INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1965-66

1972

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INTRODUCTION

Historical — The Indian Lac Research Institute came into existence as a result of the recommendation of a two-man enquiry committee (comprising Mr. H. A. F. Lindsay and Mr. C. M. Harlow) appointed early in 1920 by the then Government of India to enquire into the conditions of the Indian lac trade and suggest measures for its all-round improvement. The report of this Committee was published in 1921 in which they observed, *inter alia*, that the two major ills from which the lac trade was then suffering, namely, liability to violent price fluctuations and adulteration in times of short supply, could be cured only by increased out-turn, for which, in their opinion, recourse should be had to intensive cultivation by scientifically tested methods, rather than to extensive cultivation. In order to implement this suggestion, members engaged in the lac trade at that time constituted themselves into a private registered body under the name of the Indian Lac Association for Research. This Association set up the Indian Lac Research Institute in 1925.

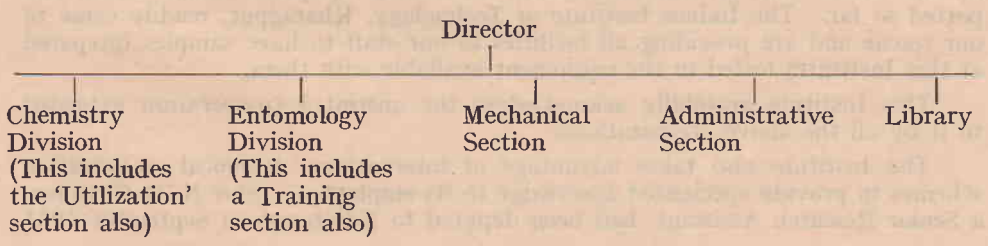
The Association maintained the Institute till 1931 when it was taken over by the Indian Lac Cess Committee, a statutory body formed under an Act of the Central Legislature, on the recommendation of the Royal Commission for Agriculture (1927). With the abolition of this Committee with effect from the 31st March of this year (1966), the Institute is to be taken over by the Indian Council of Agricultural Research under the Ministry of Food and Agriculture, Government of India.

The Institute is situated at Namkum, about nine kilometres east of Ranchi. The laboratories of the Institute consist of three fair-sized separate buildings housing the Chemistry Laboratory, the Entomology Laboratory and the Experimental Factory. Apart from these, the Institute also has an adjoining plot of over 35 hectares for use of an experimental plantation. For outstation experiments, areas/trees have been taken on long term lease.

The Institute is headed by the Director who also functions as Head of the Chemistry Division; the Head of the Division of Entomology is the Entomologist.

Objectives and structure — The main objectives of the Institute is to carry on research towards effecting improvement in the cultivation, processing, standardization and modification of lac through scientific research so as to intensify cultivation and extend utilization. In addition, the Institute is also to carry on publicity and maintain liaison with and provide technical service to the indigeneous industries towards improving the quality of their products and increased utilization of lac.

The present structure of the Institute is indicated in the following plan:



Visitors

This Institute has always been a regular attraction to most visitors to Ranchi particularly scientists and technologists. During the year under report also, it received the usual complement of visitors including students and trainees from different colleges and institutions, officials, and other V.I.Ps. A few deserving special mention are —

1. Dr. B. P. Pal, D.G. & V.P., I.C.A.R.
2. Shri K. P. A. Menon, O.S.D., I.C.A.R.
3. Shri N. S. Sreekantiah, Secretary, I.C.A.R.
4. Dr. S. M. Sikka, Agricultural Commissioner with the Government of India.
5. Development Commissioner, Bihar, Patna.

Reviewing Committee — The Indian Lac Cess Rules provide for the periodic appointment, by the Government of India, of a Reviewing Committee to review the working of the Indian Lac Research Institute and make recommendations for its improvement. One such committee was appointed during the year under report. This consisted of (1) Prof. T. R. Seshadri, F. R. S., Emeritus Professor, Centre of Advanced Study in the Chemistry of Natural Products, University of Delhi as chairman and (2) Dr. V. P. Rao, Chief Entomologist, Commonwealth Institute of Biological Control, Indian Station and (3) Mr. M. Russell, Chief Technical Officer, Messers. Angelo Bros Limited, as members. The committee met at the Institute in the last week of March 1966, went round the Laboratories, plantation and factory and held discussion with the Director and other members of the staff. The report of the committee is awaited.

Collaboration with other institutions — Apart from work within its own premises, the Institute has always sought to take advantage of technical know-how and facilities available in other institutions also for the furtherance of its objectives. A Research Project is being implemented since 1960 under which the constitution of lac is being studied simultaneously (i) at the Chemistry Laboratory of the Delhi University under the guidance of Prof. T. R. Seshadri F.R.S., (ii) at the National Chemical Laboratory, Poona, under the guidance of Dr. Sukh Deo and (iii) at the Department of Chemical Technology, Bombay University, Bombay, under the guidance of Dr. S. V. Puntambekar, an Ex-Director of this Institute. In addition, the constitution of lac dye is also being investigated at the National Chemical Laboratory, Poona, under the guidance of Prof. K. Venkataraman and development of shellac based leather finishes at the Central Leather Research Institute, Madras, both under separate schemes.

Another organization which co-operates with this Institute in its research activities is the Indian Institute of Technology, Kharagpur. In view of the tremendous consumption potential, this Institute initiated work on shellac rubber combinations. A scientist was given the necessary training in the National College of Rubber Technology, London, and a combiroll mill imported for taking up the work. But, for various reasons, the testing equipment could not be imported so far. The Indian Institute of Technology, Kharagpur, readily came to our rescue and are providing all facilities to our staff to have samples (prepared at this Institute) tested in the equipment available with them.

This Institute gratefully acknowledges the unstinted co-operation extended to it by all the above organizations.

The Institute also takes advantage of international technical co-operation schemes to provide specialized knowledge to its employees. Shri N. S. Chauhan, a Senior Research Assistant, had been deputed to Edinburgh in September 1963

for higher training in Insect Genetics at the Institute of Animal Genetics, Edinburgh, under the Colombo Plan. He returned in January 1966 after successfully completing the training and obtaining the M.Sc. degree of that University.

The Institute continued to collaborate, as usual with the Indian Standards Institution in the formulation of Indian Standards for lac and lac products and allied materials, and to extend technical assistance to the Bihar State Lac Co-operative Marketing Federation Limited.

Advisory Services — The Institute provides two courses of training of six months duration (i) on the cultivation of lac and (ii) on industrial uses of lac. The training is given to deputees of Central and State Governments and industrial undertakings.

For the benefit of the trade and industry, the Institute also maintains Regional Analytical Laboratories in the major lac processing centres of the country. Five such laboratories were functioning at the beginning of the year under report, viz. one each at Namkum (Ranchi District, Bihar), Balarampur (Purulia District, West Bengal), Gondia (Bhandara District, Maharashtra), Bilaspur (Madhya Pradesh) and Daltonganj (Palamau District, Bihar). The last two, however, had to be closed down during the year due to poor workload.

Finances — Since its inception, lac research has been financed through a cess levied on all exports of lac. Since 1962-63, however, some grants were also received from the Government of India, as income from the cess was found inadequate.

The revised budget estimates of the Institute for the year 1965-66 amounted to Rs. 13,21,235 only. The actual expenditure during the period, however, was only Rs. 11,21,317, chiefly because most of the vacant posts could not be filled up and imports of items provided for effected in time.

PROGRESS OF RESEARCH

A. ENTOMOLOGY DIVISION

(Entomologist Dr. A. Bhattacharya, M.Sc., Ph.D., D.I.C.)

Work on the various problems were continued as on the approved research programme of the Division (vide Appendix A).

The staff position continued to be difficult as before. The posts of Scientific Officer (Insect Genetics) and Scientific Officer (Biology) remained vacant throughout the year. The S.R.A. of the Insect Genetics Section also left by the end of May 1965. In addition, none of the vacant posts of R.A.s were filled up excepting one, and two R.A.s resigned. The S.O. (Insect Physiology) also resigned and left in December 1965. The weather during the year was also one of the worst for lac due to severe drought which was fairly extensive.

Despite these handicaps, progress in research was maintained. Among the more important findings during the year, particular mention may be made of the conclusion, it has been possible to arrive at after five years of study, that, for obtaining a high yield of *stick lac* from *ber* (*Zizyphus mauritiana*), it is best to harvest the crop (lac) as *ari* during May and not in April or in June/July and that the optimum rate of brood to be used for raising a crop is 1 metre of healthy brood for every 25 metres of inoculable shoots. In the case of *palas* (*Butea monosperma*), however, yield of crop is highest when it is completely harvested as *ari* between 15th and 20th April.

In another experiment on *palas*, the same study relating to harvesting-cum-pruning within October/November, showed that medium inoculation (200 gm of *brood* per tree) during October/November and complete harvesting a year later (i.e., October/November next year) allowing self-inoculation during the intervening June/July gave better results in regard to total yield of *broodlac* and *stick lac*.

Other notable findings were (i) that, the yield of lac per *bhalia* (*Moghania macrophylla*) bush was highest when the elements N.P.K. were supplied as inorganic fertilizers simultaneously. No beneficial effect results by providing N, P and K either individually or in combination of any two, in building up the vigour of the bushes or the yields of lac per bush. (ii) that as a result of breeding studies of the yellow lac insects in relation to the host specificity on four different hosts, it has been possible to show that the body colour of the lac insects is not dependent on the host plant differences. It would appear that the body colour of the insects is largely a function of the genotype and is little influenced by differences in the nutritional environment of the insects.

A detailed report of the results of investigations of the various problems now follows.

I. RESEARCHES COMPLETED

1. Determination of proper time of harvesting and optimum density of larval settlement for *ber* in *Baisakhi* season

The study was initiated in 1960-61 and was conducted every season with the following 9 treatments:

Treatments	Brood rate (used for inoculation in October/ November	Month of harvesting the crop
A	0·5 N	April
B	1·0 N	-do-
C	2·0 N	-do-
D	0·5 N	May
E	1·0 N	-do-
F	2·0 N	-do-
G	0·5 N	June/July
H	1·0 N	-do-
I	2·0 N	-do-

N in the above Table stands for "normal" brood rate which has been fixed arbitrarily as 1 metre of healthy brood for every 25 metres of inoculable shoots.

For the above study, there were 4 replications with 1 tree under each treatment i.e. a total of 36 trees.

Mention was made in the previous report that inoculations for the fifth season for raising the *Baisakhi* 1964-65 crop were carried out in October, 1964 and that after the crop was harvested in October, 1965, the experiment would be concluded. The results obtained during the year under report are presented in Table 1.

The results lead to the following conclusions:

(i) The *ratio* of *stick lac* produced to the *broodlac* used for the inoculation is the maximum where half normal brood rate is used.

(ii) The actual *quantity* of crop (*stick lac*), cut as *ari* or as *broodlac*, is the maximum where the normal brood rate is used for the inoculation.

(iii) Highest yield of *stick lac* is also obtained when the crop is harvested as *ari* in May and not in April.

2. Effect of different levels of Nitrogen on the growth of *bhalia* bushes

The experiment has been in progress for a period of 4 years since 1962. The object was to find out the growth responses of *bhalia* bushes to application of different levels of nitrogen in the form of ammonium sulphate.

TABLE 1 — DETERMINATION OF PROPER TIME OF HARVESTING AND OPTIMUM DENSITY OF LARVAL SETTLEMENT FOR *Ber* IN *Baisakhi* SEASON

Crop data (*Baisakhi* 1964-65)

Treatment	No. of trees	Brood used		Yield obtained (Lac stick)			Yield obtained (stick lac)			Ratio of brood used to yield		Remarks
		Lac stick kg	Stick lac kg	Total kg	Brood kg	Rejected kg	Total kg	Brood kg	Rejected kg	Lac stick	Stick lac	
A (½ Normal)	4	1·4	0·41	7·9	*Ari lac*	7·9	1·47	*Ari lac*	1·47	1: 5·64	1: 6·02	
B (Normal)	4	2·8	0·61	11·9	do	11·9	3·05	do	3·05	1: 4·25	1: 5·0	
C (2 Normal)	4	5·6	1·00	12·75	do	12·75	3·35	do	3·35	1: 2·28	1: 3·35	
D (½ Normal)	4	1·4	0·37	15·65	do	15·65	3·075	do	3·075	1: 11·17	1: 8·31	
E (Normal)	4	2·8	0·54	10·8	do	10·8	2·725	do	2·725	1: 3·85	1: 5·04	
F (2 Normal)	4	5·6	0·95	7·7	do	7·7	1·8	do	1·8	1: 1·37	1: 1·89	
G (½ Normal)	4	1·4	0·31	8·8	0·8	8·0	1·85	0·25	1·60	1: 6·28	1: 5·97	
H (Normal)	4	2·8	0·70	17·05	0·7	16·35	3·50	0·35	2·15	1: 6·08	1: 5·0	
I (2 Normal)	4	5·6	1·30	13·9	1·7	12·2	3·40	0·4	3·00	1: 2·48	1: 2·61	

The lay out was in randomized block design on 640 bushes with the following 5 treatments replicated 8 times and with 16 bushes in each treatment.

Treatments:

A — No Nitrogen (control)
B — 8 kg nitrogen per acre
C — 16 kg „ „
D — 24 kg „ „
E — 32 kg „ „

No apparent advantage was noticeable as the treatments did not show any difference in respect of the height growth of the bushes or the available length of shoots per bush, for lac inoculation.

The experiment was, therefore, discontinued.

3. Effect of N, P and K on the yield of lac on *bhalia*

Trials with inorganic fertilizers:

The experiment was in progress since 1962. It was intended to increase the yield of lac by applying different fertilizers individually and in combination to the bushes to build up their vigour.

The experiments was laid out in randomized block design on 480 bushes with the following 8 treatments, replicated 3 times, and with 20 plants in each treatment.

Treatments:

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

For providing nitrogen, phosphorus and potassium, ammonium sulphate, superphosphate and muriate of potash respectively were applied to the bushes after a fortnight of inoculation as indicated above. The dosage was 30 kg of ammonium sulphate, 30 kg of muriate of potash and 60 kg of superphosphate per acre (1,800 bushes).

It was reported earlier (Annual Report 1964-65) that the experiment was mainly intended for raising *Kusmi* lac but due to lack of suitable brood, the bushes were used to raise the two *Rangeeni* crops. During the year, *Baisakhi* 1964-65 and *Katki* 1965 crops were raised. The *Baisakhi* crop was started in October 1964. The crop was not satisfactory due to severe mortality of insects in the following May (1965) and due to drying up of a large number of bushes on account of prolonged and severe drought during the remaining summer.

In spite of attack by cockroaches in the early stages of the developing *Katki* 1965 crop, and additional predator attack during August, the yield was rather good for this crop.

In both the seasons, it was observed that the yield data did not show any significant difference between the treatments, though the yield per plant was

higher in treatment H. Since the above results were uniform for all the 6 such crops raised so far and no beneficial effect was indicated the experiment has been concluded.

4. Studies on the rate of secretion and composition of honey dew of the lac insect.

During the year under report, inoculations on potted *bhalia* plants were carried out, at the appropriate times, for *Aghani* and *Jethwi* with *kusum broodlac*, and for *Baisakhi* and *Katki* with *palas broodlac*. The same pots were used for both the purposes. Only one shoot was kept on each of the plants on which insects were reared and the rest of the shoots were removed. Insect populations were also thinned out and the honey dew secreted was collected with the help of the rotating drum of a " Curgon Siccatometer " which also enabled determination of the rate of secretion as well. Studies were made almost every fortnight and the honey dew analyzed by paper partition chromatography for the carbohydrate composition. Alongside, two-dimensional standard chromatograms were also prepared for lactose, maltose, glucose, fructose, sorbose, galactose, sucrose, cellobiose, mannose, melezitose, melibiose, rhamnose, arabinose, trehalose, raffinose, ribose, xylose, glycogen, inulin, starch and agar-agar, for comparison.

Results obtained so far regarding the rate of secretion are to be processed and the carbohydrates yet to be identified.

The amino acid components of the honey dew have already been determined and reported last year. Further work had to be suspended as the workers engaged in this investigation resigned and left.

5. Studies on the requirements of major, minor and trace elements and their influence on resin secretion, sex-ratio and facundity etc., of the insect. (By growing host plants in culture solutions under completely controlled conditions and also by foliar spray of the nutrients)

This experiment was initiated during *Katki* season in July, 1963 and was carried out during the same season in 1964 also as the insect passes through the shortest life-cycle at this time.

Failure of the experiment was reported last year (A. Rep. 1964-65). Another attempt was made during the *Katki* season 1965 for conducting the experiment on the same lines.

Six *wilayati babul* (*Acacia farnesiana*) and six *galwang* (*Albizzia lucida*) seedlings were removed and placed in the culture and control solutions. Only 4 each of the seedlings of two species were inoculated with lac insects. Development of the insects continued for some time on only 5 seedlings, viz. on one *wilayati babul* in distilled water, three *wilayati babul* in nutrient solution and one *galwang* in nutrient solution. However, the insects all died much before maturity.

With three successive failures, it was felt that further planning was required. The experiment has, therefore, been discontinued.

6. Breeding studies on the yellow variety of lac insect in relation to host specificity

The study on the yellow variety of lac insects collected from *Ficus* species in Delhi was started in July, 1962 and was continued with a collection from Jodhpur

which was also of yellow colour. The insects were continuously reared every season during *Baisakhi* and *Katki* on *bhalia, galwang, wilayati babul* and *ber*. Progenies were obtained from previous generations on the same hosts.

The continued trials of raising Jodhpur yellow lac insects on the above mentioned hosts have shown no effect of the host plant differences on the body colour of the lac insects. They retained their colour throughout their development. It is therefore, concluded that the body colour of the lac insect is largely a function of the genotype and is little influenced by differences in the nutritional environment of the insects within fairly wide limits. The experiment is concluded.

7. Life history studies and development of breeding techniques for important indigenous parasites

It was reported last year (A. Rep. 1964-65) that studies regarding (a) *Brachymeria tachardiae* Cam. and (b) *Elasmus claripennis* Cam., the former a pupal parasite of both *Eublemma amabilis* Moore. and *Holcocera pulverea* Meyr. and the latter an external parasite of *E. amabilis* had been completed. Routine breeding of these two parasites were carried out on a small scale from August 1965 to January 1966, with the availability of parasites in the field, thereby completing the remaining aspects. (c) *Eurytoma pallidiscapus* Cam. another endoparasite of *H. pulverea* was taken up for study of the life history during the year and a breeding technique was developed by using the alternate (laboratory) host *Corcyra cephalonica* Staint.

The parasite stung the hosts rather reluctantly and in most of the cases eggs were not laid. When the parasite was supplied with hosts (pupa) paralyzed by *B. tachardiae*, eggs could be detected in the host pupae. The parasite was also able to attack the larvae of both *H. pulverea* and *C. cephalonica* when offered in a paralysed state-paralysed by *Microbracon hebetor* Say. and *Perisierola pulveriae* Kurian under laboratory conditions. The parasite larvae showed cannibalistic attitude and mortality in the young stages was rather high.

The following observations were made during the study.

The incubation period varied from 12 to 18 hours and the larval period lasted from 5 to 8 days with an average of 6·8 days. The pupal period varied from 5-9 days (average 7·8 days) and the total life cycle was completed in 14 to 18 days with an average of 15·5 days. The longevity of adults was fairly long and was found to be 11 to 37 days with normal oviposition activity and moistened split raisins as food. The sex ratio was 76·4 females to 23·5 males.

A note on the findings is under preparation. As recommended by the Recent Reviewing Committee — no further studies are to be made of the indigenous parasites; the studies have therefore, been discontinued.

II. RESEARCHES IN HAND

1. Potentiality Trials on *Ber*

Determination of optimum density of larval settlement on ber in Katki season

It was indicated in the previous year's report (A. Rep. 1964-65) that due to the unsatisfactory condition of the *broodlac* used for inoculation, the results obtained were not dependable and that further studies were necessary.

Unfortunately, the *Katki* 1965 crop (June/July to October/November season) could not be raised on the experimental *ber* trees as they did not, after pruning, produce suitable shoots for receiving inoculation. A few more trials are necessary before conclusive results can be obtained.

2. Potentiality Trials on *Palas*

(i) *Determination of optimum density of larval settlement on palas in hot areas (at Kundri)*

The experiment was started at Kundri in 1963 on the same lines as on *kusum* and *ber* which were completed earlier. The brood rate was arbitrarily fixed as 'heavy' and 'light' instead of ½ N, N and 2 N rates since *palas* never produces as many shoots like the other two hosts and, consequently, the area of infectable shoots available is too low.

The experiment was continued for the second year. There were, in all 14 groups (treatments A to N) with 10 trees in each group. Groups A to H were given "heavy inoculation i.e., with *broodlac* ranging from 1·5 kg to 5 kg with increase of 0·5 kg of *broodlac* from treatment to treatment. Groups I to N were given "light" inoculation, i.e., with 0·25 kg to 1·5 kg of *broodlac* with increase of 0·25 kg per treatment as per schedule. The Groups A to H were harvested in April, 1965. The rest (I to N) were left to self-inoculation in June/July and were completely harvested in October/November, 1965 i.e. a year after inoculation. The results obtained are given in Table 2.

It will be seen that, where the crop was collected in the same season, the highest yield of scraped lac was obtained where the rate of *broodlac* used was 4·5 kg for 10 trees, and the crop was harvested as *ari* in April (treatment G), and where the crop was collected one year after inoculation, maximum amount of *broodlac* was available as also the scraped lac when 1·5 kg of *broodlac* was used (treatment N). During October 1965 the whole set of 140 trees were again inoculated as per schedule for further study.

(ii) *Studies on the proper time of harvesting-cum-pruning on palas within April-May*

So far, in lac cultivation, it is the general practice to carry out pruning of the hosts and harvesting of the crop as separate operations. It has been observed from experiments already concluded that the maximum yield of lac (*stick lac* of commerce) is obtained if the harvesting is carried out (as *ari*) during April or May. Hence, study was taken up to see whether pruning and harvesting cannot be carried out at the same time, i.e., utilize harvesting as the pruning operation itself, so that the cost of cultivation could be brought down.

The experiment was continued at Kundri where it has been in progress since 1963. The following five treatments were studied involving different times of pruning and harvesting with 4 replications and 10 trees under each treatment, and laid out in randomized block design in a fixed plot.

Treatment:

A — Complete pruning-cum-harvesting in the first week of April.
B — Complete pruning-cum-harvesting between 15th and 20th April.
C — Partial (i.e., new shoots were left uncut) pruning-cum-harvesting between 15th and 20th April.
D — Complete pruning-and-harvesting between 15th to 20th May.
E — Partial (as in C above) pruning-cum-harvesting between 15th to 20th May.

TABLE 2 — DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT ON *Palas* IN HOT AREAS (AT KUNDRI)

Crop yield data 1964-65 (10 trees under each treatment)

Treatment	Wt. of brood used		Yield obtained in April		Yield obtained in October/November (Lac stick)			Yield obtained in October/November (Stick lac)			Ratios of brood used to yield obtained		
	Lac stick in kg	Scraped lac in kg	Lac stick	Scraped lac	Brood in kg	Rejected in kg	Total in kg	Brood in kg	Rejected in kg	Total in kg	Lac stick	Stick lac	Brood lac
A	1·5	0·275	30·0	3·540							1 : 20	1 : 12·8	
B	2·0	0·300	35·950	5·500							1 : 17·9	1 : 18·3	
C	2·5	0·350	42·550	7·900							1 : 17·2	1 : 22·5	
D	3·0	0·450	31·200	6·900							1 : 10·4	1 : 15·3	
E	3·5	0·600	34·950	8·170							1 : 9·9	1 : 13·6	
F	4·0	0·650	32·700	7·450							1 : 8·1	1 : 11·4	
G	4·5	0·650	41·250	9·150							1 : 9·1	1 : 14·0	
H	5·0	0·700	29·600	7·100							1 : 5·9	1 : 10·1	
I	0·25				9·700	9·300	19·00	0·750	1·400	2·15	1 : 76·0	1 : 25·2	1 : 38·8
J	0·50				11·700	15·200	26·90	1·000	1·700	2·70	1 : 53·8	1 : 14·0	1 : 23·4
K	0·75				12·600	9·900	22·500	1·200	0·800	2·80	1 : 30·0	1 : 10·0	1 : 16·8
L	1·00				14·00	10·600	24·600	1·300	0·600	2·60	1 : 24·6	1 : 8·4	1 : 14·0
M	1·25				9·00	20·600	29·600	0·900	1·600	2·50	1 : 23·6	1 : 10·0	1 : 7·2
N	1·50				15·00	19·900	34·900	1·250	1·600	3·05	1 : 23·2	1 : 11·4	1 : 10·0

All the trees were inoculated in October/November at the rate of 4 kg of *broodlac* per 10 trees and were pruned and harvested as per schedule described above.

It was reported last year (A. Rep. 1964-65) on the basis of the data then obtained that treatments, B and C gave better performance than the rest as regards the yield of *stick lac* per tree.

Results obtained during the year under report are presented in Table 3.

It will be seen that, this year also the same treatments B and C again gave better yields than the rest thus confirming the results obtained in the previous year.

(iii) *Studies on the proper time of harvesting-cum-pruning on palas within October-November*

This study was started in October-November 1962 at Kundri with the same prupose as at (ii) above, i.e. to find out if harvesting can not serve the purpose of pruning also. The following three treatments with different *brood* rates have been set up with 5 replications and 30 trees under each treatment.

A — Heavy inoculation (approximately 400 gm per tree) in October/November and complete harvesting in April.

B — Medium inoculation (approximately 200 gm per tree) in October/November, allowing self inoculation in June/July, and complete harvesting in October/November next year.

C — Light inoculation (approximately 100 gm per tree) on October/November, allowing self inoculation in June/July and complete harvesting in October/November next year.

The inoculations for the second trial were carried out in October 1964 on 150 trees which had been initially pruned in October 1963. The crops were harvested in October 1965.

The average yield per tree under treatment A in 1964 was 0·15 kg. In 1965 the same was 0·61 kg.

In respect of Treatments B and C, yield of *broodlac* per tree in 1964 was 0·46 and 0·49 kg respectively. The figures during the period under report were 0·50 kg and 0·45 kg. Between the treatments B and C, it was found that treatment B was better as regards total yield of *broodlac* and *stick lac*. But treatment C appeared to be superior if the ratio of *brood* used to *brood* obtained is considered.

Inoculations have been carried out for the third time for the next crop to be harvested in 1966.

(iv) *Evolution of cultivation practice for palas at Kundri (Direct comparison of newly evolved plan with villager's method)*

This experiment as reported earlier (A. Rep. 1964-65) was initiated in 1963, and were continued this year also with the following treatments.

Treatments:

A — Heavy inoculation in October/November and complete harvesting in April.

B — Light inoculation in October/November, allowing self inoculation in June-July and complete harvesting in October/November of the following year.

TABLE 3 — STUDIES ON THE PROPERTIME OF HARVESTING CUM PRUNING OF *Palas* DURING APRIL-MAY 1964-65

Treatment	Number of trees	Crop data: Lac sticks: Wt. of brood in kg	Lac sticks: Wt. of phunki lac sticks in kg	Lac sticks: Wt. of lac sticks yield in kg	Brood to yield ratio (lac stick)	Stick lac: Wt. of phunki scraped (stick lac)	Stick lac: Wt. of stick lac yield in kg	Brood to yield ratio (stick lac)	Per tree yield: Lac stick	Per tree yield: Stick lac
A	40	16	6·750	95·000	1: 5·93	2·450	20·050	1: 8·18	2·375	0·51
B	40	16	6·350	109·950	1: 6·87	2·300	28·900	1: 12·55	2·749	0·722
C	40	16	6·050	101·420	1: 6·34	2·250	30·800	1: 13·73	2·535	0·700
D	40	16	5·150	58·400	1: 3·65	1·700	17·027	1: 10·01	1·460	0·425
E	40	16	6·000	72·144	1: 4·51	2·200	18·230	1: 8·28	1·803	0·455

C — Heavy inoculation only once in October/November and thereafter partial harvesting in April and October-November continuously for a number of year.

C is considered to be as villagers' method.

There were 500 trees under each treatment. Inoculations were carried out in treatments A & B during October/November in 1964. C treatment had the inoculation in 1963. The crop was harvested as per schedule in October 1965, and the crop data are presented in Table 4.

It was reported last year that in respect of *broodlac* yield and total yield, treatment B was found to be superior to all other treatments. The present data reveal that in respect of *broodlac* yield, treatment B is better than C like previous year, whereas in respect of *total* yield treatment A was superior to treatment C. Results of A is not in conformity with the data obtained in the previous year.

500 trees each under treatments A and B have been inoculated and the *Baisakhi* 1965-66 crop is fairly satisfactory inspite of the severe drought during 1966 and will be harvested in October 1966.

