvesting for maximizing yield of sticklac, by C. P. Malhotra and S. Krishnaswami [*Indian Journal of Entomology*, Vol. **24**, Part I (March 1962), pp. 53-57].
13. *Tachardia decorella* — a misnomer, by R. K. Varshney [*Indian Journal of Entomology*, Vol. **24**, No. 4 (Dec. 1962), pp. 282-3].

APPENDIX F

List of Patents Applied for

1. A process for the manufacture of a reconstituted or rebuilt shellac possessing outstanding adhesion, hardness, elasticity and flexibility, No. 82557, by Y. Sankaranarayanan, S. S. Chopra and A. K. Sen Gupta.

2. A process for the preparation of an improved shellac varnish whose air-dried films as well as baked films possess outstanding heat- and water-resistance and improved adhesion and flexibility, No. 86212, by Shravan Kumar and Y. Sankaranarayanan.

APPENDIX G

Statement Showing Appointments, Promotions, Resignations, Retirement, Etc., During 1962-63

APPOINTMENT

Administrative Section

1. Sri Md. Samiullah, Junior Clerk	7th July 1962
2. Sri A. K. Choudhary, Junior Clerk	21st July 1962
3. Sri B. N. Mishra, Librarian	22nd December 1962
4. Sri Sita Ram Jha, Labour Supervisor	30th October 1962
5. Sri Tulsi Ram, Tindal	5th March 1963

Chemistry Division

1. Sri Shravan Kumar, Senior Scientific Officer	29th May 1962
2. Sri S. C. Sinha, Senior Research Assistant	1st June 1962
3. Sri V. S. Iyer, Senior Research Assistant	8th June 1962
4. Sri Nagendra Mahto, Laboratory Assistant	31st August 1962
5. Sri R. K. Modi, Research Assistant	4th December 1962

6.	Sri T. T. Samuel, Junior Clerk	27th November 1962
7.	Sri Tutun Bihari, Farash	26th November 1962
8.	Sri A. R. Mahandale, Research Assistant	24th December 1962
9.	Sri P. N. Sivankutty, Junior Clerk	7th July 1962
10.	Sri Umeshwar Sahay, Laboratory Assistant	5th January 1963
11.	Sri Balaram Muzumdar, Laboratory Assistant	7th January 1963
12.	Sri Ranbir Banerjee, Senior Research Assistant	4th March 1963 (F/N)
13.	Sri B. B. Chakravarty, Laboratory Assistant	19th June 1962
14.	Sri M. C. Ghosh, Laboratory Assistant	15th March 1963
15.	Sri Chhedi Lall, Durwan	14th March 1963

Entomology Division

1.	Dr. T. P. Singh Teotia, Entomologist	18th October 1962
2.	Sri V. K. Sehgal, Senior Research Assistant	11th June 1962
3.	Sri R. K. Varshney, Senior Research Assistant	11th June 1962
4.	Sri Ajmer Hussain, Laboratory Assistant	30th July 1962
5.	Sri Chotelal Dhimar, Durwan	3rd October 1962
6.	Sri A. K. Sen, Research Assistant	27th December 1962(A/N)
7.	Sri R. B. Sinha, Laboratory Assistant	5th January 1963
8.	Sri K. L. Choudhury, Laboratory Assistant	11th January 1963
9.	Sri D. Prasad, Laboratory Assistant	21st January 1963
10.	Sri Gopi Krishna Jha, Laboratory Assistant	22nd January 1963
11.	Sri Manoranjan Burman, Research Assistant	4th March 1963
12.	Sri R. Vishwanathan, Insect Physiologist	1st February 1963

Promotion

Chemistry Division

1.	Sri S. C. Sen Gupta, appointed as Senior Scientific Officer	13th April 1962
2.	Sri S. S. Chopra, appointed as Senior Research Assistant	14th May 1962 (A/N)
3.	Sri V. S. Rao, appointed as Senior Research Assistant	14th May 1962 (A/N)
4.	Sri A. K. Ghosh, appointed as Senior Research Assistant	14th May 1962 (A/N)
5.	Sri P. N. Sivankutty, appointed as Steno-typist	21st November 1962
6.	Sri M. Kujur, promoted as Mechanical Supervisor	29th August 1962

Entomology Division

1.	Sri T. S. S. Dikshith, appointed as Senior Research Assistant	14th May 1962 (A/N)
2.	Sri Y. S. Krishnan, appointed as Senior Research Assistant	14th May 1962 (A/N)
3.	Sri R. S. Gokulpure, appointed as Senior Research Assistant	16th May 1962
4.	Sri S. M. Kulkarni, appointed as Senior Research Assistant	18th February 1963 (A/N)
5.	Sri Nelson Lakra, promoted as Fieldman	8th January 1963

