INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1955-56

1957

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INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR

ANNUAL REPORT FOR THE FINANCIAL YEAR 1955-56

ADMINISTRATIVE AND GENERAL

General — The Institute pursued its research and other activities under the general supervision of its Director, Dr. S. V. Puntambekar. Dr. Puntambekar also held the additional charge of the post of Special Officer for Lac Cultivation, lying vacant since the resignation of Shri M. Srinivasan, I.F.S., till Shri H. D. Singh joined the post substantively on 1-10-55.

During the period under report, several schemes on lac were drawn up to be worked as part of the Second Five-Year Plan. Under these schemes a few field research stations and testing laboratories are to be set up in the different parts of the country.

The plan also envisages the establishment of a pilot plant for making bleached lac at the Institute, and a bleached lac factory in Vindhya Pradesh. A few lac godowns including an air-conditioned one at suitable localities, the latter by way of assisting the primary producers of lac under a co-operative basis, are also to be constructed.

An item of special interest to note is the deputation at the Institute of Dr. L. A. Jordan, Director, Paint Research Station, Teddington, England under the Colombo Plan. Dr. Jordan arrived at Namkum early in November and stayed here for nearly three months, studying and assessing progress made so far in the practical applications of lac, particularly in the field of varnishes and paints. Dr. Jordan has already submitted his report embodying his recommendations, some of which are of a far-reaching character.

As usual, the Institute continued to attract a large number of visitors from the various parts of the country and abroad, of whom a few deserving special mention are listed below:

1. Aryant Kunjakul, Economic Entomologist, Bangkok, Thailand
2. Delegation for Animal Husbandry Wing Meeting of I.C.A.R. — 40 in all
3. Sri C. B. Sharma, Deputy Minister, Revenue, U.P.
4. Sri D. A. Mourya, M.L.A., U.P.
5. Development Officers of Community Project Organization
6. Dr. Liu Chung Lo, Institute of Entomology of Chinese Academy of Sciences, Peking
7. Miss Wu Yen Lu, a member of Chinese delegation to the Indian Science Congress
8. Mr. Parathon, Irrigation Engineer, Bandug, Indonesia
9. Dr. R. Mohamad Inonoedin, Senior Officer of the Health Inspectorate for East Java, Indonesia
10. Sri Kwet Kaw, Forest Economist, Burma
11. Sri N. A. Golovko, of the Trade Representation of the U.S.S.R. in India
12. Sri Ram Narayan Singh, M.P., Bihar
13. Sri D. Sandilya, Accountant General, Orissa, Ranchi
14. Sri A. C. Guha, Minister for Revenue & Defence Expenditure, Government of India

Among the members of the Governing Body of the Indian Lac Cess Committee, Sri B. L. Singh and Sri Bazle Karim visited the Institute during the period, the latter having visited twice.

Roads and Buildings — Maintenance and repairs continued to be carried out by the C.P.W.D. One room in the Entomological laboratory was air-conditioned during the period.

As decided by the Committee previously, all the Institute staff quarters were fitted with fans.

No new quarters were constructed. The plans of the previously sanctioned Administrative and Technology Blocks were not finalized, so that their construction is yet to start.

Supply of Water and Electricity — As reported already, the installation of the new 4 in. cast-iron pipe line in replacement of the old G.I. pipe line, had been completed in February 1955. The remaining work of installing a new pump at the river-bed, matching the capacity of the new line, was completed during the period. The position of water supply as a result, has improved appreciably, but the maximum advantage of the newly laid line cannot be taken till the net-work of distributing pipes in the Institute premises, which, too, are very old and choked in places, is also changed.

Since September 1, 1955, the Institute employees in common with Ranchi people, have been getting their supply of electricity from the Damodar Valley Corporation (D.V.C.) at a reduced rate of four annas per unit; the rate previous to this was six annas per unit.

Library — Books and journals continued to be received regularly. New books and bound volumes of journals, accessioned during the year, numbered 123. In addition, miscellaneous scientific pamphlets and reprints, numbering 75 were also received.

The Institute distributed/mailed during the year over 5,600 and sold some 170 publications of its own.

The Indian Lac Cess Committee has already sanctioned the addition of a room to the Library, to cope with the increasing demand for space. The work of building is yet to start.

Training — At the commencement of the period, there were five trainees in the Entomological Section receiving training in lac cultivation. During the period 10 new trainees joined the course. Four out of this total of 15 were discharged on completion of the course, and 3 after partial training, so that at the end of the period, there were 8 trainees on the roll.

In the Chemical Section, one regular trainee was admitted to, and completed, the six months' course of training in the industrial uses of lac. Three causal trainees, one of them, a proprietor of a local shellac factory, underwent a month's training in the analysis of lac.

Staff — Shri J. M. Hazra, Asst.-in-charge expired on 4-9-55. Shri Hazra was one of the oldest recruits to the Institute and had endeared himself to all by his courtesy and constant readiness to help all. His premature demise was deeply mourned by all members of staff.

The following appointments (above Class IV) were made during the period:

1. Shri D. M. Joshi, Addl. Artist and Photographer, on 9-7-55
2. Shri V. D. Prasad, B.Sc., Analyst, on 22-7-55
3. Shri Sanjiva Rao, B.Sc. (Tech.), Junior Research Assistant, on 28-7-55
4. Shri A. K. Sil, B.Sc., Junior Research Assistant, on 8-9-55
5. Shri R. P. Dubey, B.Sc., Exhibition Assistant (Temporary), on 6-9-55
6. Shri N. Biswas, B.Com., Senior Clerk (Temporary)

Shri P. S. Negi, Entomologist, retired from his post on the afternoon of 15-3-56, Dr. S. Krishnaswami, Ph.D., temporary Biologist, taking over from the same date. Later on Dr. Krishnaswami was appointed as Entomologist from 16-3-56.

Shri J. K. Guha Roy, Senior Clerk, was promoted on 5-9-55 as Assistant-in-charge *vice* Shri J. M. Hazra deceased.

Shri J. N. Singh, Fieldman, Entomological Section, was promoted as Junior Research Assistant (Temporary) on 20-2-55 *vice* Shri A. K. Sil, resigned on 31-12-55.

The following persons (Class III) left the services of the Institute:

1. Shri S. N. Srivastava, M.Sc., Research Assistant (Physicist), on 8-2-56
2. Shri V. D. Prasad, Analyst, on 21-2-56
3. Shri A. K. Sil, Junior Research Assistant, on 31-12-55
4. Shri N. Banerjee, Junior Clerk, on 7-3-56

Persons of Class IV cadre appointed/discharged during the period are listed below:

1. Shri Sadho Oraon, as temporary Bullock Keeper, on 6-6-55. Discharged on 25-8-55; appointed Laboratory Attendant on 6-3-56
2. Shri Mangta Oraon, as temporary Farash, on 6-6-55. Discharged on 25-8-55
3. Shri Bharoo Munda, as temporary Khalasi, on 16-5-55. Discharged on 8-8-55; reappointed on 1-12-55 and discharged again on 16-2-56
4. Shri Mahadeo Oraon, as Night Chowkidar, on 25-4-55
5. Shri Jagdish Ram, as temporary Peon (Entomological Section), on 1-6-55
6. Shri Bacha Sharma, as Carpenter (Temporary), on 5-7-55
7. Shri Bindeshwari Thakur, as peon, on 12-7-55
8. Shri Ram Chander Ram, as Peon (Temporary), discharged on 1-7-55, reappointed as Library Farash on 3-8-55 and discharged again on 17-10-55
9. Shri Hawaldar Singh, as Night Chowkidar, on 21-7-55
10. Shri Chinmoy Sen Gupta, as Daftry, on 3-10-55, discharged on 1-1-56; reappointed as temporary Laboratory Attendant on 16-3-56
11. Gopeshwar Misra, as temporary Laboratory Attendant, on 16-3-56
12. Gandur Singh, as temporary Peon, on 20-3-56
13. Shri Moso Oraon, Lac Stretcher, resigned on 15-1-56
14. Srimati Buchwa, temporary Sweepress *vice* Srimati Lachhmania Hari (on leave), on 1-12-55. Discharged on 15-2-56
15. Shri Dema Oraon, as temporary Peon, on 14-10-55, discharged on 2-1-56

Shri Budhulal, temporary Factory Boy, appointed as Jeep Driver on 25-4-55 and Shri Hanuk Tigga, Night Chowkidar, transferred on 25-4-55 to the post of Factory Boy. Shri Mahadeo Oraon (No. 4 above) was appointed *vice* Shri Hanuk Tigga.

Staff Club — A representation was made to the Government to permit restoration of the I.L.C.C's grant to the club to the previous level: the Government reiterated its erstwhile decision to restrict the grant to Rs. 2 per member per annum. The Club's financial condition, therefore, was unsatisfactory and it continued to provide amenities on a very much reduced scale.

ENTOMOLOGICAL SECTION

(Dr. S. Krishnaswami, Entomologist-in-Charge)

INTRODUCTION

The following changes in the staff of the section took place during the year. Shri P. S. Negi retired from the post of Entomologist on 15-3-56, handing over charge to Dr. S. Krishnaswami, the Biologist. Later on Dr. Krishnaswami was appointed substantively as Entomologist from 16-3-56.

Shri A. Bhattacharya, Research Assistant, who was deputed for training in United Kingdom under the Colombo Plan in September 1954, continued to remain abroad under training.

I — RESEARCH AND INVESTIGATIONS

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

(i) *Large-scale experiment on preserving* Baisakhi *broodlac on* palas *by partial defoliation at Kundri forest of the Bihar Forest Department*

The above experiment is being carried out as usual in the Kundri Forest of the Bihar Government under the technical guidance of the Institute. This area serves as a good demonstration centre for improved methods of lac cultivation in Palamau District where the summer generally is very severe and the brood preservation in the *Baisakhi* crop is reported to fail almost completely. Kundri, in particular, has been experiencing very severe summer consecutively for the past few years and lac cultivation in the neighbourhood has dwindled down considerably due to high mortality of broodlac in summer. Despite this, it has been possible to bring increasingly larger number of trees under cultivation from year to year in Kundri Forest, and during the year under report, almost the entire area was covered. As against 6,215 trees under cultivation in Coupé I during last *Baisakhi* season, 12,027 trees in all (11,526 trees in Coupé III and 501 trees in Coupé II) were infected in October 1955 for the current *Baisakhi* crop (1955-56).

In addition, 2,569 lb. of surplus broodlac was sold out for Rs. 1,462-14-6 to the neighbouring lac cultivators at a rate lower than that prevailing at the time.

Baisakhi crop (1954-55) — Out of 6,215 trees under infection in Coupé I, 5,083 trees were cropped partially in July 1955, after leaving the required amount of brood on the trees themselves for growing the succeeding *Katki* crop by self-infection. 5,411 lb. of surplus brood obtained from this coupé was used to infect 2,195 trees artificially in Coupés I and II for growing the *Katki* (1955) crop. A total of 2,555 lb. of sticklac scraped from deadlac, *ari* lac and *phunki* (brood) lac was obtained from the *Baisakhi* crop.

Severe damage to broodlac was inflicted by squirrels and birds during June-July (1955) and this had resulted in poorer harvests of broodlac and sticklac being obtained than would be possible but for such damage.

Katki crop (1955) — In October 1955, the *Katki* crop from Coupés I and II were completely harvested and 17,299 lb. of broodlac was obtained. With 12,280 lb. of broodlac 11,526 trees in Coupé III and 501 trees in Coupé II were infected to grow the *Baisakhi* (1955-56) crop. The latter is progressing satisfactorily. A surplus of 2,569 lb. of broodlac was sold to *rayats* of the locality. During *Katki* season, 1,183 lb. of scraped lac was obtained from both rejected lac as well as *phunki* lac. Some damage due to birds and squirrels was noticed in this season also towards crop maturity.

In April 1955 and February 1956, 11,571 trees in Coupé III and 2,671 trees in Coupé II were pruned for growing the *Baisakhi* (1955-56) and *Katki* (1956) crops respectively.

(ii) *Residual effect of repeated partial defoliation of* palas *on lac production*

(a) *At Kundri* — During the *Baisakhi* season of 1954-55, the experiment as originally laid down in 1952 was slightly modified so as to include the villagers' type of cultivation for purposes of comparison. The results obtained from the experiment are given in Table I.

TABLE I — CROP DATA FOR THE EXPERIMENT ON THE RESIDUAL EFFECT OF REPEATED PARTIAL DEFOLIATION OF *PALAS* ON LAC PRODUCTION

Locality	No. of trees and treatment	Broodlac used in October 1954		Crop yield of lac sticks obtained in				Ratio of brood used to		Remarks
				July 1955		October 1955		Yield of brood in July-October	Total yield in July-October	
		lb.	oz.		lb.	oz.	lb.	oz.			
KUNDRI	100 partially defoliated	91	12	Brood	99	6	206	2	1:3·3	1:5·6	Broodlac was stolen in October 1954 from all the three types of infection but theft was more from village type and undefoliated trees; in October 1955, brood was stolen from undefoliated trees.
				Rejected	143	6	64	10	—		
	80 Undefoliated	77	12	Brood	44	0	113	0	1:2·0	1:4·8	
				Rejected	184	8	29	0	—		
	50 Village type	87	12	Brood	Nil		25	0	1:0·4	1:3·1	
				Cropped *ari* in April	247	0	—		—		
				Rejected	—		—		—		
NAMKUM	16 partially defoliated	28	14	Brood	37	8	23	0	1:2·1	1:5·4	—
				Rejected	11	12	83	9	—		
	16 undefoliated	34	14	Brood	108	4	10	6	1:3·4	1:6·2	—
				Rejected	33	2	65	6	—		

The data are not quite reliable as broodlac was stolen from all the three types of infection while still under infection on the trees, the theft being particularly more from villagers' type and undefoliated trees.

(b) *At Namkum* — The experiment was conducted on 32 comparable trees chosen at random of which half the number was infected without defoliation while the other half after duly defoliating. The results obtained are included in Table I.

It may be seen that at Namkum where the effect of heat mortality is not so acutely felt as at Kundri, the brood yield from undefoliated trees is as good as that from partially defoliated trees.

In order to assess the real cumulative effect of repeated partial defoliation of *palas* trees on lac production, a new experiment has been laid out at Kundri in October 1955. Under this experiment, 100 trees each of comparable size from areas with trees partially defoliated for over 10 years now and with trees that had not been defoliated at all will be compared for maximum lac production: these trees have been infected already in October 1955 and will be reaped as *ari* in April 1956. The experiment is in progress.

Stem cuttings of *Ficus* species planted during the previous year having failed, attempts were made to raise seedlings from seeds. In hollows containing soil in the trunks of *palas* trees were sown seeds of *Ficus glomerata* (*dumber*), *F. religiosa* (*peepal*) and *F. bengalensis* (*barh*) soon after the rains. Only a few seeds germinated but they did not survive.

2. (i) *Economics of utilizing* palas (*Butea monosperma*) *for* Baisakhi *crop only and* ber (*Ziziphus mauritiana*) *for* Katki *crop*

This is the first year of the experiment and it was conducted on 10 trees each of the two species, i.e. *ber* and *palas*. The crop yield data for *Baisakhi* (1954-55) and *Katki* (1955) crops are given in Table II. In this experiment *ber* has performed better than *palas* this year in *Baisakhi* season. No conclusion can as yet be drawn.

TABLE II — ECONOMICS OF UTILIZING *PALAS* FOR *BAISAKHI* AND *BER* FOR *KATKI* CROP

Host	No. of trees	Brood used (lac sticks)	Lac sticks		Scraped lac	
			Total yield	Brood to yield ratio	Total yield	Brood to yield ratio
		lb. oz.	lb. oz.		lb. oz.	
Ber	10	21 8	B 112 8	B 1: 5·23	B 22 10	B 1: 4·18
			K 32 8	B+K 1: 6·74	K 4 14	B+K 1: 5·11
			B+K 145 0		B+K 27 8	
Palas	10	32 0	B 82 0	B 1: 2·62	B 21 12	B 1: 3·16
			K 124 8	B+K 1: 6·45	K 22 0	B+K 1: 6·36
			B+K 206 8		B+K 43 12	

"B" denotes *Baisakhi* and "K" *Katki*.

(ii) *Preservation of broodlac on* ber *by partial pruning in October-November* (*before infection*) *and December-January* (*after infection*) *in the* Baisakhi *crop*

In order to assess the relative merits of partial pruning of *ber* before and after infection for the preservation of brood from *Baisakhi* crop, an experiment with the following treatments is being conducted at Namkum.

Treatment A — Partial pruning of *ber* in October-November before infection (pruned on 4-10-54).

Treatment B — Partial pruning of *ber* in December-January after infection (pruned on 8-1-55).

Treatment C — Control (No partial pruning carried out).

There were five trees under each of the treatments. In all the three cases the *Baisakhi* crop was cropped partially in June-July, so as to raise the succeeding *Katki* crop by self-infection. In October-November, the *Katki* crop was harvested completely. The results obtained are furnished in Table III (p. 7).

It may be seen that in the case of treatments A and B, the ratios of brood used to yield obtained (of scraped lac) for both the *Baisakhi* crop alone, and *Baisakhi* and *Katki* crops together, are almost the same and are better than that for treatment C. Percentages of selected brood in the *Baisakhi* season for the treatments A and B are 23·8 and 13·0 respectively, while practically no broodlac was obtained from treatment C.

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

Date of infection 15-10-54; Date of partial cropping 6-7-55; Date of full cropping 22-10-55

Particulars		Treatment A		Treatment B		Treatment C	
		lb.	oz.	lb.	oz.	lb.	oz.
Brood used		7	14	8	10	9	8
Scraped lac from brood used		2	1	2	5	2	8
Brood obtained	B	11	4	8	2	—	—
	K	4	8	5	12	1	2
	Total	15	12	13	14	1	2
Scraped lac from brood obtained	B	1	7	1	12	—	—
	K	—	15	1	2	—	5
	Total	2	6	2	14	—	5
Total yield of lac sticks	B	47	2	62	8	57	6
	K	12	7	13	6	3	4
	Total	59	9	75	14	60	10
Scraped lac from total yield of lac sticks	B	6	14	8	7	6	12
	K	12	3	2	8	—	12
	Total	19	1	10	15	7	8
Brood to yield ratio (lac sticks)	B	1: 5·98		1: 7·24		1: 6·04	
	B+K	1: 7·56		1: 8·80		1: 6·38	
Brood to yield ratio (scraped lac)	B	1: 3·33		1: 3·65		1: 2·70	
	B+K	1: 4·39		1: 4·73		1: 3·00	
Percentage of selected broodlac	B	23·8		13·0		—	
	B+K	26·44		18·28		1·86	

"B" denotes *Baisakhi* and "K" *Katki*.

3. Finding of, and Trials on, Lac Hosts for *Baisakhi* crop Including Certain *Ficus* Species

The experiments were conducted at Namkum on *Albizzia lucida* (*galwang*), *Ficus cunia* (*porho*) and *Ougeinia dalbergioides* (*sandan*), and both *palas* and *ber* broodlac were used to infect them. The results are given in Table IV (p. 8) from which it is clear that best results were obtained in the case of *Ficus cunia*.

4. Determination of the Brood-carrying Capacity of the Major Lac Hosts

The experiments were carried out at Namkum and Hesal on four of the major hosts, namely *kusum*, *palas*, *ber* and *khair* and all the four crops (*Baisakhi*, *Katki*, *Jethwi* and *Aghani*) were grown for the experiment. The results obtained are given in Table V (p. 8).