(v) *Studies to ascertain the most appropriate time for harvesting of palas broodlac for crop inoculation*

The study was undertaken with the start of the lac season in July 1965 with the object of determining the earliest period when *broodlac* could be harvested. This is of interest for purposes of despatching *broodlac* to distant places for inoculation there without any detriment to larval emergence and to subsequent development and production of the crop. The experiment was conducted at Kundri. The plan was to start harvesting *broodlac* once every week from the middle of September and to keep the harvested *broodlac* under observation for emergence of larvae and then use it for inoculation on a set of trees. The collections were to continue weekly till the time of normal emergence. Thus, there would be roughly 6 to 8 treatments depending on the actual time of larval emergence. The final collection was to be treated as control. The inoculated trees were to be left for self inoculation during June/July and the *broodlac* harvested in September (middle)/October of the next year.

The collection of *broodlac* was made according to plan. *Broodlac* from the first three treatments A, B and C (i.e. those harvested on 17th September, 24th September and 1st October respectively) had to be rejected as there was no larval emergence. With the remaining 5 lots (Treatments D.E.F.G. and H harvested on 7th, 15th, 22nd and 29th October and 5th November respectively) inoculations were carried out on 10 trees separately for each lot. Heavy larval mortality was noted in treatment D. In the rest of the treatments, the development was progressing satisfactorily. Harvesting at weekly interval was to begin again from September 1966 for further study.

3. Potentiality Trials on *Bhalia*

(i) *Evolution of cultivation schedule and determination of optimum density of larval settlement on bhalia for growing Aghani and Jethwi crops*

The lay out and design of the experiment was reported in the previous year (A. Rep. 1964-65). It was also pointed out that the bushes were being pruned to bring them into proper condition for receiving the initial inoculation in January, 1966.

TABLE 4 — EVOLUTION OF CULTIVATION PRACTICES FOR *Palas* AT KUNDRI (COMPARISON OF THE NEWLY EVOLVED PLAN WITH VILLAGER'S METHOD)

Crop yield data 1964

Treatment	Lac stick							Stick lac					Remarks
	Brood used in kg	Ari lac yield in April in kg	Brood yield in October in kg	Total yield in October in kg	Total yield in April and October in kg	Brood to brood ratio	Krood to yield ratio	Wt. of brood used in kg	Yield in April in kg	Yield in October in kg	Total yield in in kg	Brood to yield ratio	
A	200	1166·05	—	—	1166·05	—	1: 5·83	32·00	233·90	—	233·90	1: 7·30	
B	50	—	197·00	830·40	830·40	1: 3·94	1: 16·60	6·50	—	106·40	106·40	1: 16·37	
C	84	572·00	70·00	467·50	1039·50	1: 0·83	1: 12·37	11·25	173·20	29·60	202·26	1: 18·00	

Out of 4,320 bushes required in the experiment, about 3,360 were pruned by July 1965 for receiving the inoculations in January 1966 and July 1966. But response of the pruned bushes were extremely poor in the whole plot. 70-90 per cent of the bushes which were pruned in July 1965 died in the following winter. However, elsewhere in the plantation, the growth was much better. It was, therefore, opined that in the particular patch the soil conditions were not suitable.

Attempt is being made for raising the bushes on another patch. About 5,000 seedlings are proposed to be raised and transplanted during June/July 1966.

(ii) *Spacing trials on bhalia*

Although the experiment was being continued since 1960-61, certain flaws were realized later which were reported in the previous year (A. Rep. 1964-65). These were corrected during the year under report by providing 3 coupes for raising continuous and successive crops. At present, three spacings namely 1·83 × 1·83 metres (6′ × 6′), 1·83 × 1·22 metres (6′ × 4′), and 1·22 × 1·22 metres (4′ × 4′) (Treatments A, B and C respectively) with 8 replications are being tried. There are 3 × 8 = 24 plots of 11 × 11 metres (36′ × 36′) with 288, 432 and 648 bushes respectively in each of the treatments A, B and C. Five bushes are kept under observation in each plot.

Shoot study — Coupe No. I — The plants showed continuous linear growth till the end of October 1965 and thereafter the growth ceased. Further growth began again during March 1966. The overall growth of shoots in the bushes, however, was not satisfactory during the year. A large number of shoots of shorter length dried up during May and June owing probably to lack of moisture due to excessive heat.

Coupe II — The plants in coupe II were raised by transplanting of seedlings in July 1965. After transplantation, the plants continued to grow vigorously till the end of October 1965 and thereafter the growth ceased. The second phase of growth was observed during March 1966. Overall growth of shoots in plants in this coupe was somewhat better than in coupe I during the period under report.

Data of height attained, number of shoots developed and length attained are presented in Table 5.

TABLE 5 — SPACING TRIALS ON *Bhalia*
DATA ON SHOOT MEASUREMENT

Coupe No.	Treatment	Plant height in cm	No. of shoots	Total length of shoots per bush in cm
I	A. (6′ × 6′ spacing)	55·3	8·3	299·0
	B. (6′ × 4′ spacing)	72·2	10·8	451·4
	C. (4′ × 4′ spacing)	60·9	9·3	353·4
II	A. (6′ × 6′ spacing)	129·5	7·9	481·7
	B. (6′ × 4′ spacing)	128·2	6·7	416·5
	C. (4′ × 4′ spacing)	135·7	8·3	518·9

While assessing the growth of the individual plants per treatment, it is indicated that treatments B in coupe I and C in coupe II have shown better result than others in respect of height growth.

Coupe III — Transplanting of plants is to be carried out in July 1966.

Inoculation is also to be carried out in coupe II in July 1966.

(iii) *Working out plantation technique of raising bhalia*

The experiment is in progress since 1961. The treatments are as follows:

A — Direct sowing in May with 2 seed per pit
B — ,, ,, 3 ,, ,,
C — ,, June 2 ,, ,,
D — ,, ,, 3 ,, ,,
E — Transplanting 1 seedling per pit raised in March
F — ,, 2 ,, ,, ,,
G — ,, 1 ,, ,, April
H — ,, 2 ,, ,, ,,
I — ,, 1 ,, ,, May
J — ,, 2 ,, ,, ,,

Under this experiment two important factors, e.g. (a) direct sowing of seeds and (b) transplanting of seedlings are combined. There are also two different times of sowing with two seed rates in addition to three different ages of seedlings with two plant rates for transplanting. Thus in all there are 10 $(2\times2 + 3\times2)$ treatments each replicated 4 times. Transplanting is always carried out during July.

Shoot study:

Observations on the height growth, number of shoots developed and the length attained by the shoots were recorded each month till the time of inoculation. Vigorous growth of shoots was observed during the period of May to August 1965 attaining the maximum lengths towards the end of October 1965. Overall growth of the plants was quite satisfactory.

Data regarding the various growths are presented in Table 6.

TABLE 6 — WORKING OUT PLANTATION TECHNIQUE OF RAISING *Bhalia* DATA ON SHOOT MEASUREMENT

Treatment	Average plant height in cm	No. of shoots per plant	Total length of shoots per plant in cm
A	114·4	12·3	829·8
B	121·5	11·5	845·6
C	149·0	18·7	1297·6
D	126·7	13·0	987·8
E	123·1	12·5	821·7
F	143·8	13·5	1056·4
G	132·4	16·5	1198·0
H	150·4	17·9	1525·0
I	128·5	15·1	1027·2
J	134·0	13·4	1000·7

The results indicate that the Treatment H is superior to all other treatments as regards height growth and the length of the shoots. This finding is in conformity with last year's results.

(iv) *Effect of NPK on the yield of lac on bhalia (both with organic and inorganic manures)*

Trials with organic and inorganic manures — The experiment was laid out and started in 1965. The study was undertaken to evaluate the fertilizer requirements and also the different responses if any, when such manures are applied.

The experimental design was simple randomized with four replications and 5 treatments comprising of 20 bushes in each. The number of bushes are 400 ($5 \times 4 \times 20$) in all.

Treatments:

A — $N_1P_1K_1$ (Normal dose — N)
B — $N_2P_2K_2$ (Double Normal dose — 2N)
C — Organic manure (Normal dose)
D — Organic manure (Double normal dose)
E — Control (No manure)

The source of inorganic manure for N, P and K was ammonium sulphate, superphosphate and muriate of potash and the rate (normal dose) was 50 kg, 100 kg and 40 kg respectively per acre (1,800 bushes). Similarly the source of organic manure was farm yard manure with a rate (normal dose) of 18 quintals per acre.

The first inoculations were carried out on *bhalia* bushes in July 1965 and the *Aghani* crop was harvested in February 1966. *Broodlac* used in the experiment was obtained from *bhalia* and the quality was quite good. Fair coverage by lac larvae was observed on bushes of all treatments and the initial larval mortality was 35-40 per cent. Development of lac insects was satisfactory in spite of severe attack and damage caused by *Chrysopa sp.* during August/September. Incidence of *Chrysopa sp.* was observed to be abnormally high this season in comparison to the previous one. Therefore, the crop yield was affected considerably, and hand picking of such predators, resorted to in the middle of September, saved the crop to a great extent. The crop data are presented in Table 7.

TABLE 7 — EFFECT OF NPK ON YIELD OF LAC ON *Bhalia* TRIALS WITH ORGANIC AND INORGANIC FERTILIZERS

Crop data

Treatments	Lac sticks				Scraped lac			
	Brood lac used in kg.	Brood lac yield in kg.	Total yield in kg.	Brood to yield ratio	Brood lac used in kg.	Total yield in kg.	Brood to yield ratio	Yield of lac per plant in gm.
A	15·200	8·900	44·100	1 : 2·9	5·850	9·500	1 : 1·6	118·7
B	15·200	9·200	40·800	1 : 2·7	5·800	8·800	1 : 1·5	110·0
C	15·200	5·000	34·200	1 : 2·2	5·750	6·300	1 : 1·1	78·7
D	15·200	5·300	35·500	1 : 2·3	5·850	6·750	1 : 1·1	84·4
E	15·200	2·900	23·100	1 : 1·5	5·800	4·400	1 : 0·7	55·0

Results indicate significant difference between the treatments. Higher yields of lac were obtained from bushes treated with inorganic manures (NPK). Treatment A gave the maximum yield and yield was reduced (in B) when double N rate of manure (NPK) was applied.

The next inoculations for the *Jethwi* 1966 were carried out in February 1966. The crop will be harvested in July 1966.

4. Evolution of cultivation practices for *kusum* (*Schleichera oleosa*) at Hesal for maximum crop production at minimum cost and working out economics

The experiment is being conducted with the following treatments since July 1961.

Treatments:

A_1 — Rest for 1 year — Inoculation in June/July, allowing self inoculation in January/February and complete cropping in June/July (2 coupe system)

A_2 — Rest for 1 year — Inoculation in January/February, allowing self inoculation in June/July and complete cropping in January/February (2 coupe system)

B_1 — Rest for 2 years — Inoculation in June/July, allowing self inoculation in January/February and complete cropping in June/July (3 coupe system)

B_2 — Rest for 2 years — Inoculation in January/February allowing self inoculation in June/July and complete cropping in January/February (3 coupe system).

C — Rest for $1\frac{1}{2}$ years — Complete cropping after six months (4 coupe system) as in vogue at present.

There are, thus, altogether fourteen coupes being made up of four As (i.e. two A_1 + two A_2), six Bs (i.e. three B_1 + three B_2) and four Cs. Treatments A and B were tried as indicated above so that heavy expenditures involved every six months in *broodlac*, cropping as well as inoculation could be avoided. In A and B, since self inoculation was allowed after the initial artificial inoculation, *broodlac* used at the beginning was relatively small. Thus, whereas *broodlac* used for trees under C treatment was one metre of brood for 12·5 metres of inoculable shoots, for A and B it was one metre of *broodlac* for 30 metres of inoculable shoots. Each coupe had 15 trees.

Lac crops — *Jethwi* (1965)

Due to the meagre quantity of *broodlac* available from the area because of the failure of the previous crop, only partial inoculations had been done in July, 1964 on the trees in coupe C III for *Aghani* crop 1964-65, as well as in coupes A_1 II and B_1 I for *Aghani* cum *Jethwi* crop (vide A. Rep. 1964-65).

The crop from coupe C III was harvested in January/February 1965, but the crop was a failure. The inoculated trees in coupes A_1 II (7) and B_1 I (6) were, however, allowed self inoculation during January/February 1965 as per schedule and were harvested in July 1965 i.e., one year after the first inoculation. The crop was again a failure as only negligible yields were obtained. The trees in the above mentioned coupes which did not have lac were all pruned during January/February 1965, as intended, to maintain the sequence.

Aghani (1965-66) — During July 1965, sufficient quantity of *broodlac* was not available and the quality of *broodlac* obtained was also poor. However, inoculations were carried out with this *broodlac* on 15 trees each in coupes A_1 I and B_2 II for *Aghani* cum *Jethwi* crop and on only 13 trees in coupe C_1. The trees in coupes A_1 I and B_1 II are to be completely harvested in July 1966 after allowing self inoculation during January/February 1966. The crops on C_1 were harvested in January/February 1966. Only 5 trees had a little lac. They together yielded 3·50 kg of *broodlac*. The prospects of the crop in the remaining coupes were also poor and only 5 (in A_1 I) and 8 (B_1 II) trees were bearing crop to a little extent.

Jethwi (1966) — During January 1966, all the 45 trees, i.e., 15 each in the coupes A_2 I, B_2 II and C II were inoculated and the conditions of the crop on all the trees in each of the coupes were found to be exceptionally good by the end of March 1966. The crop from coupe C II only is to be harvested in July 1966, and the remaining left for self inoculation as per schedule.

During January 1966, 30 trees (15 each) in coupes A_2 II and B_2 I were pruned as these were meant to be harvested if there had been crop on these.

The years 1964 and 1965 were extremely poor for lac crops which resulted in acute shortage in *broodlac* and, as a consequence, the progress of our experiments was hampered considerably.

5. Studies on training of major lac hosts, e.g. *palas*, *ber*, *kusum*, *galwang* and rain tree into bushes for lac cultivation

This study was undertaken to determine whether the established lac hosts could be trained into bushes suitable for cultivating lac.

While conducting the study, the effect of repeated coppicing, growth response of the shoots and the economics of lac cultivation were also considered.

It was reported last year (A. Rep. 1964-65) that the trained bushes of *galwang* were brought under cultivation for the first time in 1964 and that *palas*, *ber* and *kusum* were in the process of being turned into bushes.

During the year under report, beside *galwang*, *ber* and *palas* trained into bushes were also brought under lac cultivation as follows:

Galwang — A set of 100 bushes having one year old shoots was inoculated with *Rangeeni* strain of lac insects in October 1965 for raising *Baisakhi* 1965-66 crop. The crop is progressing satisfactorily and will be harvested in June/July 1966.

The harvested lac will be used on *ber* bushes for raising the *Katki* 1966 crop with a view to alternate these two hosts during the respective seasons (crops) as indicated.

Ber — A set of 20 bushes with five months old shoots were inoculated for raising the *Baisakhi* 1965-66 crop. The development of lac insects has been found to be quite good. The crop will be harvested in May 1966 for maximizing crop production since it is a known fact that this species of host cannot sustain the insects during the summer to maturity.

Palas — Another set of 50 bushes was inoculated with *palas broodlac* (*Rangeeni*) for raising the *Baisakhi* 1965-66 crop. The crop is progressing satisfactorily.

Kusum — Attention is being paid to coppice the trees suitably to train these into bushes. The response of shoot growth so far is encouraging.

Rain tree (*Samanea saman*) — Seedlings have been raised and are growing well. At the appropriate time, they will be trained into bushes.

6. Finding out alternate hosts for *Kusmi* strain of lac insects and conducting cultivation experiments on them (e.g. *galwang*, *sandan*, *Ficus* sp. *Moghania chappar*, rain tree, etc.)

The experiments are in operation since 1962-63. It had already been reported, that the progress of the experiment was retarded due to *non-availability* of *kusum broodlac* for the last three or four seasons, (A. Rep. 1964-65).

However, fresh inoculations were carried out on *galwang* and *sandan* (*Ougeinia oojeinensis*) during July 1965 for raising the *Aghani* 1965-66 crop. In both the hosts, shoots had a fair coverage by the larvae which showed an initial mortality of 40-50 per cent. The crop, however, was damaged by *Chrysopa* attack at an early stage and, later during September by predators.

The crops were harvested in January/February 1966. The results obtained are presented in Table 8 below. Since encouraging results were obtained with *galwang*, which produced more *broodlac* than the quantity used for original inoculation, another set of *galwang* was inoculated with that *broodlac* for raising the *Jethwi* crop. Since no *broodlac* was produced on *sandan*, further inoculations on this host could not be carried out in this season.

TABLE 8 — FINDING OUT ALTERNATE HOSTS FOR THE *Kusmi* STRAIN OF LAC INSECTS

Species	Crop data					
	Lac sticks			Scraped lac		
	Brood lac used in kg.	Brood lac yield in kg.	Total yield in kg.	Brood lac used in kg.	Total yield in kg.	Remarks
A. lucida	6·500	9·700	18·200	2·400	4·350	Encouraging results are obtained
O. oojeinensis	6·700	—	10·500	2·300	2·600	Not suitable for raising Aghani crop

The proposed line of study on the above species of hosts would be as follows:

(i) *Galwang* and *sandan* will be alternated with *kusum*. Therefore, suitable inoculations were carried out for raising *Jethwi* crop (1966) on these two hosts.

(ii) Utilization of both *galwang* and *sandan* will be made for continuous rearing of *Kusmi* strain of lac insects (without any alternation).

(iii) *Galwang* will be used for raising *Jethwi* crops only and the resulting *broodlac* obtained will be transferred to *bhalia* for raising *Aghani* crops and *vice versa*.

7. Genetical and Breeding studies

(i) *Collection of various species, races and strains of lac insects from different geographical areas of the country and from neighbouring countries, and studies on their isolation, taxonomic characters and performance*

The taxonomical portion of the above study was taken up in 1963-64. It was reported during 1964-65 that on the basis of detailed taxonomic studies it was possible to separate tentatively two new species.

Thus two new species have been proposed to be added to the genus *Kerria* Targioni (Homoptera-Tachardiidae) which already contains 15 valid species. The two new species are (i) *Kerria chamberlini* sp. nov. from Rajasthan and named after late Dr. J. C. Chamberlin and (ii) *Kerria brancheatus* sp. nov. from Namkum, Ranchi, Bihar. *K. chamberlini* is yellow and grows on *Ficus* sp. Its distinguishing characters are 6-9 dimples on the branchial crater; branchial plate with a feeble collar and the dorsal spine is 2/3 in length to the width of branchial plate. *K. brancheatus* can be distinguished as red and grows on *kusum* and is smaller. It has distinctly club shaped and highly chitinized branchia.

Abstract of a paper on these findings has been published in the Proceedings of the 53rd session of the Indian Science Congress.

(ii) *Studies on crosses between Rangeeni and Kusmi strains of lac insects and also between the two colour forms of Rangeeni strains*

The work was taken up during the 1959 *Katki* season. The *Rangeeni* and *Kusmi* strains of insects were crossed along with reciprocal crossings. The insects, were reared in family lines on *bhalia* potted plants, the developing colonies were protected with 100 mesh wire-net sleeve cages. During the year under report the following rearings were undertaken.

(a) *Crosses between Rangeeni females* × *Kusmi males and vice versa* — It was reported that the last segregation occurred in F_3 generation (A. Rep. 1964-65) and two separate lines were continued to be bred.

Kusmi line — There was no further segregation in the following progenies up to the 6th generation, the females of which matured and produced the 7th generation larvae in December 1965. The 7th generation is developing without showing any change.

Rangeeni line — Similarly, in this case also no segregation was noticed in the 6th generation, the females giving rise to 7th generation larvae in October 1965 like the normal *Katki* progeny. The progeny is developing satisfactorily.

The data obtained so far imply that (1) the two strains (?) can freely interbreed giving rise to F_1 hybrid which intimately resemble the mother, (2) Segregation of the two strains (?) in F_2 and F_3 explains the early emergence frequently reported from certain localities and often referred as "spurious emergence" (A. Rep. 1963-64) and (3) The difference in the maturity time in the two strains are genetically controlled as has been evidenced from the clear cut segregation. The segregation ratio fits well with 3:1 ratio, and is suggestive of a single gene difference causing variation in the maturity time.

(b) *Crosses between crimson and yellow forms of lac insects* — The F_2 generation (A. Rep. 1964-65) as a result of the parent crossing between *Kusmi* (crimson) ♀♀×*Rangeeni* Yellow ♂♂ gave rise to F_3 generation which ultimately matured in January 1965 again giving rise to F_4 progeny which did not survive till crop maturity but died in April 1965. Therefore, the study was started afresh during June/July 1965 with the parents as mentioned above. F_1 hybrid progeny was obtained in January/February 1966. It resembled the mother in all respects and is developing satisfactorily.

(iii) *Evolution of a better yielding strain of lac insect through selection*

The study was begun during the 1961-62 *Baisakhi* season, and were continued on the same lines as reported earlier (A. Rep. 1964-65).

During the year under report, two further generations were reared, but no conclusive results could be obtained. It appeared that the size of the females and the fecundity depends mainly on the complete or incomplete impregnation.

(iv) *Isolation of pure yellow strain of lac insects*

This study was taken up again in *Katki* 1962 season. It was mentioned in the previous year's report that the purity of yellow colour was maintained throughout (in the 4th and 5th generations). During the intervening period, three further generations were raised (6th, 7th and 8th) and the 9th generation is in progress. So far, the yellow colour has been maintained without any change.

The 4th field crop (*Baisakhi* 1965-66 — 9th generation) is in progress also.

8. Biological and Ecological studies

(i) *Collecting of pests of lac host trees, and studies on the life-history and control operations against important pests*

(a) On *bhalia* and *ghont* (*Zizyphus xylopyra*)

The under-mentioned insects were under study from the previous year.

a_1 — *Hypena iconicallis* Walk.— Incidence of the pest was recorded on *bhalia* from June to November 1965 in the Namkum plantation and thereafter none of the stages could be found till March 1966. Adult females failed to lay in captivity when further attempts were made this year also. Therefore, the insects were bred on plants provided with sleeve cages inside which the adults were released.

The preoviposition and oviposition periods as observed this year, were 4 days, 2-5 days and fecundity 31-46 eggs. These differed very much from the observations made in the previous year. The study of the life history has been completed. A paper is being prepared for publication.

a_2 — *Platypeplus aprobola* Meyr.— The identification of this pest was reported last year. This is a leaf binder-cum-defoliator of *bhalia* and was found to be active during the period July to November 1965. The study was completed and the results obtained during the two previous years are being compiled.

a_3 — The tussock moth caterpillar identified as *Dasychira mendosa* Hub. (var. *fusiformis* Walk.) (A. Rep. 1964-65) was under study during the year. The activity of the pest was observed on the tender leaves of *bhalia* seedlings from July to December 1965. Some stray caterpillars were also observed during January and February 1966; the peak period of activity was, however, July to September. Five generations were reared in the laboratory from July 1965 to January 1966.

The preoviposition and oviposition periods were 2-3 days and 4-6 days respectively and eggs laid were 240-520. Larval period lasted 12-53 days, pupal period 7-19 days and the total life cycle was 26-78 days.

a_4 — Data on *Euproctis fraterna* Moore. was compiled for a paper which is under preparation.

a_5 — One of the lepidopterous defoliators *Belippa laleana* Moore, was not found in sufficient numbers in any of the hosts — *bhalia*, *ghont*, *ber* or *palas* as recorded last year. Hence further work could not progress.

a_6 — One of the unidentified leaf defoliators (A. Rep., 1964-65) was got identified as *Prodenia litura* Boisd. This is recorded to be a serious pest of tobacco and is a polyphagous species, but in Namkum it was found on *bhalia*. It was active during October to December 1965. From October to March 1966, three generations were reared in the laboratory for life history studies and the fourth generation is in progress.

The preoviposition and oviposition periods were 2-4 days, 3-4 days and eggs laid per female 183-1341. Larval period was 17-40 days, pupal period 8-32 days and total life cycle 33-78 days.

(b) On lac hosts other than *bhalia* and *ghont*. b_1 — The caterpillars of the Limacodid, a defoliator of *palas* which pupated (A. Rep. 1964-65) in November 1964, remained in that stage till late June 1965.

The adults, on emerging, started egg laying and passed into the third generation. From June 1965 to November 1965, it passed through third generation and part of the fourth generation (egg and larval stage) and pupated by 1st week of December 1965. The egg and larval stages during 3rd and 4th generations were 6-8, 40-45, and 7-8 and 38-50 days respectively. Pupal stage in the 3rd generation lasted 27-34 days. It remained active during one generation in a year and a part of the second generation and entered into a prolonged diapause from late November or early December to June/July of the next year.

b_2 — *Coried bug on palas* — Due to large scale mortality of the 2nd and 3rd instar nymphs of the first generation, as reported earlier (A. Rep. 1964-65) the laboratory culture was lost in May 1965. During the year, fresh material was collected in June (cf. July of last year) and studies begun again. By continuous rearing, the bug passed through seven generations by the end of March and is at present in the 8th generation. Till September 1965, it had completed four generations when the egg and nymphal period was 6-8 and 28-30 days respectively whereas in the remaining period the respective larval and nymphal periods were prolonged to 7-9 and 36-41 days on the average.

No other pests were encountered during the year under report. Control aspects will be taken up later.

(ii) *Surveys of lac enemies and their parasites*

(a) *General Survey-Qualitative* — The qualitative survey of inimical insects associated with lac under a reoriented study was taken up in November 1964, with the start of the *Baisakhi* season 1964-65, by inoculating two species of hosts, e.g. *palas* and *galwang* as reported last year.

The next available season started from January/February, 1965 for *Jethwi* which could not be availed of as no inoculations could be done due to scarcity of *Kusmi broodlac*. The intention was that this survey should be carried out in all the four lac seasons for a few years for determining the activity of the different inimical insects throughout the developing period of the lac insect.

In June/July 1965, when the two seasons *Aghani* and *Katki* start together, 8 *kusum* and 25 *bhalia* bushes were inoculated with *kusum broodlac* for *Aghani* 1965-66 crop, and 8 *palas* along with 4 *galwang* trees with *Rangeeni broodlac* for *Katki* 1965 crop for the supply of samples for the survey.

Subsequently, for *Baisakhi* 1965-66 crop, the required number of *palas* and *galwang* were inoculated once more in late November 1965 and another set of *kusum* and *bhalia* were used for raising the *Jethwi* 1966.

Excepting the first fortnight in which the *phunki* lacs were caged, regular collections of samples were made from the respective hosts and crops fortnightly and caged for noting the emergence.

Since the table indicating the hosts, crops, the insects emerged during the 13 fortnights (for *Kusmi* crops) from the different crops will be too unwieldy, the data is not presented. But it will suffice to point out that the Eulophid, *Tetrastichus purpureus* Cam. emerged continously for 6 fortnights from the samples of the *Katki* crops on *palas* and *galwang* till 1st November (collection) and for 9 fortnights (till 15th January 1966) excepting the 8th from the *Aghani* crop. However, the maximum number emerged in the 2nd fortnight following *phunki* removal from both the crops. The second most numerous species was the Inchneumonid, *Pristomerous sulci* Mahd. & Kolubajiv. The predators, *E. amabilis* and *H. pulverea* were, by far, the most persistant and numerous and emerged during all the fortnights till the crops were harvested.

Whereas, in the *Baisakhi* crop on *palas* and *galwang*, no emergences took place from samples collected during 2nd and 3rd fortnights till the end of March, 1966, the samples of the subsequent three fortnights showed emergence, when predators were conspicuous by their absence.

Emergences had not yet started from samples of the *Jethwi* crop 1966, at the end of the period of this report.

(b) *Seasonal incidence and extent of damage by predators on Kusmi strain of lac grown on bhalia* — This work was started in 1962. It was reported last year (A. Rep. 1964-65) that no studies could be made during the year as no *kusum broodlac* was available in either of the two seasons and it was expected to restart the study from July 1965.

Accordingly, during the year under report, 866 *bhalia* bushes were inoculated in July 1965 with *kusmi* strain of lac for *Aghani* 1965-66 crop, and thereafter the routine collection of sample from randomly selected bushes as per schedule were made every fortnight from 25 bushes — and samples were preserved suitably for microscopical examination. The examination of such a large number of samples could not be taken up soon after. Subsequently the R. A. incharge of the project resigned and left. Hence the progress of work was hampered.

The second inoculation after the break, was carried out during January/ February 1966 for the *Jethwi* 1966 crop on 400 bushes. Sample collection for examination will be started from middle of April 1966 every fortnight.

9. Biological Control of Lac enemies

Control of lac predators by use of Bacillus thuringiensis Berliner

Mention was made in the last report, that preliminary trials had indicated that the two predators of lac insect were susceptible to *Bacillus thuringiensis* Berliner. and that further work was being planned (A. Rep. 1964-65).

During the period under report the work was continued.

Another most recent formulation of this bacillus namely Thuricide " 90 T.S. flowable " or Thuricide 'R' in liquid form was obtained from Stauffer Chemical Company of New York (U.S.A.) and again small scale trials in the laboratory and field were conducted. The laboratory trials confirmed the previous findings.