Resignation

Administrative Section

1.	Dr. M. S. Muthana, Director	1st October 1962
2.	Sri B. N. Sen, Librarian	15th October 1962
3.	Sri Ban Singh Tirkey, Tindal	19th December 1962
4.	Sri Bhikha Oraon, Junior Clerk	4th May 1962

Chemistry Division

1.	Sri R. K. Modi, Research Assistant	20th January 1963 (F/N)
2.	Sri N. K. Naik, Laboratory Assistant	1st May 1962
3.	Sri A. K. Das, Junior Research Assistant	18th June 1962
4.	Sri R. C. Arora, Research Assistant	21st September 1962
5.	Sri M. M. Choudhury, Steno-typist	9th November 1962
6.	Sri O. P. Ratra, Exhibition Assistant	25th February 1963 (A/N)

Entomology Division

1.	Sri L. M. Pramanik, Research Assistant	1st April 1962
2.	Sri S. K. Banerjee, Junior Clerk	16th February 1963
3.	Sri S. Z. H. Rizvi, Laboratory Assistant	29th January 1963

RETIRED

Administrative Section

1.	Sri B. Mukhopadhaya, T.A. to Director — Proceeded on leave preparatory to retirement	3rd August 1962
2.	Sri K. B. Thappa, Labour Supervisor — Proceeded on leave preparatory to retirement	15th August 1962

DEATH

1.	Sri S. K. Deogharia, Fieldman	24th September 1962
2.	Sri Dulka Oraon, Farash	3rd November 1962

SUSPENSION

1. Sri K. N. Sinha, Chief Mechanic, Suspended from 3rd September 1962 to 16th September 1962
2. Sri P. S. S. Kumar, Assistant Mechanic, Suspended from 6th September 1962 to 16th September 1962
3. Sri Saheb Ali, Estate-Care-Taker, Suspended from 3rd September 1962 to 16th September 1962

APPENDIX H

Statistics of Production in Tonnes of Sticklac During the years 1960-61 to 1962-63

Year	*Baisakhi*	*Jethwi*	*Katki*	*Aghani*	*Total*
1962-63	30,606	1,120	10,824	4,928	47,478
1961-62	20,902	1,158	14,632	1,866	38,558
1960-61	41,055	1,213	6,982	3,546	52,796

Note: The figures of the year 1962-63 are provisional.

APPENDIX I

Tabulated Statement of Progress of Investigation

ENTOMOLOGY DIVISION

Item	Date commenced	Progress	Remarks
IIA — Research and Investigations			
Lac cultivation studies on *palas*			
(i) Large-scale cultivation	1948-49	Nearly 20,000 trees under lac. Expenditure Rs. 4,129.61 nP. Revenue Rs. 3,089.90 nP. Loss due to fall in price.	To be continued
(ii) Evolution of cultivation practice	1959	(a) Five treatments under trial. Of them, D (Light inoculation in October-November followed by complete harvesting in October-November next) gave maximum brood used to brood yield ratio, namely, 1 : 20·5 and also the maximum scraped lac.	To be continued
		(b) 11,000 trees were heavily inoculated and an equal number lightly inoculated. The latter gave better results with 0·976 kg. yield per tree.	To be continued
2. Lac cultivation studies on *ber*			
(i) Determination of optimum density of larval settlement and proper time of harvesting of *Baisakhi* crop	1961	Combination of three brood rates, namely, half-normal, normal and double-normal, and three times of harvesting, namely, April, May and at maturity, i.e. a total of nine treatments being tried. Treatment D (½ N brood rate and harvesting in May) gave the maximum brood to yield ratio (1 : 14·73) in *Baisakhi* 1961-62.	To be continued
(ii) Determination of density of larval settlement for *ber* in *Katki* crop	1962	The usual three brood rates are being tried. Half-normal brood rate gave the maximum brood to yield ratio.	To be continued
(iii) Studies on pruning time for *ber* for *Katki* crop	1960-61	Four treatments, namely, pruning in February, May, October and December are being tried. Results of *Katki* 1962 indicate treatment B (May-pruning) to be the best.	To be continued
3. Lac cultivation studies on *kusum*			
Evolution of cultivation practice	1961	Three treatments, namely: (a) 1-year rest; inoculation in January-February and June-July in separate coupés, leaving for self-inoculation in next season and harvesting 1 year after inoculation.	To be continued
		(b) 2-year rest; inoculation and harvesting as in A	