It is seen that except in the case of *palas* in the *Baisakhi* season, the broodlac yields have not been satisfactory during the year.

TABLE IV — COMPARATIVE DATA ON YIELD OF SUMMER BROOD FROM VARIOUS HOSTS

Particulars / Host and number of trees	Kind of brood used				
	Palas			*Ber*	
	Albizzia lucida	*Ougeinia dalbergioides*	*Ficus cunia*	*Albizzia lucida*	*Ougeinia dalbergioides*
	(6)	(8)	(2)	(4)	(4)
	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Brood used					
Lac sticks	5 0	14 4	5 12	3 4	6 8
Scraped lac	1 6	3 14	1 10	1 0	1 10
Brood obtained					
Lac sticks	12 13	42 0	31 8	9 7	10 14
Scraped lac	2 4	13 1	11 9	1 6	2 12
Total yield					
Lac sticks	25 13	74 5	47 14	23 13	27 4
Scraped lac	3 14	20 0	15 3	3 1	3 11
Percentage of selected brood	50·0	56·5	66·3	39·4	39·9
Brood to yield ratio					
Lac sticks	1 : 5·17	1 : 5·20	1 : 8·30	1 : 7·30	1 : 4·20
Scraped lac	1 : 2·81	1 : 5·16	1 : 9·35	1 : 3·06	1 : 2·27
Brood used to brood yield ratio as lac sticks	1 : 2·56	1 : 2·94	1 : 5·48	1 : 2·90	1 : 1·67

TABLE V — BROOD-CARRYING CAPACITY OF MAJOR LAC HOSTS

Locality	Crop	Host and No. of trees	Brood used for infection	Brood yield obtained	Ratio of brood used to brood yield
			lb. oz.	lb. oz.	
HESEL	*Jethwi* 1955	*Kusum* 20	111 2	193 11	1 : 1·79
	Aghani 1955-56	*Kusum* 16	166 12	151 4	1 : 0·91
NAMKUM	*Jethwi* 1955	*Kusum* 10	20 2	1 12	1 : 0·09
	Baisakhi 1954-55	*Palas* 10	17 12	54 4	1 : 3·05
	Baisakhi 1954-55	*Ber* 10	14 0	5 8	1 : 0·39
	Katki 1955	*Palas* 10	10 6	16 14	1 : 1·62
	Katki 1955	*Ber* 10	12 8	13 12	1 : 1·10
	Katki 1955	*Khair* 10	15 4	12 12	1 : 0·80

5. Proper Time of Harvesting for Maximizing Yields

The experiment has not been taken up so far. This problem will be particularly of importance when the regional field research stations are set up during the coming year.

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

The experiments were carried out on *kusum, palas, ber* and *khair* during the year. There were three treatments as follows for each of the species.

Treatment A — Used one third of the " actual " quantity of broodlac required on each tree.

Treatment B — Used one half of the " actual " quantity of broodlac required on each tree.

Treatment C — Used fully the " actual " quantity of broodlac required on each tree.

In the case of *kusum* there were seven blocks with three trees each, while in the case of other species of trees, there were five blocks with three trees each for the three treatments. The *kusum* in the *Aghani* season could not be infected.

The crop yield data are given in Table VI (pp. 10-12)

In the *Baisakhi* season (1954-55), treatments A and B are better than C in the case of *palas* and *ber*. In the *Katki* (1955) season, similar observations hold good in the case of *palas* only; for *ber*, treatment C appears to be better than A which in turn is superior to treatment B; for *khair*, however, treatment A seems to be better than both B and C which are nearly equal between themselves. In the case of *Kusmi* strain on *kusum* trees in the *Jethwi* season (1955), treatment A is better than B which in turn is better than C.

The crop data were analysed statistically. In the case of *palas* and *ber* in the *Baisakhi* season and *palas, ber* and *khair* in the *Katki* season, the treatments were not statistically significant. In the *Jethwi* (1955) crop, however, the treatment effect was significant at 5 per cent level and the conclusion is as follows: $\overline{A\ B\ C}$

7. Critical Study of the Effect of Change of Host Plant on Lac Cultivation

For want of sufficient number of host trees of each species, the experiment could be conducted only on a limited scale in the Namkum plantation and the results obtained are shown in Table VII (p. 13). Conclusions can be drawn only after the experiment has been carried out over a large number of seasons.

8. Determination of the Most Suitable Pruning Methods and Seasons for *Kusum* (*Schleichera oleosa*).

This experiment is being conducted with a view to evolving a pruning method which would produce suitable shoots for infection in the shortest possible time without at the same time affecting the vitality of the host and the normal crop yields. Under the experiment, two types of pruning are being studied, namely ' Apical pruning ' (i.e. cutting the branches or shoots near the apex) and ' Surface pruning ' (wherein tips of main branches and shoots are not cut, but only the lateral shoots and branches arising from them are cut flush at the point of their origin).

(i) *Shoot study* — The number and growth of shoots from January-February 1955 to January-February (1956) were recorded. Shoots were measured at weekly intervals. The data are summarized below and given in Table VIII (p. 15).

Treatment I — 18 months' interval of rest — ' apical pruning '.

Four trees forming two sets with two trees in each were under observation and on each tree observations were taken on three branches. The first set of trees (14 and 134) is being cropped in January-February and second set (180 and 124) in June-July of successive years.

TABLE VI — DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT ON VARIOUS HOSTS

(Weight of scraped lac within brackets; weight of lac sticks without brackets)

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio
	lb. oz.	lb. oz.	lb. oz.		lb. oz.	lb. oz.	lb. oz.		lb. oz.	lb. oz.	lb. oz.	
Rangeeni strain												
I	(0 3)	(1 11)	(2 4)	(1: 12·00)	(0 6)	(0 14)	(1 8)	(1: 4·00)	(0 9)	(3 0)	(3 9)	(1: 6·33)
	0 12	9 3	14 4	1: 19·00	1 2	4 9	9 10	1: 8·55	2 4	11 0	14 1	1: 6·25
II	(0 3½)	(0 9)	(0 15)	(1: 4·30)	(0 6)	(1 13½)	(2 4½)	(1: 6·08)	(0 9)	(1 8)	(2 6)	(1: 4·22)
	0 12	3 8	6 9	1: 8·75	1 2	8 2	11 4	1: 10·00	2 4	7 14	13 7	1: 5·97
Baisakhi 1954-1955 *Palas*												
III	(0 4)	(2 1)	(2 15)	(1: 11·75)	(0 6)	(3 13)	(4 5)	(1: 11·50)	(0 9)	(1 8½)	(2 2½)	(1: 3·83)
	0 12	9 6	15 10	1: 20·83	1 2	16 6	21 7	1: 19·00	2 4	6 2	13 14	1: 6·16
IV	(0 4)	(1 4)	(2 2)	(1: 8·50)	(0 5)	(1 12½)	(2 5½)	(1: 7·50)	(0 11)	(4 0)	(4 15)	(1: 7·18)
	0 12	8 2	14 6	1: 19·16	1 2	9 12	15 4	1: 13·55	2 4	18 2	27 5	1: 12·14
V	(0 3½)	(0 10½)	(0 14½)	(1: 4·14)	(0 6)	(1 12)	(2 6)	(1: 6·33)	(0 10)	(1 14½)	(3 0)	(1: 4·80)
	0 12	3 8	5 8	1: 7·33	1 2	8 3	11 4	1: 10·00	2 4	10 4	13 14	1: 6·17
Treatment	(1 2)	(6 3½)	(9 2½)	(1: 8·14)	(1 13)	(10 1)	(12 13)	(1: 7·06)	(3 0)	(11 15)	(16 ½)	(1: 5·33)
Total	3 12	33 11	56 5	1: 15·01	5 10	47 0	68 13	1: 12·23	11 4	53 6	82 9	1: 7·34
Ber												
I	(0 3)	—	(1 2)	(1: 6·00)	(0 4)	—	(2 1)	(1: 8·25)	(0 8)	—	(2 6)	(1: 4·75)
	0 12	—	7 10	1: 10·16	1 2	—	12 9	1: 11·17	2 4	—	15 2	1: 6·72
II	(0 3½)	—	(1 14)	(1: 8·57)	(0 6)	—	(4 8)	(1: 12·00)	(0 9)	—	(2 1)	(1: 3·66)
	0 12	—	8 6	1: 11·16	1 2	—	17 2	1: 15·22	2 4	—	9 2	1: 4·05
III	(0 3)	—	(1 11)	(1: 9·00)	(0 6)	(0 10)	(2 10)	(1: 7·00)	(0 6½)	(1 0)	(3 3)	(1: 7·84)
	0 12	—	8 3	1: 10·91	1 2	2 13	11 12	1: 10·44	2 4	6 2	14 5	1: 6·36
IV	(0 3½)	—	(2 4)	(1: 10·28)	(0 5)	—	(1 2)	(1: 3·60)	(0 8½)	—	(1 7)	(1: 2·35)
	0 12	—	11 0	1: 14·66	1 2	—	10 2	1: 9·00	2 4	—	10 2	1: 4·50
V	(0 3)	—	(1 2)	(1: 6·00)	(0 5)	—	(1 8)	(1: 4·80)	(0 7½)	—	(1 10)	(1: 3·47)
	0 12	—	10 4	1: 13·66	1 2	—	10 4	1: 9·11	2 4	—	8 12	1: 3·89
Treatment	(1 0)	—	(8 1)	(1: 8·06)	(1 10)	(0 10)	(11 13)	(1: 7·27)	(2 7½)	(1 0)	(10 8)	(1: 4·25)
Total	3 12	—	44 7	1: 11·85	5 10	2 13	61 13	1: 10·99	11 14	6 2	57 57	1: 5·10

TABLE VI — DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT ON VARIOUS HOSTS (*Contd.*)

(*Weight of scraped lac within brackets; weight of lac sticks without brackets*)

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio
Kusmi strain												
I	(0 6)	(0 2)	(0 8)	(1: 1·33)	(0 13)	(0 6)	(0 12)	(1: 0·92)	(1 8)	(0 3)	(0 10)	(1: 0·41)
	1 0	0 4	1 12	1: 1·75	1 8	0 12	2 13	1: 1 87	3 0	0 8	3 5	1: 1·10
II	(0 7)	(0 2)	(0 8)	(1: 1·14)	(0 10)	(0 7)	(1 0)	(1: 1·60)	(1 9)	(0 3)	(0 13)	(1: 0·32)
	1 0	0 4	2 11	1: 2·68	1 8	1 0	3 4	1: 2·16	3 0	0 8	4 4	1: 1·41
Jethwi 1955												
III	(0 7)	(0 4)	(0 10)	(1: 1·43)	(0 10)	(0 2)	(0 9)	(1: 0·90)	(1 9)	(0 4)	(0 13)	(1: 0·52
	1 0	0 8	1 12	1: 1·75	1 8	0 4	2 2	1: 1·42	3 0	0 12	3 5	1: 1·10
IV	(0 8)	(0 14)	(0 14)	(1: 1·62)	(0 18)	(0 3)	(0 15)	(1: 1·25)	(1 8)	(0 7)	(1 7)	(1: 0·96)
	1 0	0 8	2 2	1: 2·12.	1 8	0 8	3 13	1: 2·54	3 0	1 0	7 6	1: 2·46)
V	(0 8)	(0 2)	(0 8)	(1: 1·00)	(0 13)	(0 4)	(0 13)	(1: 1·00)	(1 10)	(0 3)	(2 1)	(1: 1·27)
	1 0	0 4	2 5	1: 2·32	1 8	0 8	3 9	1: 2·37	3 0	0 8	8 0	1: 2·66
VI	(0 7)	(0 5)	(0 15)	(1: 2·14)	(0 12)	(0 5)	(0 9)	(1: 0·75)	(1 8)	(0 10)	(1 8)	(1: 1·00)
	1 0	0 12	3 8	1: 3·50	1 8	0 12	2 4	1: 1·50	3 0	1 8	7 3	1: 2·40
VII	(0 9)	(0 2)	(0 5)	(1: 0·55)	(0 10)	(0 2)	(0 9)	(1: 0·90)	(1 8)	(0 2)	(0 5)	(1: 0·21)
	1 0	0 4	1 12	1: 1·75	1 8	0 4	2 2	1: 1·41	3 0	0 8	2 0	1: 0·66
Treatment	(3 4)	(1 4)	(4 3)	(1: 1·28)	(5 0)	(1 13)	(5 3)	(1: 1·03)	(10 12)	(2 0)	(7 9)	(1: 0·70)
Total	7 0	2 12	15 14	1: 2·26	10 8	4 0	19 15	1: 1·89	21 0	5 4	35 7	1: 1·69
Rangeeni strain												
I	(0 2)	(0 2)	(0 10)	(1: 5·00)	(0 4)	—	—	—	(0 9)	(0 6)	(0 14)	(1: 1·55)
	0 12	0 8	2 9	1: 3·41	1 2	—	—	—	2 4	1 12	3 14	1: 1·72
II	(0 2)	(0 1)	(0 7)	(1: 3·50)	(0 4)	(0 5)	(0 15)	(1: 3·75)	(0 9)	(0 7)	(1 5)	(1: 2·33)
	0 12	0 4	3 1	1: 3·08	1 2	1 8	4 5	1: 3·83	2 4	2 0	7 1	1: 3·14
Katki 1955 *Palas*												
III	(0 3)	(0 3)	(0 15)	(1: 5·00)	(0 4)	(0 4)	(0 12)	(1: 3·00)	(0 9)	(0 12)	(2 13)	(1: 5·00)
	0 12	1 0	4 1	1: 5·42	1 2	1 4	4 4	1: 3·78	2 4	3 4	10 6	1: 4·61
IV	(0 2)	(0 6)	(0 12)	(1: 6·00)	(0 4)	(0 9)	(1 4)	(1: 5·00)	(0 9)	(0 9)	(2 10)	(1: 4·66)
	0 12	1 12	3 12	1: 5·00	1 2	2 0	6 2	1: 5·44	2 4	3 0	11 2	1: 4·94

TABLE VI — DETERMINATION OF OPTIMUM DENSITY OF LARVAL SETTLEMENT ON VARIOUS HOSTS (*Contd.*)

(*Weight of scraped lac within brackets; weight of lac sticks without brackets*)

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio
V	(0 3) 0 12	(0 2) 0 12	(0 10) 3 4	(1: 3·33) 1: 4·33	(0 4) 1 2	(0 7) 1 12	(1 1) 4 13	(1: 4·25) 1: 4·28	(0 9) 2 4	(0 10) 3 4	(1 4) 6 7	(1: 2·22) 1: 2·86
Total	(0 12) 3 12	(0 14) 4 4	(3 6) 16 11	(1: 4·50) 1: 4·45	(0 14) 5 10	(1 9) 6 8	(4 0) 19 8	(1: 4·57) 1: 3·46	(2 13) 11 4	(2 12) 13 4	(9 2) 38 14	(1: 3·24) 1: 3·45
Ber												
I	(0 3) 0 12	(0 3) 0 8	(0 15) 7 2	(1: 5·00) 1: 9·50	(0 4) 1 2	(0 4) 1 0	(0 4) 5 3	(1: 3·50) 1: 4·61	(0 9) 2 4	(1 7) 6 2	(5 0) 22 0	(1: 8·89) 1: 10·00
II	(0 3½) 0 12	(0 10) 1 8	(1 8) 6 9	(1: 6·86) 1: 8·75	(0 6) 1 2	(0 5) 1 8	(0 11) 4 4	(1: 1·83) 1: 3·78	(0 7) 2 4	(0 14) 3 0	(1 12) 10 2	(1: 4·00) 1: 4·50
III	(0 3) 0 12	— —	(0 10) 5 1	(1: 3·33) 1: 6·75	(0 6) 1 2	(0 5) 0 12	(0 15) 5 13	(1: 2·50) 1: 5·17	(0 8) 2 4	(2 2) 5 14	(4 11) 18 3	(1: 9·37) 1: 8·08
IV	(0 3½) 0 12	(0 15) 2 0	(2 0) 6 12	(1: 9·14) 1: 9·00	(0 5) 1 2	(0 15) 2 8	(1 7) 7 4	(1: 4·60) 1: 6·44	(0 8) 2 4	(1 5) 3 8	(2 6) 9 10	(1: 4·75) 1: 4·28
V	(0 3½) 0 12	(0 2) 0 12	(0 12) 4 5	(1: 3·43) 1: 5·75	(0 5) 1 2	(1 2) 2 8	(2 3) 8 10	(1: 7·00) 1: 7·66	(0 7) 2 4	(0 10) 1 8	(1 10) 0 14	(1: 3·71) 1: 3·50
Total	(1 ½) 3 12	(1 14) 4 12	(5 13) 29 13	(1: 5·79) 1: 7·95	(1 10) 5 10	(2 15) 8 4	(6 2) 31 2	(1: 3·77) 1: 5·53	(2 7) 11 4	(6 6) 20 0	(15 7) 68 5	(1: 6·33) 1: 6·07
Khair												
I	(0 4) 1 0	(0 3) 0 12	(1 9) 5 13	(1: 6·25) 1: 5·81	(0 5) 1 8	(0 9) 2 4	(1 3) 5 4	(1: 3·80) 1: 3·50	(0 11) 3 0	(0 14) 3 0	(3 5) 12 2	(1: 4·82) 1: 4·00
II	(0 4) 1 0	(0 8) 1 12	(1 7) 4 12	(1: 5·75) 1: 4·75	(0 6) 1 8	(0 10) 2 4	(1 7) 11 6	(1: 3·83) 1: 7·58	(0 11) 3 0	(0 14) 2 12	(3 4) 8 14	(1: 4·72) 1: 2·96
III	(0 4) 1 0	— —	(0 2) 0 8	(1: 0·50) 1: 0·50	(0 5) 1 8	(0 2) 0 8	(1 0) 7 10	(1: 3·20) 1: 5·08	(0 11) 3 0	— —	(1 8) 6 2	(1: 2·18) 1: 2·04
IV	(0 3) 1 0	(0 6) 1 4	(1 3) 4 5	(1: 6·33) 1: 4·31	(0 5) 1 8	(0 2) 0 8	(0 11) 5 9	(1: 2·20) 1: 3·71	(0 11) 3 0	(0 6) 1 4	(1 4) 4 5	(1: 1·82) 1: 1·43
V	(0 4) 1 0	— —	(0 12) 4 1	(1: 3·00) 1: 4·06	(0 6) 1 8	(0 3) 0 8	(0 15) 5 1	(1: 2·50) 1: 3·37	(0 12) 3 0	(0 5) 1 0	(2 3) 7 10	(1: 2·91) 1: 2·54
Total	(1 3) 5 0	(1 1) 3 12	(5 1) 19 7	(1: 4·26) 1: 3·88	(1 11) 7 8	(1 10) 6 0	(5 4) 34 14	(1: 3·11) 1: 4·65	(3 8) 15 0	(2 7) 8 0	(11 8) 39 1	(1: 3·28) 1: 2·60

TABLE VII — EFFECT OF CHANGE OF HOST PLANT

Host with brood history	No. of trees	Lac sticks						Ratio of brood to yield (lac sticks)	Percentage of selected brood-lac	Scraped lac from				Brood to yield ratio (scraped lac)
		Brood used		Brood obtained		Total yield				Brood used		Total yield		
		lb.	oz.	lb.	oz.	lb.	oz.			lb.	oz.	lb.	oz.	
Kusmi *strain* — Jethwi (*Jan.-Feb. to June-July* 1955 crop)														
Ber (*kusum* × *ber* × *kusum*) × *kusum*	1	4	0	—	—	4	4	1 : 1·06	—	1	12	1	4	1 : 0·71
Khair (*kusum* × *khair* × *kusum*) × *kusum*	4	22	4	1	8	20	3	1 : 0·91	0·79	6	14	4	8	1 : 0·65
Pakur (*kusum* × *pakur* × *kusum*) × *kusum*	6	32	12	17	6	95	4	1 : 2·90	18·24	12	7	25	13	1 : 2·08
Kusmi *strain* — Aghani (*June-July to Jan.-Feb.* 1955-56 crop)														
Kusum (*kusum* × *pakur* × *kusum* × *pakur*) × *pakur*	2	17	6	7	4	29	12	1 : 1·71	24·37	7	10	7	8	1 : 0·98
Rangeeni *strain* — Katki (*June-July to Oct.-Nov.* 1955 crop)														
Albizzia lucida (*palas* × *A.L.* × *P.* × *A.L.* × *P.* × *A.L.* × *palas*) × *palas*	11	12	12	10	0	31	12	1 : 2·49	32·26	2	4	4	3	1 : 1·86
Sandan (*palas* × *sandan* × *palas* × *sandan* × *palas* × *sandan* × *palas*) × *palas*	11	15	6	15	2	69	14	1 : 4·54	21·64	3	10	12	0	1 : 3·31
Porho (*palas* × *porho* × *palas* × *porho* × *palas*) × *palas*	5	6	14	5	6	13	12	1 : 2·00	39·09	1	6	2	7	1 : 1·77
Albizzia lucida (*ber* × *A.L.* × *ber*) × *ber*	5	9	6	16	2	37	10	1 : 4·01	42·85	1	6	7	8	1 : 5·45
Sandan (*ber* × *sandan* × *ber*) × *ber*	5	11	0	29	4	49	14	1 : 4·53	58·64	2	12	12	7	1 : 4·55

First set of trees :

Tree No. 14 (cropped on 19-1-55)

Branch I — Primary buds appeared in the middle of March and developed into shoots. The linear growth of all except one ceased about the end of March and of the latter about the end of April. One secondary bud appeared in April and developed into shoots.