Encouraged by the above results, a field trial on a small scale was carried out on *Katki* 1965 crop on 100 bushes of *bhalia*. Two variations were tried, viz. (i) concentration and (ii) number and periodicity of spraying.

(a) *Concentration* — Four concentrations were tried viz., 0·015, 0·03, 0·04 and 0·06 per cent.

(b) *Number of periodicity of sprays* — Here again four conditions were tried viz., 3 sprays at 3 weeks interval, 4 sprays at 2 weeks interval, 6 sprays at 2 weeks interval and 4-8 sprays at weekly intervals.

There were three replications; two of these replications with 2 bushes in each and the third replication with 1 bush. Thus there were $4 \times 5 \times 5 = 100$ bushes under trial.

The lac crop was harvested on maturity and caged for noting the emergence of predatory adults. The results revealed that all the concentrations at the various intervals were effective and significant control of both the predatory insects was observed as compared to the control.

Further, beneficial insects such as *Bracon greeni* Ash. and *E. claripennis* emerged from both the treated and control cages in more or less the same numbers indicating that they were not adversely affected by the *bacillus*.

A paper on this study is being compiled on the results obtained so far.

10. Chemical control of lac insect parasites and predators

Effect of different insecticidal sprays on the incidence of parasites and predators attacking Kusmi lac crops grown on bhalia

It was reported last year that during January/February 1965, a partial inoculation could be made on only 120 bushes (out of 300) due to lack of *brood-lac* for the trial, but the resulting crop failed and full scale trials were expected to be started from July onwards. Accordingly, the study was initiated during *Aghani* 1965-66 crop when only 180 bushes out of 300 inoculated during July 1965 could be utilized. Insecticides used were "Cryolite", "Sodium fluosilicate" and "Lead arsenate". Because of the non-availability of the 4th stomach poison, "Dieldrex" was also tried. The first three were used at a concentration of 0·4 per cent and the last at 0·25 per cent. Since lead arsenate appeared to have some scorching effect on the foliage it was applied mixed with an equal quantity of lime.

The crop, which was extremely poor, was caged and the samples were examined daily for emergence of insects. No insects emerged.

Further inoculations were carried out on 200 bushes for *Jethwi* 1966 in January/February 1966. In March 1966 the condition of the crop was not at all satisfactory and only 25 bushes could be selected for application of the insecticides. Two sprayings were applied during the period.

11. Regional Field Research Station

(i) JHALDA (West Bengal)

This research station was closed down during the year on completion of the major problems of study there. The staff has been transferred to Namkum.

(ii) DAMOH (Madhya Pradesh)

(a) *Studies on the response of ghont to pruning to grow lac crops and systematic cultivation of lac on this host* — The study was continued. The experimental details are as follows:

Treatments for *Katki* crop:

A. Pruning at the time of harvesting in November } Every year
B. Pruning in the second week of February }
C. Pruning in the second week of May } 2 C Treatments operated in alternate years

Treatments for *Baisakhi* crop
A. Pruning in the second week of April
B. Pruning in the third week of May
C. Pruning in November

Shoot measurement studies revealed that only in treatment C under *Katki*, the trees produced the maximum number of primaries and secondaries which also attained the maximum length i.e. the available space for the larvae to settle was the maximum. In this respect this conformed with the previous year's findings. In respect of crop, however, the output was lower than the *brood* used.

In the case of treatments under *Baisakhi* the development of shoot, after pruning at three different times did not show any definite trend.

(b) *Determination of optimum requirement of broodlac for crop inoculation on ghont* — The experiment was continued with the object of finding out the effect of different densities of different *broodlac* rates on the ultimate crop as well as on *brood* preservation in both *Baisakhi* and *Katki* crops.

The revised treatment (A. Rep. 1963-64) are as follows:

Treatments:

A. Normal *brood* rate (Average 400 gm per tree)
B. Double-normal *brood* rate (Average 800 gm, per tree)
C. Triple normal *brood* rate (Average 1,200 gm, per tree)

No conclusions could be drawn from the results of *Baisakhi* crop since the crop failed. In the case of the *Katki* crop the results indicate that A treatment is better than B and C. In the previous year's *Baisakhi*, also A treatment was better.

(c) *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.

The modified details as indicated last year are as follows:

Treatments:

A — Pruning in April, light inoculation (average 200 gm *brood* per tree) in October/November, no partial harvesting in June/July and complete harvesting in October/November next year.

B — Pruning in April, normal inoculation (average 400 gm *brood* per tree) in October/November, no partial harvesting in June/July, and complete harvesting in October/November, next year.

C — Pruning in April, heavy inoculation (average 800 gm *broood* per tree) in October/November, *ari* cutting in April and May next year.

D — Pruning in October/November, light inoculation (average 200 gm *brood* per tree) in October/November next year, no partial harvesting in June/July, complete harvesting in following October/November. Thereafter this harvesting is also to serve as pruning.

E — Pruning in October/November, light inoculation in October/November, next year, partial harvesting in June/July, complete harvesting in following October/November. Thereafter, this harvesting also to serve as pruning.

Each treatment was tried on 5 trees and in 10 replications. Each treatment contained two coupes for use in alternate years. Thus, there are 500 trees under this experiment.

The crops failed in A, D and E-treatments and the yield was negligible in B and C.

(d) *Permanent field experiment for working out economics of cultivation of Kusmi and Rangeeni lac on bhalia under different conditions of manuring and irrigation* — By the end of March 1966 only 1 per cent of transplanted plants were surviving. These plants suffered due to termite attack and drought during May 1965.

(e) *Investigation of likely Rangeeni hosts occurring in the region and their proper use to supplement production of ghont lac* — *Baisakhi* 1964-65 crop on 5 *khair* trees inoculated with *ghont broodlac* could not survive through the summer and failed.

(f) *Selection and introduction of suitable regional* or *exotic hosts to fortify cultivation of lac on ghont* — All the 25 plants of rain tree and *galwang* died. Fresh attempts to raise other hosts will be made again.

(g) *Relative importance of enemy and friendly insects* — From mature *Katki* crop, the following common parasites and predators emerged: *T. purpureus, Parechrodryinus clavicornis* Cam., *Tachardiaephagus tachardiae* How., *Coccophagus tschirchii* Mahd., *Apanteles tachardiae* Cam., *E. pallidiscapus, B. tachardiae, Tachardiaephagus somervilli* Mahd., *B. greeni, E. amabilis* and *H. pulverea.*

From immature *Katki* crop, except for the following five all other insects as from mature *Katki* crop (above) were recorded: *T. somervilli, E. pallidiscapus, B. greeni, B. tachardiae* and *A. tachardiae. Ereneyrtus dewitzi* Mahd. which was not recorded from mature *Katki* crop emerged from immature *Katki* lac.

From immature *Baisakhi* crop *T. purpureus* alone was recorded.

(iii) MIRZAPUR (Uttar Pradesh)

(a) *Studies on the response of ghont to pruning to grow lac crops and systematic cultivation of lac on this host* — This experiment is being conducted on the same lines as at Damoh.

Both the crops — *Baisakhi* 1964-65 and *Katki* 1965 were failures.

Data on shoot measurement indicate that in *Baisakhi* period, B treatment gave better response to pruning than A and C and hence the results are at variance with previous years findings. In *Katki* period, C treatment gave better response than the others confirming the previous years' findings.

(b) *Determination of the optimum requirement of broodlac for crop inoculations on ghont and palas* — This experiment is also being conducted on the same lines as in Damoh.

Both the *Baisakhi* and *Katki* crops on *ghont* failed.

Results on *palas* trees indicate that A treatment (½ Normal *brood* rate) was better than B, C and D (normal, double normal and triple normal *brood* rate) during *Baisakhi* 1964-65 crop thus confirming the previous year's findings.

Results on *palas* during *Katki* period were not conclusive since the crop failed.

(c) *Evolution of a suitable cultivation practice to be followed for ghont and palas* — This experiment is also being conducted on the same lines as in Damoh, but with a slight modification in respect of standard (N) weights of *brood* rates — which, for *ghont*, was fixed at 500 gm as normal and for *palas* at 800 gm.

Results with *ghont* trees were not conclusive since the crop failed, where as with *palas* treatment C yielded better crop than D, A, B and E. However, previous year's findings in the case of *palas* were as D, A, E, B and C in descending order of performance.

(d) *Permanent field experiments for working out economics of cultivation of Kusmi and Rangeeni lac on bhalia under different conditions of manuring and irrigation* — This experiment is being conducted on the same lines as in Damoh.

For the first time when the bushes were available in a suitable condition, inoculations could be carried out on *bhalia* bushes for *Katki* crop on 1000 bushes with *palas broodlac* and 600 bushes with *kusum broodlac* for *Jethwi* crop during July 1965 and January 1965 respectively.

Neither of these crops could survive and ultimately failed due to extreme drought prevailing in the region.

(e) *Investigation of likely Rangeeni hosts occurring in the region and their proper use to supplement production of ghont lac — Katki* as well as *Baisakhi* crops succeeded on *kuchai*, but failed on rest of the hosts e.g., *karonda, ail, katmahuli, bansa* and *amaltas* under trial.

(f) *Selection and introduction of suitable regional or exotic hosts to fortify cultivation of lac on ghont* — Crop failed on all the plants of *bhalia*. Attempts are being made to raise another set of *bhalia* and other hosts for the purpose.

(g) *Relative importance of enemy and friendly insects* — From immature *Baisakhi* 1964-65 crop, the following common parasites and predators emerged. *T. purpureus, Eupelmus tachardiae* How., *P. clavicornis, E. dewitzi, T. tachardiae, A. tachardiae, Chelonella* sp. *Tineidae, Coleoptera* (beetles), *H. pulverea* and *E. amabilis*.

From mature *Baisakhi* 1964-65 crop, the following insects in addition to those emerged from immature crop (above) were also recorded.

E. pallidiscapus, B. greeni, P. sulci and *Ephestia* sp.

From mature *Katki* 1965 crop, the following insects in addition to those already recorded from immature and mature *Baisakhi* crop were also recorded:

E. claripennis, T. somervilli, Marietta javensis How. and *Perisierola* sp.

(iv) UMARIA (Madhya Pradesh)

(a) *Evolution of cultivation practice to be followed for kusum* — The experiment was laid out as at Hesal having following treatments:

Treatments

A — One year rest between pruning and inoculation i.e., 2 coupe system. There are 4 coupes under this treatment with 15 trees in each. Two coupes are

to be used in alternate years for inoculation in January/February, followed by self inoculation in June/July and harvesting in January/February next.

The other two coupes are to 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 years rest between pruning and inoculation i.e., three coupe system. There are 6 coupes under this treatment with 15 trees in each. Three coupes are to 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 four coupe system. There are 15 trees in each coupe. Each coupe is to be used as usual for one crop every season, without leaving for self inoculation. Harvesting in all the above treatments is also to serve as pruning.

Results indicate that A treatment was better than B and C during *Aghani* period whereas B treatment gave better results than A and C during *Jethwi*. Further studies were discontinued in view of the proposed shifting of the station to Dharamjaigarh.

(b) *Investigation of likely Kusmi hosts occurring in the region and their proper use to supplement production of Kusmi lac* — Both *Jethwi* and *Aghani* crops failed on *dhoben, renja, ghont* and *sharifa* but succeeded on *khair* trees only.

(c) *Selection and introduction of suitable regional or exotic hosts to fortify cultivation of lac on kusum* — Further attempts were not made to raise such hosts in view of the decision to shift the station to Dharmjaigarh.

(d) *Studies on the relative importance of enemy and friendly insects* — From immature *Aghani* 1964-65 crop no emergence of insect took place.

From immature *Aghani* 1965-66 the following common parasites and predators emerged *Apanteles fakhrulhajiae* Mahd., *T. somervilli, T. purpureus, T. tachardiae, E. tachardiae, E. amabilis* and *H. pulverea.*

From mature *Aghani* 1965-66 crop, only *E. amabilis* and *H. pulverea* the major predators of lac emerged.

(e) *Permanent field experiment for working out economics of cultivation of Kusmi and Rangeeni lac on bhalia under different conditions of manuring and irrigation* — All the remaining seedlings (150) of the previous year as well as 1200 seedlings transplanted during current year died.

12. Plantation at Namkum

The general upkeep of the plantation was looked after as far as possible. Due to shortage of labour, hoeing and weeding operations could not be carried out systematically throughout the plantation.

Young plants of several lac hosts were raised in the nursery beds for both planting in the gaps in the plantation and for use in the laboratory for experiments.

Bhalia seeds were supplied to various states as well as to the Chief Lac Development Officer for raising plantations of the bush.

III. RESEARCHES CONTEMPLATED

Under this head are listed experiments which are contemplated to be taken up. These include a few of the experiments which were suspended or had not

been taken up because of the staff position and those for which facilities were lacking.

1. Permanent field experiments for working out economics of cultivation of *Kusmi* lac on *M. macrophylla* under different conditions of manuring and irrigation

The layout and design of the experiment was reported last year (A. Rep. 1964-65). It was also remarked that the experiment will have to remain suspended till irrigation facilities are arranged. The study will be taken up when facilities and staff are provided.

2. Studies on varietal trials on major lac hosts — *ber, palas, kusum, arhar* (perennial), *bhalia, Acacia catechu, A. arabica* and *ghont*

This is an approved item on the programme. The objective is to study whether the different varieties of host trees apart from the existing ones will serve as suitable hosts.

The work could not be taken up due to lack of suitable staff.

3. Finding of and trials, as *brood* preservers on alternate lac hosts for *Baisakhi* crop for the *Rangeeni* strain of lac insects

The object of the experiment is to find out some alternate host plants for preserving *Baisakhi broodlac* specially during summer seasons and particularly in dry and arid zones.

Alternate hosts such as *Albizzia richardiana* and rain tree are being raised for this purpose. When the plants develop to suitable size trials will be started.

4. Studies on vegetative propagation in different varieties of major lac hosts

The object is to encourage quicker establishment of groves of varieties of lac hosts found suitable for lac cultivation.

Due to lack of suitable staff the study could not be initiated. It will be undertaken when staff is recruited.

5. Physiological studies

(i) *Rearing of lac insects under controlled environments through artificial feeding.*

(ii) *Studies on the secretion of colour of lac resin.*

(iii) (a) *Studies on the relation of host to the fecundity and resin secretion efficiency of the Rangeeni strain of lac insect.*

(b) *Studies on the relation of host to the fecundity and resin secretion efficiency of the Kusmi strain of lac insect.*

The above items of work could not be taken up as one of the Research Assistants and the Insect Physiologist resigned and left in September and December 1965 respectively.

The study will be resumed when the necessary staff is recruited.

6. Physiological studies on the secretion of resin and build up of lac cell

This problem, was to be under taken along with 5 (iii a, b) above as proposed earlier (A. Rep. 1964-65) but could not be undertaken due to acute staff position in the section indicated above.

7. A comparative study of the components of plant sap of major and minor hosts with an idea to get some information regarding the factors which limit their relative performances as lac hosts

The main objective is to find the differences in the constituents of the saps of the host plants which determine their functioning as suitable hosts.

The study on the problem was initiated in 1964 and the little progress made was reported (A. Rep. 1964-65). Further progress could not be made due to lack of proper staff. Since the study is an important one it will be resumed when suitable staff is made available.

8. Amino acids and sugar content of the lac insect body at different developmental stages

This additional problem (outside the approved programme) was undertaken for study during 1964, with a view to correlate the amino acids and sugars of the honeydew (excreted by the insect), those in the plant sap and in the body fluid of the lac insects. The study was in progress during the year but had to be suspended because the staff resigned and left.

The study of the sugar contents will be taken up again at a suitable time when staff is available.

9. Biological and Ecological studies — Studies on the inter-relationship between the population of the predators and their parasites under different ecological conditions (under grove or plantation condition and under scattered conditions) and also by providing hosts in cages in the field

Due to the lack of facility, staff etc the study could not be started.

10. Ecological studies including the influence of various temperatures and humidity conditions on the growth and development of the lac insect predators, *E. amabilis* and *H. pulverea*

No progress could be made further as the staff position became worse.

11. To evolve techniques for rearing of E. *amabilis* and *H. pulverea* on artificial media for maintaining their cultures for the mass breeding of parasites

The intended start of the work could not be effected due to staff position.

12. Study of influences of various environmental conditions on the lac insect

(i) *Studies on the effect of extreme temperature and humidity fluctuations as they occur in nature on the tolerance of lac insects in its differnt stages.*

(ii) *Determination of the appropriate time for harvesting broodlac in different regions through the use of Biometer on thermohygrograph records of field stations.*

(iii) *Determination of optimum environmental conditions for storing the brood-lac to delay emergence of larvae without any harmful effects on the progeny.*

None of the above studies could be taken up during the year for the reasons stated last year.

B. CHEMISTRY DIVISION

I. RESEARCHES COMPLETED

1. Study of the Constitution of lac — Separation of the carbonyl and carbonyl-free fractions of lac resin

Apart from the work at this Institute, the study of the constitution of lac, as already mentioned was being carried out simultaneously at three centres viz. the National Chemical Laboratory, Poona, the Chemistry Laboratories of Delhi University, Delhi, and at the Department of Chemical Technology, Bombay University, Bombay under a Research Project. The work at Bombay had to be discontinued at the end of the year under report because of the nonavailability of qualified staff to carry on the work and the retirement from service of the guide, Dr. Puntambekar and is, therefore, being reported here. The reports of the work at the other two centres as well as at the Indian Lac Research Institute will be found under the head " Researches in hand " later on in this volume.

The work in the Bombay Laboratories was mainly confined to the separation of the carbonyl from the noncarbonyl constituents of lac. It has been mentioned already (*A. Rep.* 1964-65 p. 32) that, by treatment of an alcoholic solution of lac with an alcoholic solution of 2:4-dinitrophenyl-hydrazine hydrochloride, an insoluble hydrazone was obtained and that the mother liquor, on standing, gave a soft mass and evaporation of the residual liquor gave a solid mass. During the year under report the hydrazone was first washed free from the excess phenyl hydrazine and dried. Attempts were then made to recover the parent carbonyl constituent by treating the hydrazone with pyruvic acid under various conditions but without success.

Similarly, attempts were also made to get the soft mass and the solid mass free from the excess of phenyl hydrazine by chromatography and other means. Several solid fractions were obtained having melting points ranging from 105° to 143°C but all of them gave a positive test for nitrogen indicating that none of these were really free from the hydrazine.

2. Modification of lac with 1,5-Naphthalene diisocyanate

The possibility of up-grading the performance of shellac through reaction of its hydroxyl groups with polyisocyanates to produce urethanes had been investigated earlier. Modification with toluene diisocyanate had been found to result in substantial improvement in the hardness of the films although improvement in respect of blush resistance was only moderate (Rao, V. S. & Sankaranarayan, Y., *Rep. & Industr.*, **9** (1964), **10**, 299-301). As toluene diisocyanate is a volatile and highly toxic reagent, the possibility of replacing it with the safer 1,5-naphthalene diisocyanate was investigated and the physical and chemical constants of lac modified with this reagent reported in the previous report (*A. Rep.*, 1964-65 p. 36). The film properties have now been studied.

For this purpose, four lots of dewaxed decolourized shellac were dissolved in dry dioxane and three of them treated with 3, 4 and 5 per cent diisocyanate respectively in the cold, the fourth being used as " control ". After allowing to stand overnight, the products were diluted with methylated spirit to 20 per cent solids. It was found that the viscosities of the varnishes increased slightly (from 0·5 to 0·65 poises) with increasing proportions of the diisocyanate. Varnished

panels were dried and aged for 7 days at room temperature before testing. The performance of these films was similar to those of lac modified with toluene diisocyanate. The scratch hardness in this case also increased by the modification; the control lac film had a hardness of only 400 gm, whereas the film of 5 per cent diisocyanate treated lac had a hardness of 1,200 gm. The improvement in water resistance was again only moderate.

Naphthalene diisocyanate had thus no improvement over toluene diisocyanate for this purpose except in regard to safety.

3. Use of oxalic acid in the processing of seedlac into shellac and the effect thereof

To determine the effect of oxalic acid, which is sometimes used in the processing of seedlac into shellac, different proportions of it were mixed with seedlac which was then processed into shellac by the conventional country method. It was found that 0·1 per cent of the acid produced a characteristic change in colour of the shellac (from reddish to yellow) without altering the other good qualities of lac; higher percentages had deleterious effect on these properties (*A. Rep.*, 1963-64, p. 29; 1964-65, p. 38).

The effect of amounts smaller than 0·1 per cent was investigated. It was found that the characteristic change of colour was much more pronounced in the case of 0·1 per cent than with smaller amounts.

Oxalic acid (0·1 per cent of on the weight of seedlac) is thus the optimum amount to be used for this purpose.

4. Bleached lac from refuse lac

Last year (*A. Rep.*, 1964-65 p. 39) an improved method had been described for the manufacture of good quality bleached lac from *molamma*, a byproduct of the indigenous lac industry. By adopting this method and also the conventional method, bleached lacs from four commercial samples of *molamma* were prepared and stored. Bleached lacs obtained by the improved method were found to retain their solubility in spirit for a year (so far tested) whereas those prepared by the other methods started becoming insoluble within two to three months of storage under the same conditions thus confirming the effectiveness of the improved method.

5. Specific heat of seedlac, shellac and bleached lac. Variation with temperature

Specific heats of the various forms of lac are important because of their possible correlation with their " age " (period of storage). Specific heats of seedlac and bleached lacs were determined within the range of 10° to 100°C at 10°C intervals and reported last year (*A. Rep.*, 1964-65, p. 41). The maximum value of 0·66 was obtained at 70°C for seedlac and of 0·71 and 0·65 at 60°C for regular and refined bleached lacs respectively. These data were once again confirmed. In a similar manner, the specific heat of shellac at the various temperatures was also determined. This was found to rise from 0·25 at 10°C to a maximum of 0·72 at 70°C and thereafter to gradually drop to 0·50 at 100°C. The above results are being incorporated in the form of a paper to be published shortly. These data will be used for the study of the problem of " age" of lac.

6. Heat of neutralization of lac by thermometric titration

The technique of thermometric titration had been found (*A. Rep.*, 1964-65 p. 41) to yield fairly accurate results in the determination of acid values of aleuritic acid, soft resin, hard resin and different samples of shellac comparable to the values obtained with the conventional methods of titration but without the difficulty of judging the end point.

The method was extended to determine the heat of neutralization of the various grades of shellac.

The experiment was carried out in a Dewar flask, well insulated from outside and the changes of temperature were noted with a Beckmann thermometer. The solution was thoroughly stirred before and after each addition of alkali. The total rise of temperature gave the value of total heat evolved during the neutralization of the reactants. The calculation for heat of neutralization was made on the principle that heat lost is equal to heat gained. The heat evolved due to the neutralization reaction was gained by the Dewar flask and its contents which was determined from their heat capacity data. The heat evolved during the neutralization of one gram equivalent of the reactants was calculated. The values obtained are indicated below:

Lac		*Heat of neutralization K. Calories*
Kusmi seedlac	—	10·35
Kusmi shellac	—	9·61
Platina shellac	—	9·55
Bleached lac (wax free)	—	10·69

7. Determination of unsaturation in shellac

Unsaturation in shellac has been a subject of considerable investigation and various methods have been used for its determination based mainly on halogen addition. Recently, Kamath and Nadkarni [*J. sci. Industr. Res.*, **15B** (1956), 20] postulated that halogen consumption by shellac is essentially due to substitution and concluded that lac resin does not contain any ethenoid unsaturation. This conclusion, however, is contradictory to earlier findings that shellac absorbs hydrogen and the fact that shellolic and jalaric acids, which constitute nearly 30 per cent of the lac resin, *are* unsaturated.

Sankaranarayanan *et al.* (ILRI *Bulletin*, **39**, 1939) had determined the unsaturation in shellac by catalytic hydrogenation. They however, did not take into account the hydrogenation of the aldehyde group of the resin. The present work was, therefore, undertaken in order to confirm the above findings and to determine the actual extent of *ethenoid* unsaturation by making use of catalytic hydrogenation method in presence of platinum oxide catalyst. Different samples of freshly prepared *kusum*, *ber* and *palas* shellacs were tested for hydrogen absorption. They were all found to absorb 13·87 to 14·15 cc of hydrogen per 0·5 g of the sample, corresponding to 31·71 to 32·37 in terms of iodine value.

Aldehyde group in the lac was then " protected " by reacting with dimedone or selectively reduced with lithium aluminium hydride. The products thus obtained were tested for hydrogen absorption and also their various chemical constants.

The dimedone treated lac had the same acid and saponification values as the parent lac, but no carbonyl value indicating complete protection of the aldehyde group. This material also absorbed hydrogen to the extent of 11·10 cc per 0·5 gm as against 14·16 cc of the parent lac. The hydrogen absorption of the treated sample (which clearly is only the hydrogen absorbed by the double bond) was equivalent to an iodine value of 25·40. This is just equivalent to one double bond in a molecule of shellac assuming an average molecular weight of 1,000. The difference between the hydrogen absorptions of the parent and "Carbonyl protected" lacs (3·01 cc) works out to an equivalent of one third of a carbonyl group in the shellac molecule. This would also confirm the earlier findings of this Institute that the carbonyl group present in shellac is partly (to the extent of a third) free and the rest chemically bonded.

The above observations reveal the fact that there is definitely one double bond in the average molecule of shellac.

A paper entitled "Unsaturation in shellac" has been communicated for publication.

8. Aqueous lac-tung oil-phenolic resin varnishes

Mention was made in the previous report (*A. Rep.*, 1962-63, p. 33) that aqueous lac-tung oil varnishes produced films which, on baking, show excellent resistance to heat, water, solvents, dilute acids, alkali and other chemicals and possessed good adhesion and flexibility.

Phenolics are a group of resins which form crosslinked structure with functional groups of its own or other resins thereby improving the overall properties of the product. Hence, the effect of incorporation of phenolic resins into lac-tung oil varnishes was studied. Water soluble phenolic resin was prepared by reacting phenol (100 parts), 40 per cent formalin (120 parts) and caustic soda (3 parts) for 20-30 minutes at a *p*H of 7·4-8·5. The product, after cooling, was diluted with water to 25 per cent solids.

An aqueous varnish made up of this resin, water soluble lac and maleinized tung oil in appropriate proportions produced films which were hard, smooth, glossy, flexible and resistant to water, chemicals, solvents, detergents etc. These films showed good flexibility and adhesion on metals and like substrates.

Incorporation of phenolic resin into lac-tung oil varnishes was thus found to result in an overall improvement in the film properties of the blend except in respect of flexibility.

II. RESEARCHES IN HAND

Investigations during the year were mainly based on the approved programme for the Division (vide Appendix A) laid down by the Committee. The staff position continued to be difficult and, in consequence, the research activities had necessarily to be on a restricted scale. Purchase of specialized equipment for modernizing the laboratories had also to be deferred due to non-availability in the local market and difficulties of Foreign Exchange. Despite these handicaps, the research activities were continued as far as practicable.

The present report has been arranged in the order in which the various items appear in the approved programme. As, however, some of the items had been

completed earlier and some of the items could not be taken up due to shortage of staff, the serial number of this report will not coincide with that of the item in the approved list. Therefore, the serial numbers of the item as in the approved list are indicated, at the end of each title, in parenthesis.

While the general level of work was maintained through out the year, certain findings are of particular and immediate interest. The grafting of vinyl monomers on shellac has opened up a new field for the preparation of materials suitable for application as surface coatings. Out of numerous compositions tried, the one based on shellac (100 parts) and ethyl acrylate (60 parts) or a mixture of ethyl acrylate (50 parts) and methyl methacrylate (10 parts) has given the best properties. Spirit soluble melamine resin which had earlier been found to be a valuable additive to dewaxed shellac varnish for the production of heat and water resistant French polishes, has now been found to improve shellac varnish in respect also of electrical resistance which was found to increase almost fourfold. Similarly the incorporation of shellac and particularly epoxy resin modified shellac into synthetic (styrene/butadiene) rubber has shown considerable promise. Milling qualities of the stock are improved as well as the hardness and modulus of the compounded vulcanized material. In the field of water thinned coatings, which is the latest trend in paint technology, shellac maleinized drying oil combinations have proved to be yet another valuable vehicle for the production of red oxide primers for steel. Another promising field is the possible use of water based shellac paints through the application of the latest electro-painting technique. Preliminary experiments have been started in this direction.

The research scheme sponsored by the Committee at the Central Leather Research Institute has also borne its first fruit. A top gloss composition has been developed which gives a finish comparable to lacquer finish. Large quantities have been prepared for demonstration to leading leather goods manufacturers at the more important leather industry centres of the country.

A detailed report of the findings of the Division now follows.

1. Separation and study of constitution of the various components of Shellac (Problem No. 1)

(i) *Constitution of the neutral fraction*

In the previous report (*A. Rep.*, 1964-65 p. 30) an easier method for the isolation of the neutral fraction from *palas* seed lac had been described and it was observed that the fraction was a mixture of at least seven components. In an attempt to isolate pure components, the neutral fraction was chromatographed over neutral alumina and eight fractions collected. Preliminary thin layer chromatography (TLC) examination of the fractions indicated that the last one was a pure component. But re-examination of the fraction using other solvent systems showed it to be composed of four components.