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
		(c) 1½-year rest; 4 coupés to be used as usual. 2-year rest gave the best result in *Jethwi* 1962 crop.	
4. Growing lac hosts under bush conditions			
(i) *Albizzia lucida*	1957-58	*A. lucida* trained into bushes and inoculated for *Jethwi* 1962 gave a poor crop, namely, 1 : 0·91 ratio of brood to yield of scraped lac, due to high initial larval mortality. *Jethwi* 1963 showed about 50 per cent initial larval mortality.	To be continued
(ii) *Ber*		*Baisakhi* 1961-62 harvested as *ari* in May from bushes grown from coppiced *ber* plants gave the ratio of brood to yield (scraped lac) as 1 : 4·4. *Baisakhi* 1962-63 crop is progressing satisfactorily.	To be continued
(iii) *Moghania macrophylla*		C treatment (4′ × 4′ spacing) of *Moghania macrophylla* is the best in respect of available space for larval settlement in a plot of fixed size.	To be continued
		F treatment (transplanting of 2 March-raised seedlings) per pit gave the best results.	To be continued
	1962	Effect of nitrogen, phosphorus and potassium on the yield is under trial in different combinations. H treatment (combination of all the three fertilizers) gave the best result in respect of per tree yield of scraped lac and brood to yield ratio.	To be continued
	1962	Effect of different levels of nitrogen on the growth of bushes is under trial. E treatment (Use of 40 kg. ammonium sulphate per acre) gave the best result.	To be continued
5. Finding out alternative hosts for the *Kusmi* strain of lac insects	1962	*A. lucida*, *Ougeinia oojeinensis* and *Ficus cunia* are being tried by inoculating them with *kusmi* brood and alternating the resultant crop between *kusum* trees and the hosts under trial.	To be continued
6. Survey of lac insect enemies and their parasites	1961	*Agathis* sp. reported last year as a new internal parasite of *Holcocera pulverea*, was identified at the British museum (N.H.), London, as *Agathis coryphe* Nixon (Braconidae). No new insects were encountered this year.	To be continued
7. Biological control of lac insect enemies			
(i) Life-history studies:			
(a) *Apanteles fakhrulhajiae*	1959	Higher parasitization was found in *Aghani* and *Katki* crops.	To be continued
(b) *Brachymeria tachardiae*	1961	Development was found to be quicker at 27°C. controlled temperature than at mean laboratory temperature 25·5°C.	To be continued

APPENDIX I (*Contd.*)

Item	Date Commenced	Progress	Remarks
(c) *Elasmus claripennis*	1962	Seven generations could be bred in the laboratory. The life-cycle period increased at lower atmospheric temperatures.	To be continued
(d) Mass rearing of *Bracon greeni*	1959	Work could not progress due to non-availability of the larvae of the host, *Etiella zinckenella*, at all times.	To be continued
(e) Mass rearing of *Apanteles tachardiae*	1957	Thirteen generations with a total of 1,14,435 parasites were reared. On an average 55 per cent host larvae were parasitized.	To be continued
(ii) Liberation of *A. tachardiae*	1957-58	Only 9,200 were released in *Aghani* 1962-63 by September 1963, as sufficient numbers were not available at the time of periodical release.	To be continued
(iii) Incidence of predators on *kusmi* lac grown on *M. macrophylla*	1962	Freshly laid in February 1963. 25 samples being collected fortnightly for examination for the presence of predators and to ascertain the extent of damage by them.	To be continued
8. Chemical Control of lac hosts			
Effect of insecticidal spray residues on the longevity and oviposition of *Eublemma amabilis* and *Holcocera pulverea*	1962	Freshly emerged adult predators are liberated in battery jars sprayed with 100 c.c. each of 0·25 and 0·5 per cent dieldrin and aldrin. 0·5 per cent dieldrin spray reduced the longevity and fecundity most.	Concluded
9. Physiological studies:			
(i) Relation of host plant to the fecundity and resin secretion efficiency of the lac insect			
(a) *Rangeeni* strain	1962	Isolated mature female insects from *ber, ghont, khair, palas, Acacia farnesiana* and *M. macrophylla* were studied. Maximum average number of larvae emerged from *khair* insects and minimum from *A. farnesiana*. Resin secretion is under study.	To be continued
(b) *Kusmi* strain	1962	*Kusum* showed the best result in respect of fecundity as well as secretion of resin.	To be continued
(ii) Studies on the honeydew of lac insect	1963	Chromatographic study for amino-acids and sugars in the honeydew is being carried out.	To be continued
(iii) Comparative study of components of plant sap of major and minor hosts	1963	Similar studies as under (ii) are being carried out with the plant sap.	To be continued
(iv) Comparative study on the effect of major nutrients applied to *M. macrophylla* plants on the development of lac insect	1962	Twelve treatments by using ammonium sulphate, superphosphate, calcium chloride, muriate of potash and magnesium chloride, singly or in combination, are under trial. Treatment F (supply of calcium); Treatment B (supply of phosphorus + potassium + magnesium + calcium), Treatment H (supply of nitrogen + potassium + magnesium + calcium,	Discontinued