Branch II — Primary buds appeared in February and all continued to grow till March-April. Secondary shoots grew from damaged as well as undamaged primaries early in September and these shoots had shown growth up to the middle of October.

Branch III — Primary buds appeared in February and developed into shoots that continued to grow till March-April. Due to the damage of tip-buds of primaries a set of secondaries developed in the middle of October and another set late in November but their growth was rather slow.

Tree No. 134 (cropped on 8-2-54)

Branch I — The primary shoots of previous year did not show linear growth. New primaries also did not appear. Secondary buds appeared in March on the tips of damaged primaries and continued to grow into secondary shoots till the end of March.

Branch II — Only new secondary buds appeared and continued to grow into shoots till April.

Branch III — Secondary shoots of previous year started growing in February-March linearly and continued to do so till April. New secondary shoots grew from primaries whose tips were damaged.

Second set of trees :

Tree No. 180 (cropped on 1-7-54)

Branch I — No new growth was observed in previous year's primaries; nor did any new primary shoots arise. Secondary shoots grew from the damaged as well as undamaged primaries; similarly tertiary shoots grew from damaged as well as undamaged secondaries and all continued to grow till April-May. Two sub-tertiary shoots also developed.

Branch II — The primaries of previous year did not show any linear growth during this period. The primaries whose growing tips were damaged or broken gave rise to secondaries early in March; the growth of those secondaries stopped after March but one secondary continued to grow till June.

Branch III — Secondary shoots of previous year grew linearly till March. New secondary and tertiary shoots appeared in March and grew till the end of March. Two tertiary shoots developed in June.

Tree No. 124 (cropped on 28-6-55)

Branch I — A set of primary buds started coming out towards the end of July and the shoots arising from these attained maximum length by the end of August. Further another set of primary shoots appeared in the middle of September and continued to grow till the end of the month after which no growth was observed. Some secondary shoots came out at the end of August and some towards the middle of September but the growth of all ceased by the end of September.

Branch II — Primary buds appeared on the main branch in late July, developed into shoots and continued to grow till the end of August. There was no further linear growth up to the end of September when many secondary buds developed on damaged tips of some primaries. One tertiary shoot also developed.

Branch III — Primary buds appeared on the main branch towards the end of July and grew till the end of August. By the middle of September, 8 more new primary shoots developed but their growth was slow. Some secondary shoots also began to appear early in September from the damaged portions of former primaries.

Treatment II — 12 months' interval of rest — ' Apical pruning '.

Three trees were under observation.

Tree No. 36 (cropped on 28-6-55)

Branch I — Five primary buds appeared on the main branch in late July and developed into five primary shoots which attained maximum length by the end of August. A set of secondary buds appeared from the broken tips of primaries in September and developed into shoots.

TABLE VIII — RESULTS OF SHOOT STUDY FROM JANUARY-FEBRUARY 1955 TO JANUARY-FEBRUARY 1956

Branch No.	Date of cropping	Primaries			Secondaries			Tertiaries			Condition of shoots	Larval settlement and lac encrustation
		Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)	Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)	Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)		
2	3	4	5	6	7	8	9	10	11	12	13	14
						Treatment I						
I	9-1-53	83·33	5	5·17 (0·25-10·50)	100·00	1	2·50	No tertiaries			Apex of sec. shoot dried up	*Tree No.* 134 — *Cropped in February* 1956 Branch I — Encrustation on 1 primary very good and all round and on 2, very poor. All the secondary shoots have encrustation of which 3 have excellent encrustation.
II	9-1-53	100·0	10	2·65 (0·75-5·50)	62·50	10	1·90 (0·50-450)	No tertiaries			1 br. dried up and 1 br. damaged and broken	Branch II — Fair and continuous encrustation on the neutral region of 2 primaries and on 2 scattered encrustation. Except 2 all secondaries have encrustation of which 2 are continuous and good, and others partial and in patches.
III	9-1-53	80·00	8	3·28 (1·25-6·25)	71·43	5	0·95 (0·25-2·0)	No tertiaries				
				3·42			1·64					Branch III — Encrustation on 2 primaries scattered and on lower side but of good quality. On 3 secondaries—fair and continuous encrustation and on 2 covered with dead cells. The tertiary has very poor encrustation but with well-developed cells.
I	28-6-55	81·25	13	3·17 (0·50-6·25)	75·00	12	2·12 (0·50-3·75)	100·00	1	1·75		
II	28-6-55	71·43	10	2·30 (0·75-7·50)	64·70	11	1·57 (0·50-3·50)	100·00	1	1·00		
III	28-6-55	72·22	13	2·75 (0·25-5·0)	70·00	7	1·36 (0·75-2·0)	100·00	1	1·50	3 prs. dried up and 3 secs. damaged and dried up. Apex of 2 prs. dried up	*Tree No.* 180 — *Infected in January* 1956 Branch I — The primaries have no settlement. Sparse settlement and in patches on 4 secondaries and the others have no settlement.
				2·78			1·74			1·42		
I	6-2-56	85·17	6	3·12 (1·50-6·0)	71·43	10	3·82 (0·73-7·0)	No tertiaries			1 pr. broken and lost. 1 sec. dried up. Apex of 3 secs. dried up	Branch II — Only 2 primaries have scattered settlement on the mid region of shoots. Settlement on 2 secondaries good and continuous; on 5, scattered and on the lower side; and on others no settlement.
II	6-2-56	100·00	6	9·17 (5·0-21·50)	68·00	17	3·76 (0·50-11·50)	No tertiaries			1 pr. broken and 3 secs. dried and fallen	
III	6-2-56	80·00	8	8·44 (2·50-30·0)	62·50	5	13·25 (1·5-22·0)	100·00	1	1·50		Branch III — The primaries have no settlement. Poor settlement on 3 secondaries and the others have no settlement. Sparse settlement in patches on 3 tertiaries.
				7·06			5·26			1·50		
I	1-7-54	100·00	2	7·62 (7·0-8·25)	80·00	8	8·59 (1·0-16·25)	100·00	5	5·95	Apex of 2 sec. dried up	
II	1-7-54	100·00	6	12·08 (1·25-18·75)	75·00	15	14·05 (3·75-42·50)	No tertiaries			1 pr. broken. Upper portion of 3 prs. and 2 secs. dried up	
III	1-7-54	80·00	4	10·06 (3·50-19·25)	81·81	9	11·12 (2·0-27·50)	62·62	5	6·70 (2·0-15·75)	1 pr. dried up and apex of 2 secs. dried up	
				10·03 4·83			11·86 5·69			6·32 5·19		
						Treatment II						
I	28-6-55	71·43	5	3·25	60·00	3	0·67				1 pr. dried up and 2 secs.	*Tree No.* 114 — *Cropped in January* 1956

Treatment II

I	28-6-55	71·43	5	3·25 (1·0-8·75)	60·00	3	0·67 (0·25-1·0)			1 pr. dried up and 2 secs. damaged and fallen
II	28-6-55	83·33	5	10·05 (1·0-18·50)	100·00	1	1·50			
III	28-6-55	62·50	6	4·08 (1·25-7·0)	66·67	2	0·87 (0·50-1·25)			Apex of 2 prs. dried up and 1 sec. damaged
				5·69			0·87			
I	27-1-56	75·00	6	5·54 (2·50-9·75)	72·72	13	2·23 (0·25-5·50)			2 secs. damaged and fallen
II	27-1-56	100·00	3	17·42 (3·25-25·0)	87·50	7	5·39 (2·25-12·50)	100·00	1	3·50 2 sec. dried up
III	27-1-56	50·00	4	3·62 (1·0-6·50)	75·00	6	1·83 (0·75-2·75)	100·00	3	6·33 (4·25-7·25) 1 pr. and 1 sec. dried up. Apex of 1 pr. dried up; 1 tert. dried up and fallen
				7·69			2·99			5·62
I	14-1-55	77·78	7	4·32 (1·50-8·25)	58·33	7	2·89 (0·25-6·50)			1 pr. damaged and fallen
II	14-1-55	80·00	8	3·97 (1·25-7·75)	46·15	6	3·46 (1·0-8·0)			1 pr. dried up and broken. 4 secs. damaged and fallen
III	14-1-55	75·00	3	4·50 (1·0-8·50)	100·00	1	8·50			
				4·19			3·53			
				5·67			2·88			

Tree No. 114 — *Cropped in January* 1956

Branch I — No lac encrustation on primaries because lac larvae that had settled died at the early stage. 2 secondaries have very good encrustation but the other have poor and scattered encrustation throughout.

Branch II — Scattered encrustation with well-developed cells at the mid region of primary shoots. 2 secondaries have fair encrustation and other shoots have partial encrustation and in patches. No encrustation on tertiaries.

Branch III — A few living lac cells found at the mid portion of one primary shoot. No encrustation on secondaries. The tertiaries have very poor encrustation.

Tree No. 161 — *Infected in January* 1956

Branch I — Only 1 primary has settlement at the mid-region of shoot. A few lac larvae fairly settled on 1 secondary but others do not have any settlement.

Branch II — On 2 primaries settlement found throughout but in patches and all others have no settlement. Lac Larvae settled on secondary shoot have all died.

Branch III — Settlement on 2 primaries very good and continuous and on the third very poor. Settlement was only in patches on secondary shoot.

Treatment III

	21-7-55	50·00	1	1·25						
II	21-7-55	No buds appeared								
III	21-7-55	66·67	2	1·62 (0·75-2·50)	100·00	3	1·33 (0·50-2·0)			1 sec. dried up
				1·12			1·33			
I	27-1-56	No buds appeared								
II	27-1-56	75·00	3	2·75 (1·0-3·75)	66·67	6	10·96 (9·0-13·0)	No tertiaries		1 pr. shoot dried up
III	27-1-56	100·00	7	2·21 (0·25-2·50)	66·67	2	4·25 (2·25-6·25)	No tertiaries		1 pr. shoot dried up
				2·75			9·28			
I	16-1-55	100·00	3	5·25 (2·25-8·0)	66·67	2	1·37 (0·75-2·0)			
II	16-1-55	66·67	6	8·42 (3·25-11·50)	No secondaries and tertiaries					
III	16-1-55	100·00	1	4·25	No secondaries and tertiaries					
				7·05			1·37			
				4·29			6·23			

Tree No. 128 — *Cropped in January* 1956

Branch II — The primaries do not have any lac encrustation. The secondaries have poor encrustation at the mid neutral region.

Branch III — 3 primaries have been encrusted with well-developed cells; 2 have encrustations in patches and others have no encrustation. Encrustation on secondaries is very good and all round.

Tree No. 190 — *Infected in January* 1956

Branch I — On 1 primary lac larvae settled on the lower side; others have poor settlement. 1 secondary has fair settlement throughout; no settlement on the other.

Branch II — Scattered settlement and in patches on all primaries.

Branch III — Settlement very good and continuous.

Treatment IV

II	14-1-55	80·00	5	3·97 (1·25-7·75)			
III	14-1-55	75·00	3	4·50 (1·0-8·50)	100·00	1	8·50
				4·19			3·53
				5·67			2·88

Treatment III

	21-7-55	50·00	1	1·25				
II	21-7-55	No buds appeared						
III	21-7-55	66·67	2	1·62 (0·75-2·50)	100·00	3	1·33 (0·50-2·0)	1 sec. dried up
				1·12			1·33	
I	27-1-56	No buds appeared						
II	27-1-56	75·00	3	2·75 (1·0-3·75)	66·67	6	10·96 (9·0-13·0)	No tertiaries
III	27-1-56	100·00	7	2·21 (0·25-2·50)	66·67	2	4·25 (2·25-6·25)	No tertiaries
				2·75			9·28	
I	16-1-55	100·00	3	5·25 (2·25-8·0)	66·67	2	1·37 (0·75-2·0)	
II	16-1-55	66·67	6	8·42 (3·25-11·50)	No secondaries and tertiaries			
III	16-1-55	100·00	1	4·25	No secondaries and tertiaries			
				7·05			1·37	
				4·29			6·23	

Treatment IV

I	31-1-56	50·00	1	1·50	No secondaries and tertiaries			
II	31-1-56	75·00	3	2·0 (1·0-3·0)	No secondaries and tertiaries			
III	31-1-56	50·00	1	2·75	No secondaries and tertiaries			
				2·05				
I	2-7-55	81·81	9	1·39 (0·25-3·50)	No secondaries and tertiaries			
II	2-7-55	No buds appeared						
III	2-7-55	No buds appeared						
				1·39				
				1·62				

Branch III — Settlement on 2 primaries very good and continuous and on the third very poor. Settlement was only in patches on secondary shoot.

Tree No. 128 — *Cropped in January* 1956

Branch II — The primaries do not have any lac encrustation. The secondaries have poor encrustation at the mid neutral region.

Branch III — 3 primaries have been encrusted with well-developed cells; 2 have encrustations in patches and others have no encrustation. Encrustation on secondaries is very good and all round.

1 pr. shoot dried up

Tree No. 190 — *Infected in January* 1956

Branch I — On 1 primary lac larvae settled on the lower side; others have poor settlement. 1 secondary has fair settlement throughout; no settlement on the other.

1 pr. shoot dried up

Branch II — Scattered settlement and in patches on all primaries.

Branch III — Settlement very good and continuous.

Tree No. 70 — *Cropped in January* 1956

Branch I — No lac encrustation.

Branch II — Good encrustation at the base portion of shoots.

Branch III — A few living cells found at the mid portion of the shoot.

Tree No. 214 — *Infected in January* 1956

Branch I — Only 2 primaries have lac larvae fairly settled on them.

Branch II — The primary buds that appeared in late July, developed into shoots and their growth was arrested after first week of September.

Branch III — The primary shoots developed in the last part of July and in most cases attained their maximum length by the end of August. Secondary shoots started coming out early in October and grew till the end of this month.

Tree No. 114 (cropped on 30-6-54)

Branch I — Primary shoots of previous year showed linear growth in March-April. One new primary shoot developed and grew till the end of March. The primary shoots whose tips were damaged gave rise to secondaries and some of them grew upto middle of May.

Branch II — Primary shoots of previous year showed some linear growth in March-April. The secondary shoots arising from the tips of damaged primaries had a slow growth till the end of May.

Branch III — The primary and secondary shoots that had already appeared, did not show any subsequent growth during this period. New primary and secondary shoots appeared early in March and continued to grow into shoots till the end of April. The tips of damaged secondary shoots gave rise to tertiary shoots.

Tree No. 161 (cropped on 14-1-55)

Branch I — Primary shoots appeared early in March and continued to grow till the end of the month but one of them continued to grow till May. Secondary shoots started coming out in the last week of August and attained their greatest length by the end of September but their growth was rather very slow.

Branch II — The primary buds appeared in the last week of February and grew into shoots till the end of March. Three more new primary shoots appeared in the last week of September and ceased to grow after the first week of November. The secondary shoots appeared early in August from primaries whose tips had dried up.

Branch III — Primary shoots developed early in March and continued to grow till the end of the month. At the end of September one secondary bud appeared and developed into shoot.

Treatment III — 12 months' interval of rest *"Surface pruning"*.

Three trees were under observation.

Tree No. 42 (cropped on 1-7-55)

Branch I — One primary shoot developed in the middle of August and continued to grow till the first week of September.

Branch II — No buds appeared.

Branch III — The primary buds appeared in the middle of August and developed into shoots. Due to damage of tip buds of primaries, a few secondary shoots developed early in September and attained maximum length by the middle of September.

Tree No. 128 (cropped on 30-6-54)

Branch I — No buds appeared.

Branch II — The primary shoots of previous year did not show any linear growth during the active period of March-April. Secondary and tertiary shoots appeared in March and grew linearly till the middle of April.

Branch III — New primary and secondary shoots developed early in March and continued to grow till the end of the month but no further growth was observed in previous years' primaries.

Tree No. 190 (cropped on 16-1-55)

Branch I — Primary buds appeared early in March and continued to grow into shoots till the end of March. Secondary shoots grew from the tips of damaged primary shoots.

Branch II — Primary buds appeared early in March and continued to grow as shoots till middle of April.

Branch III — One primary shoot developed in March and continued to grow till the end of first week of April.

Treatment IV — 6 months' interval of rest — *" Surface pruning "*.

Two trees were under observation.

Tree No. 70 (cropped on 12-1-55)

Branch I — One primary bud appeared in the last week of February and it continued to grow till April.

Branch II — Primary buds appeared early in February and developed into shoots.

Branch III — One primary bud appeared and developed into shoot which stopped growing linearly after March.

Tree No. 214 (cropped on 2-7-55)

Branch I — Primary buds appeared early in October and continued to grow till end of the month.

Branch II — No buds appeared.

Branch III — No buds appeared.

The details of the shoot study are summarized in Table VIII.

(ii) *Yield of lac* — The data for *Jethwi* 1955 and *Aghani* 1955-56 are given in Table IX: The data show that in *Jethwi* crop the best results were obtained from Treatment I (1½ years: apical pruning) and in *Aghani* crop from Treatment III (1 year: surface pruning).

The data for both the crops taken together show that the best results were obtained from treatment I (1½ years: apical pruning).