Since it was not possible to get pure fractions by the above method, the possibilities of hydrolytic fission were investigated. The neutral fraction (50 g) was hydrolysed with 0·5*N* alcoholic (95 per cent) caustic soda solution (400 ml) for 48 hours at room temperature. The alcohol was then completely distilled off under low pressure and the residue dissolved in water (500 ml) and kept overnight at 5°C. The precipitate was collected, washed with water and dried (E2; 0·58 g).

The aqueous mother liquor was repeatedly extracted with ether and the nonacidic portion (E; 2·08 g) was recovered from the dried ethereal extract. The aqueous liquor was then evaporated to dryness and the residue dissolved in

alcohol (500 ml). The resulting solution was passed through cation exchange resin and the liberated mixture of acids recovered by distilling off the alcohol under low pressure. This mixture was then esterified with methanolic hydrogen chloride. A portion (E3; 27·5 g) was found soluble in ether and the rest (E4; 15·0 g) insoluble. The latter was, however, soluble in chloroform. The unesterified acid was recovered from the sodium carbonate extract (E5; 4·1 g). E1 to E4 were examined by TLC using trichlorethylene: chloroform: methyl alcohol (5:2:1) as the solvent system and each one of them was found to give two to three major spots.

The nonacidic portion from E1 may be a mixture of hydrocarbons and/or alcohols and was very small in quantity compared to the acidic portion. Hence it may be said that the neutral fraction is mainly a mixture of an inter – or intra – ester of hydroxy acids.

The fraction E3, being by far the largest, was studied further. It was fractionated over silicic acid using increasing amounts of ether in benzene and nine fractions (S_1 to S_9) were collected. The fractions were examined by TLC. The results are given in Table 1 below.

TABLE 1 — FRACTIONATION OF FRACTION E3 OVER SILICIC ACID

Weight taken — 25.00 gm.

Sr. No.	Solvent system	Weight of the fractions in gm.	T.L.C. observations
S_1	Benzene: Ether 1000 : 0	13·005	Long streak with 3 major spots
S_2	Benzene: Ether 1000 : 0	0·897	3 spots
S_3	Benzene: Ether 1000 : 0	0·139	2 spots
S_4	Benzene: Ether 1000 : 0	0·039	3 spots
S_5	Benzene: Ether 450 : 50	0·014	3 spots
S_6	Benzene: Ether 250 : 250	0·307	4 spots
S_7	Benzene: Ether 0 : 1000	2·468	Streak with 3 major spots
S_8	Methanol 1000	6·655	2 spots (one major)
S_9	Methanol 1500	0·637	2 spots (one major)

Fraction S_8 appeared to consist of one major constituent with traces of another. This was purified by rechromatography over silicic acid. The product, after several recrystallizations from aqueous methyl alcohol, melted at 64-65°C, and had a saponification value of 196. The melting point and acid and hydroxyl values of the corresponding acid were found to be 95-96°C, 181 and 590 respectively. The ester had the same Rf value as that of methyl aleuritate indicating that it was methyl aleuritate.

Further work is in progress.

(ii) *Constitution of soft resin*

It had been reported last year (*A. Rep.*, 1964-65 p. 31) that constituent acids from soft resin, after esterification with methyl alcohol, were fractionated into nine fractions and that fractions 1 and 2 being similar were mixed together and refractionated into urea adducted and nonadducted esters. It was also pointed out that the non- and mono-hydroxy esters were concentrated more in the adducted fraction.

With the idea of isolating the non- and mono-hydroxy esters in the pure state, the adducted fraction was repeatedly chromatographed over silicic acid. The fractionation was monitored by TLC and, ultimately, the nonhydroxy esters and ω-hydroxy esters were obtained in the pure state. TLC examination on silver nitrate impregnated plates showed that both of them consisted of saturated and unsaturated esters.

The ω-hydroxy esters were then fractionated over silver nitrate impregnated silica gel and the unsaturated ester obtained as a liquid and the saturated one as a solid.

Another lot of soft resin was hydrolyzed and the acids converted to methyl esters. The methyl esters were fractionated into urea adducted and nonadducted esters. TLC examination showed that the adducted fraction consisted mainly of a mixture of non- and mono-hydroxy esters and the nonadducted one a mixture of non-, mono-, di- and tri-hydroxy and other esters. It was evident that a substantial amount of non- and mono-hydroxy esters were left behind in the nonadducted fraction. The nonadducted fraction was, therefore, again fractionated over neutral alumina into nine fractions in increasing order of polarity. The first two fractions contained mainly a mixture of non- and mono-hydroxy esters. Further work is in progress.

(iii) *Isolation and identification of the free acids present in shellac*

(a) Mention was made in the previous report (*A. Rep.*, 1963-64, p. 32 and 1964-65, p. 30) that eight fractions (C_1 to C_8) consisting of free fatty acids (5·6 per cent) had been separated by chromatography of dewaxed shellac over cellulose, and that the second fraction (C_2) was rechromatographed over silicic acid and eleven fractions (S_1 to S_{11}) obtained of which S_1 to S_5 were found to be mainly a mixture of non-hydroxy acids, S_6 to S_{10} to be mainly a mixture of mono- and di-hydroxy acids and S_{11} mainly di-hydroxy acid. Fractions C_3 to C_8 had been mixed together, dewaxed from methanolic solution and fractionated by urea, the adducted fraction from which was found to contain mainly non- and mono-hydroxy acids and the non-adducted mainly dihydroxy acid.

The work was continued. Since fractions S_1 to S_5 were similar, these were mixed up and the non-hydroxy acidic portion of the mixture separated from the hydroxy portion by repeated chromatography over silicic acid. During this separation, a small amount of monohydroxy acid was separated but the major portion of the hydroxy acids could not be resolved into mono- and di-hydroxy acids. Therefore, this mixture was taken up together with fractions S_6 to S_{10} and the urea non-adducted fraction obtained from C_3 to C_8 for further processing as all of them contained both mono- and di-hydroxy acids.

This mixture and the urea adducted acidic mixture were separately chromatographed and rechromatographed over silicic acid and the non-hydroxy, mono- and di-hydroxy acids were isolated. Except the non-hydroxy fraction, the others were not perfectly pure. An acidic portion which had polarity lying

between non- and mono-hydroxy acids always came along with the latter. The approximate proportion of the various acids isolated so far from dewaxed lac are as follows:

Acid constituent	*% on dewaxed lac*
1. Mixture of non-hydroxy acids	0·33
2. Mixture of mono-hydroxy acids	0·90
3. Mixture of di-hydroxy acids	0·95
4. Mixture of mono- and di-hydroxy acids	2·07
5. Waxy material	0·73
Total	4·98

Alternate methods for the isolation of free acids

(b) The following alternate method for the isolation of the free acids present in lac resin was also worked out which facilitated collection of the material in larger quantities for further work. A 30 per cent solution of dewaxed decolourized shellac (300 g) in 95 per cent alcohol was exhaustively extracted with hexane (12×1000 ml) and twelve fractions collected. TLC examination of the fractions showed those to contain mainly four constituent acids such as non-, mono- and di-hydroxy acids. The fractions were taken together, dissolved in ether and extracted with 10 per cent sodium carbonate solution leaving the neutral portion in the ether. The acidic mass was recovered from the carbonate extract by decomposition with dilute hydrochloric acid and extraction with ether. The last traces of wax was removed from it by chilling its methanolic solution. It was then fractionated into urea adducted (1·13 g) and nonadducted (17·34 g) fractions. The adducted one appeared to be a mixture of non-hydroxy, mono-hydroxy, one in between them and trace of di-hydroxy acids while the non-adducted one of mono-hydroxy, di-hydroxy and trace amount of tri-hydroxy acids.

The non-hydroxy portion from the adducted fraction was isolated by repeated chromatography over silicic acid. The hydroxy acids could not be isolated in the pure form. Attempts were also made to separate the individual acids from the non-adducted portion but pure fractions could not be isolated. As it is known that esters are easier to fractionate, the non-adducted fraction was converted into methyl ester. A part of the ester was soluble in light petroleum ether (b.p. 40-60°) and the rest in ether. TLC examination of these showed that the petroleum ether soluble ester fraction was a mixture of 6-hydroxy (butolate), ω-hydroxy and di-hydroxy esters while the second one a mixture of ω-hydroxy, di-hydroxy and tri-hydroxy (trace) esters. Further work is in progress.

(c) In the above investigations, no definite indication to the presence of aleuritic and jalaric acids in the free acids of lac could be obtained, although their presence have been reported by earlier workers (*loc. cit.* 1963-64, p. 32). This may be due to the fact that these acids are insoluble in hexane and hence have not been extracted. Hexane extraction, obviously, has not isolated *all* the free acids present in the resin. To achieve this end, the following alternate method was tried.

Powdered *palas* seedlac was dissolved in 10 per cent sodium carbonate solution by warming and the cold solution filtered to remove wax and impurities. The sodium salts of lac resin were salted out with saturated sodium chloride solution and allowed to stand overnight. The clear liquor was decanted and the residue washed twice with sodium chloride solution. The solutions were mixed

together and extracted with ether to remove the neutral portion, if any. It was then decomposed with dilute hydrochloric acid and extracted with ethyl acetate followed by butyl alcohol. Removal of the solvents gave dark coloured soft masses. The ethyl acetate extract on TLC examination showed the presence of non-, mono, di- and tri-hydroxy acids while butyl alcohol extract responded to aldehyde test showing the presence of jalaric acid. Further work is in progress.

(iv) Apart from the above work at the Indian Lac Research Institute, the study of the constitution of lac was also carried out, as mentioned earlier, at the Chemical Laboratories of Delhi University, at the National Chemical Laboratory, Poona and the Department of Chemical Technology, Bombay University, Bombay, on the basis of a Research Project sponsored by this Institute. The results of investigations in the first two institutions are described below. Those of the Bombay University have been described already on page of this report under the Head " Researches Completed ".

(a) *Delhi University* — Lac resin had been separated by fractional precipitation into hard resin I, hard resin II and soft resin. The above fractions had been iodinated and deiodinated to give a mixture of fatty and terpenic acids (*A. Rep.*, 1963-64, p. 40 and 1964-65, p. 31). The fatty acids obtained have now been studied by paper and gas chromatography methods to determine the quantities and distribution of the fatty acids. Hard resin I and hard resin II have been found to consist predominantly of C_{16} acids with small amounts of C_{14} acids, while soft resin of C_{14} acid as the main chain length with C_{16}, C_{18} and C_{12} also present in decreasing order.

By the action of hydrogen chloride gas on the above fractions and other grades of shellac, an increased yield of aleuritic acid as its *erythro* form has been obtained (*loc cit*). The increased yield of aleuritic acid obtained by this method, which is almost double the quantity obtained by simple alkaline hydrolysis, confirms that in lac resin there are considerable proportion of ether linkages, involving aleuritic acid, which are not affected by alkali.

(b) *National Chemical Laboratory, Poona* — The earlier reports (*A. Rep.*, 1963-64, p. 41 and 1964-65, p. 31) mainly included work on the isolation and identification of different acids obtained after hydrolysis of hard resin prepared from *palas* seedlac. Jalaric acid and acids resulting from this acid, viz. shellolic, epishellolic, laksholic and epilaksholic acids, had been isolated and structures assigned.

The studies were continued and the results during the year under report are as follows

Estimation of jalaric and aleuritic acids — Estimation of jalaric and aleuritic acids in hard and soft resins from different varieties of seed lacs and in fractions of hard resin from *palas* seed lac, was carried out. Jalaric acid was estimated using the colorimetric method of Lappin and Clark [*Anal. Chem.*, **23** (1951), 541]. The percentage of aleuritic acids was determined by the procedure standardized by Sen Gupta and co-workers. Aleuritic acid was estimated both before and after hydrolysis. The aleuritic and jalaric acid contents of various samples and fraction of lac determined are indicated in Table 2.

Oxidative degradation — It was reported last year (1964-65) that repeated fractionation of hard resin yielded a number of almost pure fractions. One of these fractions (F8) was taken for oxidation studies.

6 g of the fraction was oxidized with chromic acid under standardized conditions. After the usual work up, the oxidized material was hydrolysed with

TABLE 2 — ESTIMATION OF JALARIC AND ALEURITIC ACIDS

Variety of seed lac	Hard/Soft resin	% of jalaric acid	% of aleuritic acid (before hydrolysis)	% of aleuritic acid (after hydrolysis)
Palas	Hard	30·29	11·4	38·5
	Soft	36·15	9·5	16·1
Kusmi	Hard	37·2	11·48	45·00
	Soft	33·4	12·2	25·7
Jalari	Hard	35·5	13·2	38·5
	Soft	34·15	11·4	28·5
Intermediate fraction (8) from Hard resin of Palas seed lac	—	36·29	11·28	34·0
Pure fraction from hard resin of Palas seed lac	—	30·09	5·6	34·0

aqueous alkali at room temperature. The saponified mass was methylated and a portion, 0·4109 g, was distilled at 2·5 mm pressure at a bath temperature of 150°C. 0·0845 g of material distilled over (20·64 per cent) which was analysed by VPC on polyester column. It contained 50·54 per cent azelate and 38·34 per cent pimelate.

2·7074 g of the methylated portion was chromatographed over a column of silica gel (70 g) and the column eluted with different solvent systems. The results of the experiments are summarized in Table 3 below:

TABLE 3 — CHROMATOGRAPHIC RESULTS OF METHYLATED PRODUCT OF OXIDISED F_8 FRACTION

Fr.	Fr. Nos.	Solvent used for elution	Wt. of combined fraction	Results of TLC
A	1-21	Petroleum ether: Benzene 1 : 1 Benzene. Ethyl acetate 95 : 5	0·6693	Single elongated spot Rf 0·82
B	22-30	Benzene: Ethyl acetate 90 : 10	0·4256	Two spots Rf 0·69; Rf 0·69 Strong faint
C	31-50	Benzene: Ethyl acetate 90 : 10 Benzene: Ethyl acetate 75 : 25	1·1079	Two spots Rf 0·6; 0·75 Strong faint
C	51-64	Benzene: Ethyl acetate 75 : 25	0·3704	Two pots with a little streaking below Rf 0·4; 0·36
E	65	Ethyl acetate only	0·1362	Streak in the range Rf 0·0; 0·5

The various fractions were studied by TLC in a solvent system, benzene: ethyl acetate: acetone (7: 41 : 5). Fractions giving similar spots were combined and were purified further where necessary.

Fraction A, which was shown by TLC to be mainly a mixture of esters of fatty acids, was distilled and analyzed by GLC (Fractions 1-21). It was a mixture of azelate and pimelate with small quantities of two more substances. Fraction 13 was pure azelate and Fraction 20 was 90 per cent pimelate.

Fraction B on rechromatography over silica gel gave a crystalline substance, m.p. 94-95°C, Rf 0·69. It displayed IR bands for OH (3530, 1078, 1115 cm^{-1}), methoxy carbonyls (1725, 1750 cm^{-1}), conjugated trisubstituted double bond (1655, 795, 815 cm^{-1}) and UV absorption λ^{EtOH} 230 mμ, ϵ, 6070. The physical data collected so far suggest that in all probability it has structure (I).

The combined fraction (C) was rechromatographed on a column of alumina grade II to give a crystalline substance, m.p. 131-132°C. Rf 0·6. It displayed IR bands for OH (3520, 1117, 1022 cm^{-1}), methoxy carbonyls (1720, 1740 cm^{-1}) and conjugated trisubstituted double bond (1653, 818, 792 cm^{-1}). Its UV absorption λ^{EtOH} 224 mμ, ϵ, 4900 supports the carbonyl function in conjugation with olefinic linkage.

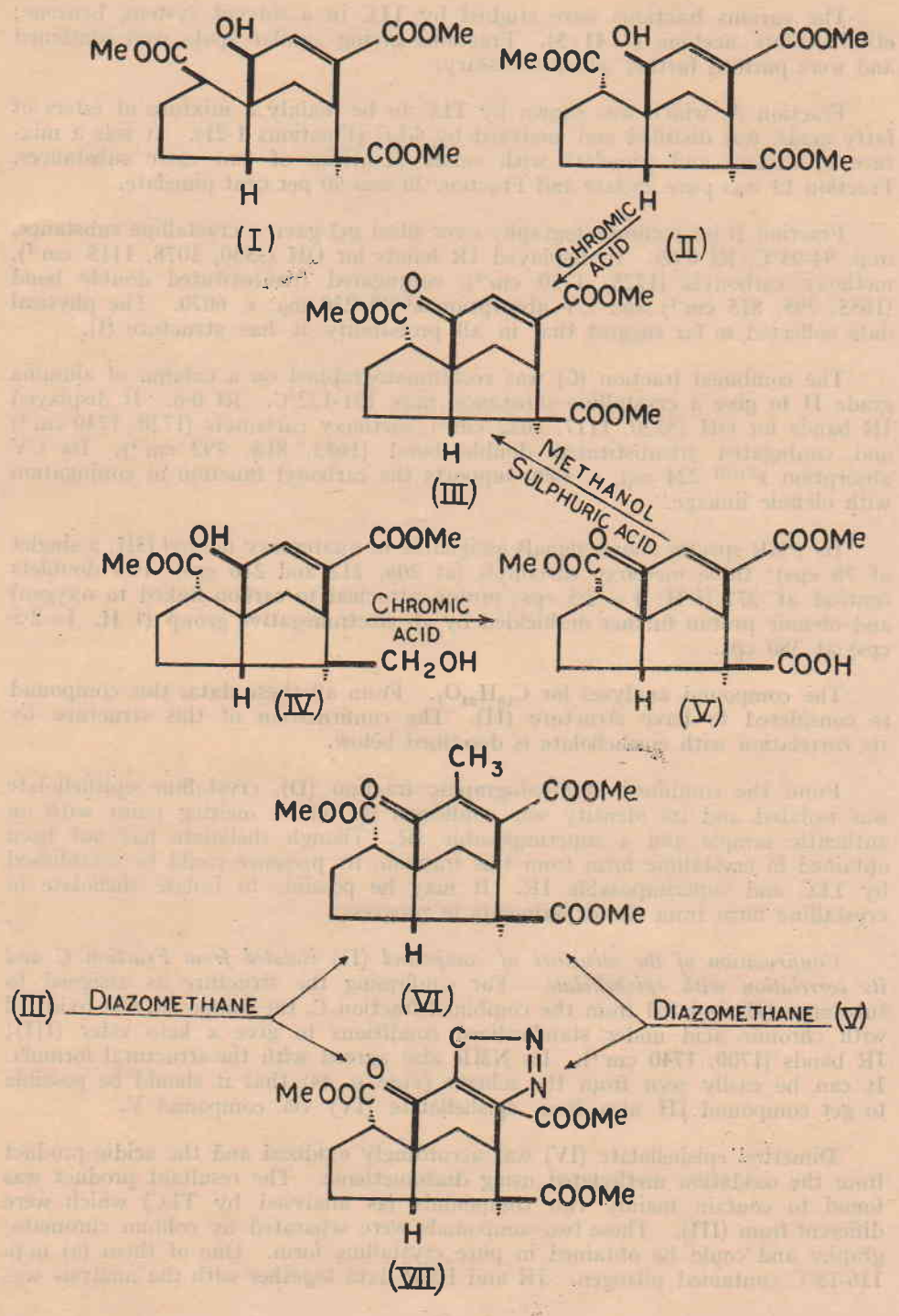
Its PMR spectra shows signals assignable to quaternary methyl (3H, a singlet at 78 cps); three methoxy carbonyls (at 206, 212 and 216 cps); two doublets centred at 277 (1 H, J = 2·5 cps; proton attached to carbon linked to oxygen) and olefinic proton further deshielded by an electronegative group (1 H, J=2·5 cps) at 380 cps.

The compound analyses for $C_{18}H_{24}O_7$. From all these data, this compound is considered to have structure (II). The confirmation of this structure by its correlation with epishellolate is described below.

From the combined chromatographic fraction (D), crystalline epishellolate was isolated and its identity was confirmed by mixed melting point with an authentic sample and a superimposable IR. Though shellolate has not been obtained in crystalline form from this fraction, its presence could be established by TLC and superimposable IR. It may be possible to isolate shellolate in crystalline form from the experiments in progress.

Confirmation of the structure of compound (II) *isolated from Fraction C and its correlation with epishellolate* — For confirming the structure as assigned to substance (II) isolated from the combined fraction C, the compound was oxidized with chromic acid under standardized conditions to give a keto ester (III); IR bands (1700, 1740 cm^{-1}). Its NMR also agreed with the structural formula. It can be easily seen from the scheme (vide p. 44) that it should be possible to get compound III also from epishellolate (IV) via compound V.

Dimethyl epishellolate (IV) was accordingly oxidized and the acidic product from the oxidation methylated using diazomethane. The resultant product was found to contain mainly two compounds (as analysed by TLC) which were different from (III). These two compounds were separated by column chromatography and could be obtained in pure crystalline form. One of them (a) m.p. 116-18°C contained nitrogen. IR and PMR data together with the analysis was


OH
Me OOC
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(I)
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O
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METHANOL
SULPHURIC ACID
CHROMIC ACID
CH_2OH
(IV)
COOH
(V)
CH_3
(VI)
DIAZOMETHANE
(III)
DIAZOMETHANE
(V)
C
N
N
(VII)

completed for the two compounds. The PMR spectrum of (b) m.p. 123-4°C, showed absence of the signal for olefinic proton and on the other hand showed a sharp singlet at 120 cps indicative of a methyl at the position of the olefinic proton. Diazomethane can add up to the double bond in the molecule (V) as given below and would give compounds (VI) and (VII).

All the physical data obtained for compounds (a) and (b) referred to above, exactly agrees with the structures assigned to VI and VII. If the structure given to compound III is correct then compound III on treatment with diazomethane should end up to yield VI and VII. This has been experimentally proved, thus giving a conclusive proof for the structure assigned to compound II and its correlation with epishellolate.

Hydrolysis of hard resin using lipase — Experiments were conducted to hydrolyse hard resin of *palas* seed lac, selectively, using *lipase*. For this purpose *lipase* from castor seeds was prepared and its activity was determined. Hydrolysis of hard resin was attempted using this *lipase* under a variety of conditions. The results obtained were, however, not satisfactory.

Other oxidative degradation — Oxidation of shellolate and polyaleuritate under standardized conditions was also studied. The product obtained in these experiments would serve as reference compounds while studying the oxidation of intermediate fraction F8 and the pure fraction. It is expected that the quantitative data obtained during the oxidative degradations for compounds I, II epishellolate, shellolate, azelate, pimelate and a few other substances still under investigation is going to yield valuable information regarding the linkages of different acids in the lac molecule.

Oxidation of pure fraction of hard resin has been carried out and separation of the products of oxidation is in progress.

(v) *Constitution of lac dye*

Under another scheme sponsored by this Institute, as mentioned earlier the constitution of lac dye was being also investigated at the National Chemical Laboratory, Poona, under the guidance of Prof. K. Venkataraman. The results obtained during the year are reported below:

(a) *Erythrolaccin* — The structure of erythrolaccin, which was determined on the basis of colour reactions, ultraviolet, infrared, nuclear magnetic resonance (NMR) spectra, was confirmed by synthesis of the tetramethyl ether. This method, unlike the synthesis outlined by Yates in 1964, leaves no room for doubt about the structure given below:

(b) *Isolation of lac dye constituents* — When the preparation of lac dye by the method described in the previous report was repeated, it was noticed that the percentage of dye isolated from *Kusmi* sticklac varied widely from batch to batch. Lac dye was also isolated from an old sample of the calcium lake. Methylation of these dye samples showed that they all contained the same major constituents and they all gave the five ether-esters described earlier.

(c) *Constitution of laccaic acid* III, *the nitrogenous constituent of lac dye* — In the last report, the complete structure for a laccaic acid, which did not contain

nitrogen, was proposed. In the present report the data obtained so far on the structure of a second laccaic acid, designated laccaic acid III, are discussed. Laccaic acid III corresponded to methylated laccaic acid (MLA-III), m.p. 243°C mentioned earlier. When water crystallized lac dye was submitted to chromatography on a column of polycaprolactam powder, using butanol saturated with 0·3*N* hydrochloric acid for development and elution, two major red bands appeared. Extraction of the eluate of the lower band with saturated aqueous sodium acetate, followed by acidification with cold conc. hydrochloric acid, yielded a crystalline product containing 2·4 per cent nitrogen. Although a second major red band and several minor bands were separated by the chromatography of lac dye using butanolic hydrochloric acid on polycaprolactam powder or benzene and ethanol (9 : 1) on silica gel impregnated with oxalic acid, only one laccaic acid containing nitrogen had so far been isolated; but the presence of other nitrogenous constituent could not be excluded.

Laccaic acid III appeared to be identical with laccaic acid A_1, recently isolated by Schofield in 1965 from sticklac by concentration of an aqueous extract, acidification with conc. hydrochloric acid, and column chromatography of a methanol solution on cellulose powder using ethyl acetate, acetic acid and water (4 : 1 : 5) for elution. Laccaic acid A_1 was assigned the probable molecular formula $C_{26}H_{21}NO_{12}$, while laccaic acid III had the molecular formula $C_{26}H_{19}NO_{12}$ or $C_{26}H_{17}NO_{11}$, H_2O. Schofield had confirmed the observation made by Venkataraman *et al.* earlier that laccaic acid III is a purpurin derivative and contains one C-methyl group and a non-basic nitrogen atom. Schofield found that the nitrogen can be estimated by the van Slyke method, but concluded that a primary amino group was generated under the conditions of the van Slyke estimation because there was no evidence of the presence of basic nitrogen atom by titration with perchloric acid in glacial acetic acid. It is believed, however, that the van Slyke value is anomalous.

MLA III had the molecular formula $C_{31}H_{27}NO_{11}$. The NMR data showed the presence of a C-methyl group, two methylene groups (one probably benzylic or $N\text{-}CH_2$ and the other $O\text{-}CH_2$), five methoxyl groups, one NH group, and four aromatic protons. Two of the methoxyl groups occurred as carbomethoxyl groups. Laccaic acid III and MLA II were optically active. Laccaic acid III did undergo the purpurin-xanthopurpurin change. Methylation of the product yielded MXLA III, m.p. 162-163°C, identical with MXLA III described earlier. MXLA III had the molecular formula $C_{32}H_{31}NO_{11}$. The NMR spectrum gave a total proton count of 31 and showed the presence of a C-methyl group, six methoxyl groups, two methylene groups, one NH group, and five aromatic protons.

The experiments now under progress will shortly lead to the complete structure of laccaic acid III.

(d) *2-Phenylanthraquinone derivatives* — The arylation reaction, to which a reference had been made in the previous report, is being applied to the preparation of a series of alizarin derivatives containing a 3-aryl group. It is hoped that, in the light of this work, chemical modification of lac dye will yield useful dyes for cotton, wool, silk, nylon, cellulose acetate, and polyester fibres; and this part of the work will be undertaken as soon as substantial quantities of lac dye precipitated as the calcium salt have been collected and some information obtained on its cost.

2. Physico-chemical studies of lac solutions (Problem No. 3)

Dielectric strength of films obtained from shellac butylated melamine resin varnishes

Incorporation of butylated melamine resins into shellac spirit varnishes have been found to effect outstanding improvement in film properties such as resistance to heat, water, alcoholic liquors etc. It was, therefore, considered desirable to study the electrical characteristics also of these blends in order to extend utility of lac in the electrical industries.

Dewaxed decolourized shellac and " Biomine ", a commercial butylated melamine resin, were dissolved separately in methylated spirit to give 25 per cent solutions. These were then mixed in the proportions of 0:100, 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, 90:10 and 100:0 respectively. Dielectric strengths of the various blends were then determined according to IS-352. For this purpose tissue papers were coated with these compositions by dipping and allowed to air dry. They were then conditioned at 27 ± 2°C and 95 per cent humidity for 24 hr. Their breakdown voltages were then determined.

It was found that the compositions in the proportion of 40:60, 50:50 and 60:40 showed the maximum breakdown voltages, about 1,700 volts/mil; the corresponding value for the parent dewaxed lac was 270-300 volts/mil. The modified formulations are thus much superior in electrical insulating properties to the conventional air drying spirit type insulating varnishes. Their use as improved insulating varnishes is thus indicated.

3. Modification of lac to improve its heat, blush and spirit resistance [Problem No. 7(c)]

(i) *Modifications with butylated melamine formaldehyde resin*

The development of shellac/melamine resin spirit varnish for wood possessing outstanding resistance to heat, water and spirit, had been reported already (*A. Rep.*, 1964-65, p. 35). Its shelf life was under investigation.

This varnish (containing 25 per cent solids made up of dewaxed lac and butylated melamine/formaldehyde resin in the ratio of 100:40) had been in storage in glass and polythene containers for 3 years now without any appreciable thickening and deterioration in the film properties indicating excellent storage stability.