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
		and Treatment I (supply of nitrogen + phosphorus + magnesium + calcium) increased the percentage of males and Treatment B (supply of nitrogen), and Treatment K (supply of nitrogen + phosphorus + potassium + calcium) increased the percentage of females.	
10. Genetical studies on lac insects :			
(i) Mode of reproduction	1962	Virgin as well as impregnated female insects were studied. Effective parthenogenesis was not indicated in both the strains, which is contrary to previous findings.	To be continued
(ii) Inter breeding experiments	1962	Crosses between *rangeeni* and *kusmi* strains indicate that the two strains can interbreed. Crosses between the crimson and yellow forms indicate that colour may be an inheritated character with crimson as the dominant character. Yellow form also did not reproduce parthenogenetically.	To be continued
(iii) Evolution of a better resin yielding strain of lac insect by selection	1962	Progenies of the ' bold ' and ' small ' mother cells were studied. Very little difference in the size of the progeny was found which is not indicative of the evolution of a better resin yielding strain through selective breeding.	To be continued
(iv) Studies on the yellow variety of lac insect in relation to host specificity	1962	Yellow insects from *Ficus* sp. were inoculated on *A. lucida*, *A. farnesiana* and *ber* for raising a pure breeding yellow form on these hosts. Yellow females failed to reproduce parthenogenetically.	To be continued
(v) Chromosomal cytology of the two strains and yellow form of lac insects	1961	Chromosome number of the females of both the *kusmi* and *rangeeni* strains and that of *rangeeni* male was found to be 18.	To be continued
(vi) Oogenesis and spermatogenesis of the two strains and yellow variety of lac insect	1962	Studies on the pattern of spermiogenesis and meiosis in the males of *rangeeni* strain have been concluded and the *rangeeni* females have been taken up. Sperms of the male progeny of the X-ray irradiated *kusmi* brood did not show any abnormality.	To be continued
11. Ecological studies on lac insect Determination of optimum environmental conditions for storing the broodlac to delay emergence of larvae	1963	Brood in 4-5 day stage of ovules from *Aghani* 1962-63 crop was stored both at 17·5°C. laboratory temperature and controlled temperature of 14·5°C. ±1. Inoculation from both the stocks on the day the larvae emerged in the laboratory stock and thereafter from the controlled temperature stock was carried out.	to be continued
12. Pests of host trees			
(i) Pest of *palas*	1961	*Holotrichia serrata* (Melolonthidae) is being studied. It passed through	To be continued

APPENDIX I (*Contd.*)

Item	Date Commenced	Progress	Remarks
		only one life-cycle in a year in the laboratory.	
(ii) Pest of *ber*	1961	*Thiacidas postica* Walker is being studied. Total life-cycle period was found to vary from 37 to 215 days. Three generations were completed from the larvae collected from field in August 1961.	To be continued
(iii) Pests of *ghont*			
(a) Hairy caterpillar (No. 2)	1962	Larvae of this defoliator appeared in July and August in the field. Field-collected larvae passed through 8 larval instars in the laboratory.	To be continued
(b) *Pagyda traducalis* Zell	1962	The larvae of this leaf-roller were found in the field from July to September. Field-collected larvae moulted 2-4 times before pupation.	To be continued
(c) Hairy caterpillar (No. 6)	1962	Two generations of this defoliator could be successfully reared in the laboratory and the third is continued. The life-cycle of the first generation was completed in 78·2 days average and of second generation in 58·9 days.	To be continued
(iv) Pests of *M. macrophylla*			
(a) *Hypena iconicalis* Walker	1962	The larvae of this defoliator were found in July to October in the field. Field-collected larvae of July completed the cycle in August.	To be continued
(b) *Hemithea* sp.	1962	The larvae of this looper defoliator collected from the field in September completed four generations by March.	to be continued
(c) *Nephopteryx leucophaella* Zell	1962	Larvae of this defoliator-cum-leaf-binder collected from field in October completed two generations and the third is in progress.	To be continued
IIB — Regional Field Research Stations			
1. Jhalda (W. Bengal)			
(i) Spurious emergence of larvae in *kusum* lac	1959	*Kusum* trees inoculated with pure *kusum*, *ber* and *palas* and mixed broods. No early emergence was observed in *Jethwi* 1962 crop but mild spurious emergence was observed in *Aghani* 1962-63 crop from trees inoculated with *kusum* brood.	To be continued
(ii) Alternative *kusmi* hosts	1959	*Ber* showed the best results both in *Jethwi* 1962 and *Aghani* 1962-63 crops, brood to yield ratio being 1 : 1·63 and 1 : 2·71 respectively. More than one-third of *M. macrophylla* plants transplanted last year are growing well.	To be continued
2. Damoh (M.P.)			
(i) Pruning response of *ghont*	1959	For *Katki* crop, pruning in December (Treatment A) was replaced by pruning at the time of harvesting in	To be continued