TABLE IX — YIELD OF CROP FROM *KUSUM* AT HESAL

Treatment No.	Interval of rest and type of pruning	*Jethwi* 1955			*Aghani* 1955-56			*Jethwi* & *Aghani* comb.		
		No. of trees	Ratio of brood-lac used to yield of lac		No. of trees	Ratio of brood-lac used to yield of lac		No. of trees	Ratio of brood-lac used to yield of lac	
			Lac sticks	Scraped lac		Lac sticks	Scraped lac		Lac sticks	Scraped lac
I	18 months: 'Apical'	20	1 : 4·61	1 : 2·79	16	1 : 2·20	1 : 1·16	36	1 : 3·17	1 : 2·11
II	12 months: 'Apical'	15	1 : 0·77	1 : 0·21	15	1 : 2·10	1 : 2·14	30	1 : 1·09	1 : 0·69
III	12 months: 'Surface'	16	1 : 1·52	1 : 0·52	10	1 : 3·27	1 : 2·44	26	1 : 2·28	1 : 1·29
IV	6 months: 'Surface'	15	1 : 2·18	1 : 0·95	9	1 : 2·16	1 : 2·23	24	1 : 2·17	1 : 1·22

In carrying out statistical analysis, the yield figures of a set of 4 comparable trees under each of the treatments in *Jethwi* as well as *Aghani* season were taken into consideration. The statistical analysis was kindly undertaken by the Statistical Officer of the I.L.C.C. The results of analysis together with crop data are given in Table IX (a), (p. 19).

TABLE IX (a)— CROP COMPARISON RATIOS IN TERMS OF SCRAPED LAC AND STATISTICAL ANALYSIS

Treatment No.	Interval of rest and type of pruning	*Jethwi* 1955		*Aghani* 1955-56	
		Tree No.	Brood to yield	Tree No.	Brood to yield
I	18 months: 'Apical'	87	1: 0·50	142	1: 2·13
		88	1: 1·80	143	1: 1·70
		89	1: 0·52	148	1: 1·05
		90	1: 1·18	151	1: 0·58
		Total	3·28		5·16
		Mean	0·82		1·37
II	12 months: 'Apical'	159	1: 0·05	113	1: 3·39
		162	1: 0·40	115	1: 0·80
		164	1: 0·24	117	1: 0·17
		223	1: 0·09	118	1: 0·98
		Total	0·78		5·34
		Mean	0·19		1·34
III	12 months: 'Surface'	189	1: 0·85	129	1: 1·39
		192	1: 0·11	130	1: 0·57
		193	1: 0·37	131	1: 0·47
		198	1: 0·44	133	1: 1·20
		Total	1·77		3·63
		Mean	0·44		0·91
IV	6 months: 'Surface'	303	1: 2·17	60	1: 0·18
		207	1: 0·16	63	1: 0·25
		208	1: 0·75	67	1: 2·82
		209	1: 1·20	72	1: 2·27
		Total	4·28		5·52
		Mean	1·07		1·38

Analysis of variance for Jethwi (1955) *crop*

Source	S.S.	D.F.	M.S.	F.
Between treatments	1·8162	3	0·6054	2·5
Within treatments	2·9050	12	0·2421	—
Total	4·7212	—	—	—

Conclusion: The 'F' value is not significant at 5 per cent level and hence the treatments do not seem to have had any effect on yield. S.E. of difference between means of treatments — 0·246. Only Treatment II differs significantly from Treatment IV, although on the whole no difference exists.

Analysis of variance for Aghani (1955-56) *crop*

Source	S.S.	D.F.	M.S.	F.
Between treatments	0·6185	3	0·2062	0·18
Within treatments	13·0117	12	1·1343	—
Total	14·2302	—	—	—

Conclusion: Since the sum of squares 'between treatments' is smaller than that 'within treatment', the treatment effects are not significant. The S.E. of difference between means of treatments is 0·75 and none of the treatment differences is significant at 5 per cent level.

9. Growing of Lac Hosts Under Crop and Bush Conditions

(i) *Under crop conditions* — 240 *Arhar* (*Cajanus cajan*) plants raised in the plantation were infected with *Rangeeni* brood for growing *Baisakhi* (1954-55) crop. The settlement and development of lac larvae were found to be satisfactory in the beginning, but with the summer heat gradually increasing, most of the plants died as a result of the severe drought, and *ari* cutting of the crop had to be done. Only 25 (10·5%) plants survived till June-July, i.e. up to the maturity of the lac crop. The crop yield data are given below:

No. of plants	240
Broodlac used	10 lb. 12 oz.
Broodlac obtained from 25 plants	3 lb. 6 oz.
Total yield of lac sticks	43 lb.
Brood to yield (lac sticks) ratio	1: 4·00
Brood to yield (scraped lac) ratio	1: 3·66

(ii) *Under bush conditions* — *Flemingia congesta, Inga dulce, Albizzia lucida,* rose and *ber* are being raised as bushes in the plantation. *A. lucida, F. congesta* and rose plants were infected with *Rangeeni* broodlac to produce *Baisakhi* (1954-55) crop. The lac insects after settlement did not survive on rose bushes. The crop data for the other two species where lac crop survived till maturity are given in Table X.

TABLE X — RESULTS OF CROPS RAISED UNDER BUSH CONDITIONS DURING *BAISAKHI* (1954-55)

Yield particulars	Host Plants	
	Flemingia congesta	*Albizzia lucida*
No. of trees infected	50	15
Brood used	12 lb. 4 oz.	6 lb. 2 oz.
Broodlac yield	3 lb. 2 oz.	22 lb. 12 oz.
Total yield	61 lb. 8 oz.	71 lb.
Brood to yield (lac sticks) ratio	1: 5·02	1: 11·58
Brood to yield (scraped lac) ratio	1: 2·38	1: 7·68

10. Collecting Pests of Host Trees, Noting Their Parasites and Control Operations Against Various Pests

(i) *Pests of* kusum: *Tessaratoma javanica,* Thunb. — In the third week of July 1955, a serious outbreak of this pest on *kusum* trees at Hesal-Berwari area was noticed. Trees particularly with young shoots were very badly damaged. All tender shoots of the trees were literally covered with teeming numbers of the adult bugs and they dried up following the attack. The gravid females were observed to lay eggs profusely on all sorts of vegetation found in the locality and even on other belongings of the villagers in the area.

(a) *Control measures* — Mechanical: Sweeping the bugs with the help of hand nets and killing them in kerosenated water (1 oz. in 1 gallon) was found to be an effective and cheap method of control. Dislodging bugs from the branches on to cloth sheets smeared with a paste of rosin in castor oil mixture (rosin melted and mixed with equal quantity of castor oil while hot) was the next best method of control particularly for small trees from where the bugs could be easily dislodged. The paste lost its sticky properties if water came in contact with it during the rains.

(b) *Chemical* — 5 per cent gammexane dust was not found to be quite effective as application on these huge trees with hand-operated rotary dusters during the windy season did not give adequate coverage.

Sprays of gammexane emulsion concentrate and gammexane 50 per cent wettable powder suspension at strengths of 0·3 per cent and 0·6 per cent respectively, gave fairly satisfactory control. Kerosene emulsion and lime-sulphur sprays were also tried on a few trees. While the former had some effect the latter had none: it only scorched the leaves.

A paper on the bionomics of control of this pest was published during the year.

(ii) *Pests of* palas — Coptosoma ostensum, *Dist. family* Pentatomidae, *Sub-family* Plastaspidinae — It is a pest of leaves, tender shoots and inflorescence of *palas* trees. It appears in February and continues to breed in the field till May. With the onset of rains in June, the breeding declines. The bugs reappear in September. They are kept in check in nature by two enemies. An egg parasite belonging to the genus *Telenomus* is very active in April-May and a very high percentage of parasitization of the eggs is reached in May. A Coccinellied beetle (*Synia melanarix*) and its grub also prey on the nymphs of the bugs. Work on the life-history of the pest and its enemies is under progress.

Lampides boeticus Linn. (Lycaenidae) — The larva of this butterfly is a serious pest of the *palas* flowers. It feeds on vital portions of the flower and completely damages them. Even the calyx and corolla are damaged. With the appearance of inflorescene in February, light green eggs are freely laid on the calyx by the female butterflies. The hatching larva enters the un-opened bud or the opened flower and feeds on the vital parts inside and even at times reaches the thalamus or the flower stalk, causing the flower to fall. When full grown, they pupate either inside or outside the flower.

An " annotated list of some of the insect pests of host trees of lac and their control " is awaiting publication.

11. Determination of the Various Races, Strains and Species of Lac Insects, Their Performance, Selection of Good Strains and Cross-infestations, etc.

Collection of lac stick samples through correspondence has not been very satisfactory since samples are received mostly from areas where broodlac sent from Namkum was used for infection. Attempts, however, are being made to collect samples from new areas whenever the staff of the section happen to go on tour in connection with some other work.

12. Influence of Various Environmental Conditions on the Lac Insect

During the year, the work on this aspect received a set-back owing to the two refrigerators in which constant temperature conditions were obtained, going out of order during the course of the experiments. One of them having failed in the first week of September 1955, work in the other at a constant temperature above 24°C. was continued, which also had to be stopped in October resulting from a failure of the second machine as well.

Both for *Rangeeni* and *Kusmi* strains, the experiments had to be started anew to observe the effect on the first generation but none of the female insects under either controlled or field conditions completed the life-cycle. In the case of male, the life-cycle was completed in the *Katki* crop in the field on *Albizzia lucida* in 45·3 days and on *Acacia farnesiana* in 52·4 days; the male insects developing under controlled conditions (24°C.) died before completing the life-cycle. During the *Katki* crop, the temperature and humidity conditions in the field were as follows:

Average mean temperature	27·2°C.
Temperature range	21·1° to 34·14°C.
Relative humidity range	61 to 100%

In the case of the *Kusmi* strain, the males under both field and controlled temperature conditions died prematurely before completing the life-cycle.

13. Survey of Lac Enemies and Their Parasites

Caging of lac samples — (i) During the year under report, 14 small samples of lac collected from different localities and crops and at different stages of development were under observation for emergence of insects associated with lac crops. Except for three miscellaneous chalcids whose exact role is not known and a few beetles, which are mostly scavangers, no new enemy insects or their parasites could be recorded.

The parasites and predators collected are recorded below:

Enemy chalcids:	*Tetrastichus purpureus* Cam.	816
	Eupelmus tachardiae Howard	21
	Parechthrodryinus clavicornis Cam.	15
	Erencyrtus dewitzi Mahd.	289
	Tachardiaephagus tachardiae Howard	207
	Coccophagus tschirchii Mahd.	11
	Tachardiaephagus somervilli Mahd.	—
	Marietta javensis Howard	—
Beneficial chalcids		
	Elasmus claripennis Cam.	—
	Eurytoma palidiscapus Cam.	4
	Brachymeria tachardiae Cam.	10
Braconids:	*Bracon greeni* Ashm.	34
	Apanteles fakrulhajiae Mahd.	1
	Apanteles tachardiae Cam.	15
	Chellonus cyclopyra (?)	1
Ichneumonid:	*Pristomerus testaceicollis* (?)	16
Bethylid:	*Perisierola pulveriae* Kurian	—
Predators:	*Eublemma amabilis* Moore	51
	Holcocera pulverea Meyr	306
	Chrysopa sp.	1
Miscellaneous:	*Chalcids*	3
	Coleoptera	22

(ii) *Predators*: Both the species, namely *Chrysopa madestes* and *C. lacciperda* were met with in *Rangeeni* and *Kusmi* lac during the rainy season but the attack was only mild this year. Stray cases of attack were also noticed in March 1956.

(iii) *Squirrels and birds* — Examination of the stomach contents of the squirrels and birds shot during the summer of 1954 having established that the squirrels and some of the birds do damage to the maturing living lac cells, more detailed investigations were continued during the year. Direct observations on the behaviour, mode of feeding and nesting habits of the squirrels and birds were made in the field (at Kundri) in June-July 1955. In addition, 24 squirrels and 35 birds visiting the lac-bearing trees were also shot for being examined later for stomach contents.

A few specimens of woodpeckers and squirrels which were actually observed on trees doing damage to lac cells were shot, dissected and examined on the spot and the presence of freshly devoured living lac female insects was detected. Also a few squirrels caught alive were kept in confinement with fresh twigs bearing living lac insects and the squirrels freely fed on them producing the typical damage on the lac sticks.

It has been observed during the 2 years of study (1954 and 1955) that the damage is caused only after May, i.e. during June-July in the *Baisakhi* crop and to some extent in *Katki* crop during late September to October-November. The damage is serious in the *Baisakhi* crop since a considerable part of even the small quantity of broodlac saved from the intense summer heat by improved methods of cultivation is lost as a result of damage. In July 1955, the extent of damage by these agencies was assessed on 50 trees. On 25 of

them, the survival of lac insects was comparatively better while on the other 25, it was poor. In the former case, lac insects on 15·4 per cent of the twigs were completely dead (due to heat) and in the latter, on 49·4 per cent. Of the twigs bearing living lac cells, up to 48·2 per cent was found damaged by these agencies in the case of the first group and up to 21·6 per cent in the case of the second. When all the 50 trees were taken together as one single group, lac insects on 28·1 per cent of the twigs were completely dead due to heat and of the twigs bearing living cells, up to 47·8 per cent were damaged by squirrels and birds. The damage was also assessed on the basis of actual count of lac cells, i.e. as (a) grown up dead due to heat, (b) living and (c) damaged by birds and squirrels. For this, 3 twigs at random from each of the 25 trees under the 2 groups (namely with better and poor survival of lac insect) were collected and examined. It was found that in the group of trees with better survival of lac insects, up to 35·9 per cent of the cells survived the effect of heat as against only 10·4 per cent in the other group. Of the surviving cells, up to 61·9 per cent were damaged by squirrels and birds in the former case and 44·8 per cent in the latter. Taking all the 150 twigs together as representing the entire Kundri area, it was found that the survival of lac cells from heat worked out to 23·9 per cent and out of this 58·4 per cent cells were damaged by squirrels and birds together.

During the 2 years of study, 56 squirrels and 62 birds were collected and got identified at the Zoological Survey of India, Calcutta. All the specimens of squirrels belong to one species, namely *Funambulus pennanti* Wroughton. The identification of the specimens of birds is as follows:

Sl. No.	*Popular name*	*Scientific name*	*No. of specimens*
1	The crow pheasant	*Centropus sinensis* (Stephens)	1
2	The copper smith	*Megalaima haemacephala* (Muller)	3
3	The golden backed woodpecker	*Brachypternus benghalensis* (Linn.)	12
4	The mahratta woodpecker	*Dryobates mahrattensis* (Lathan)	10
5	The Indian pitta	*Pitta brachyura* (Linn.)	1
6	The red-vented bulbul	*Mobpastes cafer* (Linn.)	5
7	The common Iora	*Aegithina tiphia* (Linn.)	2
8	The small minivet	*Pericrocotus peregrinus* (Linn.)	6
9	The jungle babbler	*Turdoides somervillei* (Sykes)	2
10	The rufous backed shrike	*Lanius schach* (Linn.)	6
11	The wood shrike	*Tephrodornis pondicerianus* (Gmelin)	3
12	The house sparrow	*Passer demesticus* (Linn.)	4
13	The common weaver bird	*Ploceus philippinus* (Linn.)	1
14	The common myna	*Acridotheres tristis* (Linn.)	2
15	The golden oriole	*Oriolus oriolus* (Linn.)	1
16	The king crow	*Cicrurus macrocercus*	3
		Total	62

Table XI (p. 24) gives the results of further examinations of stomach contents of the squirrels and birds during the year.

14. Cultural and Preventive Methods of Control of Lac Enemies

(i) *Use of wire-net baskets* — Infections through the wire-net baskets are carried out with a veiw to keeping down the incidence of parasites and the predators of lac insects in the field. But these wire-net baskets and the broodlac inside were damaged by squirrels and rats. In order to prevent this, the wire-nets are being enclosed within cheap bamboo baskets and then used for infections for the last two years. It has been found that emergence of lac larvae is in no way interfered with and at the same time both broodlac and wire-net baskets are saved from damage by the rodents. During June-July 1955, 1,463 bamboo-baskets were used to enclose the wire-net baskets and broodlac and out of these only one bamboo-basket

TABLE XI — EXAMINATION OF CONTENTS OF ALIMENTARY CANAL OF SQUIRRELS AND BIRDS SHOT AT KUNDRI

Serial No.	Date of specimen shot	Bits of lac resin	Lac larvae	Grown-up female lac insects		Termites	Other miscellaneous insects
				Entire or almost entire	In fragments		
			Squirrels				
1	14-6-55	2	—	4	1	788	—
2	14-6-55	in good number (not counted)	—	61	24	103	—
3	14-6-55	15	—	16	4	304	One round worm
4	14-6-55	1	—	1	—	273	—
5	14-6-55	7	—	8	1	99	—
6	14-6-55	—	—	—	—	598	—
7	14-6-55	—	—	—	—	476	—
8	15-6-55	3	—	1	—	570	—
9	15-6-55	—	—	1	2	170	—
10	15-6-55	13	—	45	5	834	—
11	13-6-55	8	—	13	9	342	—
12	-10-55	—	—	—	—	213	—
			The golden backed woodpecker				
13	17-6-55	in few numbers (not counted)	18	5	3	580	Black and red ants — 224
14	17-6-55	—	2	1	3	223	Ants — 12
15	20-6-55	—	—	—	—	—	Ants — 340
16	20-6-55	—	6	—	—	—	Ants — 19
17	21-6-55	—	—	—	—	6	Ants — 103 & bugs — 4
18	22-6-55	—	—	—	—	21	Ants — 55
19	22-6-55	—	—	—	—	—	Ants — 2 & beetles — 2
20	—	—	—	—	—	52	—
21	24-6-55	—	—	—	—	—	Few beetles only

was damaged by the rodents while no damage occurred either to the wire-net baskets or the broodlac.

In order to ascertain the number of insects trapped in wire-net baskets during the course of infection, 25 wire-net baskets collected at random from each season of infection were examined after *phunki* removal and the insects trapped recorded. Later, the *phunki* lac from the wire-net baskets was caged for further emergence of the insects. The results are given in Table XII (p. 25). It is seen that more insects were trapped during infection within the baskets.

Further the effect of the use of wire-net baskets on the prevalence of the enemy as well as beneficial insects in the crop produced was investigated as follows. Equal quantities of sticklac obtained from crops produced with and without the use of wire-net baskets for infection were caged immediately after harvest for noting the emergence of insects from these samples. The results of emergence are given in Table XIII (p. 26). It is noted that both predators and parasites emerged in larger numbers from the lac obtained from crops where no wire-nets were used for infection.

15. Control of Enemies of Lac by Use of Insecticides

The investigations are being carried out under three separate experiments as follows: with D.D.T. and B.H.C. being applied in both dust form at 5 per cent strength and spray form at 0·1, 0·25 or 0·3 per cent strengths.