The use of this varnish for coating of anodized aluminium parts to protect them from the action of lime and cement was also investigated. It was found satisfactory by a leading firm of the country.

It has now been found that apart from the conventional French polishing technique, this composition with a slight modification, is also suitable for application by spray. It could be sprayed at 32-34 per cent solids and containing 10-12 per cent *n*-butanol added, at a spray pressure of 30-40 lbs. It has been further found that the varnish (containing 33 per cent solids) could be pigmented with various pigments without any gelling or precipitation. The resulting products gave on glass, metal and wood highly durable, water and heat resistant films.

(ii) *Acid catalysed shellac-urea resin lacquer*

Amino resins cure in the cold in presence of organic and inorganic acids and acid esters, to form hard, adherent and durable films. Shellac is acidic in nature. Hence its suitability as a curing agent was studied. It was found to cure mela-

mine resins in the cold but not urea resin. Addition of a little hydrochloric, nitric or *p*-toluene sulphonic acid, however, did cure the urea resin also.

This acid catalysed shellac-urea resin varnish produced highly glossy, adherent and durable films on wood and glass, which were resistant to heat (boiling water temperature), water (7 days immersion) and spirituous liquors. It could also be applied by spraying at 35-40 lb pressure, after addition of 7-10 per cent of butanol and making the solid content to 32-34 per cent, to give a glossy finish on wood. Dewaxed variety of lac was found to give better performance than ordinary wax containing lac.

A commercial firm has found this varnish to be satisfactory for coating of anodized aluminium.

Pigmentation of the above composition is under study.

(ii) *Modification of shellac with polyesters*

The combination of shellac with its erstwhile rivals, viz., synthetic resins, resulted in films of improved properties. Polyesters are another type of modern synthetic resins finding increasing use in surface coatings and particularly for "solventless" coatings where they are used dissolved in a polymerizable monomer (styrene) and cured *in situ* by the presence of initiators, accelerators etc. The modification of shellac with polyesters, both based on saturated and unsaturated acids, were consequently considered to be of interest to see how far such modifications would improve the film properties of either.

Improvements in the film and moulding properties of shellac with the incorporation of polyesters have already been referred to in literature (Weisberg, L. to Barrett Co., U.S. Pat., 1,413,144-5/1922; 1,424,137/1922). These, however, being patents, very little information is available about the properties of the various compositions and the optimum conditions under which these are to be prepared, blended and used. A systematic study was, therefore, taken up and the results so far obtained are indicated below.

(a) *Polyesters using saturated aliphatic dicarboxylic acids* — The polyesters, described in the above patents were prepared under the simplest of conditions, namely, by heating together the various constituents — glycerol, phthalic anhydride and adipic acid — in different proportions in an open vessel, just short of their curing times. The resulting materials were dissolved in alcohol and/or acetone as the case may be to a nonvolatile content of 25 per cent. Dewaxed lac varnish in alcohol of the same concentration was separately prepared and the two mixed in different proportions to yield varnishes of 25 per cent nonvolatiles. Film properties of these blends were then determined, both air dried as well as baked at 100°C for one hour and 150°C for 30 minutes. The best properties were obtained when the ratio of dewaxed lac to polyester was 3:1 and that too only on baking the films. The major improvement was in respect of blush resistance and elasticity; the improvement in regard to hardness being only moderate.

As these polyesters had substantial residual acidities, the possibility of using them in aqueous (ammoniacal) solution along with aqueous ammoniacal shellac varnishes was investigated. These polyesters could be readily dissolved in ammoniacal water and the resulting solutions formed clear blends on mixing with aqueous shellac varnishes. Blends of the above varnishes containing different proportions of the polyesters and lac were then prepared and their film properties examined under the same conditions as those of the alcoholic varnishes. It was

seen that, here again, the optimum proportions were 3 parts of lac to 1 of the polyester and that the improvement was most marked in respect of elasticity; the blush resistance improving only when the films were baked at 150°C.

(b) *Polyesters using unsaturated dicarboxylic acid* — Polyesters were next prepared using maleic anhydride in place of the adipic acid as described above and the film properties of the resulting products along with lac studied both in alcoholic and aqueous ammoniacal solutions in order to determine the effect of introducing the unsaturation in the polyesters. Maleic anhydride based polyesters behaved exactly as the polyesters from adipic acid, both in alcoholic and in aqueous solutions. The optimum proportion was 3 parts of lac to one of the polyester and substantial improvements resulted only in regard to elasticity and blush resistance, and the latter only in baked films.

The effect of driers, initiators and other catalysts in the blends as well as polyesters based on polyglycerols, ethylene glycol and polyethylene glycols as the polyols are proposed to be investigated together with the possibility of using glycerol monoallyl ether as the polyfunctional monomer solvent for lac solventless coatings.

(c) *Substituting adipic acid and maleic anhydride by lac acids* — As part use of the aliphatic dicarboxylic acid in glycerol/phthalic anhydride resin is intended to reduce brittleness and increase toughness and elasticity of the resulting products, the possibility of using lac acids, in place of the comparatively costlier and (in this country) more difficultily obtainable adipic acid and maleic anhydride, in the above composition was investigated.

During the preparation of hydrolysed lac from shellac nearly 30 per cent is lost along with the aqueous portion. This water soluble portion had been recovered and found to be a hard, brittle, pale reddish orange mass, rather sensitive to moisture, with an acid value of the order of about 260 (*A. Rep.*, 1952-53, p. 37). This material was re-examined and was also found to contain both unsaturated and carbonyl groups.

As the high acid value indicated the possible presence of dicarboxylic acids in this mixture, this product was investigated in the polyester formulation. Glycerol, phthalic anhydride and this water soluble hydrolysed lac in the proportion of 1 : 0·75 : 0·25 were heated together at 180-200°C and the drop in acid value with time noted. It was found that the product could be heated for a very long time without gelation and at the end of 6·5 hours, the acid value had come down to 65·7. The product was still completely soluble in alcohol. This was a hard brittle resin with a softening point of 115°C and melting point of 125°C. The film properties were, however, poor; the scratch hardness being as low as 300 gm and flexibility very poor.

For comparison, the possibility of using the water insoluble hydrolysed lac was then investigated. Glycerine, phthalic anhydride and hydrolysed lac in the ratio of 1 : 0·75 : 0·25, were heated together at 180°C for about 3·5 hr, by which time the acid value dropped to about 92·4. The resulting product was soluble in alcohol, but the films were extremely tacky although the scratch hardness was of a very high order and the elasticity outstanding. Baking the films at 150°C for 45-60 minutes, eliminated the tackiness altogether and improved the blush resistance also without affecting the other properties.

Further work is in progress.

4. Studies in the modification of shellac by reacting it with acrylonitrile [Problem No. 9 (a)]

(i) *Hydroperoxide of lac*

The optimum conditions for the preparation of hydroperoxide of lac were determined last year (*A. Rep.*, 1964-65, p. 36). These were to pass oxygen through a 20 per cent ammoniacal solution of lac containing 3 per cent of catalyst (potassium persulphate) on the weight of lac at a temperature of 50°C. It has now been found that this lac hydroperoxide solution remained stable at room temperature only for 10 days but that when the hydroperoxide was recovered as a solid by acidification, it retained its stability for upto 2 months at room temperature.

(ii) *Grafting of vinyl monomers on lac hydroperoxide*

(a) It has already been mentioned (*loc cit*) that a graft polymer based on lac hydroperoxide and ethyl acrylate gave films possessing superior properties over those of the parent lac.

Adopting the same method, lac hydroperoxide in solution was copolymerized with methyl methacrylate in presence of formaldehyde sodium sulphoxylate at a temperature of 40 ± 1°C. The polymer mixture was reclaimed by air drying the solution on glass plates whereby the films peeled off easily. The powdered polymer mixture was then extracted first with alcohol and then with toluene at room temperature for 48 hr. The mixture was found to contain 18·7 per cent of alcohol soluble unreacted lac, 15·4 per cent of toluene soluble homopolymer and 66·23 per cent of material insoluble in both solvents (graft polymer). The insolubility of the last fraction in alcohol and toluene indicated that a certain proportion of lac had combined with the methyl methacrylate to form the graft polymer.

Evidence of grafting having thus been obtained, grafting on lac of different percentages of ethyl acrylate, methyl methacrylate and their mixtures was tried. After a series of experiments it was found that the maximum improvement in film properties is obtained when the grafting is carried out with 60 per cent of ethyl acrylate or a mixture of 50 per cent of ethyl acrylate and 10 per cent of methyl methacrylate on the weight of lac. Both the air dried and baked films showed better flexibility, gloss and resistance to impact, water and heat than those of the parent lac.

Copolymerization of lac with ethyl acrylate or styrene was also tried in aqueous medium in presence of redox catalyst such as ammonium persulphate and sodium bisulphite but the results were not encouraging.

Further work is in progress.

5. Modification of epoxide chain with shellac or hydrolysed shellac (Problem No. 10)

(i) It had earlier been mentioned (*A. Rep.*, 1964-65, p. 37) that there is a gradual fall in the acid value and epoxide content of lac epoxy mixture during fusion and that the decrease in epoxide content is almost equivalent to the drop in acid value indicating that the reaction is between the epoxy and the carboxyl groups.

The above inference was confirmed from their infrared spectra. The infrared spectrum of a physical mixture of shellac and epoxy resin (70 : 30) showed charac-

teristic bands of both the resins. Prominent absorption bands for shellac were in evidence at 3500 cm^{-1} due to OH group and at 1715-1760 cm^{-1} due to carbonyl. Absorption bands characteristic of epoxy resin (epikote 1001) were seen at 3030, 1344, 1250, 1105, 916, 862 and834 cm^{-1}. The bands at 1250, 915 and 862 cm^{-1} have been attributed to epoxy group and the band at 3030 cm^{4} to the methylene group.

Absorption spectrum of the product obtained after 15 minutes fusion at 150°C showed marked change in absorption at 1250, 915 and 862 cm^{-1} indicating a decrease in epoxide content whereas the bands at 3500 and 1730 cm^{-1} showed increased absorption. The increase in the 3500 cm^{-1} region indicated creation of more hydroxyl groups. This was also supported by increase in intensity in the region 1730 cm^{-1} which indicated formation of ester groups. In the case of the product obtained by carrying out the fusion for 30 minutes the intensity of most of the absorption bands was reduced to a marked extent and many of them disappeared. This was possibly due to crosslinking of the molecules which, incidently, made the product insoluble.

(ii) *Modification of lac with epichlorohydrin*

In recent years, epoxy resins have attained much importance in many fields, such as surface coatings, adhesives, castings, laminates, etc. The superior properties of epoxy resins are attributed to the presence of epoxy groups and ether linkages in the resin molecule. Epoxies are generally prepared by the reaction of epichlorohydrin with compounds containing more than one hydroxyl such as polyhydric phenols, di- and poly-glycols, glycerol, polyhydric alcohols, etc. Since there are five hydroxyl groups in lac molecule, it was considered desirable to see if it would be possible to introduce epoxy group in lac by reacting with epichlorohydrin so that a product similar in reactivity to epoxy resins could be obtained.

Shellac (1 mol) and epichlorohydrin (5 mol) were heated together at 80-85°C for 10-12 hrs. The reaction mixture was freed from unreacted epichlorohydrin under vacuum. A product of very low acid value (2·5) and high saponification value (288-293) was obtained. The epoxy value of this product was nil.

When, however, the reaction was carried out in the presence of aqueous sodium hydroxide (*p*H within 7·5) at 80-85°C for four hours and the product was washed with hot water and dried in vacuum, the resulting material had an acid value of zero and the same hydroxyl and saponification values as the parent lac (i.e., 250 and 212 respectively). The epoxide equivalent/100 g of this product was found to be only 0·0317.

In another experiment, epichlorohydrin was condensed with lac in the presence of boron trifluoride etherate at 80-85°C for two hours and the reaction mixture dissolved in dioxane and refluxed with sodium aluminate for a further period of eight hours. After filtration and removal of the solvent, a sticky resinous mass was obtained with an acid value of about 2, epoxide content of 0·128 per cent and saponification value of 218.

The above experiments indicate that probably the acid group of lac react with epichlorohydrin. Curing of the products is proposed to be investigated.

6. Improvements in the manufacture of seedlac, shellac, bleached lac, etc. (Problem No. 12)

(i) *Loss incurred during the bleaching of lac*

In the production of bleached lac by the conventional hypochlorite process a loss of 5-10 per cent is encountered (*A. Rep.*, 1956-57, p. 46). In an

attempt to account for the loss, the aqueous liquor left after the precipitation of the bleached lac was treated with 2: 4-dinitrophenyl hydrazine. A small amount of hydrazone melting at 113-115°C was obtained (m.p. of 2: 4 dinitrophenyl hydrazone of azelaic semialdehyde — 114-115°C). This suggests that a small portion of aleuritic acid molecule breaks down during the bleaching operation giving rise to water soluble oxidation products.

(ii) *Technical preparation of aleuritic acid*

Aleuritic acid is one of the major constituent acids of lac and is believed to be present to the extent of nearly 35-40 per cent. It is a 9,10,16-trihydroxypalmitic acid and by virtue of its structure is a potential raw material for various synthetic products particularly in the domain of perfumery. Demand for the product is, therefore, gradually increasing.

By the conventional alkaline hydrolysis with aqueous 5*N* caustic soda, aleuritic acid is obtained only in an yield of 20 per cent. A systematic study was undertaken and a simplified method was developed but the yield could not be increased (*A. Rep.*, 1962-63, p. 35; 1963-64, pp. 37, 68).

The work has once again been taken up with the idea of increasing the yield by direct aqueous alkaline hydrolysis, or other suitable pretreatments, if necessary, followed by alkaline hydrolysis. To start with, dewaxed lac was chosen as the starting material with the intention that, after standardization, the method would be extended to seedlac and finally to refuse lacs.

Different alkalies, alkaline salts and their mixtures were tried for the precipitation of sodium aleuritate. After a series of experiments, the yield of crude aleuritic acid could finally be raised from 20 to 25 per cent by carrying out the hydrolysis with aqueous alkali in presence of 5 per cent of sodium sulphite. It was also found that it was best to add the sulphite after the alkaline hydrolysis had proceeded for two days and that complete precipitation of sodium aleuritate occurred in about ten days from the start of hydrolysis. This was in accordance with the earlier observations. Further improvements are under study.

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

Lac wax is a valuable byproduct which is lost in substantial quantities during the washing of sticklac into seedlac. It has been found that most of this is lost in the wash water and is precipitated along with the sludge when the wash water is treated with sulphuric acid. The dry sludge contains nearly 10-12 per cent of wax and a method had already been developed for its recovery by extraction with commercial hexane. In a 7 kg extractor the yield was 90 per cent (*A. Rep.*, 1962-63, p. 23; 1963-64, p. 29).

On the basis of the above findings a steam heated stainless steel semipilot plant (capacity — 25 kg per charge) was set up. The dry powdered sludge (25 kg) was taken in six (60 × 10 cm) cloth bags which were then suspended inside the extractor and extracted with commercial hexane (110 l). It was found that 12 extractions (each extraction took 30-35 min) could extract only 73 per cent of the total wax. Further extraction did not extract any more material. Some modifications are therefore called for which are being worked out. The loss of hexane per charge was 800 ml.

(iv) *Recovery of lac dye*

The water soluble dye associated with sticklac goes with the wash water during the washing of sticklac to seedlac. Sulphuric acid treatment of this wash

water precipitates a substantial portion of this dye along with the sludge. The rest of the dye remains in the clear liquor.

Attempts were made to recover the dye retained in this clear liquor as an insoluble salt by treating with suitable chemicals in solution or with solid calcium carbonate (precipitated chalk). The latter was found to serve the purpose very well. The amount of calcium carbonate necessary for complete precipitation was only 1 g per litre of the liquor. The precipitated calcium salt of the dye could be converted into the sodium salt by treating a suspension with an equivalent of sodium carbonate. Sodium was removed from the sodium salt solution by passing through cation exchange resin and the dye recovered by concentration. The dye thus obtained was bright red in colour and completely water soluble. It amounted to 0·15 to 0·2 per cent on the weight of sticklac. Further work is in progress.

(v) *Fractionation of shellac by aqueous electrolytes*

As is well-known, lac resin is a solid solution of inter- and intra-esters of carboxylic acids. Obviously, it should be possible to separate the constituents or group of constituents by simple physical means. Various attempts have been made in the past to fractionate the constituents by solvent extraction or by fractional precipitation from solvent but none of these met with complete success and they were impracticable for commercial purposes.

Methylated spirit is one of the cheapest and most easily available solvents for lac, and water the cheapest nonsolvent. Addition of water to alcoholic solution of lac or *vice-versa*, however, results in colloidal solutions. Presence of small quantities of electrolytes is known to readily precipitate the resin.

A systematic study was, therefore, taken up to see if fractions of lac of improved properties for commercial utilization could not be obtained by precipitating alcoholic solution of lac with dilute aqueous solutions of electrolytes.

For the investigation, 10 per cent solution of seedlac in methylated spirit was considered to be the most suitable for the initial experiments as the same could be readily freed from wax and other insoluble materials by filtration.

250 g of seedlac were dissolved in 1800 g of methylated spirit in the cold by continuous mixing for 2 hr. After allowing to stand overnight, the solution was filtered and the concentration adjusted to 10 per cent (w/w) by addition of the requisite amount of alcohol.

For precipitating the fractions, 100 ml of the solution were taken and, under efficient mechanical stirring, a known amount of 1 per cent aqueous sodium chloride solution was added slowly. After the addition was complete, the stirring was continued for 10 minutes more.

The precipitate soon settled down and, after allowing to stand for one hour, the clear supernatant liquid was decanted off and the gelly-like precipitate triturated with water in a mortar and pestle till it turned granular after which it was filtered under suction, washed and dried in air.

Fractions were thus obtained using 30, 40, 50, 75, 100, 200 and 300 ml of the electrolytic solution per 100 ml of lac solution. The yield of dry precipitate obtained was 3·1, 5·4, 5·6, 7·1, 7·1, 7·9, 7·9 gm respectively. The total nonvolatiles in 100 ml of the alcoholic solution was 8·36 gm. This indicated that precipitation of lac increased with increasing proportions of non-solvent and that a maximum of 94·5 per cent was precipitated when 200 ml of the electrolytic

solution were used; further increase in the quantity of electrolyte did not result in increased yield of the precipitate. The physical and chemical constants of these fractions are being determined. The study is to be continued using, for precipitation, aqueous solutions of different concentrations of the same electrolyte as well as electrolytes of di- and tri-valent metals to study their effect, if any, on the nature of the products separating.

(vi) *Dry distillation of lac*

The well known methods of preparation of ketones, aldehydes, etc., by thermal pyrolysis of calcium salts of higher fatty acids were tried in case of lac and reported (*A. Rep.*, 1936-37, p. 3 and 1938-39 p. 7). However, the pyrolysis products had not been studied in detail for their chemical compositions or possible uses in different fields. The work was resumed during the year under report in order to develop an economic use for refuses containing upto 20 per cent of lac, from the lac industry. For the preliminary studies, however, shellac was used.

A mixture containing equal parts of shellac and hydrated calcium oxide was subjected to dry distillation at atmospheric pressure and at reduced pressure (40-50 mm). Heating was done by direct gas flame and the distillate fractions were collected in a series of receivers, cooled with ice. Average yield of distillate including water was 51·2 per cent (w/w). The fractions from the receivers were mixed up and extracted with ether. A dark brown viscous, oily and fluorescent product, was obtained in an yield of 35 per cent on the weight of shellac taken.

Qualitative tests for the product indicated the presence of free carboxyl unsaturation, aldehyde, ketone and ester groups and hydrocarbon, and the absence of ether group. There were also indications of the presence of phenol and quinones. The oil had an acid value of 30·08, saponification value of 129·10, (ester value — 99·02), iodine value of 90·74 and hydroxyl value of 53·15.

The study of the products is being continued.

7. Improvements in the analytical methods of lac and problems connected with grade *cum* specifications (Problem No. 13)

Correlation of specific heat, flow and insolubles of seedlac with age

Specific heat of lac had been found to vary with the temperature at which it is determined as well as the degree of polymerization of the lac. The difference between the specific heat of fresh lac and that of the same lac after heat polymerization had also been found to be widest at 70°C. Specific heat being a factor that can be determined with a high degree of accuracy, it was considered desirable to investigate if specific heats (at 70°C) can be used to determine the "age" (period of storage) of lac for which there is no scientific method yet.

Six representative samples of seedlac of different regions had been stored under ordinary laboratory conditions at Namkum and their specific heats at 70°C determined from time to time. At the end of last year as mentioned in the Annual Report (*A. Rep.*, 1964-65 p. 41) there was no noticeable change in the specific heats of three of the six samples after seven months of storage. However, a drop of 6 to 9 per cent in the values was noticed after one year's storage in all the six samples. At the end of one and a half years the drop was 7·7 to 10 per cent from the original value i.e., a further drop by 1·0 to 1·7 per cent from the values obtained after 12 months' storage. (See Table 4).

TABLE 4 — CHANGE OF SPECIFIC HEAT OF SEEDLAC WITH AGE

Sl. No.	Source & locality	Progeney and kind of lac	Crop	Received on	Specific heat at 70°C of the sample determined in			
					July 1964	Jan. 1965	July 1965	December 1965
1.	Mirazpur	Palas × palas Palas	Baisakhi 1963-64	25-5-64	0·660	0·657	0·616	0·600
2.	Damoh	Palas	Baisakhi 1964	12-6-64	0·668	0·627	0·617	0·610
3.	Balarampur	Ber	Baisakgi 1964	17-5-64	0·660	0·600	0·600	0·600
4.	Daltaonganj	Palas	Baisakhi 1964	9-6-64	0·658	0·635	0·603	0·603
5.	Jhalda	Palas × Ber Ber	Baisahi 1963-64	13-5-64	0·689	0·687	0·623	0·615
6.	Gondia	Ber	Baisakhi	16-7-64	0·631	0·630	0·593	0·582

The same samples tested for specific heat were also tested for flow and insolubles. For flow, Victor's method was adopted. Samples were ground to 30 mesh and conditioned for 24 hr in a desiccator containing a saturated solution with some free crystals of sodium dichromate (52 per cent humidity). After 14 months it was observed that the flow had shown a decrease of 15 to 29 mm (vide Fig. I below) while in the case of insolubles no substantial change was noticed. No appreciable change either in flow or insolubles could be observed when the samples were again tested after another 5 months.

8. Plasticizing lac films for special purposes (Problem No. 14)

Modification of lac with polyamide

In the previous report (*A. Rep.*, 1964-65, p. 42) mention was made that nylon-66, after modification with paraformaldehyde and a monohydric alcohol in acid conditions, was compatible with lac varnish and that the films obtained from such a blend showed flexibility and adhesion to tin, glass and wood but that the blend hardly was any improvement over the parent lac in heat, water and chemical resistance.

Continuing the work further, conditions were worked out by which lac was made to chemically combine with the modified nylon. Nylon, in formic acid solution, was treated at 65°C with an ethanolic solution of paraformaldehyde to form the methylol derivative. To this a concentrated ethanolic solution of dewaxed decolourized lac was added and stirred thoroughly for 30 minutes keeping the temperature constant at 65°C. The reaction mixture after dilution with 90 per cent aqueous acetone was treated with ammonia when a fluffy mass was precipitated. The mother liquor, when acidified, did not give any precipitate of lac, showing that all the lac had reacted with the modified nylon.

This lac modified nylon product gave clear varnishes in methyl, ethyl and propyl alcohols. A varnish in ethyl alcohol produced hard, smooth and highly flexible films on glass, metal and wood. On baking at 150°C for 20 minutes, the

films became resistant to toluene, water, lubricating oil and acids. No greening of copper foil was observed after prolonged baking.

Further work is in progress.

9. Nature of urea and melamine modified lac (Problem No. 18)

Modification of shellac with urea

Various attempts had been made, from time to time, to upgrade the performance of shellac for use, in the surface coating field, by improving its softening and melting points, and resistance to moisture through modifications especially with the help of curing agents or accelerators. One of the most efficient and cheapest accelerator studied is urea (ILRI Bull. 14, 1933).

The curing of shellac is very much accelerated by small amounts of urea and several shellac-urea combinations have been studied. An important modification of shellac has, however, been described (U.S.P. 2,387,049/1945) wherein very large proportions of urea, at least one fourth of the weight of shellac, was fused with shellac at 140-180°C to give a fusible and alcohol or alkali soluble product. Various claims have been made with regard to their uses but the nature of the products have not been studied nor have their immense potentialities been thoroughly explored. The study was therefore taken up during the year under report.

At the outset, the "life under heat" of shellac with various proportions of urea was studied. It was found (vide Fig. II below) that the "life" (curing time) dropped rapidly initially upto about 10 per cent of urea and increased thereafter gradually with higher proportions. The curing time with 32 per cent of urea rose to 23 min and with 33 per cent the mixture did not polymerize at all. This indicated that shellac can be heated with a minimum of 33 per cent of urea to effect any combination without fear of gelling. That moisture, which might be present in hygroscopic urea, did not play any part in this reaction was verified by repeating the life under heat of a mixture of shellac, urea and various amounts of water. It was found that the change in life was only of the order of less than 10 min even when nearly 100-500 per cent of water was used on the weight of urea.

As 33 per cent of urea was thus the minimum proportion to result in practically unlimited "life" of shellac, the properties of shellac modifications containing this and higher proportions of urea were next examined. Combinations of 1 part of urea with 1, 2 and 3 parts of shellac were prepared by heating together at 150°C under mechanical stirring. Samples were removed at intervals and acid values and water soluble contents determined. These were found to decrease progressively with increase in cooking time. The products obtained from the first two combinations were comparatively soft and tacky and consequently were unlikely to find much use in the surface coating industry. The third one was promising and was, therefore, studied in more detail. The fusion of 1 part of urea with 3 parts of shellac was carried out at 150, 165 and 180°C respectively. A temperature of 165°C was found to be the most suitable as at this temperature the reaction was smooth without any portion of the product becoming insoluble. The various constants of a sample (before and after washing) from a typical run obtained by reacting at 165°C were determined. It was found that after 20 hr heating the water soluble content came down to 5·8 per cent and the acid value to as low as 7·81. The washed products showed higher melting points than the parent lac. Apparently urea had combined with shellac as the nitrogen content

of the water washed material was 8·5 per cent which would amount to 18·24 per cent urea. The precise nature of this combination has to be investigated.

As a period of 20 hr was too long for practical purposes, the possibility of accelerating the reaction with *p*-toluene sulphonic acid or α-naphthylamine was tried but without success.

Properties of the product

The product freed from water solubles was insoluble in hydrocarbons but dissolved completely in alcohol and in a mixture of alcohol and aromatic hydrocarbons. It was completely thermoplastic and could further be heated for 10 hr more at 165°C without gelling or becoming insoluble. Films from alcohol or mixture of solvents, after air drying and also baking, were examined, but none of them was found to be any improvement over the parent shellac. The addition of plasticizers also did not improve the films very much.

Esterification

As the material could be heated for long periods without fear of gelling, the free hydroxyl groups of this combination were esterified with fatty acids of oil by heating together at 180°C in presence of 0·5 per cent of *p*-toluene sulphonic acid. Esters with acid values as low as 10 could be obtained. They were alcohol soluble and though elastic films could be obtained after drying and baking, their water resistance was still poor.

The castor oil fatty acid ester was a tough material with no tendency to polymerize at elevated temperatures. Its cohesion was of a high order as with a little effort it could be pulled off whole from glass or metal surfaces but the adhesive force was a little higher than that of compositions used for strip coating. Though incorporation of stearic acid, aluminium stearate and calcium stearate reduced the adhesion, the product was too sensitive to moisture to be of any practical utility.

The properties of the products obtained by shorter periods of heating as well as the possibility of modification of these combinations with formaldehyde are proposed to be investigated.

10. Aqueous lac varnishes and stiffening of fabrics (Problem No. 20)

(i) *Aqueous lac–linseed oil varnishes*

In the previous reports (*A. Rep.*, 1963-64, p. 34; 1964-65, p. 43) it had been mentioned that aqueous lac–linseed oil varnishes produced from dewaxed lac and maleinized linseed oil (1 : 1) gave films which, on baking, showed excellent resistance to heat, water, alcohol and dilute acids and possessed good adhesion, flexibility and impact resistance property.

The effect of drier, such as cobalt, on the drying properties of these above varnishes was studied during the year under report. It was found that incorporation of the drier did not result in any improvement.

(ii) *Water thinned red oxide primer*

(a) *Lac-linseed oil primer* — The possibility of using aqueous lac-maleinized linseed oil compositions as a vehicle for the production of water thinned red oxide primer for steel, had been taken up for investigation last year (vide *A. Rep.*, 1964-65, 44) and a primer of good corrosion resistance had been formulated.