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
		October/November and the same treatment was added for *Baisakhi* crop. Treatment A (pruning in April) under *Baisakhi* crop and Treatment C/D (Pruning in May of previous year) under *Katki* crop showed the best results.	
(ii) Optimum brood requirement for *ghont*	1959	In *Baisakhi* 1961-62 crop normal brood rate and in *Katki* 1962 crop double-normal brood rate showed the highest brood to yield ratio.	To be continued
(iii) Evolution of a cultivation practice for *ghont*	1961	*Baisakhi* 1962-63 crop is progressing satisfactorily.	To be continued
(iv) Trials with regional hosts	1959	*Baisakhi* 1962-63 crop on *palas* and *khair* only is progressing satisfactorily.	To be continued
(v) Introduction of exotic hosts	1959	*Samanea saman, A. lucida, O. oojeinensis* and *M. macrophylla* are growing satisfactorily.	To be continued
3. Mirzapur (U.P.)			
(i) Pruning response of *ghont*	1960	April-pruning (Treatment A) in *Baisakhi* 1961-62 and February-pruning (Treatment B) in *Katki* 1962 crop showed the best results.	To be continued
(ii) Optimum brood requirement for *ghont* and *palas*	1960	No conclusions could be drawn from *Baisakhi* 1961-62 and *Katki* 1962 crops.	To be continued
(iii) Evolution of a cultivation practice for *ghont* and *palas*	1960	Higher larval mortality was observed in all the three treatments in *Baisakhi* 1962-63 crop on *ghont* than on *palas*.	To be continued
(iv) Trials with regional hosts	1960	*Ber* in *Baisakhi* 1961-62 and *khair* in *Katki* 1962 crops gave the highest brood to yield ratio of scraped lac.	To be continued
4. Umaria (M.P.)			
(i) Evolution of a cultivation practice for *kusum*	1961	Three treatments as under 3 above are being tried. Treatment C (1½-year rest) gave the highest brood to yield ratio in one year.	To be continued
(ii) Trials with regional hosts	1961	No host under trial gave satisfactory results.	To be continued
(iii) Introduction of exotic hosts	1961	*M. macrophylla* plants are developing satisfactorily.	To be continued
III—Plantation at Namkum		General upkeep maintained. *M. macrophylla* and other hosts raised.	
IV—Training and Advisory Service			
(i) Training		Fifty-nine trainees completed 6-month course in two sessions. Three trainees completed 1-month course in two sessions. One trainee received a fortnight's *ad-hoc* training.	
(ii) Extension and advisory service		Technical advice given to various parties and extension work done at various Forest Institutions.	

APPENDIX I (*Contd.*)