TABLE XII — CATCHES OF INSECTS IN WIRE-NET BASKETS FROM BROODLAC DURING INFECTION AND COLLECTION OF INSECTS FROM THE SAME AFTER INFECTION IS OVER

Name and No. of insects	*Baisakhi* 1954-55 25 baskets containing 2 lb. 12½ oz. of *palas* lac sticks		*Jethwi* 1955 25 baskets containing 3 lb. 6½ oz. of *kusmi* sticklac		*Katki* 1955 25 baskets containing 2 lb. 8 oz. of *palas* lac sticks		*Aghani* 1955-56 25 baskets containing 4 lb. 5 oz. of *kusum* lac sticks	
	During infection	From *phunki*	During infection	From *phunki*	During infection	From *phunki*	During infection	From *phunki*
Chalcids:								
Marietta javensis	—	—	—	2	—	—	—	5
Tetrastichus purpureus	27	—	2	—	17	—	1	—
Eupelmus tachardiae	27	—	15	—	2	—	18	—
Parechthrodrynus clavicornis	—	—	—	—	—	—	—	—
Erencrytus dewitzi	11	—	1	—	2	—	9	—
Tachardiaephagus tachardiae	126	—	742	—	7	—	17	—
Tachardiaephagus somervilli	16	—	—	—	—	—	—	—
Euritoma palidiscapus	—	—	—	—	—	—	—	—
Brachymeria tachardiae	4	—	—	—	—	—	—	—
Elasmus claripennis	—	—	—	—	—	—	—	—
Braconids:								
Bracon greeni	—	—	2	—	1	—	—	—
Apanteles fakhrulhaziae	—	—	1	—	—	1	21	5
Apanteles tachardiae	2	—	—	—	2	—	16	—
Chellonus cyclopyra	5	—	—	—	—	—	1	—
Ichneumonid:								
Pristomerus testaceicollis	3	—	—	—	—	6	—	—
Bethylid:								
Perisierola pulveriae	—	—	—	—	—	—	3	—
Predators:								
Eublemma amabilis (adults)	105	—	71	1	105	18	61	—
(Larval & Pupal stages)	—	—	—	—	45	—	2	—
Holcocera pulverea (adults)	169	8	110	2	2	40	72	5
(Larval & Pupal stages)	—	—	—	—	128	—	10	—
Chrysopa sps.	—	—	—	—	—	—	—	—
Other insects:								
Beetles	114	85	16	6	17	14	14	—
Tinidae	—	—	3	—	—	—	—	—

Experiment 1 — Host trees are treated once only (1 to 7 days) before infection to see whether this preventive treatment will give any protection to the lac crop from its enemies.

Experiment 2 — Host trees are treated once every week after *phunki* removal (i.e. from the fourth week onwards) to see if this repeated weekly treatment will give sufficient control of the predators and parasites and also if it has any adverse effect on the lac insects themselves.

Experiment 3 — Lac sticks immediately after harvesting and freshly scraped (stick) lac at crop maturity were treated with insecticidal sprays and dusts or fumigants and they

TABLE XIII — PREVALENCE OF INSECTS IN LAC PRODUCED WITH AND WITHOUT USE OF WIRE-NET BASKETS

N.B.— *Exptl.*: *Lac produced with use of wire-net baskets; Control*: *Lac produced without use of wire-net baskets.*

Details	Kind and quantity of lac	Insects emerged from lac				
		Eublemma	*Holcocera*	Chalcid enemies	Beneficial insects	Miscellaneous insects
Katki 1954, mature fresh, exptl.	*Ber*, 10 lb.	37	150	133	17	42
Katki 1954, mature fresh, control	*Ber*, 10 lb.	121	510	3,128	194	14
Katki 1954, mature fresh, exptl.	*Palas*, 10 lb.	37	150	133	17	42
Katki 1954, mature fresh, control	*Palas*, 10 lb.	21	420	654	56	4
Aghani 1954-55, mature fresh, exptl.	*Kusum*, 20 lb.	48	443	1,451	271	97
Aghani 1954-55, mature fresh, control	*Kusum*, 20 lb.	100	640	2,331	1,051	29
Baisakhi 1954-55, mature fresh, exptl.	*Ber*, 10 lb.	9	22	106	1	—
Baisakhi 1954-55, mature fresh, control	*Ber*, 10 lb.	39	71	647	51	14
Baisakhi 1954-55, mature fresh, exptl.	*Palas*, 20 lb.	37	254	837	21	48
Baisakhi 1954-55, mature fresh, control	*Palas*, 20 lb.	92	383	1,183	85	81
Katki 1955, mature fresh, exptl.	*Ber*, 10 lb.	74	174	251	135	31
Katki 1955, mature fresh, control	*Ber*, 10 lb.	85	160	318	150	72
Katki 1955, mature fresh, exptl.	*Palas*, 10 lb.	79	100	398	186	45
Katki 1955, mature fresh, control	*Palas*, 10 lb.	93	147	435	223	94

were caged for emergence of enemy as well as friendly insects with a view to determine if carry-over of enemies from the harvested crop to the next crop could be prevented.

Under experiments (1) and (2), there were 2 trees under each of the treatments and three 3 in. samples of stick (total length 9 in.) were examined, once after larval settlement, again about the time of male emergence and finally at crop maturity, for mortality of lac insects due to parasites and predators and other causes as well. Table XIV (p. 28) gives the detailed stick examination data and the crop yield data for *Jethwi* 1955 and *Baisakhi* 1954-55 crops.

The data reveal that neither one treatment during the life of the crop nor the weekly treatment of any of these insecticides has had any effect on the incidence of damage by the predators and parasites. The yield figures also indicate that the treatments were ineffective in the control of the enemies. At the same time it also appears that these treatments do not have any adverse effect on the development of the lac insects themselves.

In view of the above results, the experiments were slightly modified and re-laid as follows with larger number of trees (6) under each of the following treatments in the *Katki* 1955 crop.

Treatments		Intervals of treatment		No. of trees
D.D.T. dust 5% D.D.T. spray 0·1% D.D.T. spray 0·3% B.H.C. spray 0·3% Control (no treatment)	×	Once in a week Once in three weeks Once in six weeks	×	6 —

$5 \times 3 \times 6 = 90$ trees in all.

Stick examinations of three 3 in. samples (9 in. total length) were made as usual after larval settlement, about the time of male emergence and at crop maturity. Table XV (p. 29) gives results of stick examination and the crop yield data.

There are indications that 0·3 per cent D.D.T. spray is somewhat better than the other treatments and this higher concentration at all the three intervals, namely once in a week, once in three weeks and once in six weeks, has given consistently higher yields than the rest of the treatments.

Under experiment (3), 3 lb. of lac sticks and 2 lb. of scraped lac were used for each of the treatments. For spraying, just enough quantity of the chemical suspension was used. For dusting, the ratio of the chemical dust to the lac stick or scraped lac treated was 1: 100. Dosage of fumigants used is given against each fumigant. Lac thus treated was caged immediately after treatment to note emergence of adult insects. The results are furnished in Table XVI (p. 30) and it is seen that among the fumigants, carbon disulphide has given the best result. Among insecticides, it is difficult to draw any conclusions since D.D.T. & B.H.C. dusts in *Baisakhi* and *Jethwi* seasons have given better results while in the *Katki* season the sprays have given better results.

16. Biological Control

(i) *Mass breeding and large-scale liberation of* Bracon greeni *in the field and estimation of the effect of liberations.*

(a) *General* — A scheme for the above study was sanctioned during the year for a period of three years in the first instance. Two field areas at Berwari and Maheshpur-Sirka have been chosen for the purpose. The trees at one of them (at Berwari) have already been acquired and work has started. Infection for the first crop was done in January-February and the crop is progressing well. The new area at Maheshpur-Sirka was completely surveyed and the trees there were enumerated and marked in map. Due to the change in the ownership of the lands and forests resulting from the recent land reforms act, taking the trees on lease in this area will have to pend till a final settlement is reached with the revenue and forest departments. When this area is also taken, one of them will serve as a control area and the other be utilized for releasing parasites, etc.

An air-conditioning plant is being installed in one of the rooms of the laboratory at Namkum and very soon mass breeding of the parasites will commence for large-scale liberations in the field.

(b) *Parasites of* Eublemma amabilis

(i) *Mass breeding of* B. greeni *on alternative hosts in the laboratory* — Mass breeding of this parasite was carried out on only one alternative (unnatural) host, i.e. *Etiella zinkenella* (Pod borer of *Crotolaria saltiana*). The breeding went on at a slow rate for want of more space and constant-temperature room facilities. Out of a total of 14,640 hosts offered for parasitization, 15·7 per cent were parasitized and the average number of adults of *B. greeni* bred per host was 1·17. The percentage of females was 62·9.

An abstract of the breeding data is given in Table XVII (p. 32).

TABLE XIV — RESULTS OF STICK EXAMINATION OF THREE 3″ SAMPLES (TOTAL LENGTH 9″) AND CROP YIELD DATA FOR *JETHWI* (1955) AND *BAISAKHI* (1954-55) CROPS

Treatment	Dates of		Initial larval settlement	Percentage of mortality						Ratio of brood to yield obtained
				About the time of male emergence			At crop maturity			
	Application of the treatment	Infection of the crop		Natural	Due to enemies	Total	Natural	Due to enemies	Total	
*** Experiment No. 1** (Treatment only once before infection) *Jethwi* 1955										
D.D.T. 5% dust	Once on 10-1-55	12-1-55	2,274	8·9	1·0	9·9	27·9	6·7	34·6	1 : 5·20
D.D.T. 0·1% spray	do	do	1,896	34·3	1·5	35·8	46·9	1·1	48·0	1 : 2·10
B.H.C. 5% dust	do	do	1,840	36·1	0·2	36·3	65·4	4·6	68·0	1 : 0·50
B.H.C. 0·1% spray	do	do	1,221	25·6	4·5	30·1	53·3	5·7	59·0	1 : 0·87
Control	do	do	1,687	20·3	0·3	20·6	64·4	0·4	64·8	1 : 0·87
Baisakhi 1954-55										
D.D.T. 5% dust	Once only on 12-10-54	6-10-54	4,314	14·0	3·8	17·8	28·6	10·2	38·8	1 : 3·00
D.D.T. 0·1% spray	do	do	1,986	4·4	34·3	38·7	19·9	17·0	36·9	1 : 4·00
B.H.C. 5% dust	do	do	2,772	5·9	17·9	23·8	28·8	37·9	66·7	1 : 4·70
B.H.C. 0·1% spray	do	do	3,445	28·6	19·3	47·9	26·0	17·0	43·0	1 : 3·50
Control	do	do	3,493	6·8	28·5	35·3	34·8	13·4	48·2	1 : 3·70
Experiment No. 2 (Weekly treatments after *phunki* removal) *Jethwi* 1955										
D.D.T. 5% dust	21 treatments from 17-2-55 to 11-7-55	12-1-55	3,108	16·3	1·2	17·5	72·9	1·6	74·5	1 : 1·70
D.D.T. 0·1% spray	do	do	1,885	30·3	1·3	31·6	53·0	1·1	54·1	1 : 0·83
B.H.C. 5% dust	do	do	1,890	19·2	0·3	19·5	71·6	—	71·6	1 : 0·16
B.H.C. 0·1% spray	do	do	1,648	52·6	0·2	52·8	68·0	1·0	69·0	1 : 0·66
Control	do	do	2,030	31·2	0·6	31·8	78·6	1·8	80·4	1 : 0·50
Baisakhi 1954-55										
D.D.T. 5% dust	34 treatments from 30-10-54 to 25-6-55	6-10-54	1,836	5·6	0·1	5·7	35·7	6·8	42·5	1 : 4·10
D.D.T. 0·1% spray	do	do	2,748	19·8	0·4	20·2	31·8	15·7	47·5	1 : 3·00
B.H.C. 5% dust	do	do	2,174	40·6	—	40·6	23·0	17·0	40·0	1 : 4·00
B.H.C. 0·1% spray	do	do	2,572	23·1	—	23·1	49·0	11·0	60·0	1 : 3·30
Control	do	do	4,076	27·6	—	27·6	34·7	13·0	47·7	1 : 3·70

* For experiment No. 1 the last column gives " brood to brood ratio " and *not* " brood to yield ratio ".

TABLE XV — RESULTS OF STICK EXAMINATION OF THREE 3″ SAMPLES (TOTAL LENGTH 9″) AND CROP YIELD DATA FOR *KATKI* 1955 CROP

Treatment	Interval of application	Date of infection of the crop	Initial larval settlement	Percentage of mortality						Ratio of brood to yield
				About the time of male emergence			At crop maturity			
				Natural	Due to enemies	Total	Natural	Due to enemies	Total	
D.D.T. dust 5%	Once in a week	2nd July	1,703	16·5	9·3	25·8	17·3	43·0	60·3	1 : 5·3
	Once in 3 weeks	do	2,333	—	—	—	30·9	36·1	67·0	1 : 3·6
	Once in 6 weeks	do	2,558	12·0	7·6	19·6	24·1	30·9	55·0	1 : 5·2
D.D.T. spray 0·1%	Once in a week	do	1,990	24·0	12·0	36·0	33·1	28·6	61·7	1 : 5·6
	Once in 3 weeks	do	2,301	27·0	20·9	47·9	14·5	50·1	64·6	1 : 4·7
	Once in 6 weeks	do	3,397	—	—	—	33·6	18·3	51·9	1 : 0·8
D.D.T. spray 0·3%	Once in a week	do	1,183	15·4	7·6	23·0	29·6	5·4	35·0	1 : 7·7
	Once in 3 weeks	do	1,752	23·1	6·6	29·7	35·3	39·1	74·4	1 : 7·0
	Once in 6 weeks	do	1,888	15·1	16·3	31·4	16·6	26·7	43·3	1 : 6·9
B.H.C. spray 0·3%	Once in a week	do	—	18·9	8·5	27·4	12·1	41·8	53·9	1 : 3·8
	Once in 3 weeks	do	2,207	25·7	10·1	35·8	28·7	47·8	76·5	1 : 3·6
	Once in 6 weeks	do	3,170	16·3	15·9	32·2	45·2	28·7	73·9	1 : 4·7
Control	(No treatment)	do	1,826	19·7	24·2	43·9	46·7	22·5	69·2	1 : 4·8

TABLE XVI — EFFECT OF DIFFERENT INSECTICIDES AND FUMIGANTS ON LAC STICKS AND SCRAPED LAC

Lac samples	Treatment	Emergence of				
		Predators			Parasites of	
		Hol.	*Eub.*	Total	Lac insects	Enemies of lac insects
Baisakhi 1954-55	*Insecticides used*					
Palas lac sticks	0·1% B.H.C. spray	120	—	120	94	3
do	0·25% B.H.C. spray	60	2	62	60	7
do	5·0% B.H.C. dust	8	7	15	10	1
do	0·1% D.D.T. spray	20	5	25	39	2
do	0·25% D.D.T. spray	11	1	12	30	1
do	5·0% D.D.T. dust	17	5	22	27	1
do	Control to above	75	12	87	80	3
Palas scraped lac	0·1% B.H.C. spray	1	1	2	11	—
do	0·25% B.H.C. spray	4	—	4	7	2
do	5·0% B.H.C. dust	—	2	2	6	—
do	0·1% D.D.T. spray	—	—	—	14	—
do	0·25% D.D.T. spray	—	3	3	42	1
do	5·0% D.D.T. dust	—	—	—	22	—
do	Control to above	168	—	168	33	5
Palas lac sticks	*Fumigants used*	—	—	—	4	—
	Carbon tetrachloride @30 lb. to 1000 cu. ft.					
do	Carbon disulphide @ 6¼ lb. to 1000 cu. ft.	—	—	—	—	—
do	Killoptera @ 25 lb. to 1000 cu. ft.	—	—	—	2	—
do	Control to above	16	1	17	4	2
Palas scraped lac	Carbon tetrachloride @ 30 lb. to 1000 cu. ft.	—	—	—	—	—
do	Carbon disulphide @ 6¼ lb. to 1000 cu. ft.	—	—	—	—	1
do	Killoptera @ 25 lb. to 1000 cu. ft.	—	—	—	9	—
do	Control to above	—	—	—	23	—
Jethwi 1955	*Insecticide used*					
Kusum lac sticks	0·1% B.H.C. spray	16	75	91	—	3
do	0·25% B.H.C. spray	11	49	60	1	1
do	5·0% B.H.C. dust	26	5	31	2	4
do	0·1% D.D.T. spray	25	43	68	6	12
do	0·25% D.D.T. spray	24	39	63	8	8
do	5·0% D.D.T. dust	6	23	29	—	4
do	Control to above	117	15	132	6	16

TABLE XVI — EFFECT OF DIFFERENT INSECTICIDES AND FUMIGANTS ON LAC STICKS AND SCRAPED LAC (*Contd.*)

Lac samples	Treatment	Emergence of				
		Predators			Parasites of	
		Hol.	*Eub.*	Total	Lac insects	Enemies of lac insects
Kusum scraped lac	0·1% B.H.C. spray	12	24	36	1	4
do	0·25% B.H.C. spray	18	9	27	—	1
do	5·0% B.H.C. dust	—	—	—	—	—
do	0·1% D.D.T. spray	8	21	29	2	1
do	0·25% D.D.T. spray	13	23	36	—	2
do	5·0% D.D.T. dust	2	5	7	—	—
do	Control to above	60	6	66	7	23
Kusum lac sticks	*Fumigants used*					
	Carbon tetrachloride @ 30 lb. per 1000 cu. ft.	25	4	29	—	1
do	Carbon disulphide @ 6¼ lb. per 1000 cu. ft.	3	—	3	2	—
do	Killoptera @ 30 lb. per 1000 cu. ft.	90	2	92	1	3
do	Control to above	157	14	171	7	30
Kusum scraped lac	Carbon tetrachloride @ 30 lb. per 1000 cu. ft.	8	1	9	1	—
do	Carbon disulphide @ 6¼ lb. to 1000 cu. ft.	—	—	—	—	—
do	Killoptera @ 25 lb. to 1000 cu. ft.	51	16	67	2	2
do	Control to above	108	18	126	11	20
Palas lac sticks	5% B.H.C. dust	78	46	124	37	17
do	0·1% B.H.C. spray	3	1	4	5	—
do	0·25% B.H.C. spray	—	—	—	8	1
do	5% D.D.T. dust	191	41	232	23	12
do	0·1% D.D.T. spray	—	—	—	21	—
do	0·25% D.D.T. spray	4	—	4	31	4
do	Control to above	128	22	150	28	19
Palas scraped lac	5% B.H.C. dust	47	3	50	11	—
do	0·1% B.H.C. spray	—	1	1	9	—
do	0·25% B.H.C. spray	6	11	7	9	—
do	5% D.D.T. dust	43	5	48	23	—
do	0·1% D.D.T. spray	7	—	7	11	—
do	0·25% D.D.T. spray	5	2	7	14	1
do	Control to above	83	16	99	48	6

TABLE XVII — MASS BREEDING OF *B. GREENI* ON ALTERNATIVE HOST *ETIELLA ZINKENELLA* DURING 1955-56

Months		Condition of host	No. of larvae						No. of days in contact	No. of adults bred			% of female	No. per host	Remarks
			Pre-sented	Parasi-tized	%	Living	Dead	Pupated		Male	Female	Total			
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
April	1955	Offered in tissue domes	1,200	65	5·40	666	462	7	3 days	55	65	120	54·16	1·80	
May	1955	do	1,240	56	4·50	682	465	37	3 ,,	34	49	83	59·00	1·40	
June	1955	do	1,200	130	10·80	535	519	16	3 ,,	40	67	107	62·60	0·80	
July	1955	do	1,240	210	16·90	503	510	17	3 ,,	63	107	170	62·90	0·80	Attacked by mites
August	1955	do	1,240	67	5·40	470	646	57	3 ,,	25	45	70	62·20	1·04	,,
September	1955	do	1,200	139	11·50	496	551	14	3 ,,	62	87	149	58·30	1·07	
October	1955	do	1,240	222	17·90	571	428	19	3 ,,	139	203	342	59·30	1·50	
November	1955	do	1,200	281	23·40	637	227	5	3 ,,	72	189	261	73·50	0·90	
December	1955	do	1,240	252	20·30	728	260	—	3 ,,	67	147	214	68·60	0·80	
January	1956	do	1,240	226	10·16	664	346	4	3 ,,	177	240	417	57·50	1·80	
February	1956	do	1,160	337	29·05	576	238	9	3 ,,	119	311	430	72·30	1·27	
March	1956	do	1,240	324	26·12	523	348	45	3 ,,	152	197	349	56·40	1·07	
		TOTAL	14,640	2,309	15·70	7,051	5,050	230		1,005	1,707	2,712	62·90	1·17	

(ii) Elasmus claripennis — *ecto-parasite of the larvae of* E. amabilis — The parasite occurs in the lac crop between August-September and January-February. Work on the life-history studies was started in September as the parasite became available in the field. In single-pair cages, oviposition was not obtained in the laboratory but females confined in large numbers along with males in larger cages (measuring $11\frac{1}{2}'' \times 14\frac{1}{2}'' \times 16''$) did oviposit and this method was adopted for continuing the laboratory-bred stock. In January 1956, however, oviposition even in these cages ceased and breeding work had to be terminated.