Further experiments have shown that the optimum composition for such a primer consists of equal parts of lac and maleinized oil and ground with 35 per cent of red oxide of iron in a ball mill for 15-18 hr. This primer could be applied by any of the conventional methods and, on baking, after a flash off period of 5-7 min., at 150°C for 30 min, gave films having excellent adhesion, hardness and flexibility. These films, when subjected to impact test, showed no cracking or peeling off on the dented edges and withstood continuous immersion in water upto one month without any rusting or blushing. These also showed excellent wetting to synthetic enamels, oil paints and nitrocellulose lacquers without any bleeding tendency. Baked films on mild steel panels withstood satisfactorily 40 days' exposure in a humidity cabinet and the salt droplet test for 4 days without any development of rust or corrosion spots. No corrosion spots or other changes could also be noticed at the end of 6 months' exposure under natural weathering conditions.

The primer films were also found to be resistant to solvents and chemicals. Samples of this primer are to be sent to major consumers for their evaluation.

(b) *Lac-tung oil-phenolic resin primer* — The lac-tung oil-phenolic resin blends described earlier were also tried as vehicles for water based primers of the baking type.

A composition containing appropriate proportion of the blend was ground to a pigment volume concentration of 35 per cent with red oxide of iron for 18-20 hr in a ball mill to give a uniform primer. This primer could be applied by dipping, spraying or brushing and the films thus obtained showed a typical matt finish. Baked films had excellent wetting and hold out to various types of top coats.

Salt droplet and sulphur dioxide exposure tests upto 96 hr showed no corrosion. Natural weathering tests are in progress.

(iii) *Electrodeposition of shellac paints on mild steel surfaces*

Electrodeposition of paints or electropainting as it is popularly known, is the latest trend in paint application technique, particularly suitable for water thinned paints. In general, all water based paints are suitable provided they can be charged electrically. The object to be coated is made the anode in a D.C. circuit, the cathode being the paint container if made of metal or provided separately.

Lac, being acidic in nature dissolves in aqueous alkaline solutions and under the influence of electric potential migrates towards the anode. As lac possesses practically all the characteristics needed for electrodeposition, a systematic study has been undertaken to find out the optimum conditions for application of water thinnable lac paints by this method.

A cell was specially designed for the purpose and fabricated in the Institute workshop. It was put in the electrical circuit using senitsive voltmeter and ammeter to read the voltage and the current during the deposition. Supply of electric current was obtained from 230 volt D.C. generator and variation of voltage was done by the use of lamp resistors.

A mild steel plate of approximately 50 sq. cm, cleaned with acid and alkali, was used as anode and the cathode was a copper plate and the whole thing was taken inside a glass jar. The recently developed water thinned red oxide primer was used as the paint to be applied. A number of preliminary experiments were carried out by varying the voltage between 40 and 120, current between 0·2 and to 1·2 amps for the total area, time of deposition from 5 secs to 2

mins. and electrode distance from 8 cm to 14 cm respectively. The coated panel, after each experiment, was thoroughly washed and dried in air at room temperature. It was found that films had poor adhesion in all cases and peeled off of its own accord.

Further work is being continued.

11. Shellac based leather finishes (Problem No. 21)

As mentioned already this work was being carried out under a scheme being implemented at the Central Leather Research Institute, Madras. The investigations reported last year (*A. Rep*, 1964-65, p. 45) were continued during this year also. The results obtained are given below.

(i) *Development of a top gloss composition*

The successful formulation of a top gloss composition, based on lac and polyethylene glycol modified resin, giving glossy, wet rub resistant and flexible films on leather, had been reported already (*loc. cit.*). Two types of Top Dress materials, MS and MSS, were prepared and compared with resin finished and topped with lacquer in thinner. Top Dress MS gave a finish comparable to lacquer finish and dried out quickly. The film was nontacky, noncracking and waterproof. Top Dreses MSS gave more gloss and was partially spirit based. The two materials were suitable for black and brown finishes and during the year, 235 kg. and 130 kg. respectively were produced for demonstration to leading tanners and leather goods manufacturers at Agra, Kanpur and Calcutta. To increase the waxy feel of the products, lac wax was incorporated. An optimum amount of 20-25 parts of wax was emulsion for 40 parts of lac solution and 35 parts of wax emulsion for 40 parts of lac solution and 35 parts of modified lac was found to give satisfactory results. Nearly 100 kg. of this wax emulsion were supplied to a tanner who had approved the same.

The tentative costing of the product comes to Rs. 2.60 per kg. Full scale production of the same is proposed to be taken up coming year.

(ii) *Shellac as principal binder for leather finishes*: *Hydrolysed lac as plasticizer.*

The use of hydrolysed lac as plasticizer for ammoniacal lac binder has been found to improve the overall properties as compared to sulphated fish oils as plasticizer. It produced better gloss and could be hot plated.

Sulphated seedlac prepared by different mothods did not vary much in their fat liquoring properties. Fullness, tightness and finish performance were good but strength, grain crackiness and feel only satisfactory. When used as plasticizer for ammoniacal lac, it gave better gloss and withstood hot plating.

Hydrolysed lac, ammoniacal lac and lac modified with oleic acid, glycerine and oleic acid-glycerine were found to serve as a finishing agent for various types of leathers. Lacryl binder, a new type of finish prepared by copolymerizing acrylic esters with lac in emulsion, when used to finish chrome retan leathers had been found to give good gloss and better characteristics. Shellac top finish had also been used to finish shark skins and shrunken grain shark skins.

(iii) *Impregnation and retanning studied*

(*a*) *Lac as impregnant* — The work on impregnation and retanning of leathers with lac and modified lac was continued. Lac had been found to be a good impregnating agent for oil seal leathers, cycle saddles etc. Full chromo crast

leather, vegetable retan leather and shellac retan leather were impregnated with 50 per cent and 60 per cent of glyceerine modified lac. Percentage uptake modified lac was more in case of full chrome crust leather than the other two. The last two were, however, more oil resistant than the former. Impregnated shellac retan leather absorbed less water and had more apparent density than the other two. Abrasion resistance was uniform in chrome and shellac retan leathers whereas in vegetable retan leather, it increased rapidly.

(b) *Lac as retanning agent*: — Phenol and lac sulphenates have no tanning properties of their own. But the sulphonated lac phenolate showed good tanning property. This lac syntan was prepared by the following two methods:

(i) Sulphonation first followed by condensation.

(ii) condensation first followed by sulphonation. Lac and phenol were condensed in the ratio of 1:1 and there was a gradual reduction in acid value upto 2 hrs followed by an increase thereafter indicating that condensation reaction was complete within 2 hrs. Sulphonation was done taking lac phenolate and cocentrated sulphuric acid in the proportion of 1: 0.5. The product was salted out with 30 percent sodium chloride and the excess acid removed by washing. Afterwards, the product was neutralized to *p*H 3·2 with 10 per cent ammonia.

The product obtained by the first method gave a good auxiliary tanning agent whereas in the second case the penetration was good from the flesh side only. In general the syntan gave a fuller leather in retanning, and grain was coarser and tighter.

Retanning with sulphated and other lacs

Using 3,4,5, and 10% of sulphated lac as retanning agent, it was observed that the product imparted more fullness, tightness and prominence to the grain with increased temper to the leather. Filling effect was more prominent than fat liquoring effect. There was an increase in thickness of 20 per cent. It was further noted that increase in the amounts of sulphated lac resulted in a softer leather and the combination of sulphated lac and fish oil gave a softer leather with fat liquoring effect.

Use of seedlac as retaning agent was only limited since it preduced a coarser grained leather. As far as hydrolysed lac was concerned, it gave better fullness, greater thickness and coarse grain. Lac-oleic acid modified lac produced a soft leather with pipy grain which did not possess full fat liquored effect.

The study is being continued.

12. Shellac etch primer (Problem No. 26)

(i) The single pack shellac etch primer, which had earlier been developed by this Institute and which is already in commercial production in this country by a leading firm of paint manufacturers, has one major limitation; the zinc chrome to be used has to be specific i.e., the chromic and zinc oxide contents can vary only within a very narrow limit. Consequently, many commercial samples failed to be satisfactory. This limitation had been overcome by incorporating, into the composition, about 2 per cent of malic, citric or tartaric acid. By such incorporation, any sample of zinc chrome could be used and the etch primers produced were identical in all respects with the earlier standardised sample. Indeed, even the more alkaline zinc tetroxychromate could be used. In this case, the phosphoric acid had to be completely replaced and about 20 to 25 per cent of

malic acid had to be used in its place. This resulted in an etch primer which behaved exactly like the standardized earlier primer and possessed, in addition, the welcome property of outstanding adhesion and elasticity on steel also (*A. Rep.* 1964-65, p. 47).

Etch primers of the above composition had been prepared and stored for judging their storage stability. Side by side, panels of aluminium, galvanized iron and brass as well as mild steel had also been coated with this primer and partly coated with finishing coats of oil paints, synthetic enamels and nitrocellulose lacquers and exposed over the roof of this laboratory for determining their weather resistance.

At the end of over twelve months so far, the primers (stored in bright plate friction top containers) were found to have undergone no change either in viscosity or in performence. The pigments that had settled down could be easily redispersed by gentle stirring with a spatula or glass rod.

In regard to natural weathering, the aluminium, brass and galvanized iron panels at the end of 12 months so far, were found to be in perfect condition with no noticeable deterioration. On the mild steel panels, however, a few rust spot appeared at the end of 5 to 6 months although the films except at the rust spot continued to remain firmly adherent to the panel.

Two papers summarizing the development of these two primers have been compiled and communicated for publication.

As zinc is an imported material, the possibility of using zinc-free pigments such as barium chromate and barium potassium chromate, which are indigenously produced, are also proposed to be investigated.

Improving corrosion resistance on steel — As mentioned above, the etch primer based on dewaxed lac, zinc tetroxychromate and malic acid has excellent adhesion to and elasticity on steel. But natural weathering of the panel had indicated that its corrosion resistance needed further improvement. As phosphate ions are known to effect substantial improvement in this regard, the incorporation of phosphoric acid in the composition was investigated. After various trials the optimium amounts of each ingredient were found to be shellac-100 parts, zine tetroxychromate-50 parts, phosphoric acid-15 parts and malic acid 5 parts in the usual solvents. A large batch was prepared and examined for its storage stability. Films were prepared, from time to time, on cleaned aluminium panels by brushing and examined after 24 hrs. for scratch hardness and flexibility.

It was found that upto 150 days storage so far, the primer has stored without loosing any of its properties except in respect of slight elasticity at the end of one month.

The adhesion of the primer on various metal surfaces such as aluminium, copper, galvanized iron, brass and steel were also examined after a month's storage and found to be excellent (over 2 kg in each case). Its further storage stability as well as natural weathering properties are under study.

(ii) *Function of the inhibitors in preventing gelation*

The function of malic, citric or tartaric acid in the prevention of the thickening of shellac varnishes when ground with certain samples of zinc chrome or any zinc tetroxy-chromate was then investigated. These chromates contain certain proportion of zinc oxide. Since barium chromate as well as barium potassium chromate had no gelling action when ground with shellac varnish, it was presumed that the zinc oxide was responsible for the thickening. That zinc oxide does help

gelling of shellac varnish when ground or boiled under reflux was observed by Kamath and Bhattacharya (LSRB, Tech. Paper 22,1942) and Gardner (U.S.P. 1,918, 804, 1933). According to Kamath and Bhattacharya, zinc oxide forms a bridge between two or more molecules of shellac through groups other than carboxyl. Zinc oxide also forms complexes with malic acid [*J. Amer, chem. soc*,. **60** (1938), 2314]. Therefore, it may be presumed that the prevention of gelling of shellac varnishes with zinc chrome or zinc tetroxy-chromate in presence of malic acid (or other acids) is due to the preferential complexing of zinc oxide with malic acid. The observation that more of this inhibitor (malic acid) is necessary in case of zinc tetroxychromate which has a larger proportion of zinc oxide than zinc chrome, further lends support to this presumption.

(iii) *Chemical reactions taking place in shellac etch primers*

The chemical reactions involved in the primer itself was next studied. A primer was prepared under the standard conditions from 100 parts dewaxed shellac, 100 parts ethanol, 82 parts butanol, 95 parts zinc tetroxychromate and 20 parts of malic acid and studied after about a month. A 10 g. sample was diluted with excess alcohol and the insoluble portion (4·13 g) separated. This insoluble portion was boiled under reflux separately with glacial acetic acid and with ethyl alcohol containing dilute hydrochloric acid in order to break up any shellac metal complex formed. The suluble material was filtered from the insoluble residue and the dissolved matter precipitated by dilution with water. This precipitate was identified as shellac and amounted to about 17 per cent. The residue was found to contain 15 per cent of iron oxide and 68 per cent insolubles. The isolated shellac had acid value-98·5, hydroxyl value-45·18 and carbonyl value-nil as against 70·39, 270·39 and 25·8 respectively for the parent shellac.

The alcoholic mother liquor obtained by dilution of the 10 g primer portion was a deep green solution from which unreacted shellac (2 g) was recovered on dilution with water. This isolated shellac was 80 per cent of the original amount (2·5) and had acid value-62·66, hydroxyl value-238·16 and carbonyl value-26·5 which agreed reasonably well with those of the parent shellac. The unreacted malic acid present in the liquor was determined by titration and found to be only 0·066 g. as against 0·5 g used in the primer.

It would thus appear that most probably the zinc oxide had formed inoluble complexes with most of malic acid (87%) and only with a small proportion (20%) of the shellac present. This once again confirmed the earlier inference that zinc oxide reacts with malic acid in preference to shellac thereby preventing the gelling of the primer.

Further, the deep green colour of the alcoholic filtrate of the primer indicated that the chromat had oxidized one or more of the ingredients, alcohol, malic acid and shellac. A thorough investigation had shown that both malic acid and shellac were oxidized and the rato of oxidation was comparatively slower in the case of shellac.

It was further observed that no complex precipitated out of an alcoholic solution of malic acid and shellac after one month's storage and that there was no change in acid value either. This suggested that there was no combination between malic acid and shellac.

The condition of the primer when freshly prepared as well as after six months' storage are proposed to be examined to follow the course of the reaction.

13. Shellac rubber combinations

(i) *Shellac-natural rubber latex.*

It was reported last year (*A. Rep.* 1964-65, p. 49) that attempts to graft shellac to natural rubber latex failed and the failure was attributed to the presence of non-rubbery constituents in the latex.

Accordingly, grafting was attempted with centrifuged latex (from which non-rubbery constituents had been separated) in presence of the redox catalyst, tertiary butyl hydro-peroxide and ferrous sulphate activated by tetraethylene pentamine. Evidence of some grafting was obtained as the amount of shellac, which could be extracted with a solvent, after grafting, was less than that extractable from a physical mixture of the latex and shellac.

Further work is in progress.

(ii) *Shellac/synthetic rubber* (*styrene butadiene cold* 1502)

Preliminary experiments showed that shellac did not combine with styrene/butadiene rubber as such but did combine when milled in presence of the usual rubber compounding ingredients (loc. cit.). During this year, a systematic study was taken up of the effect, on the resultant properties, of the incorporation of various proportion (0 to 20 parts) of shellac per 100 parts of rubber in gum stock (i.e. without filler) and in the presence of various fillers such as carbon black. The milling and mixing were done on a combiroll mill and moulding at 140-141°C under a pressure of 4000 p.s.i. for 30, 45 and 60 mts. The optimum time of vulcanization was estimated from modulus.

(a) *In gum stock* (i.e. without filler)—Shellac was found to enhance the plasticity of the stock during its compounding with styrene butadiene rubber (as shown by lowering in Mooney Number) and thus assist in the milling and mixing of various rubber compounding ingredients.

In the vulcanized product, the improvements noticeable because of the incorporation of shellac were increase in hardness, tensile strength and modulus, although accompanied by a lowering in abrasion resistance which might probably be due to shellac being a hard and brittle substance.

(b) *With high abrasion furnace carbon black as the filler* — This filler is alkaline (*p*H 8.9) and gives a high degree of reinforcement to rubber. The compositions were such as are suitable for use in tyre tread.

The improvements noted here by the corporation of shellac were in the plasticity of the unvulcanized and hardness of the vulcanized compositions. There was an improvement in tear resistance when lower ratio of shellac (2.5 per cent as the weight of incorporated.

(c) *With easy processing channel black as the filler*—This filler is acidic (*p*H. 4-5). The compositions prepared with this filler were such as are suitable for use in shoe soles and heels.

The improvements noticed when shellac was used with this filler were in the plasticity of the unvulcanized, and modulus and hardness of the vulcanized stocks. Besides this, the resistance of the rubber to benzene, petroleum other and water absorption was also improved.

The abrasion resistance was, however, impaired.

(d) *With clay as the filler*—The compositions prepared with this filler were such as are suitable for use in flooring, tubing, hoses, etc.

The improvements brought about by the incorporation of shellac were in the plasticity of the unvulcanized and hardness resilience, modulus and tear resistance of the vulcanised compositions. There was a little lowering in abrasion resistance but the lowering was much less than that with carbon black as the filler. Clay thus appeared to be the best filler for use with shellac in styrene butadiene rubber.

(iii) *Epoxy resin modified lac synthetic rubber (styrene butadiene cold* 1502)

The effect of incorporation, styrene butadiene rubber of a modified lac, prepared by fusing together lac and epoxy resin (Epikote 1001) in the ratio 7:3 at 150°C for 15 mts., was also studied. The epoxy resin modified lac had an acid value of 38, softening point 80-82°C and melting point-90-93°C. It was expected that because of lower acidity (higher acidity interferes in vulcanization of rubber), this compound might behave better than straight shellac. The results obtained are described below.

(a) *In gumstock*—The improvements in hardness, tensile strength, modulus and tear resistance of the rubber brought about by the incorporation of this modified were found to be more than those brought about by straight shellac while abrasion resistance was of the same order.

(b) *With high abrasion furnace carbon black as the filler* — Epoxy resin modified lac was similar to straight shellac as regards its effect on plasticity, hardness resilience and abrasion resistance of the rubber but the modified lac brought about greater improvement in tansile strength and tear resistance.

(c) *With easy processing channel carbon black as the filler* — The improvements noticed with epoxy resin modified lac were the same as those with straight shellac.

Resistance of the rubber towards swelling in benzene and petroleum ether was, however, improved to a greater extent but water absroption also increased.

(d) *With clay as the filler* — Epoxy resin modified lac behaved in the same manner as straight shellac as regards beneficial effect on hardness and modulus but brought about greater improvement in plasticity and tear resistance.

From the above, it can be inferred that epoxy resin modified lac is distinctly superior to straight shellac in gum stock although only slightly better in the presence of fillers.

14. Ad-hoc researches (Problem No. 29)

(i) *Moulding powders*

Some parties showed interest in fllllerless moulding powders based on lac having good flow, with the moulded articles resistant to impact and water. Accordingly, attempts were made to prepare fillerless thermosetting moulding powders from ordinary or modified lacs.

Incorporation of preformed urea formaldehyde resin with lac under hot rolling at 100°C had given products with satisfactory resistance to impact and water but with poor flow. The impact resistance was found to increase with increasing proportions of the urea resin. With 50 per cent of the urea resin on the weight of lac, the impact resistance was 3.66 cm kg/per sq. cm as against 1.08 cm kg/per sq. cm for 15 per cent. Butylated urea resin also behaved similarly but the flow was somewhat better. When jute stick powder was used as filler, the impact resistance increased from 3.66 cm kg/sq. cm to 6.1 cm kg/sq. cm

and the flow was also better when butylated urea resin was used. The moulded articles obtained with butylated resin also showed some toughness and elasticity.

(ii) *Lac and polyvinyl chloride combinations*

Polyvinyl chloride (PVC) is a hard brittle thermoplastic resin extensively used for moulding many useful articles. Generally, some ester or ketones are incorporated with it to improve hardness and overcome brittleness. Preliminary work on the incorporation of the butyl ester of hydrolysed lac was found to reduce brittleness of PVC moulding powders. PVC decomposes at high temperatures and hence some stabilizer is used. The optimum amounts of butyl ester and stabilizer (litharge) required for the best moulding composition are being investigated.

(iii) *Insulating enamel for copper wire*

An insulating composition obtained by heating nylon (25 parts), shellac (8·75 parts) an *m*-cresol (110 parts) at water bath temperature for 1 hr. and then dissolving in solvent naphtha was found to give satisfactory coatings on cooper wire on baking at 320°C for 90 seconds. Six such coats gave the required thickness specified in ISI specification. The final film was resistant to transformer oil at 100°C for 6 hr., and methanol, xylol, and xylol/butanol mixture at 70°C for 8 hr.

Another composition based on equal parts of dewaxed lac and cashewnut shell liquid (crude or distilled) and baked at 270°C for 90 seconds also gave films resistant to the foregoing solvents.

(iv) *Compositions for picktest of paper*

At the request of a paper mill, work on the development of compositions to replace imported Dennison waxes for picktest of paper was taken up. Seventeen compositions with varying proportions of lac and rosin were prepared and sent for test by the party concerned. Their report is awaited.

(v) *Laminated plastic paper for wrapping chewing tobacco*

Investigations, in collaboration with Central Tobacco Committee, were taken up to develop laminated plastic paper which will stand sharp bending without forming any cracks, for use as wrapper for chewing tobacco. A paper was developed by cementing (1·25 mil) tissue paper to (1·5 mil alkathene sheet with a spirit solution of refined bleached lac as the bond. This laminated paper has been approved by the Central Tobacco Committee. The cost per sheet, 50 cm $\times$75 cm, comes to 70 paise approximately.

(vi) On request from few parties several diamond fixing compositions based on lac were prepared and sent for trials.

(vii) *Shellac as binder for sand moulds*

The study of shellac as a binder for sand moulds was taken up in cooperation with the laboratories of the Foundry Forge Plant of the Heavy Engineering Corporation, Ranchi.

Materials and formulations were supplied from this Institute and samples produced and tested at the Foundry Forge Laboratories.

Various formulations were tested. A composition containing one part of shellac, one part of dextrine and 0·5 part of hydrolysed lac in aqueous ammonia for 97·5 parts of sand was found, by laboratory tests, as satisfactory. Formulations based on shellac and boiled linseed oil and/or glycerine were also prepared and are awaiting trials.

METEOROLOGICAL REPORT FOR THE YEAR 1965-66

The average meteorological data for each month during the year 1965-66 were as follows

Month and year	Mean barometric pressure (mm)	Mean wind speed (km/hr)	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean dry bulb temperature (°C)	Mean humidity (%)	Mean sunshine (hr per day)	Total rainfall (mm)	Highest maximum temperature (°C)	Lowest minimum temperature (°C)
April 1965	703·62	3·256	34·2	19·4	30·5	55·5	8·65	65·50	38·5	13·3
May 1965	700·36	3·137	38·0	23·2	34·0	53·0	7·80	24·80	42·0	20·0
June 1965	697·24	4·391	37·6	25·0	34·3	53·0	5·39	116·18	41·5	21·1
July 1965	698·07	2·670	29·7	22·4	26·6	85·0	3·04	552·44	33·0	20·0
August 1965	700·50	1·977	30·6	22·5	27·4	83·0	3·55	244·00	37·0	21·1
September 1965	701·67	1·366	29·3	21·6	27·0	79·0	4·91	262·19	32·5	19·5
October 1965	705·70	0·487	30·4	18·2	27·0	71·0	7·61	17·99	33·0	16·1
November 1965	708·74	0·875	28·1	13·1	24·4	67·0	8·70	nil	32·8	10·6
December 1965	708·73	0·995	24·0	8·7	20·4	66·0	7·90	nil	26·7	4·2
January 1966	710·39	1·875	23·1	9·1	19·0	66·0	7·41	70·83	26·7	6·2
February 1966	707·56	2·412	29·0	13·0	25·2	55·0	9·29	6·10	33·9	7·3
March 1966	705·20	3·041	33·0	16·3	28·5	69·0	8·67	Traces	39·5	11·1

The highest maximum temperature recorded was 42·00°C on 19th May, 1965, and the lowest minimum 4·20°C on 30th December, 1965. The total rainfall during the year amounted to 1360 mm. of which the monsoon (June-Sept.) rainfall was 1174 mm. The rainfall during the year was less than that of 1964-65, the total rainfall for that year being 1463 mm. of which the monsoon rainfall was 1000 mm. The highest wind speed* recorded during the year under report was 212 kms. on 1965, and lowest 0·5 km. on 24th December, 1965. There were hailstorm on 1st April, and 22nd May, 1965.

LIST OF PAPERS PUBLISHED DURING 1965-66

Sl. No.	Authors	Title of paper	Name of Journal/ Date of publication
A. Entomology Division			
1	Gokulpure, R. S., Mehra, B. P., Krishnaswami, S., Teotia, T. P. S. and Sah, B. N.	Systematic trials of lac cultivation on *ghont* (Zizyphus xylopyra Willd.), in Madhya Pradesh-pruning	*Indian Forrester*, Vol. **91**(6) June, 1965
2	Kulkarni, S. M.	Studies on the population fluctuations, sex ratio and damage caused by *Molanagromyza obtusa* (Malloch) (Diptera-Agromyzidae) to *Moghania macrophylla* (Willd.) O. Ktze. seeds in the field	Proceedings 53rd Indian Science Congress: Part III — January, 1966
3	Majumdar, N. and Teotia, T. P. S.	Anomalous leaves of *Albizzia lucida* Benth (Fam. Leguminosae)	*Indian Forrester*, Vol. **91**(4), April 1965
4	Majumdar, N. and Teotia, T.P.S.	Biology of *Holotrichia serrata* (Fabricius)	*Indian Journal of Entomology*. Vol. **27**(2) June, 1965
5	Mehra, B. P.	Host relationship of *genus Anastatus* Mots (Eupelmidae) and its Indian species	*Indian Journal of Entomology*. Vol. **27**(3), September 1965
6	Mehra, B. P.	Biology of *Chrysopa madestes* Banks (Neuroptera-Chrysopidae)	*Indian Journal of Entomology*. Vol. **27**(4), December 1965
7	Sah, B. N. and Mehra, B. P.	Bionomics of *Dilinia medardaria* Herrich-Schaffer (Lepidoptera – Geometridae) pest of Zizyphus xylopyra Willd.	*Indian Journal of Entomology*. Vol. **28**(1), March 1966
8	Varahney, R. K.	The Indian Lac Insect a change in nomenclature	*Indian Journal of Entomology*. Vol. **28**(1), March 1966
9	Varshney, R. K.	Two new lac insects from India (Abstract)	Prodeedings 53rd Indian Science Congress: Part III, January 1966
B. Chemistry Division			
1	Ghosh, A. K. and Sen Gupta, S. C.	Use of soft coke in shellac manufacture	*Research and Industry*, Vol. **10**(10) (1965), 299.
2	Kumar, Shravan	A heat and water proof shellac finish	*Paint Technology* (London), Vol. **30**(2) (1966), 16
3	Kumar, Shravan	Shellac in metal lacquering	*Paintindia*, Vol. **15**(7) (1965), 15
4	Kumar, Shravan	Shellac in water thinned organic coating	*Proc. All India Paint Conference*, Vol. II (1966)
5	Kumar, Shravan	Water thinnable lac drying oil finishes, Part-I Lac/Tung oil finishes	*Paint Technology* (London), Vol. **29**(12) (1965), 15
6	Kumar, Shravan and Misra, G. S.	Modification of lac with polyamides	*Proc. Indian Sc. Congr., 53rd Session* (1966), 147
7	Kumar, Shravan and Sankaranarayanan, Y.	Modification of lac with synthetic resins: Part I — With phenolic resins	*Paintindia*, Vol. **15**(1) (1965), 119

Sl. No.	Authors	Title of paper	Name of Journal/ Date of publication
8	Kumar, Shravan and Sankaranarayanan, Y.	Modification of lac with synthetic resins: Part II —With urea resins	*Paintindia*, Vol. **15**(1) (1965), 123
9	Pandey, A. and Bhattacharya, P. R.	Gravimetric determination of hydroxyl value of shellac	*Indian Journal of Chemistry*, Vol. **3**, (1965), 181-82
10	Sankaranarayanan, Y.	Recent advances in shellac primers	*Proc. All India Paint Conference*, Vol. 2 (1966)
11	Tripathi, S. K. M., Kumar, Shravan and Misra, G. S.	Modification of lac with epoxy resins	*Indian Journal of Technology*, Vol. **4**(1) (1966), 15

EXTENSION

1. Cultivation

There is a separate wing of the Indian Lac Cess Committee under a "Chief Lac Development Officer" entrusted with the responsibility for all activities regarding extension of lac cultivation. The function of this Institute, as far as extension of cultivation is concerned, is consequently, limited to providing the necessary technical assistance to those interested. One such instance is the collaboration with the Bihar Forest Department in their large scale cultivation experiments of lac in *Kundri* and the establishment and maintenance of a *Kusmi brood* lac-cum-demonstration Farm at Mahesphur-Sirka. In both the cases, the Forest Department provides the *host* trees, labour and other incidental requirements and produces lac, and the Entomology Division of this Institute provides technical guidance.

(a) *Large scale cultivation experiments on palas at Kundri*

These experiments have been going on in *Knndri* (Dist. Palamau) Lac Orchard for the past several years as indicated earlier (*An. Rep.* 1964-65). The orchard has a total of about 40,000 *palas* trees.

Details of operations and itemwise costs are as hereunder.