CHEMISTRY DIVISION

Item	Date commenced	Progress	Remarks
I—Grading and Analysis			
1. Bleach index and bleachability	1957	The method developed by this Institute has been communicated to the Secretariat of ISO/TC-50 for the consideration of the participating countries. A Round Robin test has been agreed to. Samples are awaited from U.S.A.	
2. Determination of 'age' of lac	1962	Specific heats of lac of different ages have been found to be different. Specific heat at 70°C. of fresh lac is 0·68 and of a sample 13 years old 0·32. Possibility of using this observation for the determination of the age of lac is being investigated.	Work is being continued
3. Determination of insoluble lac resin in old sample	1962	Quantity of insoluble lac present in a sample of seedlac or shellac has been found out by determining the hot alcohol insolubles in the usual way and by using alcohol containing 0·6 c.c. of 1:1 sulphuric acid in 125 c.c. Difference of the results of these determinations gives the quantity of insoluble lac present in the sample.	Work completed
4. Correlation of quality, especially colour of sticklac with areas of cultivation	1960	Twenty more samples have been tested during the year under report. There are differences in qualities, but their bearing on climatic conditions are not yet clear.	Work is being continued
II—Improvement in the Manufacture of Seedlac, Shellac, Bleached Lac, etc.			
1. Improved method of washing		Washing of lac with potassium permanganate in barrel and the acid treatment in the pit below the barrel have been done. The results are same as in the tub washing. Yield is 5 per cent higher and bleach index is same as with washing with soda. Washing with caustic soda and borax have been done in barrel but with only 50 per cent of chemical as in tub, yield is more by 1·5-2 per cent but the lowering of bleach index is same, i.e. 10 units.	Results are being published
2. Use of centrifuge for drying of seedlac		Washed lac-drained in basket-contains 36·4 per cent water. On centrifuging for ten minutes at 1170 r.p.m., water content drops down to 11·3 per cent. Further centrifuging does not help much.	Investigations on further drying in a rotary dryer are being taken up.
3. Preparation of shellac by alkali extraction method		Storage stability of shellac prepared by dissolving seedlac in solution of sodium carbonate and sulphite and	The study will be continued

APPENDIX I (*Contd.*)

Item	Date Commenced	Progress	Remarks
		treating the solution with hydrosulphite and precipitating with acid was examined after 18 months. The material is soluble but life and flow are slightly adversely affected. Properties of film produced, from the shellac prepared as above and by *bhatta* melting, were found to be identical.	
4. Dewaxing of lac using aqueous alkalies		Alkaline solution of seedlac when boiled with barytes powder (80 per cent on the weight of seedlac) and allowed to stand, the barytes settles taking down the wax. The dewaxed lac obtained by acidifying the solution contains 0·04 per cent wax. Same lot of barytes may be used twice for dewaxing.	The study will be continued
5. Making of shellac using soft coke in place of charcoal		With a slight modification in the existing *bhatta* (oven), soft coke could be advantageously used in place of wood charcoal. The product does not suffer in quality or yield. By this method, the cost of production is reduced by Rs. 2 per maund of seedlac.	Work completed. The result will be given publicity
6. Economic Utilization of the by-products			
(a) Recovery of lac from *molamma*		Lac was extracted from different varieties of *molamma* by alkali (sodium carbonate, sodium sulphite and hydrosulphite). Colour indices were between 26 and 32.	Study to be continued
(b) Recovery of wax lost during the processing of sticklac into seedlac		It has been determined that 0·76 per cent of wax is lost with factory effluent of a seedlac factory. The wax contained in crude dye precipitated by acid treatment of the effluent has been extracted with white spirit. The wax obtained is hard and melts at 85°C. Extraction of wax from *molamma* which contains 8·04 per cent of wax was possible up to 90 per cent when the material was mixed with an equal weight of the acid precipitated crude dye before extraction.	Bigger scale extraction will be done
7. Bleached lac			
(i) Chemistry of bleaching		(a) Action of sodium hypochlorite on aldehydic acid, a major constituent of shellac, was studied. It has been observed that if the acid is dissolved in sodium carbonate and precipitated by adding sulphuric acid, a portion becomes soluble in water which has higher acid and hydroxyl values, but no carbonyl value. If the precipitation is carried out after the	

APPENDIX I (*Contd.*)

Item	Date Commenced	Progress	Remarks
		action of hypochlorite solution, this portion is more. A certain amount of chlorine enters the molecule of acid lowering the iodine value. But the drop in I.V. does not account for the chlorine content. Tentative inference is that chlorine reacts by substitution. Aldehydic acid prepared according to the method either of Sengupta or Kamath had carbonyl value of 17·0 whereas theoretical value should be 200. So the purity of the prepared acid is only 8·9 per cent. This has been confirmed by the yield of dinitro-phenyl hydrazone of the acid. (b) To study the action of hypochlorite on erythrolaccin-water-insoluble dye of lac-attempts were made to isolate the compound by the methods suggested by 'Tschirch and Farner', and 'Wright' but without success.	The work will be continued
(ii) Stabilizer for bleached lac		Three organic tin salts, viz. dibutyl-tin-maleate, dibutyl-tin-dinonyl maleate and dibutyl-tin-laurate were tried in place of lead thiosulphate. Life of bleached lac improved from 10 to 15 min. with 2 per cent of chemicals. Tin salts were not better than lead thiosulphate for this purpose.	
(iii) Preparation of chlorine-free bleached lac	1962	Attempts were made to prepare chlorine-free bleached lac by passing gaseous oxygen through sodium carbonate solutions of lac under different *p*H and temperature and in presence of various catalysts. No bleaching was observed. Hydrogen peroxide, benzoyl peroxide, sodium perborate, etc., were tried but without any effect.	To be continued
(iv) Rapid method of bleaching of lac	1961	The properties of bleached lac prepared by rapid method, such as storage stability, colour, texture, chlorine content and film property, were found to be quite similar to bleached lac by the conventional process.	
(v) Bleached lac pilot plant	1957	The production of bleached lac in the pilot plant was continued and some modifications of the plant have been made resulting in better and smooth working. Experiments are being continued to investigate the possibility of using alternate materials of construction for the bleaching and precipitation tanks.	To be continued