The longevity and total life-history data are given in Table XVIII.

TABLE XVIII — LONGEVITY AND LIFE-HISTORY IN DAYS

Month	Longevity in days				Total life-cycle period in days			
	Males		Females		Males		Females	
	Variation	Average	Variation	Average	Variation	Average	Variation	Average
September 1955	1-2	1·30	1-4	1·30	—	—	—	—
October 1955	1-6	1·50	1-10	3·61	—	—	—	—
November 1955	1-12	2·40	3-29	9·58	16-19	21·98	16-29	22·03
December 1955	1-10	4·10	3-36	16·00	25-33	26·56	25-34	28·40
January 1956	—	—	—	—	20-28	24·40	20-28	23·14
February 1956	—	—	—	—	13-18	16·32	15-18	16·73

The egg period throughout the period of study was only one day while the average larval periods were 8·95, 10·99, 8·82 and 7·48 during the months of November, December, January and February respectively. The females had an average pupal period of 10·03, 14·47, 14·58 and 7·84 days respectively for the above four months. The corresponding average pupal periods for males were 12·08, 16, 41, 13·32 and 8·25 days respectively.

(ii) *Parasites of* Holcocera pulverea

(a) Apanteles tachardiae (*Braconid*) — *endo-parasite of* H. pulverea Larva — A technique for the breeding of the parasite on the larvae of *H. pulverea* and *Corcyra cephalonica* was developed in July 1955, but still it requires to be improved for the purpose of mass breeding. Cannibalism among the host larvae is a serious impediment to be overcome. For life-history studies, single-pair cages were started. In the case of *Holcocera*, one to two-day old larvae were settled on fresh lac sticks and exposed to a pair for parasitization. Similarly 1 to 2-day old *corcyra* larvae, settled in a thin layer of coarse wheat flour, were exposed to single pairs. The parasites were fed on dried split grapes. After exposure for 24 hours, the parasites were removed and the larvae allowed to develop.

Life-history studies were made with both *Holcocera* and *Corcyra* larvae as hosts. The results are summarized in the Table XIX (p. 34).

(b) Apanteles fakrulhajiae (*Braconid*) — *endo-parasite of* H. pulverea larva — A similar technique as for the above species with slight modification was tried for this species as well and the parasite was successfully reared for the first time during March 1956 on *C. cephalonica* larvae as alternative host. The technique will be further developed and perfected for the mass rearing of this parasite. The data on life-history

TABLE XIX — LIFE-HISTORY DATA FOR *APANTELES TACHARDIAE*

Host larva	Month	Sex of parasite	Endo-parasite period*		Cocoon period		Total life-cycle period	
			Variation	Average of number	Variation	Average of number	Variation	Average of number
H. pulverea								
	July-Aug.	—	11-15	12·87 (5)	5-6	5·4 (5)	17-19	17·8 (8)
	,,	—	—	21 (1)	—	6 (1)	—	27 (1)
	March-April	—	17-13	24·5 (4)	4-5	4·7 (4)	22-36	29·25 (4)
C. cephalonica								
	July-Aug.	—	10-17	12·72 (25)	5-6	5·26 (23)	15-23	18·3 (27)
	October	—	14-16	14·9 (7)	6-6	6 (7)	20-22	20·9 (7)
	,,	—	13-15	13·87 (23)	6-7	6·4 (23)	19-21	20·26 (23)
	February-March	—	—	—	—	—	28-40	35·0 (8)
	,,	—	—	—	—	—	37-38	37·3 (3)

*Period in days

showed that males take on an average 33·4 days (average of 21 observations) and females 32·0 days (average of 2 observations) for completing the life-cycle.

(c) Perisierola pulveriae (*Bethylid*) — *ecto-parasite of* H. pulverea larva — Work on the bionomics of this parasite which stopped in March 1955 due to unfavourable weather conditions was started again in July 1955 when the parasite became available in the field. Four direct generations were bred from July to October 1955 under laboratory temperature and humidity conditions and five generations between January and April 1956 under a constant temperature of 27°C.

The details of breeding are given in Tables XX (p. 35) and XXI (p. 37) for the oviposition and life-history cages respectively.

A black chalcid (to be identified) emerged as a parasite of the cocoon of this Bethylid. Attempts were made to breed this parasite as well. One female parasitized 5 out of 6 cocoons presented for oviposition but only 3 males emerged. For want of females further breeding could not be done.

II — INSTITUTE PLANTATION, NAMKUM

The general upkeep of the plantation was maintained within the limits of funds available. Young trees and plants were manured with farm yard and chemical manure, whenever possible, *boga* (*Tephrosia candida*) was grown to suppress the growth of grasses and to improve soil texture. *Crotolaria saltiana* was cultivated with a view to make use of the pod-borer larvae of *Etiella zinkenella* as an alternative host to breed *Bracon greeni* in the laboratory. Young plants of several hosts were raised in the nursery for experimental work in pots and also for general use in the plantation. *Palas, khair, ber* and *kusum* seeds were directly sown in their respective plots to fill up the gaps. For experimental work only a limited number of trees (325) were infected to grow the various crops.

TABLE XX — BETHYLIDAE — (*PERISIEROLA PULVERIAE*)

(*Vr.* = *Variation* *Av.* = *Average*)

Started from to	No. of adults caged		No. hosts offered	No. of parasitized	Percentage	No. of eggs laid	Pre-oviposition period Vr. / Av.	Total oviposition Vr. / Av.	No. of eggs per female Vr. / Av.	Longevity		Remarks
	Male	Female								Male Vr. / Av.	Female Vr. / Av.	
1	2	3	4	5	6	7	8	9	10	11	12	13
I — Oviposition and longevity under laboratory condition												
First generation	120	25	143	75	52·45	536	3-21	1-29	7-83	2-43	4-39	
17-7-55 to 1-9-55							7·05	14·70	41·23	10·08	18·48	
Second generation	73	17	86	13	15·12	82	3-12	1-9	5-23	2-18	3-23	
2-8-55 to 17-9-55							5·67	3·83	13·67	6·73	10·00	
Third generation	10	16	57	14	24·56	49	7-15	1-10	1-11	4-23	4-23	
20-8-55 to 22-9-55							10·78	3·89	5·44	10·67	13·75	
Fourth generation	4	8	15	6	40·00	35	6·00	12·00	—	6-90	21-23	Mass oviposition cage only started, and from this only male emerged, so this was discontinued.
14-9-55 to 10-10-55							6·00	12·00		6·70	4·60	
Fifth generation	3	4	20	5	25·00	29	4-8	4-6	5-7	5-11	10-18	
4-3-56 to 5-4-56							6·00	5·00	14·50	7·00	12·50	

TABLE XX — BETHYLIDAE — (*PERISIEROLA PULVERIAE*) (*Contd.*)

(*Vr.* = *Variation* *Av.* = *Average*)

Started from to	No. of adults caged Male	No. of adults caged Female		No. hosts offered	No. of parasitized	Percentage	No. of eggs laid	Pre-oviposition period Vr. / Av.	Total oviposition Vr. / Av.	No. of eggs per female Vr. / Av.	Longevity Male Vr. / Av.	Longevity Female Vr. / Av.	Remarks
1	2	3		4	5	6	7	8	9	10	11	12	13
II — Oviposition and longevity in Incubator at 27°C. and on *Holcocera* larvae — Adults caught from field and caged to lay the first generation eggs — food supplied — *kismis*													
24-1-56 to 10-2-56	3	3		31	22	70·90	135	—	3-32 / 22·3	12-68 / 45·00	Adults were caught from field.		
First generation 3-1-56 to 8-3-56	—	16		28	No oviposition							2-27 / 2·20	Host used only *Holcocera*
Second generation 23-12-55 to 4-2-56	1	5		48	33	68·80	189	2-5 / 3·40	2-19 / 12·00	9-55 / 37·80	4 days / 4·00	10-30 / 24·20	Adults (second generation) from L.T. caged. Host used only *Holcocera*.
Third generation 2-2-56 to 21-3-56	6	6	*Hol.*	65	43	66·15	235	1-4 / 2·16	23-43 / 30·16	14-62 / 43·60	2-12 / 8·00	19-44 / 31·16	Host used *Holcocera, corcyra* larvae both.
			Corcyra	11	5	45·40	27						
				76			262						
Fourth generation 22-2-56 to 8-4-56	9	9	*Hol.*	44	16	36·30	88	2-15 / 7·60	5-34 / 14·33	8-72 / 34·00	2-21 / 11·80	11-39 / 28·20	do
			Corcyra	70	36	51·40	218						do
				114	52								
Fifth generation 24-3-56 to 9-4-56	4	4	*Hol.*	4	—	—		3-9 / 5·70					(2 cages are in progress)
			Corcyra	22	9	40·90	48						
				26									

TABLE XXI — BETHYLIDAE (*PERISIEROLA PULVERIAE*)

(Vr. = Variation. Av. = Average)

Started from to	No. of eggs under observation	No. hatched	Egg period	Active larval period Vr. / Av.	No. puputed	Total larval period Vr. / Av.	Adults emerged: Male	Female	Total	Pupal period Vr. / Av.	Life-history: Male Vr. / Av.	Female Vr. / Av.	% of Adults bred	% of Female
Life-history under Laboratory Conditions														
First generation 11-7-55 to 20-8-55	216	209	1 day	2-4 / 2·5	181	4-7 / 5·0	137	29	166	4-6 / 4·9	10-13 / 11·00	10-12 / 10·80	76·86	17·4
Second generation 22-7-55 to 14-9-55	536	524	1 day	3-6 / 3·66	320	3-6 / 4·54	124	151	275	3-11 / 5·45	10-16 / 10·69	10-13 / 11·22	51·31	54·91
Third generation 9-8-55 to 15-9-55	83	73	1 day	3-5 / 3·75	52	3-6 / 4·38	4	27	31	5-8 / 6·60	11 / 11	11-13 / 10·19	37·47	87·10
Fourth generation 21-9-55 to 4-10-55	30	Laid in mass oviposition cage No. 101 when there were 8 females and different development was not noted here-further males emerged here and so discontinued.												
Life-history at Control Temperature 27°C.														
First generation 28-1-56 to 9-3-56	130	104	1 day	2-6 / 4·8	pupal period not been recorded		42	54	96	not recorded	11-16 / 13·50	11-19 / 11·16	73·80	56·25
Second generation 3-1-56 to 12-1-56	There was no oviposition at all by the first generation adults of control temperature and so caged second generation adults from L.T. (laboratory temperature).													
Third generation 26-12-55 to 10-2-56	189	145	1-2 / 1·4	3-5 / 3·3	31 & rest not recorded	5-7 / 5·3 rest not recorded	93	6	99	6-8 / 7·09	13-17 / 13·70	16-0 / 16·00	52·30	6·06
Fourth generation 6-2-56 to 22-3-56	255	239	1 day	3-5 / 3·3	204 & 10 not recorded	5-7 / 6·13 (for 122)	37	156	193	5-10 / 5·60	12-18 / 14·60	12-18 / 14·60	75·80	80·8
Fifth generation 24-2-56 to 3-4-56	300	272	1 day	2-6 / 3·3	178	4-9 / 5·3	24	123	147	5-12 / 8·04	11-17 / 14·60	12-18 / 14·30	49·0	83·6

III — TRAINING AND ADVISORY SERVICE

(i) *Training* — In all there were 15 trainees under training during the year; of whom four were from Bihar, three from U.P., two each from PEPSU and the organization of the Special Officer for Lac Cultivation (I.L.C.C.) and one each from Andhra, Assam and Vindhya Pradesh. Two lac supervisors from U.P., one Forester from Vindhya Pradesh and one Lac Inspector from S.O.L.C.'s organization completed their full one year's training, while the Forester from Andhra and a scholarship-holder from Assam received only a short term training for 6 months and 3 months respectively during the period. One of the Foresters from PEPSU was relieved after about 5 months' training owing to his falling sick and the necessity of having him segregated from the other trainees. The rest of the trainees are continuing.

(ii) *Advisory Service*

(a) *To outsiders* — Various institutions from different parts of the country and individuals interested in lac cultivation were given the necessary advice. During the year a large number of enquiries were received from the Community Project and National Extension Service Administrations and all necessary help was rendered as far as possible. Publications of the Institute were sent either free of cost or at a nominal price.

Exhibits were sent on request to a large number of educational and other institutions and to exhibitions in rural and urban areas. In some of the exhibitions, active part was taken and actual demonstrations were given.

As usual a large number of visitors came to the Institute and were shown the various activities of research carried out at this section.

Advice was also given to various State Governments in the formulation of the Second Five-Year Plan Schemes for lac development work.

(b) *To Special Officer for Lac Cultivation* — A large number of lac samples were examined and necessary advice given by correspondence and personal discussions.

TABLE XXII — A STATEMENT OF LAC PRODUCED AND ITS DISPOSALS, DURING THE YEAR 1955-56

(*From 1st April* 1955 *to* 31*st March* 1956)

Crop and locality	Scraped or broodlac produced and its disposal											
	Produced			Under use in department			Driage			Supplied to Chemical Section		
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.
Baisakhi 1954-55 Namkum	3	33	10½*	—	—	—	0	33	10½*	3	0	0*
Jethwi 1955 Namkum	0	38	11*	—	—	—	0	8	15*	0	29	12*
Jethwi 1955 Hesal	3	10	9*	0	2	15*	0	19	10*	2	28	0*
Katki 1955 Namkum	2	35	12½*	—	—	—	0	19	8½*	2	16	4*
Aghani 1955-56 Hesal	4	28	14*	4	7	10*	0	21	4*	—	—	—
Aghani 1955-56 Namkum	0	10	6½*	0	10	6½*	—	—	—	—	—	—

N.B. — *Denotes scraped lac.

RECEIPTS

	Quantity Md.	sr.	ch.	lb.	oz.	Value Rs.	as.	ps.
1. (a) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Baisakhi* 1954-55)	3	0	0	246	0	228	0	0
(b) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Jethwi* 1955) ...	0	29	12	61	0	65	7	3
(c) By supply of scraped lac for use in the dept. from Hesal plantation (*Jethwi* 1955) ...	0	2	15	6	0	6	7	6
(d) By supply of scraped lac to Chem. Sec. from Hesal plantation (*Jethwi* 1955) ...	2	28	0	221	8	237	9	6
(e) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Katki* 1955) ...	2	16	4	197	12	158	13	0
(f) By supply of scraped lac for use in the dept. from Hesal plantation (*Aghani* 1955-56)	4	7	10	346	12	280	12	6
(g) By supply of scraped lac for use in the dept. from Namkum plantation (*Aghani* 1955-56)	0	10	6½	21	5	17	6	3
TOTAL	13	14	15½	1,100	5	994	8	0
2. (a) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Baisakhi* 1953-54)	0	34	8	70	2	55	1	3
(b) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Katki* 1954) ...	2	35	12	237	2	176	8	3
(c) By supply of scraped lac to Chem. Sec. from purchased lac (*Katki* 1954)	0	6	0	12	12	9	2	3
(d) By supply of scraped lac to Chem. Sec. from Namkum plantation (*Aghani* 1954-55) ...	1	20	2	123	4	129	4	3
(e) By supply of scraped lac to Chem. Sec. from Hesal plantation (*Aghani* 1954-55) ...	5	36	4	483	0	507	14	9
TOTAL	11	12	10	926	4	877	14	9
3. (a) By supply of scraped lac to Chem. Sec. from purchased lac (*Aghani* 1954-55) ...	0	3	8	8	4	7	8	9
(b) By supply of scraped lac to Chem. Sec. from purchased lac (*Jethwi* 1955)	0	25	5	51	14	55	11	0
(c) By supply of scraped lac to Chem. Sec. from purchased lac (*Aghani* 1954-55) ...	0	36	0	74	4	77	7	0
(d) By supply of scraped lac from miscellaneous lac from Hesal (*Aghani* 1954-55) ...	0	4	6	9	0	9	5	9
TOTAL	1	29	3	143	6	150	0	6

CHEMICAL SECTION

I. FUNDAMENTAL

1. Chemical Constitution of Shellac

(i) *Synthesis of butolic acid* — One more intermediate (*I.L.R.I. Annual Report*, 1954-55, p. 47) was prepared:

Ethyl chloroadipate — A mixture of thionyl chloride (18 gms., 15 per cent excess) and ethyl hydrogen adipate (20 gms.) was heated on the water-bath at 50°C. for 12 hrs., followed by refluxing for an hour. The excess of thionyl chloride was removed by (mild) vacuum distillation. The ethyl chloroadipate distilled at 130°-132°C./9 mm. press: yield 18 gms.

Analysis: Calculated for $C_8H_{13}O_3Cl$: Cl, 18·41%; found Cl, 18·43%

Next, attempts were made to prepare octyl magnesium bromide from octyl bromide and magnesium by the usual methods in a suspension of ether, but without success owing perhaps to the presence of traces of moisture. Ether has been re-dried further over sodium wire as a preliminary to fresh experiments.

(ii) *Periodic acid oxidation of aleuritic acid and shellac*

(a) *Oxidation of aleuritic acid* — Aleuritic acid, on oxidation with periodic acid, is expected to yield an acidic part (azelaic semi-aldehyde) and a neutral part (hydroxy-heptanal). The oxidation was carried out in aqueous alcohol medium in the dark for half an hour and the reaction mixture poured in a large volume of water. The aqueous liquor was extracted repeatedly with ether. The ethereal extract was then re-extracted with sodium carbonate solution to remove the acidic portion. The neutral portion, left behind in ether, was obtained as a sweet smelling volatile light yellow liquid. It gave a semi-carbazone on prolonged standing which melted at 82°-85°C.

The alkaline extract was decomposed with dilute sulphuric acid and extracted with ether. The ether extract gave a semi-solid product. It yielded a semi-carbazone which after decolourization, and recrystallization from aqueous methyl alcohol melted at 162°-163°C. (*lit.* for semi-carbazone of azelaic semi-aldehyde 162°-163°C.).