A total of 5,816·20 kg of *scraped-lac* and 3,264·00 kg of *broodlac* was produced in the area during 1965-66. Only 127 kg of the *broodlac* could be sold to cultivators even at a subsidized rate (Re 1/- per kg). It was thus clear that there was no demand for *broodlac* this year unlike the previous one. However, sale of both *broodlac* and *sticklac* fetched a total revenue of Rs. 6,835·42 as against the total expenditure of Rs. 2,533·34. Thus a net profit of Rs. 4,302·08 was made during the year. (An amount of Rs. 717.50 was also obtained by disposing off of 758·0 kg *scraped lac* which was not accounted for earlier.)

(b) *Establishment of Kusmi brood lac-cum-demonstration farm at Mahesphur-Sirka (Dist. Ranchi)*

The production of lac on *Kusum* had always an element of uncertainty and unpredictability. Crops often failed for no accountable reason. With a view to enquiring into this and to evolve a remedy, if possible, a request from the Bihar Forest Department and the then Chief Lac Development Officer for technical collaboration for proposal to establish a fairly big *Kusmi* farm suitably located near about Ranchi to be operated by the farmer primarily with the following objectives.

(i) To stimulate *Kusmi* lac production, and

(ii) to study the behaviour of *Kusum* trees in the production of lac during different seasons.

Accordingly, a preliminary survey of the trees was made and pruning operations etc. were initiated in July, 1965.

2. Processing and Utilization of Lac

(a) *Technical Service*

Unlike extension of cultivation, extension activities in regard to the processing and utilization aspects of lac are the full responsibility of this Institute as far industries in India are concerned. For this purpose, the Institute is maintaining a "Utilization" section under a Senior Scientific Officer. Although a reasonable team has been provided for, this section had, during the year under report, only the S.S.O. and one Exhibition Assistant in position. Despite this handicap, the section functioned as fruitfully as possible. Its more important activities are described below:

As usual, during the year under report also, a number of enquiries were received for advice regarding the possibility of using shellac and shellac compositions in different industries. These were all attended to. Some parties also sent samples of products for which they wanted shellac based substitutes. These were analysed and, wherever possible, shellac formulations were recommended. In addition, contacts made earlier were maintained and new contacts established with processors and present and potential consumers of lac and lac products through correspondence, personal visits etc. As a result of these activities, the following formulations were finalized and recommended to the enquirers.

(i) Use of bleached shellac as the bond for lamination of polythene and tissue paper for use in the packaging of chewing tobacco. The Indian Central Tobacco Committee who were the enquirers, are understood to have been satisfied with this composition and to have passed on the information to one of its members for adoption.

(ii) A composition based on hydrolysed lac (40) and shellac (10) in aqueous ammonia was formulated for use as a stopper to prevent leakage of air into vacuum rubber hoses of the Railway. Details of the composition together with two samples of hose pipes treated with it were supplied to the Research, Design and Standard Organization of the Railways for their tests. Their report is awaited.

(iii) Water soluble shellac, developed by this Institute, was recommended to the Central Sugarcane Research Institute, Lucknow, for use to prevent driage of cane setts. The initial experiments there being successful, a larger (25 kg) sample has been supplied for field trials.

(iv) Technical lac dye (produced in the Institute) was recommended and a sample was supplied to a firm in West Cermany for use in the polishing of violins. The sample was reported, by the firm, as the best dye for that use, in appreciation of which the firm sent in a token present by cheque.

In addition to the above, samples of products such as shellac etch primer and water thinned red oxide primers which had been developed and extensively tried out at the Institute, were sent for service tests to major prospective consumers. As a result, the etch primer was reported as satisfactory for use on aluminium bodies of buses by the Bihar State Road Transport Corporation. The red oxide primer was reported as satisfactory for use on steel castings by the Foundry Forge Plant Laboratories of the Heavy Engineering Corporation, Ranchi. Reports of the Shalimar Paint Works, Hindusthan Motor, and the Railways about the primer are still awaited.

(b) *Development Work*

Specific schemes were also requested by the following parties for the commercial production processing of different forms of lac.

(i) Department of Industries, West Bengal, and Madras Government Shellac Factory, for bleached lac.

(ii) Gujrat Chamber of Commerce for processing of sticklac into seedlac and shellac.

(iii) A prominent shellac manufacturer — for autoclaves for the manufacture of shellac.

(iv) The Bihar State Co-operative Lac Marketing Federation for a lac processing factory.

These were all prepared and supplied.

(c) *Publicity and propaganda*

The Institute had developed a heat and water proof shellac composition suitable for use as an improved French polish and applied for an Indian patent for the same. A present note on the same was prepared and issued. This appeared in some of the more important dailies of the country. A copy of the note was also endorsed to the ICAR for onward transmission to the All India Radio.

(d) *Exhibits and Exhibitions*

The Institute deputed staff and took part in an exhibition organized by the All India Paint Association during their Annual Conference at Kanpur. Exhibits, maps and charts were also sent, as usual, for display in several other exhibitions in the country on request.

(e) *Compilation of literature*

A compilation is being made of all material published in literature regarding formulations containing lac and modifications of lac and methods of their utilization for publishing as a "Shellac Formulary". About 500 pages of draft material have been complied so far.

(f) *Pilot Production Unit*

The Pilot Production Unit continued to function throughout the year and five grades of special shellacs, viz. two grades of bleached lacs (BRF-refined grade and BR-regular grade), two grades of water-soluble lacs (DL-dewaxed grade and AL-autoclave grade) and one grade of Autoclave shellac (ASK grade), were manufactured and sold to interested purchasers and consumers. Besides these, lac wax, saponified lacs and lac based varnishes were also prepared and supplied.

Sales: During the period under report, the unit sold 3,449·45 kg of the above special shellacs, for Rs. 17,533/70 p. Other lac products sold amounted to Rs. 501/60 p. bringing the total sales for the year to Rs. 18,035/30 p. This quantity was about 23 per cent higher than the previous year's total sales of 2,685·70 kg the increase being mainly in regular (wax containing) bleached lac, DL grade water soluble lac and autoclave shellac. Several reputed firms and Government Organizations continued to purchase these special shellacs for their use. These include (1) Controller of Stores S.E. Rly. Kharagpur (2) Forest Utilization

Officer, Madras, (3) M/s Gravure Process Works, Bombay and (4) M/s Daylight Industries, Indore.

All the seedlacs required for the manufacture of bleached lacs and autoclave shellac were prepared by the "Sticklac Processing Unit" which started operating from last year. No extra labour or supervising staff was recruited for this Unit; it was run with the existing staff and labourers employed for the Production Unit.

TABLE 5 — THE SALE FIGURES OF THIS UNIT FOR THREE YEARS

Grade	Sales during 1963-64		Sales during 1964-65		Sales during 1965-66	
	Quantity kg	Value Rs	Quantity kg	Value Rs	Quantity kg	Value Rs
1. BRF	1,160·55	8,090·91	625·30	4,343.44	317·10	1,896.80
2. BR	649·14	3,897.33	486·25	2,836.54	925·95	6,405.00
3. DL	681·30	4,099.87	154·70	1,000.60	253·60	1,758.10
4. AL	121·20	661.09	89·10	487.43	51·60	309.00
5. ASK	311·20	897.60	1,330·35	4,463.80	1,901·20	7,164.60
6. Miscellaneous including lac wax		417.30	—	864.30	—	501.60
Total	2,923·39	18,064.60	2,685·70	13,996·21	3,449·45	18,035.30

(g) *Advertisement and Publicity*

As in the previous year, publicity of our products by periodical insertions in dailies and periodicals through the Directorate of Advertisement and Visual Publicity was discontinued during this year also. Letters in the form of circular and informative leaflets were, however, distributed and sent to intending purchasers. Free samples together with price lists, methods of use and businses terms for our different products were also sent to about 90 parties on request. Free samples exceeding the normal quantities were also sent to a few firms of repute to meet their specific demands for preliminary experiments.

3. Training and Advisory Service.

As mentioned already, this Institute provides two courses of training, (i) on improved methods of lac cultivation and (ii) on industrial uses of lac.

No candidates were deputated by any party for training during the first (April-Sept. 1965) session. However, seven candidates (three from the Forest Department, Madras and four from the Forest Department, Bihar) joined the course in the second (October, 1965 to March, 1966) session for training in 'Improved Methods of Lac Cultivation'. All the seven completed the training satisfactorily and received their certificates.

Apart from the above, the staff of the Institute also delivered special lectures on improved methods on lac cultivation at Forest Guards' Schools at Mahilong and Betla on request.

SUMMARY

A. ENTOMOLOGY DIVISION

Work on various problems carried out during the period under report was based on the approved programme.

During the year, work on a few more of the problems could be resumed as *brood* supply position improved slightly. The staff position, however, did not improve.

The following studies were carried out during the year

Potentiality Trials

(i) *On ber* — Potentiality trials on *ber* were continued for determining the proper time of harvesting as well as the optimum *brood* rate for *Baisakhi* crop. It was found that the *ratio* of *broodlac* to *sticklac* produced was highest when ½ Normal *brood* rate was used. However, the *actual yield* (crop) of *sticklac* was highest in four out of five seasons so far produced when *brood* was applied at normal rate. In either case the crop was best when harvested as *ari* in May. Further, normal rate of *brood* also gave consistently higher yields of *broodlac* harvested at maturity.

It is thus proved that for obtaining the maximum *crop* of *sticklac*, inoculation has to be carried out with the normal rate of *broodlac* (one metre of *brood* for every 25 meters of infectible shoots) and that harvesting of lac should be done, as *ari*, during May and not in April. The experiment has been concluded.

(ii) *On palas* — The maximum yields of *broodlac* as well as *sticklac* on this host were obtained when the inoculation was light, i.e, at the rate of 1·5 kg *broodlac* per 10 trees. Being the first experiment, these results are to be confirmed in further trials.

In regard to the proper time of harvesting-cum-pruning of *palas* during April/May, it was found that increased yields of crop per tree were obtained under when this was carried out, partially or fully between 15th and 25th April. This observation agreed with the results obtained earlier.

For harvesting-cum-pruning during October/November, again on *palas* increased *broodlac* and *sticklac* yield were obtained with medium inoculation (200 gm per tree) in October/November,—self inoculation and complete harvesting/pruning (in October/November next year) than that with light inoculation (100 gm per tree) and which did not conform with the results obtained with the first trial of the previous year.

(iii) *On other hosts* — The study could not be carried out on *bhalia* due to non-availability of suitable plants (which were being raised) and on *ber* due to the poor response of its inoculable shoots.

Evolution of Cultivation practices

Evolution of cultivation practices are being attempted to maximise yield with simultaneous reduction in the cost of cultivation.

In respect of *palas*, the second year's experiments showed that the maximum yield of *broodlac* per tree (0·594 gm) was obtained by light inoculation of the tree in October/November, permitting-self-inoculation in June/July and complete harvesting in the next October/November. In regard to the actual yield of *sticklac*, however, heavy inoculation in October/November and complete harvesting in April gave the best results.

Regarding *kusum*, no conclusions could be arrived at as both the crops (*Jethwi* and *Aghani*) were failures. Fresh inoculations for *Jethwi* were carried out in February 1966.

Arboricultural studies

Experiments were started from July 1965 of manuring of *bhalia* bushes with both organic and inorganic manures to study the effect on the yield of lac. It was found that bushes treated with fertilizers (inorganic manures normal dose of N, P & K was 10, 20 and 20 kg per acre respectively) gave better yields both of *broodlac* and of scraped lac than those treated with organic manures (normal dose 18 quintals per acre). There was no significant difference by doubling the amount of the fertilizer.

As regards the effect of NPK on the growth of the bushes, none of the five treatments tried showed any significant difference. The experiment was therefore concluded at the end of 4 years. No specific conclusions could be drawn.

About 400 *galwang* plants, trained into bushes, were already available and experiments were continued on some of these. Besides, about 80 *ber* and 100 *palas* were also available in bush form. These were inoculated for the first time for *Katki* and, latterly, for the *Baisakhi* crop. All the three hosts were carrying the *Baisakhi* crop at the end of the year. About 50 *kusum* trees were also being trained into bushes.

Inoculations were carried out with *kusmi brood* on the two alternate hosts *galwang* and *sandan* during Feb. 1966. No inoculation was possible in the previous year due to non-availability of proper *brood*. Seedlings of rain tree (*Samanea saman*) have been raised and growing well. At the appropriate time these will be trained into bushes.

Bushes of *bhalia*, with three different spacings, were being raised for a 3 coupe system so that all the consequitive crops could be obtained regularly. Measurements of growth, shoot length etc., were carried out. The first inoculation is to be made during June/July 1966.

Similarly, experiments on the technique of raising a plantation of *bhalia* bushes were continued. Various factors such as direct sowing, transplanting, different times of sowing and different seed rates are under investigation. Results indicate that transplanting of two seedlings in April gave the best results in regard to height growth and length of shoots attained. This finding is in conformity with the last year's results.

Physiological studies

The determination of the amino acid components of honey-dew had already been completed and reported last year. Work was continued for the study of the carbohydrate components of honey dew for which standard chromatograms of various pure carbohydrates were prepared. Some work was also carried out

to determine the frequency and rate of secretion of honey dew by lac insects but no significant results could be obtained.

Studies on the amino-acids and sugar contents of the total extract of lac insects at different stages of development for both *Rangeeni & Kusmi* strains were in progress. Chromatogram for different stages and strains were made and processed. For this purpose, lac insects were specially reared on *bhalia* for regular supply of material.

In order to determine the requirements of major trace elements etc., inoculations were carried out in July 1965 on seedlings of *bilayati babul* and *galwang* grown on culture solution for the 3rd time during the year, but the experiment failed again. The study was therefore, suspended for devising some better methods.

A comparative study of the components of the plant sap was initiated during the latter part of the previous year and the first initial study was completed during the year. Identification of the amino acids found are yet to be made.

Genetical studies

A discrepancy in the correct generic name of the lac insect was reported last year. A note on the correct name viz *Kerria lacca* (Kerr) has been published. Another note on the correct author of the pseudo lac insect *Tachardiana theae* (Green) — (Not Green & Mann) has also been published.

Studies on crosses between *Rangeeni* and *Kusmi* strains of lac insects and also between the two colour forms viz, crimson and yellow of the *Rangeeni* strain, were continued. Segregation having occurred previously, the different strains were maintained in pure lines. Progenies obtained from crossing *Rangeeni* females and *Kusmi* males passed through the 7th generation. Similarly, progenies obtained from crossing *Rangeeni* crimson females and *Rangeeni* yellow males were in their 5th generation. The F_1 generation obtained by crossing *Kusmi* crimson female and *Rangeeni* yellow males also developed satisfactorily. So far no mutant was obtained and the insects were behaving like their parents.

Selective breedings of lac insects for evolving a better yielding strain by crossing boldest females and males were continued and two generations were raised, the last presently passing through 8th generation. So far, no colony consisting entirely of bold cells has been obtained.

Breeding of isolated pure yellow strain of *Rangeeni* lac was continued. The 9th generation was developing, both in the laboratory and in the field successfully true to its colour.

Progenies of yellow lac insect of a Jodhpur strain were maintained on four species of potted host plants, viz. *bhalia, galwang, ber* and *bilayati babul* to examine whether the colour has any relation to the host. All the surviving insects were retaining their yellow colour as before.

Biological and ecological studies

Collection and study of the various pests of different hosts were continued throughout the year depending on the availability of the pests. The pests on *bhalia* were *Hypena iconicalis, Platypeplus aprobola, Dasychira mendosa* (form-*fusiformis*), *D. mendosa* (form-*basalis*), *Prodenia litura* and *Belippa laleana*, and that on *ber* and *ghont* was *Euproctes fraterna*. Two unidentified pests — a

limacodid and another coried bug on *palas* were also under study. Life history studies were completed on *H. iconicalis* and *E. fraterna*.

Biological control of lac enemies

Life history studies on *Brachymeria tachardiae* and *Elasmus claripennis*, an internal pupal parasite and an ectoparasite respectively of *Eublemma amabilis*, having been completed earlier, general breeding of these two were maintained from August to January when the strains were lost. The cause is not known.

Studies on *Eurytoma palidiscapus*, another pupal parasite of the predator *Holcocera pulverea*, were undertaken and small scale breeding was carried through four generations. Certain critical observations were made on the longevity and development time from egg to adult stage.

Progress was hampered on the studies on the incidence of predators (*E. amabilis* and *H. pulverea*) on the *Kusmi* strain of lac grown on *bhalia* due to the lack of any crop towards the early part of the year. However, with the availability of *brood*, a crop was raised and regular periodical samples have been collected for the assessment of the incidence.

A qualitative and quantitative survey of lac enemies and their parasites was started afresh from November 1964, when crops were raised on 5 *palas* and 5 *galwang* trees. Periodical samples at fortnightly intervals were collected for the recording of species of enemical insects associated with lac. In July 1965, further inoculations were carried out on 8 each of *kusum* and *palas*, 4 trees of *galwang* and 25 bushes of *bhalia*. The population of different species of enemical insect from the different strain of lac insects developing on different hosts, throughout the developing period was being assessed.

A small scale field trial was conducted with spraying *Bacillus thuringiensis* on *Katki* crop raised on *bhalia* bushes. Results so far indicate that with different doses of application there was a fair reduction in the population of predatory insects. Since this was the first trial, further studies were to be continued for which the next crop was raised and the "thuricide" sprayed.

Chemical control of insect parasites and predators

Inoculations were carried out in July 1965 on 300 bushes, but only 180 bushes with lac were found to be suitable for use in the experiment. The insecticides (stomach poisons) used were 'cryolite', 'sodium fluosilicate' and 'lead arsenate' and dieldrex — in the absence of the fourth stomach poison. There were significant differences in the emergences from treated and control samples.

Regional field stations

The usual routine investigations were carried out at Damoh and Mirzapur on the local host *ghont* in addition to *ber* and *palas*. The station at Jhalda was closed down. Steps were taken to shift the station at Umaria to Dharamjaigarh.

Training and advisory service

Seven trainees completed their six months' course in lac cultivation.

Routine enquiries were answered and investigations carried out and advice etc. given where necessary.

B. CHEMISTRY DIVISION

Separation and study of constitution of the various components of shellac

Lac resin had been shown by earlier workers to contain a neutral fraction, an ether soluble fraction known as soft resin and a few acids in the free state. Study of the constitution of these which has been going on in the previous year was continued during the year under report also. The neutral fraction was hydrolysed and esterified and the ester mixture subjected to analysis by the latest chromatographic technique. As a result, it has been found that it is mainly a mixture of esters of hydroxy acids, one of which is aleuritic acid. Similar study is being continued on soft resin and the free acids also, the latter having been found to contain traces of aleuritic and jalaric acids.

Apart from the above, the study of the constitution of lac resin was also in progress simulataneously in three other Centres. As a result of the work at the Delhi University (which was one of these centres) it was shown that under certain conditions of treatment lac resin yielded twice the quantity of aleuritic acid obtained by the conventional method and that too in a new "erythro" form. Work at the National Chemical Laboratory, Poona (another Centre) showed that soft resin as well as the ether insoluble fraction of lac viz. hard resin from different varieties of lac contain aleuritic acid and jalaric acid to the extent of 16-38·5 and 30-40 per cent respectively. Hard resin had been separated, by very modern techniques, into a number of almost pure fractions which should make the study of their constitution easier. At the Department of Chemical Technology, Bombay University (the third Centre), the attempt was to separate lac into fractions containing and not containing the carbonyl group. The experiment was not completely successful.

Apart from the above study on lac resin, the constitution of the two dyes associated with lac was also under investigation in the National Chemical Laboratory. As a result it has been finally possible to confirm the structure of the spirit soluble dye of lac known as "erythrolaccin". The study of the water soluble dye is, however, continuing.

Physico-chemical studies of lac solutions

The effect of addition of spirit soluble "melamine" resin (commercial "biomine") on the electrical properties of dewaxed lac varnishes was determined. It was found that the maximum resistance (B.D.V. 1,700 volts per mil) was obtained when the varnish had 40-60 per cent of "biomine" on the weight of lac.

Modification of lac

Shellac varnish modified with spirit soluble melamine resin was also found to have good storage life. It was found suitable for application by spray and could also be pigmented to give highly durable, water and heat resistant films. It gave an attractive glossy finish on wooden dolls and was also reported, by a consumer, to be satisfactory for coating anodized aluminium parts used in building construction for protection against the action of cement and lime.

Addition of a little hydrochloric or nitric or *p*-toluene sulphonic acid to shellac-urea resin varnish resulted in films that possessed outstanding resistance towards heat, water and spirituous liquors. The varnish was also found to be satisfactory for coating anodized aluminium and could be applied by spray.

Polyesters, another class of synthetic resins produced from glycerol, phthalic anhydride and adipic or maleic acid by fusing together were also found to be compatible with shellac. Blends in alcohol or aqueous (ammoniacal) solution gave films which, on baking, were superior to these of the parent lac, especially in flexibility.

Shellac hydroperoxide, produced by passing oxygen through an ammoniacal solution of the lac, has been found to remain stable in solution for 10 days and in the solid state for 2 months. It was established that grafting took place when the hydroperoxide (in aqueous solution) was copolymeriszd with methyl methacrylate in presence of catalysts. Grafts, obtained with 60 per cent of ethyl acrylate or a mixture of 60 per cent of ethyl acrylate and 10 per cent of methyl methacrylate on the weight of lac, gave films superior to those of the parent lac. However, grafts from lac and ethyl acrylate or styrene in aqueous medium in presence of redox catalyst were not satisfactory.

Modification of lac with 1,5-naphthalene di-isocyanate

The reaction of 1,5-naphthalene di-isocyanate with lac was found to be similar to that of toluene di-isocyanate. Addition of the former above 6 per cent on the weight of lac resulted in insoluble products. As this was no improvement over toluene diisocyanate, the work was discontinued.

Modification of epoxide chain with shellac:

Infra-red examination of the fusion products of shellac and epoxy resins confirmed the earlier view that the reaction of the epoxy group is with the carboxyl group of lac and that, on further curing, cross linking takes place making the product insoluble.

Reaction of lac with one of the starting materials of epoxy resins, *viz.* epichlorohydrin was tried under various conditions. A sticky resinous substance, having an acid value 2 and epoxide content of 0·218 per cent was obtained by condensing lac with epichlorohydrin in the presence of boron trifluoride etherate at 80-85°C. This study showed that the carboxyl group in lac reacts with the epichlorohydrin.

Improvements in the manufacture of seedlac etc.

The mixing of oxalic acid with seedlac upto 0·1 per cent on the latter's weight before melting produced shellace with a slight change in colour from reddish to yellow without any deleterious effect on other properties. With lower proportions the change in colour was less pronounced.

Bleached lacs were prepared from four commercial samples of *molamma* by the modified method. Samples so obtained retained their solubility in spirit for a year whereas those prepared by the conventional method started becoming insoluble within two to three months. The loss incurred during the hypochlorite bleaching of lac was found to be partly due to oxidation of the aleuritic acid chain present in lac.

In the preparation of aleuritic acid by hydrolysis of lac with strong alkali, it was found that addition of 5 per cent of sodium sulphite added 2 days after the start of the hydrolysis increased the yield of aleuritic acid from 20 to 25 percent.

The sludge obtained by acid treatment of lac factory effluents contains wax to the extent of nearly 10 per cent. Attempts were made to recover this wax with

hexane in the semipilot plant set up recently. So far only 73 per cent of the total wax could be extracted.

The mother liquor, left over after acid precipitation of the sludge, retains an appreciable amount of lac dye. This dye could be recovered as its insoluble calcium salt by treatment of the liquor with calcium carbonate. The pure dye could be regenerated via its sodium salt and treatment through cation exchange resin.

In order to get fractions of lac of improved properties for commercial utilization, alcoholic solution of lac was fractionally precipitated with dilute aqueous solutions of sodium chloride. The physical and chemical constants of these fractions are being determined.

Dry distillation of lac with calcium oxide at atmospheric or reduced pressure yielded an oily product. Qualitative tests of the oil indicated the presence of carboxyl, carbonyl and ester groups and unsaturation.

Improvements in the analytical methods

The determination of specific heats of seedlac and bleached lacs from 10 to 100°C at intervals of 10° were repeated and the previous data confirmed. The specific heat for shellac was found to rise from 0·25 at 10° to a maximum of 0·72 at 70° and thereafter to gradually drop to 0·50 at 100°C.

The heat of neutralization of various grades of lac was determined by thermometric titration. The values obtained for *kusmi* seedlac and shellac, platina shellac and dewaxed bleached lac were 10·2-11·8, 9·2-9.6, 9·5-11·0 and 10·6-12·0 K. Cals. respectively.

In connection with the correlation of specific heat with the age of lac, continued work showed that after a storage of one year there was a drop, in the specific heat, of 6 to 9 per cent and a further drop of 2 per cent after another six months. The samples were also tested for flow and insolubles. After 14 months storage the flow showed a decrease of 15 to 29 mm while no appreciable change was noticed in the insolubles. After another 5 months, there were no further change in flow and insolubles.

Unsaturation in lac was determined by catalytic hydrogenation. Hydrogen absorption corresponded to an iodine value of 31·0 to 32·5. This came down to 25·4 when the aldehyde group was protected. These results confirms that shellac has one double bond and one third of the aldehyde group free.

Plasticizing lac films

Nylon as such is not compatible with shellac even on fusion but when modified with paraformaldehyde to form the methylol derivative it was found to be compatible. Lac varnishes containing this modified nylon gave films which, after baking, were hard, smooth and flexible and resistant to lubricating oils, water and toluene.

Nature of urea and melamine modified lac

Shellac when heated with a large excess (33 to 100 per cent of its weight) of urea gave an indefinitely thermoplastic product. By reacting shellac with 33·3 per cent of urea at 165°C for 20 hr. a product was obtained which, after removal of water solubles, melted at 98°C and had acid and hydroxyl values of the order of 12·5 and 96·7 respectively. Films from this product even after baking was quite sensitive to water. The resin could be esterified with drying

and non-drying fatty acids resulting in hard and tough materials. However, films from these also were water sensitive.

Aqueous lac varnishes

Addition of drier (cobalt acetate) to aqueous lac-linseed oil varnishes effected no appreciable improvement in their film properties. An aqueous varnish made up of water soluble phenolic resin, lac and maleinized tung oil gave films having excellent flexibility, adhesion and resistance to water, chemicals, solvents, etc.

Red oxide primers based on shellac, tung oil and phenolic resin, and shellac and maleinized linseed oil in aqueous media were found to produce baked films of good adhesion, elasticity, resistance to solvents and chemicals and to salt droplet test and sulphur dioxide exposure upto 96 hr. Baked films of the latter also withstood exposure to natural weathering for 6 months and in humidity cabinet for 40 days.

Electrodeposition of paints is an outstanding achievement in recent times in the field of paint technology; preliminary work showed that water thinnable red oxide primer could be applied by this method although the films deposited on mild steel had poor adhesion.

Shellac based leather finishes (Sponsored Research).

A top dressing composition based on lac, formulated last year, was t ken up for regular production and marketing in Pilot Plant Scale. The material is being popularized by practical demonstrations.

Hydrolysed lac and modified lacs were found useful in the formulation of leather finishes. They showed excellent adhesion. A new polymer emulsion was developed from shellac and ethyl acrylate for use in leather finishing.

Lac and modified lacs were also found to be good impregnating agents for various leather goods. Regarding tanning, while seedlac dispersions did not possess any tanning capacity by themselves, a lac-phenol formaldehyde condensation product showed tanning capacity.

Sulphonated lac mixed with free oils showed promise as a filling and fat-liquoring agent.

Shellac etch primer

Single pack etch primer based on lac with any zinc chrome or even zinc tetroxy chromate, malic acid and appropriate alcoholic solvents, was found to store well upto one year so far tested. Films on aluminium, galvanized iron and brass withstood natural weathering for one year without any noticeable deterioration. It was established that malic acid is mainly responsible for the prevention of gelling of etch primer on storage as it reacts with zinc oxide in preference to shellac thus allowing shellac to remain in solution.

A new formulation was also developed based on lac (100 parts), zinc tetroxychromate (50 parts), phosphoric acid (15 parts) and malic acid (5 parts) in usual solvents for improving corrosion resistance on steel.

Shellac rubber combinations

(i) Though shellac could not be grafted to natural rubber latex, some evidence of grafting was obtained by treating shellac with centrifuged rubber latex in the presence of redox catalyst.

(ii) Shellac was found to enhance the plasticity of the stock during compounding with styrene-batadiene rubber, carbon black or channel black or clay and other usual rubber compounding ingredients thus assisting in milling and mixing. A modified lac, obtained by fusing 7 parts of lac with 3 parts of Epikote 1001 at 150°C was found to be even better than lac alone. Higher hardness, resilience and tear strength were obtained. Of the fillers, clay appeared to be the best for use with shellac-styrene butadiene rubber.