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
III—Fundamental Research			
1. Constitution studies — separation and study of components of fraction V	1961	The neutral fraction in fraction V has been found to have the empirical formula $C_{21}H_{37}O_3$.	To be continued
2. Differential thermal analysis	1962	The apparatus have been assembled and the cell is being calibrated in terms of known heat of reaction of $CuSO_4$. $5H_2O$.	To be continued
IV—Modification and Uses			
1. Modification of lac with diisocyanate	1961	The physical and chemical constants of the modified lac have been determined.	To be continued
2. Shellac etch primer (single pack)			
(a) Modification of the primer	1957	The effect of incorporation of synthetic resins into the primer composition was investigated. The primer with 10 per cent phenolic resin possessed a fair storage stability. The incorporation of phenolic resin into the primer improved the adhesion to steel even when without urea and dibutyl phthalate.	To be continued
(b) Natural and dynamic weathering		The weathering tests continue to be satisfactory.	
(c) Storage stability		It was found that the critical alcohol content of the spirit for the preparation of the primer is 90 to 92·5 per cent.	To be continued
(d) Shellac etch primer as primer for steel		The zinc chrome washed with boiling water produced a satisfactory primer in this respect but the product was not reproducible. Other modified primers are being tried.	To be continued
(e) Shellac etch primer for refrigerator finishes		Shellac wash primer of standard composition as well as with various modifications were tried without much success.	
3. Hydrolysed lac	1962	It was found that the complete saponification of lac was achieved with 1·0N alkali at boiling water temperature for 3·25 hours with about 40 per cent excess alkali.	
		Possibility of hydrolysing lac by heating under pressure without the use of alkali or acid and with and without catalyst was investigated without much success.	To be continued
4. Reconstituted shellac	1961		
(a) Improving water resistance		The spirit soluble synthetic resin (20-40%) were incorporated into reconstituted shellac solutions resulting in baked films which were resistant to water even up to 7 days immersion.	To be continued

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
(b) Reducing acid value		The acid value of reconstituted shellac could be reduced by reacting total hydrolysed lac with alcohol (ethylene glycol) with or without *para*-toluene sulphonic acid as catalyst but the resulting product showed very poor film properties.	
(c) Bleaching of reconstituted shellac		The reconstituted shellac can be bleached by usual hypochlorite bleaching method but better yield was obtained by rapid bleaching method.	An Indian patent has been applied for to cover the process of manufacture of reconstituted shellac
5. Modification of shellac with synthetic resins	1961	The modification of lac with spirit soluble synthetic resins such as phenolics and amino resins were continued.	
(a) With phenolic resins		Incorporation of phenolic resin (50% on the weight of shellac) with lac resulted in moderate improvement in regard to heat- and water-resistance of the air-dried films, whereas baked film (100°C./1 hour) showed remarkable properties.	
(b) With urea-formaldehyde resins		Dewaxed lac varnish containing 40 per cent butylated urea-formaldehyde resin proved very satisfactory as heat- and blush-proof French polish.	Larger quantities of samples are being prepared for service trials
(c) With melamine-formaldehyde resin		Incorporation of spirit soluble melamine-formaldehyde resin (40 % on the wt. of lac) with lac proved to be better than butylated urea-formaldehyde resin.	
(d) Modified shellac varnish for use as tin plate lacquers		Baked films of shellac varnish (100°C./1 hour or 150°C./10-15 mins.) modified with urea resins (20% on the wt. of lac) served satisfactorily as regards improved elasticity for tin plate lacquering.	
6. Aqueous shellac-drying oil varnishes	1962	An aqueous shellac varnish was formulated by incorporating water-soluble *tung* oil (prepared by maleinization process) with water-soluble lac. The baked films (150°C./30 mins.) showed excellent resistance to water, dilute solutions of mineral and organic acids, elasticity, etc.	To be continued. Other drying oils such as linseed and tobacco seed oils are being studied.
7. Lac-drying oil insulating varnish		The optimum conditions for the preparation of an insulating varnish conforming to the I.S.I. Specification No. 350-1962 were determined combining shellac, linseed oil, glycerine and phthalic anhydride for use as baking type clear insulating varnish for the impregnation of coils, etc., and for the manufacture of yellow insulating cloth, tape, etc.	A sample of the varnish was sent to Government Test House, Alipore for evaluation. Their report is awaited
8. Modified shellac for moulding composition	1962	Investigations on the preparation of moulding compositions incorporating phenolic resins are being carried out.	