(b) *Separation of oxidized products from shellac*—The oxidation of shellac by periodic acid has been attributed to the presence of free adjacent hydroxyl groups of aleuritic acid. This aleuritic acid molecule, present in shellac, may have (i) its end -OH group free or (ii) its carboxyl group free or (iii) both its carboxyl and end -OH groups combined. One of the products of oxidation of shellac, in the first case, will be hydroxy-heptanal and in the second case azelaic semi-aldehyde.

The oxidation of shellac for separation of oxidized products was carried out as follows: A sample of fresh *Kusmi* shellac was oxidized with periodic acid in 80 per cent acetic acid medium for half an hour in the dark. The oxidized shellac was precipitated in presence of a large volume of water and repeatedly washed with boiling water and dried.

The acid, saponification and hydroxyl values of the oxidized shellac were found to be 71·81, 224·2 and 190·86 respectively while the corresponding values for original shellac were 72·9, 230·0 and 253·75. The decrease in the hydroxyl value of oxidized shellac clearly shows that periodic acid has definitely oxidized some adjacent hydroxyl groups in shellac.

Solvent extraction of the aqueous liquor gave a very small amount of a mixture of solid and liquid products having a pleasant odour. The liquid product gave a semi-carbazone, m.p. 235°C. with decomposition and the mixed m.p. with the

semi-carbazone of the aldehyde acid of shellac was the same. Work is to be continued.

(c) *Estimation of total amount of aleuritic acid present in shellac and seedlac* — When shellac or seedlac is hydrolysed, it is expected that the whole of aleuritic acid will be set free and the estimation of this amount will give an idea of its total amount present in shellac or seedlac. The procedure adopted for this estimation was as follows: Shellac or seedlac was saponified with 0·5*N* (alcoholic) NaOH for 3 hrs. on the water-bath, neutralized with an equivalent amount of 0·5*N* H_2SO_4 and oxidation with periodic acid carried on as usual. Various authentic and commercial samples of shellac and seedlac were tested and the percentage of aleuritic acid was found to vary within 33-36 per cent in shellac and 31-36 per cent in seedlac, the corresponding percentage of dihydroxy compound in the original (unhydrolysed) samples being 11-15 per cent and 12-16 per cent.

On replacing alcoholic caustic soda by aqueous caustic soda, it was found that after saponification, addition of sulphuric acid resulted in the precipitation of some shellac acids which could be oxidized only after dissolution with a large volume of some solvent.

The percentage of aleuritic acid liberated with the progress of hydrolysis at room temperature was also determined thus: shellac (4 gms.) was dissolved in alcoholic or aqueous 0·1*N* KOH (200 cc.) and after suitable intervals 5 cc. of the solution were pipetted out and poured into an equivalent amount of 0·1*N* H_2SO_4 (15 cc. of glacial acetic acid were added in case of aqueous alkali). The oxidation was carried out as usual. The results are shown in Table I.

TABLE I — ESTIMATION OF ALEURITIC ACID IN SHELLAC WITH PROGRESSIVE HYDROLYSIS AT ROOM TEMPERATURE

Time in hrs.	% of aleuritic acid when saponification is carried on with	
	0·1*N* alc. KOH	0·1*N* aq. KOH
1	26·07	14·24
2	27·70	19·53
3	29·32	20·75
4	30·96	22·78
5	30·65	23·60
6	30·65	25·39
12	31·77	29·70
24	32·18	31·30
36	32·18	—
48	32·18	31·74
72	32·18	30·92
96	31·77	32·15
120	31·77	—
144	32·58	—
312	—	31·74
336	32·18	—

It will be seen from the table that almost the whole of the aleuritic acid present in shellac is liberated on hydrolysis at room temperature within 4 hrs. in case of alcoholic caustic potash, and 24 hrs. in case of aqueous caustic potash. Prolonged contact with excess of alkali does not change the values appreciably, suggesting

that the adjacent hydroxyl groups of aleuritic acid do not undergo any change in contact with excess of alkali (0·1*N*).

(iii) *Fractionation of aleuritic acid* — Aleuritic acid as obtained by recrystallization from hot water or aqueous alcohol or alcohol-ethyl acetate mixture always records an m.p. of 100°-101°C. Microscopic examination shows it to be composed of different types of crystals. Endeman (*J. Franklin* Inst., 1907, **164**, 285) isolated an acid, m.p. 100°-101°C. and designated it as 10, 11, 15 — trihydroxy-palmitic acid. Rittler (Cf. Tschirch and Stock, "*Die Harze*", vol. **II**, part 2, p. 1302) reported 8, 9, 16 — trihydroxy-palmitic acid melting at 101°C. Hunsdiecker (*Ber.*, 1943, **76B**, 142-49) designated the natural aleuritic acid as the β-isomer having the *cis*-configuration. Baudert (*Compt. rend.*, 1945, **221**, 205-6) synthesized aleuritic acid and recorded m.p. of 131°-132° for the α-isomer and 102°-104° for the β-isomer. Mitter *et al.* (*Science & Culture*, 1942, **8**, 273) also synthesized aleuritic acid, m.p. 125° and found the mixed m.p. with natural aleuritic acid to be 101°C.

From the above it appears likely that ordinary aleuritic acid is a mixture of isomeric acids. To test whether it is actually so, fractionation of aleuritic acid was undertaken.

Aleuritic acid, m.p. 100°-100·5°C., was dissolved in acetone-free methyl alcohol by slight warming and kept in a refrigerator for a few days for crystallization. The crystals (about 57 per cent) obtained were filtered off and washed with cold methyl alcohol. Microscopic examination showed the crop to be made up of one type of crystals only, melting at 102°-102·5°C. The alcoholic filtrate on further standing in the cold even for a long period did not give any more crystals. Most of the alcohol was distilled off, still nothing crystallized out indicating that the remaining part is highly soluble. On gradual evaporation of the solvent, however, very fine clusters (about 42·8 per cent), m.p. 96°-97°C. were obtained. The product was once again recrystallized from aqueous methyl alcohol in the form of clusters of fine needles, m.p. 97°-97·5°C. and is being further studied.

(iv) *Separation of aldehydo-lactonic acid and shellolic acids from* Kusmi *shellac* — As already reported (*I.L.R.I. Annual Report*, 1953-54, p. 28) water-soluble acids from hydrolysed shellac mainly consist of aldehydo-lactonic and shellolic acids which could be isolated by solvent extraction. It has further been found that the lead salt of the former is soluble in water while that of the latter is not. Hence, attempts were made to obtain pure acids through the soluble- and insoluble-lead salts according to the following procedure:

Hydrolysis of *Kusmi* shellac was carried out as described before (*I.L.R.I. Annual Report*, 1954-55, p. 50). The liquor was neutralized with an equivalent amount of dilute acetic acid and the precipitated liquid acid separated by filtration. During filtration, some solid gradually precipitated from the filtrate which recrystallized from hot water as a mixture of several crystals. The crystalline shapes were totally different (hexagonal and cubic) from those of usual aleuritic acid crystals; m.p. and mixed m.p. with aleuritic acid being 99°-101°C. To the filtrate a 10 per cent aqueous solution of lead acetate was added in excess and the precipitated lead salt separated and thoroughly washed. The filtrate on concentration gave a thick syrup. Addition of water gave a precipitate. The process of concentration and precipitation was repeated several times. The individual salt fractions obtained will be investigated.

N. R. Kamath (private communication) claims to have isolated an aldehydic acid from *Jalari* seedlac to the extent of about 50 per cent on the weight of lac resin. The 2, 4-dinitrophenyl hydrazone derivative had m.p. 231°-232°C. with decomposition. To confirm his findings, work has been undertaken with *Kusmi* seedlac. Fifty gms. of seedlac were dissolved in 500 cc. of aldehyde-free alcohol, allowed to stand overnight at room temperature and filtered. Fifty-six gms. KOH in 500 cc. aldehyde-free alcohol and 63 gms. Na_2SO_3 in 1000 cc. water were added to the seedlac solution and allowed to stand for 24 hrs. at room temperature. It was then acidified with dilute HCl in presence of ether. The ethereal layer was extracted with water and the aqueous portions were mixed with the mother liquor which was decolourized and concentrated on the water-bath. During concentration, there gradually separated out a liquid mass which was dissolved in ethyl acetate and dried over

anhydrous Na_2SO_4. Removal of solvent left a thick syrup which responded to Tollen's solution and gave a 2,4-dinitrophenyl hydrazone along with some soft mass. The aqueous mother liquor was extracted with ethyl acetate. The ethyl acetate extract gave a fluffy powder which softened at 85°C. and the aqueous liquor, a 2,4-dinitrophenyl hydrazone, m.p. 232°-233°C. with decomposition. The total amount of obtainable acid from aqueous liquor was about 67·0 per cent.

In a second experiment, alcohol was replaced by water for saponification, the rest of the procedure being the same as before. The total amount of obtainable acid from the aqueous liquor was nearly 47·0 per cent. During distillation of ethyl acetate from the ethyl acetate extract, there precipitated an acid, m.p. 164°-165°C., amounting nearly to 4·0 per cent.

Later experiments have shown that crystals of aleuritic acid separate out from the aqueous liquor on standing. Hence from the above observations, the acid obtained from the aqueous liquor appears not to be a pure one, but a mixture. It has also been previously found (*I.L.R.I. Annual Report*, 1953-54, pp. 27-28) that the aqueous liquor contained shellolic and similar acids and aldehydic acid.

Next, attempts were made to find out the actual amount of aldehydic acid in the aqueous liquor by directly preparing the hydrazone derivative. About 36 per cent of the derivative (m.p. 232°-233°C. with decomposition), equivalent to 21·6 per cent aldehydic acid could be obtained from a duplicate of the second experiment. In another case, hydrolysis of 50 gms. seedlac was carried out in absence of Na_2SO_3 by using only 14 gms. KOH (which was just in excess) in 500 cc. water. The amount of the derivative obtained was nearly 39 per cent, which is equivalent to 22·8 per cent of aldehydic acid.

The above two experiments indicate that Na_2SO_3 is not necessary during saponification, for the complete isolation of the aldehydic acid. Further confirmatory work is in progress.

Kamath (*loc. cit.*) further claimed to have separated a component from lac resin containing the carbonyl group nearly to the extent of 60 per cent. According to his method (a 10 per cent alcoholic solution of lac is added to an alcoholic solution of 2, 4-dinitrophenyl hydrazone hydrochloride) only about 34 per cent of a yellow derivative from seedlac could be obtained so far: this is being tested.

(v) *Paper Chromatography*

(a) *Hydroxy acids* — R_f values of butolic, dihydroxy stearic, aleuritic and shellolic acids were determined by means of descending and ascending methods and are given in Table II.

TABLE II — R_f VALUES OF HYDROXY ACIDS OF SHELLAC BY DESCENDING AND ASCENDING METHODS IN VARIOUS SOLVENTS

Acid	Descending method *Solvent			Ascending method *Solvent
	A	B	C	D
Butolic, m.p. 54°-55°C.	0·95	1·0	0·81	0·94
Dihydroxy stearic, m.p. 90°C.	—	1·0	—	0·93
Dihydroxy stearic, m.p. 129°C.	—	1·0	—	0·93
Aleuritic, m.p. 100°-101°C.	0·90	0·94	0·73	0·96
Aleuritic isomer, m.p. 96°-97°C.	0·90	0·94	0·73	0·96
Shellolic, m.p. 206°C.	0·80	0·83	0·44	0·92

*Solvent: A — *n*-Butyl alcohol: 90 per cent formic acid: water (4: 2. 5: 3. 5)
B — *n*-Butyl alcohol: acetic acid: water (5: 1: 4)
C — 95 per cent ethyl alcohol: liq. ammonia (100: 4)
D — Phenol saturated with water-formic acid used for saturation of the chamber.

Butolic acid and dihydroxy stearic acids moved with the solvent front in solvent B, and no spot could be traced for dihydroxy stearic acids in solvents A and C.

(b) *Shellac and rosin* — R_f values for shellac and rosin were determined by the ascending method in several other solvents and results are given in Table III.

TABLE III — R_f VALUES OF SHELLAC AND ROSIN BY ASCENDING METHOD IN VARIOUS SOLVENTS

Solvent	Shellac	Rosin
1. Petroleum ether (b.p. 60°-80°): water: acetic acid (100: 60: 10)	0·00	0·94
2. Toluene: water: acetic acid (100: 60: 5)	0·00	0·98
3. Toluene: *n*-Butyl alcohol: water: acetic acid (50: 25: 40: 5)	0·90	0·96
4. Toluene: *n*-Butyl alcohol: water: acetic acid (25: 50: 40: 10)	0·90	0·97
5. *n*-Butyl alcohol saturated with 2*N*-ammonia	Streak	Streak
6. *n*-Butyl alcohol saturated with 2*N*-ammonia: toluene (50: 25)	Streak	Streak
7. *n*-Butyl alcohol: acetic acid: water (50: 10: 40)	0·94	0·97

It will be seen from the above data on solvents 3 and 4 that change in the proportions of the solvent mixture has not changed the R_f values.

The technique of circular (horizontal) paper chromatography was applied to determine the R_f values of the hydroxy acids, and shellac and rosin but promising results could not be obtained so far.

(vi) *Loss incurred in the process of precipitating shellac by acid from alkali carbonate solution* — It has been reported [*London Shellac Research Bureau* (L.S.R.I.) *Tech. Paper No.* 26, p. 15] that there is a loss of 10-20 per cent in the yield of lac, when precipitated with acid from a sodium carbonate solution. A loss of about 12 per cent has been noticed in the yield of bleached lac also (*I.L.R.I. Annual Report*, 1954-55, p. 77). With a view to investigating the matter some preliminary experiments were carried out with shellac as follows:

One part of shellac was dissolved in 4 parts of water and 0·1 part of sodium carbonate or 0·2 part of sodium bicarbonate by warming over a water-bath. After dilution, the insolubles and wax were filtered off and the liquor acidified with excess of dilute acid under efficient stirring. Precipitated lac was separated and repeatedly washed with water till acid-free. Loss was found to be nearly 8-10 per cent.

The mother liquors were slightly pink-coloured and reduced Tollen's solution, but not Fehling's. A crystalline semi-carbazone, m.p. 235° with decomposition, was obtained from the liquors. The mother liquors gave also a pink-coloured lead salt with lead acetate.

That an acidic part had been removed away from shellac during the process was confirmed from the acid values of the original and precipitated shellac, which were 72·89 and 68·34 respectively. From later experiments about 1 per cent of aldehydic acid could be obtained from the aqueous liquor as its 2, 4-dinitrophenyl hydrazone, m.p. 208°-209°C. with decomposition. From the above findings, the loss may be assumed to be due in part to the removal of a highly soluble aldehydic acid, which might be present in shellac either in the

free state or in such a form as to be very easily saponified even with sodium carbonate and bicarbonate.

A sample of shellac, treated with hot water on the water-bath under efficient stirring for a long time, gave an aqueous extract which reduced Tollen's solution very easily, was acidic to litmus and showed yellow turbidity with 2, 4-dinitrophenyl hydrazine hydrochloride. Similar observation could be made in the case of aqueous liquors obtained by dissolving shellac in 95 per cent aldehyde-free alcohol or glacial acetic acid and re-precipitating from a large volume of water.

The aqueous liquor left after precipitation of bleached lac also reduced Tollen's solution and gave a 2, 4-dinitrophenyl hydrazone derivative, m.p. 148°-150°C. with decomposition. The yield amounted to nearly 1 per cent of lac. Further confirmatory work is in progress.

2. Physico-chemical Studies on Lac

(i) *Osmotic pressure measurements of shellac solutions* — Measurements of osmotic pressure of shellac solutions as well as of solutions of partially polymerized shellac samples were started during the period. Cellophane membranes employed for the measurements were swollen and conditioned according to the method of Carter and Record (*J. Chem. Soc.*, 1939, p. 660) and Flory (*J. Am. Chem. Soc.*, 1943, **65**, 375). Reproducible results, however, could not be obtained. Work will be continued.

(ii) *Dissociation constants of free acids in shellac and its two main constituents* — Free shellac acids as contained in Angelo's dewaxed, decolourized shellac, and in the two main constituents of shellac, namely, hard and soft resin were studied. Solutions of these resins along with their free acids in 95 per cent alcohol (ethyl alcohol) were titrated against $N/10$ alcoholic KOH. A photovolt electronic pH meter (model No. 115) was used for finding out the pH values as titration progressed. Neutralization curves of these resins along with their free acids were obtained and the dissociation constants evaluated by extrapolation.

The following values were obtained for the dissociation constants:

Shellac-free acids	...	...	$3{\cdot}98 \times 10^{-6}$
Hard resin-free acids	...	...	$3{\cdot}1 \times 10^{-6}$
Soft resin-free acids	...	...	$10{\cdot}0 \times 10^{-6}$

(iii) *Measurement of specific heat of shellac* — For measuring the specific heat of shellac the original cylindrical type of calorimeter was found to suffer from the following defects:

(a) Unequal amounts of shellac on the two sides of the heater.

(b) Unequal transfer of heat from heater towards the two sides.

(c) Thermometer as placed could not be expected to record the average temperature of shellac.

(d) There was no device to ensure even distribution of heat from the heater to the whole mass. Such a device may be considered essential in view of the poor thermal conductivity of lac.

Various means were tried to rectify these defects but it was found impossible to remove them completely if a cylindrical calorimeter were used. Finally a rectangular type of calorimeter was devised which was reasonably free from all these defects and gave quite reliable and reproducible results.

The values could be determined very quickly to an accuracy of 2-3 per cent which was sufficient for our purpose. The specific heat of *Kusmi* shellac as well as polymerized *Kusmi* shellac were determined, and are tabulated in Table IV (p. 46).

TABLE IV — SPECIFIC HEAT OF SHELLAC AT VARIOUS TEMPERATURES

No.	Temp. range in °C.	Sp. ht. of *Kusmi* shellac		No.	Temp. range in °C.	Sp. ht. of *Kusmi* shellac	
		Fresh	Polymerized			Fresh	Polymerized
1	20-25	0·33	0·30	10	65-70	0·66	0·53
2	25-30	0·34	0·30	11	70-75	0·71	0·53
3	30-35	0·39	0·32	12	75-80	0·65	0·53
4	35-40	0·40	0·34	13	80-85	0·58	—
5	40-45	0·45	0·37	14	85-90	0·57	—
6	45-50	0·54	0·45	15	90-95	0·57	—
7	50-55	0·57	0·47	16	95-100	0·57	—
8	55-60	0·64	0·47	17	100-105	0·57	—
9	60-65	0·62	0·53	18	105-110	0·56	—

The maximum specific heat 0·71 which occurs at 75°C. is taken to indicate the melting point and thus the melting point of shellac is taken to be 75°C. A paper has been prepared giving the details and communicated for publication.

(iv) *Fractionation of polyesters of diacid from aleuritic acid* — The results of fractionation of polyesters of low degree of polymerization (D.P.) (same as reported before) have been repeated for comparison with those obtained previously. The methods applied were the same and the results obtained closely resemble those reported already.

To study the fractionation of the polyesters of medium degree of polymerization, diacid from aleuritic acid was prepared following the method of Nagel and Mertins (*Ber.* 1936, p. 2050). The diacid has been purified as a preliminary to its thermal polyesterification. Further work is on hand.