Ad-hoc Researches

In an attempt to prepare fillerless thermosetting moulding powders it was found that incorporation of urea formaldehyde resin into shellac resulted in moulded products having satisfactory resistance to impact and water absorption but poor flow. Replacement of this urea resin with butylated urea formaldehyde resin, however, improved the flow a little and gave tough and elastic moulded products.

Butyl ester of hydrolysed lac have shown promise as a plasticizer for polyvinyl chloride (PVC). Preliminary work showed that addition of this ester reduces brittleness of PVC moulded articles.

An insulating enamel based on nylon, shellac and *m*-cresol, and dissolved in solvent naphtha was found to give transformer oil resistant films on copper on baking at 320°C for 90 seconds. Another composition based on shellac and cashew nut shell liquid also gave films similar to above.

Compositions to replace imported Dennison waxes for picktest of paper were prepared based on shellac and resin and sent to an interested party. Their test report is awaited.

Laminated plastic paper for wrapping chewing tobacco which withstood sharp bending without forming any crack was developed using a spirit solution of refined bleached lac as the adhesive. This paper has been approved by Central Tobacco Committee.

A composition based on shellac and hydrolysed lac to be used as binder for sand moulds was formulated by this Institute and found to be better than simple shellac by the laboratory of Foundry Forge Plant of the Heavy Engineering Corpn., Ranchi.

Utilization of lac (Publicity and Propaganda)

As usual the Institute attended to all technical enquiries and rendered technical assistance for the processing and utilization of lac. Samples of heat and waterproof varinish as well as water based red oxide primers and shellac etch primer were sent to prominent consumers for their critical examinations and reports. Composition for wax engravers, diamond fixing and sealer for Railway hose pipes were developed at the request of interested parties. Exhibits were sent to various exhibitions in the country. Regional Testing Laboratories at Namkum, Gondia and Balarampur worked regularly. Activities of the laboratories at Daltonganj and Bilaspur were suspended due to insufficient workload.

Compilation of literature

A shellac formulary is being compiled. About 500 pages of draft material have been compiled.

Pilot Production Unit

During the year, the Unit sold 3,449·45 kg. of special shellacs for Rs. 17,533.70 paise and other miscellaneous lac based products valued at Rs. 501.60 paise bringing the total sale figure for the year to Rs. 18,035.30 paise. The gross profit was Rs. 6,514.86 paise.

PERSONNEL

(A) STATEMENTS SHOWING APPOINTMENTS, PROMOTIONS, RESIGNATIONS, RETIREMENTS, ETC. DURING 1965-66

Division/Section	Name	Post to which appointed	Date of joining
(a) Appointment			
Entomology Division	1. Shri V. D. Rai	Research Assistant	11-10-1965
Chemistry Division	1. Dr. G. L. Agarwal	Senior Research Assistant	30-9-1965
	2. Shri S. C. Agarwal	Research Assistant	15-4-1965
	3. Shri G. C. Sharma	Research Assistant	10-9-1965
	4. Shri P. K. Kundu	Research Assistant	13-10-1965
	5. Shri P. K. Sinha Roy	Research Assistant	7-10-1965
	6. Shri B. P. Keshri (on transfer from ILCC's office)	Laboratory Assistant	1-4-1965
Administrative Section	1. Shri Enamul Haque	Store Keeper	1-4-1965
(b) Promotion			
Chemistry Division	1. Shri B. B. Khanna	Scientific Officer (Factory)	3-8-1965
(c) Resignation			
Entomology Division	1. Dr. P. N. Srivastava	Scientific Officer (Insect Physiologist)	20-12-1965
	2. Shri Sashi Sekhar Sinha	Research Assistant	22-10-1965 (A/N)
Chemistry Division	1. Dr. G. L. Kaul	Sr. Research Assistant	28-2-1966 (A/N)
	2. Dr. G. L. Agarwal	Sr. Research Assistant	20-1-1966 (A/N)
Administrative Section	1. Shri Tumna Munda	Assistant Mechanic	24-3-1966 (A/N)
(d) Retirement			
Administrative Section	1. Shri Chandar Mahto	Peon	17-3-1965
	2. Shri G. P. Sharma	Instrument Maker	31-3-1966 (A/N)

(Services terminated owing to reversion of Shri M. Kujur on the abolition of the post of Mechanical Supervisor).

(B) STAFF DIVISIONWISE

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-3-1966
	I. Officers		
1	Director	1	Dr. G. S. Misra
2	Senior Scientific Officer (Organic)	1	Y. Sankaranarayanan
3	Senior Scientific Officer (Utilization)	1	Dr. T. Bhowmik
4	Entomologist	1	Dr. A. Bhattacharya
5	Scientific Officer (Physical)	1	Dr. P. R. Bhattacharya
6	Scientific Officer (Cultivation)	1	Shri B. P. Mehra
7	Scientific Officer (Field Station)	1	,, C. P. Malhotra
8	Scientific Officer (Applied)	1	,, S. C. Sen Gupta
9	Scientific Officer (Decorative)	1	,, Shravan Kumar
10	Scientific Officer (Factory)	1	,, B. B. Khanna
11	Scientific Officer (Arboriculture)	1	,, U. N. Prasad
12	Scientific Officer (Utilization)	1	Vacant
13	Scientific Officer (Insect Genetics)	1	Vacant
14	Scientific Officer (Physiology)	1	Vacant
15	Scientific Officer (Biology)	1	Vacant
16	Junior Scientific Officer (Production)	1	,, P. K. Ghose
	II. Other Staff		
	Entomology Division		
17	Senior Research Assistants	8	1. Shri B. K. Purkayastha 2. ,, N. S. Chauhan 3. ,, R. S. Gokulpure 4. ,, R. K. Varshney 5. ,, A. H. Naqvi 6. ,, S. M. Kulkarni 7. ,, N. Majumdar 8. ,, Vacant
18	Instructor	1	Vacant
19	Research Assistants	16	1. Shri R. C. Misra 2. ,, P. Sen 3. ,, A. K. Sen 4. ,, Saligram Choudhary 5. ,, R. M Sundram 6. ,, U. P. Griyaghey 7. ,, B. N. Sah 8. ,, V. D. Rai
	J.R.A.s working against the vacancies of R.As.		9. ,, M. K. Chowdhur 10. ,, J. M. Das Gupty 11. ,, R. C. Maurya a
			12-16. Vacant
20	Senior Artist-cum-Photographer	1	Shri R. L. Singh
21	Junior Artist-cum-Photographer	1	,, Pyare Das
22	Junior Field Assistants	4	Vacant
23	Fieldman	17	1. Shri A. C. Chatterjee 2. ,, S. N. Sharma 3. ,, H. R. Munda 4. ,, Sant Kumar 5. ,, R. K. Paul 6. ,, R. S. Maliya 7. ,, K. C. Jain 8. ,, Jawahir Lal 9. ,, B. D. Tiwary

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-3-1966
			10. Shri B. K. Gupta
			11. ,, Shiv Shankar Prasad
			12-17. Vacant
24	Field Plantation and Store Assistant	1	Shri G. Lakra
25	Insect Collection Tender	1	,, Md. Ali Ansari
26	Laboratory Assistants	10	1. Shri H. L. Ravidas
			2. Mrs. N. Nandy
			3. Shri Azmer Hussain
			4. ,, K. L. Chowdhury
			5. ,, D. D. Prasad
			6. ,, G. K. Jha
			7. ,, R. D. Pathak
			8-10. Vacant
27	Museum Assistant	1	Miss Sati Guha Roy
28	Laboratory Attendant	10	1. Shri Jugal Singh
			2. ,, Mani Mahto
			3. ,, Jagarnath Oraon
			4. ,, Dema Oraon
			5. ,, Yakub Tirkey
			6. ,, Md. Sharif
			7. ,, Kamal Prasad
			8. ,, S. K. Chatterjee
			9. ,, H. N. Shukla
			10. ,, Mohar Sahu
29	Peon	2	1. Shri Shyamlal Ram
			2. ,, Gandur Singh
30	Mali	2	1. 1. Shri Budhua Oraon
			2. ,, Maria Oraon
31	Durwan	4	1. Shri Gendu Bouri
			2. ,, Jiwan Lal
			3. ,, Kashi Nath
			4. ,, Chhote Lal Dhimar
32	Field staff Showkidar — Contingent	18	1. Shri Dubraj Munda
			2. ,, Mukund Pahan
			3. ,, Aghnu Munda
			4. ,, Kunju Pattar
			5. ,, Ramkishan
			6. ,, Keshar Bhuian
			7. ,, Madhuri Bhuian
			8. ,, Hari Singh
			9-18. Vacant
Chemistry Division			
33	Senior Research Assistant	6	1. Shri A. K. Ghose
			2. ,, R. Banerjee
			3. ,, P. C. Ghose
			4. ,, A. Kumar
			5-6 Vacant
34	Research Assistant	17	1. Shri A. Rahman
			2. ,, P. C. Gupta
			3. ,, T. Sahu
			4. ,, R. K. Banerjee
			5. ,, S. K. M. Tripathi
			6. ,, August Pandey
			7. ,, M. Mukherjee
			8. ,, Md. Islam
			9. ,, S. C. Agarwal
			10. ,, G. C. Sharma

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-3-1966
			11. Shri P. K. Sinha Roy
			12. ,, P. K. Kundu
			13-17 Vacant
35	Senior Analyst	2	Vacant
36	Analyst	3	1. Shri L. C. Mishra
			2. ,, B. P. Banerjee
			3. ,, R. Prasad
37	Junior Analyst	3	1. Shri K. M. Das
			2. ,, B. C. Srivastava
			3. Vacant
38	Glass Blower	1	,, S. K. Dey
39	Laboratory Assistant	11	1. Shri Dominic Runda
			2. ,, N. Minz
			3. ,, G. M. Borkar
			4. ,, B. B. Chakraborty
			5. ,, Nagendra Mahto
			6. ,, U. Sahay
			7. ,, B. Majumdar
			8. ,, B. P. Keshri
			9-11. Vacant
40	Laboratory Attendant	10	1. Shri Masidas Minz
			2. ,, Siba Baraik
			3. ,, Mangta Oraon
			4. ,, Gopeswar Misra
			5. ,, P. B. Sen
			6. ,, Md. Ghaseet
			7. ,, Chinmoy Sengupta
			8. ,, Dukha Oraon
			9. ,, Chedilal
			10. Vacant
41	Peon	4	1. Shri Birsa Oraon
			2. ,, Nathanial Kachchap
			3. ,, Shiv Charan Gope
			4. ,, Dhadho Mahto
42	Durwan	3	1. Shri S. K. Deogharia
			2. ,, Ram Charitra Tiwary
			3. ,, Hari Ram
43	Factory Boy	1	,, Hanuk Tigga
44	Melter	1	,, Sukra Oraon
45	Stretcher	1	,, Lohra Oraon
Administrative Section			
46	Assistants	2	1. Shri S. K. Sircar
			2. ,, L. M. Nandy
47	Librarian	1	Shri R. P. Indwar
48	Stenographer Grade I	1	,, M. T. Rughani
49	Storekeeper	1	Shri Enamul Haque
50	Steno-typist	2	1. Shri P. N. Sivankutty
			2. ,, Vacant
51	Lower Division Clerk	11	1. Shri H. S. Munda
			2. ,, R. P. Singh
			3. Miss Sibani Hazra
			4. Shri Musafir Singh
			5. ,, Md. Samiullah
			6. ,, A. K. Chowdhury
			7. ,, E. Tirkey
			8. ,, Anwarul Haque
			9. ,, K. P. Keshri

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-3-1966
			10. Shri Rambaran Singh
			11. ,, Kuldip Pandey
52	Senior Clerk	2	1. ,, P. K. Chowdhury
			2. ,, D. P. Sen Gupta
53	Daftari	1	Shri Martin Beck
54	Peons	5	1. Shri Budhua Oraon
			2. ,, Jagdish Ram
			3. ,, Pahna Lakra
			4. ,, Mahadeo Mahto
			5. Vacant
55	Farash	2	1. Shri Mangra Oraon
			2. ,, Tutung Bihan
	Mechanical Section		
56	Chief Mechanic	1	Shri K. N. Sinha
57	Assistant Mechanic	1	Vacant
58	Instrument Maker	1	,, M. Kujur
59	Turner	1	,, A. S. Manoranjan
60	Jeep Driver	1	,, Jagdish Ram
61	Boiler Attendant	1	,, Vacant
62	Tindal	1	,, Tulsi Ram
63	Carpenter	1	,, Balku Lohar
64	Khalasi	1	,, Budhua Oraon
65	Gas Plant Attendant	1	,, Lachchan Oraon
	Estate		
66	Estate Care Taker	1	Shri Md. Saheb Ali
67	Labour Supervisor	1	,, Dharam Nath Mahto
68	Armed Guard	1	,, Jamun Jha
69	Chowkidars and Darwans	14	1. Shri Sahadeo Ram
			2. ,, Abdul Motalib
			3. ,, Hawaldar Singh
			4. ,, Mahadeo Oraon (Lodhma)
			5. ,, Mahadeo Oraon (Khijri)
			6. ,, Premdas Banerjee
			7. ,, Pryag Mahto
			8. ,, Deolal Singh
			9. ,, Mohan Bahadur
			10. ,, Ramdas Mishra
			11. ,, Chutur Oraon
			12. ,, Sanicharwa Oraon
			13. ,, Ramgulam Singh
			14. ,, Jogendra Pathak
70	Sweepers	5	1. Shri Sanicharwa Ram
			2. ,, Puneswar Ram
			3. ,, Budhu Ram
			4. ,, Patras Bando
			5. Mmt. Mundri
71	Bullock-keeper	2	1. Shri Phekua Munda
			2. Vacant (1)
	Medical Unit		
72	Authorized Medical Attendant	1	Dr. S. S. Sahay
73	Compounder	1	Shri B. N. Munda

APPENDIX A

Approved Programme of Work and Priorities

(Regrouped under proper heads as per recommendation of Ad hoc Entomology Research Subcommittee)

Research Problems	Priority
I. *Potentiality trials on ber*	A
(i) Determination of optimum density of settlement for *ber* in *Katki* season.	
(ii) Determination of proper time of harvesting and optimum density of larval settlement for *ber* in A*aisakhi* season.	
(iii) Studies on the response to pruning of *ber* for growing *Katki* crop.	
(iv) Studies on the relative merits of *ber* and *palas* broodlac.	
II. *Potentiality trials on* palas	A
(i) Dtermination of optimum density of larval settlement on *palas* in hot areas (at Kundri).	
(ii) Studies on the proper time of harvesting-cum-pruning on *palas* within April-May.	
(iii) Studies on the proper time of harvesting-cum-pruning on *palas* within October-November.	
(iv) (a) Evolution of cultivation practices for *palas* at Kundri for maximum crop production in minimum cost and working out economics.	
(b) Evolution of cultivation practice for *palas* at Kundri (Direct comparison of newly evolved plan with villager's method). [Started on concluding (a) and not included in programme.]	
(v) Studies to ascertain the most appropriate time for harvesting of *palas* broodlac for crop inoculations (at Kundri).	
III. *Potentiality trials on* Moghania macrophylla	A
(i) Evolution of cultivation schedule and determination of optimum density of larval settlement on *Moghania macrophylla* for growing *Aghani* and *Jcthwi* crops.	
(ii) Spacing trials on *M. macrophylla*.	

APPENDIX A (*Contd.*)

Research Problems	Priority
(iii) Working out plantation technique of raising *M. macrophylla.*	
(iv) Effect of NPK on the yield of lac on *M. macrophylla* (both with organic and inorganic manures).	
(v) Effect of different levels of Nitrogen on the growth of *M. macrophylla* bushes.	
IV. *Permanent field experiment for working out economics of cultivation of* Kusmi *lac on* M. macrophylla *under different conditions of manuring and irrigation*	A (Long-range programme)
V. *Evolution of cutlivation practices for* Kusum *at Hesal for maximum crop production at minimum cost and working out economics*	A
VI. *Studies on training of major lac hosts, e.g.* palas, ber, kusum, Albizzia lucida *and* rain tree *for lac cutlivation*	B (Long-range programme)
VII. *Studies on varietal trials on maior lac hosts* ber, palas, kusum, arhar (*perennial*), Moghania, Acacia catechu, A. arabica *and* ghont	
VIII. *Finding out alternate hosts for the* Kusmi *strain of lac inset and conducting cultivation experiments on tcm* (*e.g.* Albizzia lucida, Ougeinia oojeinensis, Ficus sp., Moghania chappar, rain tree, *etc.*)	B (Long-range programme)
IX. *Finding of and trials, as brood preservers, on alternate lac hosts for* Baisakhi *crop for the* Rangeeni *strain of lac insect* (*e.g.* Ficus *sp.*, Albizzia *sp.*, rain tree, *etc.*)	B (Long-range programme)
X. *Studies on vegetative propagation in different varieties of major lac hosts*	C
XI. *Physiological studies*	
(i) Rearing of lac insects under controlled environments through rtificial feeding	A
(ii) Studies on the secretion of colour of lac resin.	B
(iii) (a) Studies on the relation of host to the fecundity and resin secretion efficiency of the *Rangeeni* strain of lac insect.	

APPENDIX A (*Contd.*)

Research Problems	Priority
(b) Studies on the relation of host to the fecundity and resin secretion efficiency of the *Kusmi* strain of lac insect.	
(iv) Studies on the rate of secretion and composition of honeydew of the lac insect.	B
(v) Studies on the requirements of major, minor and trace elements and their influence on resin secretion, sex-ratio and fecundity, etc., of the lac insect. (By growing host plants in culture solutions under completely controlled conditions and also by foliar spray of the nutrients.)	B
(vi) Physiological studies on the secretion of resin and build up of the lac cell.	C
(vii) A comparative study of the components of plant sap of major and minor hosts with an idea to get some information regarding the factors which limit their relative performance as lac hosts (the finding of this study will also be made use of in developing an artificial medium for feeding of lac insects).	A
(viii) Amino-acids and sugar contents of the lac insect body at different developmental stages. (Undertaken in lieu of iv and vii above for the nutritional equirements of the lac insect.).	(N.B.—Not in the approved programme but suggested elsewhere)
XII. *Genetical and breeding studies*	
(i) Collection of various species, races and strains of lac insects from different geographical areas in the country and from neighbouring countries, and studies on their isolation, taxonomic characters and performance.	A
(ii) Studies on crosses between *Rangeeni* and *Kusmi* strains of lac insect and also between the two colour forms of *Rangeeni* strain.	A
(iii) Evolution of a better yielding strain of lac insect through selection.	A
(iv) Isolation of pure yellow strain of lac insect (Undertaken as a separate problem as encouraging results were obtained).	
(v) Irradiation studies on the lac insect with the object of evolving a superior quality mutant strain.	B

APPENDIX A (*Contd.*)

Research Problems	Priority
(vi) Experiments on the mode of reproduction in lac insects.	A
(vii) Studies on the chromosomal cytology of the different strains of the lac insect.	A
(viii) Studies on the mode of oogenesis and spermatogenesis of the different strains of the lac insect.	B
(ix) Breeding studies on the yellow variety of lac insect in relation to host specificity.	B
(x) Studies on the genetical evidence of parthenogenesis in the lac insect.	A
XIII. *Biological and ecological studies*	
(i) Collecting the pests of lac host trees, and studies on the life-history and control operations aginst important pests.	C (Long-range programme)
(ii) Survey of lac enemies and their parasites:	B (Long-range programme)
(a) General Survey — Qualitative.	
(b) Seasonal incidence and extent of damage by three important predatory enemies — qualitative and quantitative.	
(c) Preliminary studies on lac insect pathology.	
XIV. *Biological control of lac enemies*	
(i) Life-history studies and developing breeding techniques for important indigenous parasites, e.g. *Bracon greeni, Apanteles fakhrulhajiae, Perisierola pulveriae Elasmus claripennis Pristomerus sulci* and *Brachymeria tachardiae.*	A (Long-range programme)
(ii) Nutritional requirements of the adult parasites including studies on the use of honeydew for feeding adult parasites.	B
(iii) Mass breeding 1nd large-scale libertion of *Apanteles tachardiae* and *Bracon greeni* in the field and estimation of the effect of these liberations.	A
(iv) Studies on the interrelationship between the population of the predators and their parasites under different ecological conditions (under grove or plantation condition and under scattered condition) and also by providing hosts in cages in the field.	B

APPENDIX A (*Contd.*)

Research Problems	Priority
(v) Ecological studies including the influence of various temperature and humidity conditions on the growth and development of the lac insect predators, *Holcocera pulverea* and *Eublemma amabilis*.	B
(vi) Studies on the tropic reactions (both physical and chemical including repellants) of the two predators of lac insect, viz. *Holcocera pulverea* and *Eublemma amabilis*.	C
(vii) To evolve techniques for rearing of *E. amabilis* and *H. pulverea* on ratificial media, for maintaining their cultures for the mass breeding of parasites.	A
(viii) Control of lac predators by use of *Bacillus thuringiensis* Berliner. (Not proposed in the programme but introduced subsequently.)	
XV. *Studies of influences of various environmental conditions on the lac insect*	
(i) Studies on the effect of extreme temperature and humidity fluctuations as they occur in nature on the tolerance of lac insect in its different stages.	B
(ii) Determination of the appropriate time for harvesting broodlac in different regions through the use of Biometer on thermohydrograph records of Field Stations.	A
(iii) Determination of optimum environmental conditions for storing the broodlac to delay emergence of larvae Vithout any harmful effects on the progeny.	A
XVI. *Chemical control of lac insect parasites and predators*	B
(i) Effect of different insecticidal sprays on the incidence of parasites and predators attacking *Kusmi* lac crop grown on *Moghania macrophylla*.	

REGIONAL FIELD STATION PROBLEMS

1. Studies on the cause of spurious emergence of lac larvae at times other than normal and finding out methods to prevent such occurrence and/or its utilization to the best advantage of lac cultivation.	A

APPENDIX A (*Contd.*)

Research Problems	Priority
2. Investigation of likely *Kusmi* lac hosts occurring in the region and their proper use to supplement production of *Kusmi* lac.	B (Long-range programme)
3. Selection and introductionof suitable regional or exotic hosts to fortify cultivation of lac on *kusum*. (Emphasis on introduction of *Moghania macrophylla*.)	A
4. Investigation of likely *Rangeeni* lac hosts occurring in the region and their proper use to supplement production of *ghont* and/or *palas* lac	A (Long-range programme)
5. Selection and introduction of suitable regional or exotic hosts to fortify cultivation of lac on *ghont* and/or *palas*. (Emphasis on introduction of *M. macrophylla*.)	A
6. Studies on the response of *ghont* to pruning to grow lac crops and systematic cultivation of lac on this host.	A
7. Determination of the optimum requirement of broodlac for crop inoculation of *ghont* and/or *pa'as*.	A
8. Evolution of suitable cultivation practice to be followed for *ghont* and/or *pa'as*.	A
9. Evolution of a cultivation practice to be followed for *kusum*.	A
10. Survey of lac enemies and their parasites — (a) General Survey — qualitative. (b) Seasonal incidence and extent of damage by the important predatory enemies — qualitative and quantitative study.	B (Long-range programme)
11. Studies on the relative importance of vertebrate enemies of lac, e.g. monkey, squirrel and rat, etc.	C
12. Collecting the pests of lac host trees and studies on the life-history and control operations against important pests.	C (Long-range programme)
13. Studies on the varietal trials of major lac hosts (e.g. *ber palas kusum perennial arhar, Moghania Acacia catechu, A. arabica* and *ghont, etc.*)	B

AD HOC WORK

It has been recommended that 'lac cultivation' by improved methods (without defoliation), on a large scale, may be continued at Kundri as an item under 'Training and Demonstration'. [Treated under 2 iv.(c)1.

APPENDIX A (*Contd.*)

Research Programme for the Chemical Section Recommended by the Advisory Board and Adopted by the Governing Body

As finally approved in the Meeting of the Indian Lac Cess Committee at Calcutta on 24-1-58

Note: (i) Items marked priority AA and A should be immediately intensified with the help of the members of the present staff.
(ii) Tangible results in all cases are expected in the course of 3 to 4 years from the time the work is taken in hand provided sufficient staff is made available unless otherwise stated.
(iii) Item Nos 6, 13 and 16 of the programme recommended by the Reviewing Committee have been dropped by the Advisory Board for the present till specific nature of the research problem is given by the Director, Indian Lac Research Institute.

Sl. No.	Research Problems	Priority	Remarks
1.	(a) Separation and study of constitution of the various components of shellac.	A	First the monograph be prepared as priority AA — *Long-term programme*
2.	(a) Further chemical examination of lac collected at different intervals during harvesting in both the seasons on host trees not already examined.	C	
	(b) Properties of lac in relation to the quality and composition of sap of the host tree (work to be conducted together with Entomological problem No. 7).	C	Long-term programme
3.	Physico-chemical studies of lac solutions. The characteristics of shellac varnishes in Isopropyl alcohol.	B	Monograph be prepared first
4.	(a) Chemical changes in the bleaching of seedlac by different methods.	A	
	(b) Working out optimum conditions for bleaching of seedlac.	A	
	(c) Standard methods of test for study of bleach index and bleachability.	A	
5.	Kinetics of polymerization and depolymerization of shellac.	A	
6.	A fundamental study of the reaction between shellac and urea leading to films of increased hardness and in the production of moulding compositions. How far it differs from hardening of shellac by its thermal or chemical polymerization ?	A	

APPENDIX A (*Contd.*)

Sl. No.	Research Problems	Priority	Remarks
7.	(a) Effect of different metal salts on the properties and storage of shellac spirit solutions; to explore the use of suitable metal containers for its packing; effect of removal of small portion of soft resin of high acid number from shellac on its corrosion characteristics.	A	
	(b) Solubility of lac in various solvents and the dilution ratio of lac and nitro-cellolose in different solvents and diluents	A	
	(c) Modification of lac to improve its heat, blush and spirit resistance.	A	
8.	Improvement in the adhesive characteristics of shellac by reacting it with different aldehydes on the lines of the preparation of polyvinyl butyral.	B	
9.	(a) Studies in the modification of shellac by reacting it with acrylonitrile.	B	
	(b) Studies in the preparation of polyurethanes through isocyanates; making use of the active hydrogen of OH and COOH groups in shellac.	B	
10.	Modification of epoxide chain with shellac or hydrolysed shellac; utilizing the carboxylic group in shellac for reaction with OH groups of epoxy chain, these modifications also to be studied with and without fatty acid modification of shellac.	B	
11.	Preparation of strip coating composition from shellac.	B	
12.	Improvement in the manufacture of seedlac and shellac with emphasis on yield, colour and utilization of by-products and allied problems.	AA	
13.	Improvement in the analytical methods of lac and problems connected with grade-cum-specifications.	A	
14.	Plasticizing lac film for special purposes.	B	
15.	Failure of lac urea films with age.	B	
16.	Nature of shellac melamine films.	B	
15.	Failure of lac urea films with age.	B	
16.	Nature of shellac melamine films.	B	
17.	Nature of shellac-urea and shellac-melamine spirit varnishes.	B	
18.	Nature of urea and melamine modified lac.	B	

APPENDIX A (*Contd.*)

Sl. No.	Research Problems	Priority	Remarks
19.	Comparative film properties of bleached lac and decolourized and ordinary shellac.	A	
20.	Aqueous lac varnishes and stiffening of	B	
21.	Shellac leather finishes ... Preparation of a modified shellac composition readily immulsifiable in water and giving heat resistant non-tacky films of good flexibility and feel.	B	
22.	Shellac in printing inks —		
	(a) Solvent release of shellac, dewaxed lac and bleached lac films for different solvents and mixed solvents.		
	(b) Esterification of lac varnishes in storage especially in the presence of basic dyes used in printing inks such as auramine, rhodamine, victoria blue, malachite green, etc., in 95 and 78 per cent alcohol.		
	(c) Compatibility and film properties of lac with other resins in printing inks such as ethyl cellulose nitrocellulose maleinized rosin, etc.		
	(d) A modified shellac soluble in aromatic hydrocarbon like toluene.	A	
23.	Re-examination of lac/oil combination from analogy with alkyds.	A	
24.	Use of surface active agents in the formation of lac oil combination.	A	
25.	Lac Tall oil combinations.	A	Indian source of tall oil or comparable oil to be ascertained in the first instance
26.	Lac in place of polyvinyl butyral for wash primers.	B	
27.	Use of stainless steel equipment for Otoclave to produce shellac of light colour and use of infrared technique in drying of shellac also drying of shellac in film form by use of hot rollers to be investigated.	A	
28.	Use of lac in adhesive for plywood compositions with a filler to cheapen.	A	Mr. Narayan Murty to be contacted in the first instance
29.	*Ad hoc* problems ...		
	(a) The relationship, if any between the life and flow of shellac and the variation of these factors under different conditions of conditioning.		

APPENDIX A (*Contd.*)

Sl. No.	Research Problems	Priority	Remarks
	(b) Adhesion between mica and shellac of different types of known hosts and sourses.		
	(c) Modification o shellac to improve its heat and moisture resistance and electrical properties retaining adequate adhesion to mica.		
	(d) Modification of shellac to improve its elasticity and flexibility, retaining adequate adhesion to mica.		

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