APPENDIX I (*Contd.*)

Item	Date commenced	Progress	Remarks
9. Shellac composition for use as bed material for hydraulic models	1959	Two compositions, based on shellac, urea, coal-dust or barytes and calcium stearate were developed and are having large-scale field trials as bed material for hydraulic models by Central Water & Power Research Station, Poona.	
10. Technical preparation of Aleuritic acid		A systematic study was undertaken to simplify the process of manufacturing and improve the yield, if possible, of aleuritic acid.	To be continued
V—Utilization of Lac in India — Publicity and Propaganda			
1. Varnish and lacquers			
(a) Shellac picture varnish		Attempts were continued to popularize shellac picture varnish.	
(b) Shellac spirit varnish		Notes on the method of preparation and use of different types of shellac varnish were supplied for lacquering of dolls, varnishing of rubber goods, making of leak-proof containers for hydro-carbon oils and investigations for use as insulating varnishes.	
2. Water-soluble lac		Samples were sent for varnishing earthenware, finishing leather goods, and preparation of emulsion paints. Water-soluble lac was found better than fish glue for photo-engraving.	
3. Adhesive and cement		A mica shellac adhesion tester as designed by B.S.I. was fabricated and supplied to a firm.	
4. Sealing wax		A diamond fixing composition for polishing diamond was supplied to a firm.	
5. Lac wax		Government Lac Utilization Centre, Pendra was supplied detailed method of extraction of lac wax from sludge (crude dye) from lac factory effluent.	
6. Bleached lac		Method of preparation of bleached lac was supplied to Director of Biological Science, Botanical Institute, U.S.S.R., and method of dewaxing lac for preparing bleached lac was supplied to a firm in Australia.	
7. Shellac etch (wash) primer		Satisfactory reports about the performance of the primer after long service trials from Railways, State Transport Organizations including that from Prof. Ross, Curator of Insects, Science Museum, California whose aluminium body Van was coated with the primer, which covered about 34,000 miles in India, Burma, Malaya, Australia and Japan. A direct mail folder on the primer was brought out and distributed. A firm in New York was supplied details of the preparation of the primer.	

APPENDIX I (*Contd.*)

ITEM	DATE COMMENCED	PROGRESS	REMARKS
		Director, Central Electro Chemical Research Institute, Karaikudi has been supplied technical literature on the primer for research on paints as protective agents against corrosion of light gauge structures and pre-treatments before painting.	
8. Technical assistance to manufacturers and consumers		Fullest cooperation and technical assistance were provided to manufactures of seedlac and State Trading Corporation in the operation of scheme of seedlac purchase. Seedlac supplied by a firm was processed to Autoclave shellac in our pilot plant and sent to them to explore the marketing possibilities within the country and abroad.	
9. Regional testing laboratory		Two more testing laboratories, one in May 1962 at Namkum and the other in February 1963 at Bilaspur have been started. Samples tested during this year: Gondia 2658, Balarampur 2661, Daltonganj 878, Namkum 1217 and Bilaspur 157.	
10. Exhibitions and exhibits		Exhibits were supplied for 15th Technical Exhibition of the Oil and Colour Chemists' Association in London and Indian Exhibition at Moscow.	
VI—PILOT PRODUCTION UNIT		2674·35 kg. of special shellacs valued at Rs. 12,574 and other miscellaneous products priced at Rs. 871·28 were sold during the period with a gross profit of Rs. 5069·61 nP. only.	
VII—STICKLAC PROCESSING UNIT	1962	Scheme for processing 5000 quintals of sticklac into seedlac has been approved by the Government and steps are being taken to implement the scheme.	

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