3. Standardization, Grading and Analysis

(i) *Determination of the bleach index/bleachability of seedlac*

(a) *The Institute method for the determination of the bleach index/bleachability of shellac* — It will be recalled that the recently evolved Institute method for the determination of the bleach index/bleachability of seedlac has been accepted as one of the methods for evaluation of this quality of lac by the Indian Standards Institution and is being referred to as the " Indian method ". At the time of considering this method at last years' meeting of the International Standards Organization (ISO-TC-50), it was explained by other member countries that although they had no experience of this method, it appeared to be on right lines and that British scientists were already working on a similar procedure. It was, however, recommended that some further work should be carried out in determining the colour ratios of several samples of lac using 60, 70, 80, 100 and 120 cc. of bleach liquor and that bleach index — colour ratio curves should be drawn on semi-logarithmic scale instead of on the linear to eliminate steepness of the curve at higher values of the bleach index.

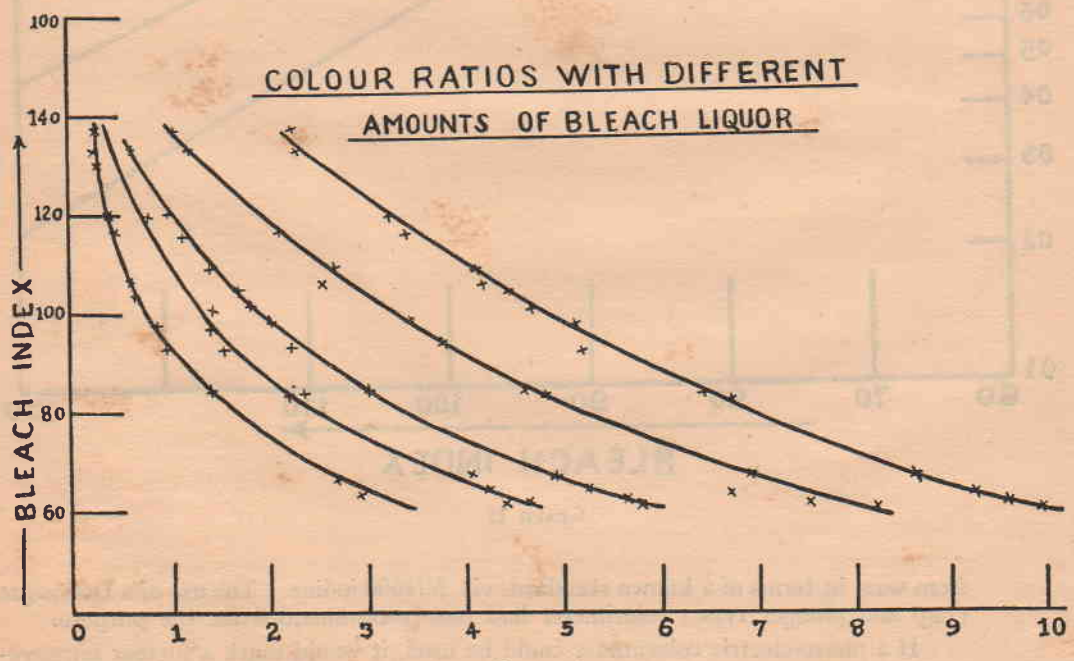
This work has now been carried out with eight samples, two each belonging to Grade IA, IB, IIA and IIB respectively. The procedure followed was as described in the new method (Sankaranarayanan Y. and Bose, P. K., *J. Sci. & industr. Res.*, 1954, Vol. **13B**, No. 7, pp. 506-12). The volumes to which the extract was made up and the amount of bleach liquor added in each case were calculated as detailed in Table V (p. 47).

TABLE V

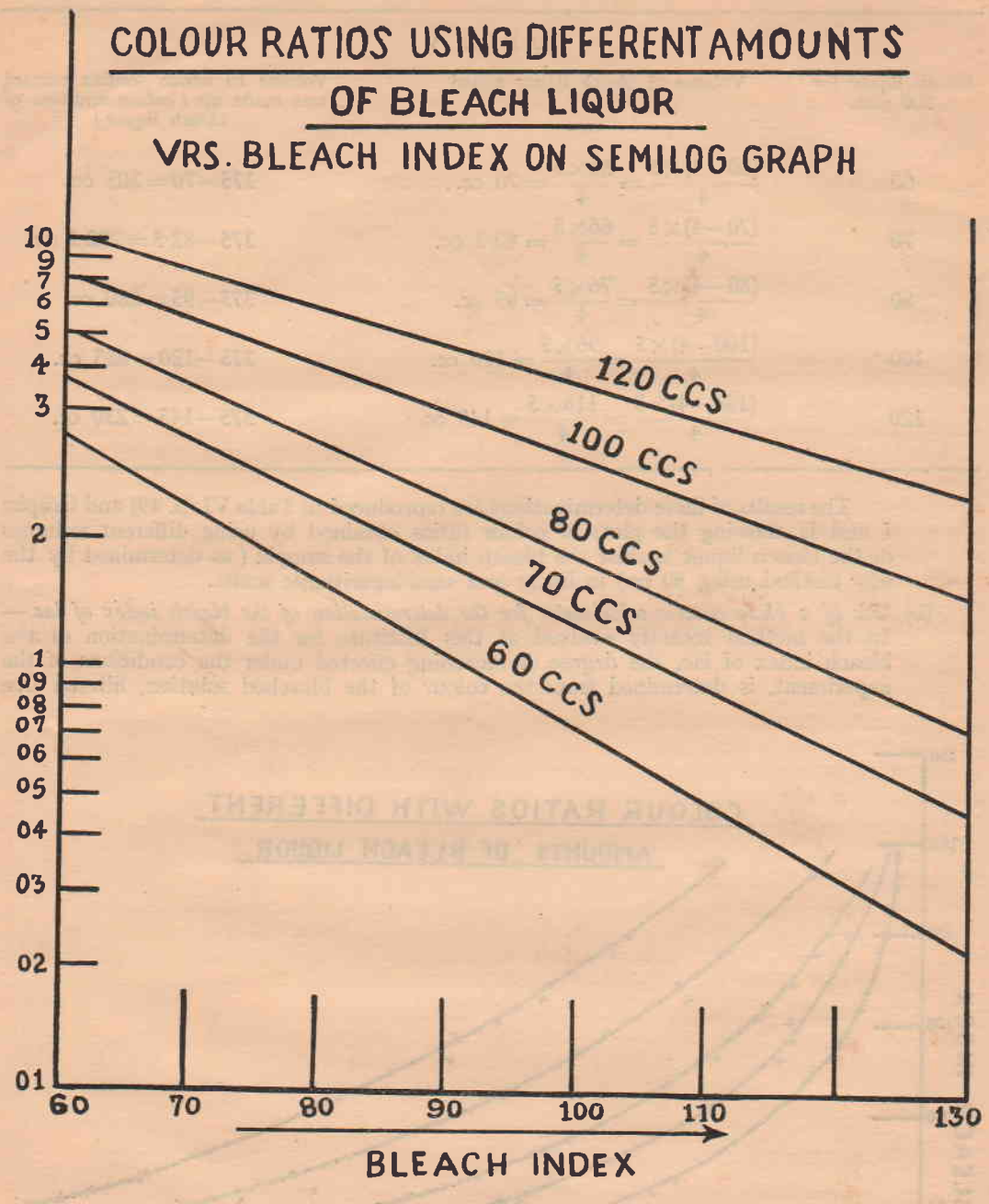
Bleach liquor for 300 gms.	Volume of bleach liquor added	Volume to which seedlac extract was made up (before addition of bleach liquor)
60	$\frac{(60-4)\times 5}{4} = \frac{56\times 5}{4} = 70$ cc.	375 − 70 = 305 cc.
70	$\frac{(70-4)\times 5}{4} = \frac{66\times 5}{4} = 82{\cdot}5$ cc.	375 − 82·5 = 292·5 cc.
80	$\frac{(80-4)\times 5}{4} = \frac{76\times 5}{4} = 95$ cc.	375 − 95 = 280 cc.
100	$\frac{(100-4)\times 5}{4} = \frac{96\times 5}{4} = 120$ cc.	375 − 120 = 255 cc.
120	$\frac{(120-4)\times 5}{4} = \frac{116\times 5}{4} = 145$ cc.	375 − 145 = 230 cc.

The results of these determinations are reproduced in Table VI (p. 49) and Graphs I and II showing the plots of colour ratios obtained by using different volumes of the bleach liquor against the bleach index of the sample (as determined by the new method using 80 cc.) in linear and semi-logarithmic scales.

(b) *Use of a photo-electric colorimeter for the determination of the bleach index of lac* — In the method recently evolved at this Institute for the determination of the bleach index of lac, the degree of bleaching effected under the conditions of the experiment, is determined from the colour of the bleached solution, filtered free



GRAPH I



GRAPH II

from wax, in terms of a known standard, viz. $N/1000$ iodine. The use of a Dubosque (cup and plunger type) colorimeter had been recommended for the purpose.

If a photo-electric colorimeter could be used, it would mark a further improvement inasmuch as personal element in the colour comparison would be eliminated

TABLE VI

	Sample IA_1		Sample IA_2		Sample IB_1		Sample IB_2		Sample IIA_1		Sample IIA_2		Sample IIB_1		Sample IIB_2	
	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean	Colour ratio	Mean
Bleached with 60 cc.	(a)2·7	2·65	(a)3·6	3·5	(a)0·87	0·91	(a)1·3	1·4	(a)0·64	0·66	(a)0·54	0·55	(a)0·20	0·20	(a)0·42	0·42
	2·6		3·4		0·95		1·5		0·68		0·56		0·20		0·42	
	(b)2·8	2·83	(b)3·5	3·5	(b)0·81	0·82	(b)1·5	1·6	(b)0·60	0·60	(b)0·50	0·50	(b)0·206	0·205	(b)0·37	0·36
	2·86		3·5		0·83		1·7		0·60		0·50		0·204		0·35	
Bleached with 70 cc.	(a)4·06	4·03	(a)4·4	4·35	(a)1·44	1·46	(a)2·05	2·15	(a)1·31	1·36	(a)1·15	1·1	(a)0·38	0·39	(a)0·76	0·75
	4·00		4·3		1·48		2·25		1·41		1·05		0·40		0·74	
	(b)4·0	4·2	(b)4·65	4·6	(b)1·35	1·35	(b)2·3	2·3	(b)1·10	1·12	(b)1·0	1·0	(b)0·38	0·38	(b)0·72	0·72
	4·4		4·55		1·35		2·3		1·14		1·0		0·39		0·72	
Bleached with 80 cc.	(a)4·9	4·9	(a)5·7	5·65	(a)2·2	2·25	(a)3·0	3·0	(a)1·86	1·85	(a)1·65	1·55	(a)0·48	0·48	(a)1·0	1·1
	4·9		5·6		2·3		3·0		1·84		1·45		0·48		1·2	
	(b)5·2	5·25	(b)5·7	5·8	(b)2·1	2·0	(b)3·15	3·08	(b)1·70	1·65	(b)1·52	1·4	(b)0·57	0·575	(b)0·94	0·95
	5·3		5·9		1·9		3·00		1·60		1·28		0·58		0·96	
Bleached with 100 cc.	(a)7·0	6·9	(a)7·4	7·5	(a)3·7	3·74	(a)4·5	4·6	(a)3·1	3·05	(a)2·45	2·5	(a)1·1	1·15	(a)2·0	2·08
	6·8		7·6		3·78		4·7		3·0		2·55		1·2		2·15	
	(b)6·6	6·7	(b)8·0	8·2	(b)3·4	3·44	(b)4·9	4·8	(b)2·8	2·9	(b)2·68	2·65	(b)1·04	1·02	(b)1·7	1·81
	6·8		8·4		3·48		4·7		3·0		2·62		1·0		1·92	
Bleached with 120 cc.	(a)8·8	8·6	(a)9·5	9·55	(a)5·2	5·15	(a)6·24	6·39	(a)4·6	4·65	(a)4·0	4·15	(a)2·2	2·2	(a)3·38	3·34
	8·4		9·6		5·1		6·54		4·7		4·3		2·2		3·30	
	(b)9·0	9·2	(b)8·8	9·9	(b)5·1	5·1	(b)6·65	6·7	(b)4·3	4·4	(b)4·0	4·1	(b)2·3	2·25	(b)3·1	3·2
	9·4		10·0		5·1		6·75		4·5		4·2		2·2		3·3	

and there would be no eye fatigue that usually occurs when a number of determinations are carried out with the aid of the visual colorimeter. A photo-electric colorimeter would also do away with the necessity to prepare fresh iodine standard solutions from time to time once the colorimeter is properly calibrated. The practicability of using a photo-electric colorimeter in these determinations was, therefore, investigated.

A Klett-Summerson photo-electric colorimeter was used, the procedure adopted being as follows: Seedlac coarsely powdered to pass through a 10-mesh sieve, was rolled on paper to ensure uniformity. $37{\cdot}5 \pm 0{\cdot}1$ gm. of this powder and $3{\cdot}7 \pm 0{\cdot}1$ gm. anhydrous sodium carbonate were then weighed into a 400 cc. tall form beaker and mixed with 110 cc. of hot water at $70° \pm 2°C$. The beaker with contents was then transferred to a boiling water-bath and the contents stirred with a glass rod, vigorously at first till the initial frothing subsided, and occasionally thereafter. After exactly half an hour's heating, the beaker was removed from the water-bath and 25 cc. of hot water ($70° \pm 2°C$.) poured down the sides of the beaker. After thorough mixing, the solution was immediately strained through a copper or brass 100-mesh wire-gauze filter cone into a 500 cc. graduated cylinder. The beaker and residue were washed with hot water at $70° \pm 2°C$. taking care that the total extract including washings does not exceed 250 cc. This was then cooled to room temperature in a stream of running water and made up to 280 cc. with distilled water. It was then drained into a tall form 400 cc. beaker and mixed with 95 cc. of bleached liquor, having available chlorine content of $3 \pm 0{\cdot}05$ per cent. The solution was occasionally stirred with a glass rod for half an hour and then covered with a watch glass and left standing overnight in a cool dark place. Next morning, the wax that had collected at the surface was cautiously stirred into the solution without disturbing the sediment at the bottom. Exactly 300 cc. of the sediment-free supernatant solution were then measured and poured into a 400 cc. beaker and treated with another 4 cc. of the bleach liquor. After stirring well and allowing to stand undisturbed for half an hour, an aliquot portion was filtered through a dry filter paper. The first 2-3 cc. was rejected being somewhat cloudy. The colour of the subsequent clear filtrate was then determined by matching against $N/1000$ iodine (in potassium iodide) solution in a Dubosque colorimeter. From the colour ratio, the bleach index was read by reference to the bleach index-colour ratio curve.

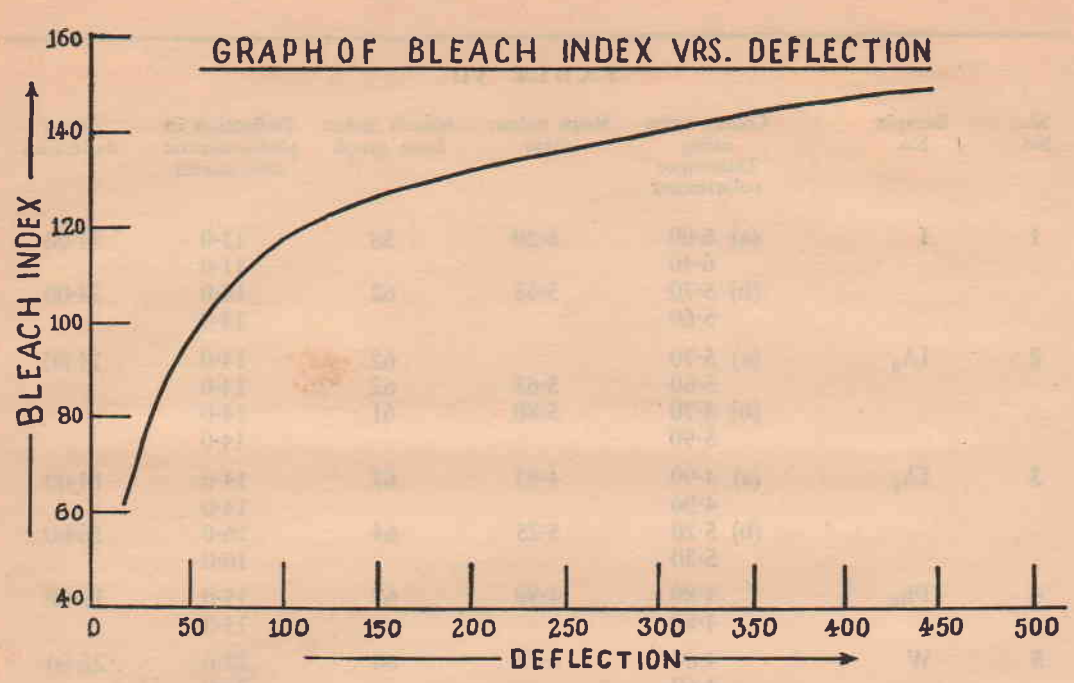
The same solution was then examined in the photo-electric colorimeter. A glass cell with an effective depth of 20 mm. and the green filter (KS-54-approximate spectral range 500-570 mμ) were found to be most convenient. With these settings the absorption caused by interposition of the bleached solution in the light path was read out from the graduations on the dial attached to the knob.

Fifty samples of seedlac were similarly examined and a curve drawn by plotting the photo-electric (absorption) readings against the bleach indices of the samples. The results of the experiments and the shape of the curve are brought out in Table VII (p. 52) and Graph III (p. 51) respectively.

From the nature of the curve, it would appear that a photo-electric colorimeter can be conveniently used for the determination of the bleach index/bleachability of lac by the Institute's new method.

A short note embracing these results has been sent for publication in the *Journal of Scientific & Industrial Research.*

(ii) *Acid value of bleached lac using aqueous alkali* — One of the items considered by the recent meeting of the International Standards Organization (ISO-TC-50) on lac was the acid value of bleached lac. It was pointed out on behalf of the American delegation that the U.S.A. was tending to use aqueous alkali for determination of this value and that quite satisfactory results were being obtained as long as care was taken to ensure that the reagent



GRAPH III

was free from carbonate. It was agreed that member countries should try this method and see how it compared with the current method of using alcoholic alkali for the purpose.

This work was undertaken in this Institute during the period under report, with results as follows:

The method — The reagents used were:

(a) *Phenolphthalein Indicator* — 0·2 gm. of phenolphthalein dissolved in 60 cc. of 90 per cent neutral ethyl alcohol and diluted with distilled water to a volume of 100 cc.

(b) *Neutral Ethyl Alcohol* — Rectified spirit (95 per cent by volume) containing a few drops of phenolphthalein, and neutralized with alcoholic KOH to a faint but persistent pink colour.

(c) *Standard alcoholic potassium hydroxide* — Approximately 0·1*N* alcoholic alkali in aldehyde-free 95 per cent alcohol.

(d) *Standard aqueous alkali* — A stock concentrated solution of potassium hydroxide was prepared and allowed to settle in a stoppered bottle for several days. The clear liquid was decanted and to it was added barium hydroxide solution until no further precipitate of barium carbonate was formed. The solution was again allowed to settle, and the clear portion decanted and diluted with water.

The strength of this alkali was determined by titration against pure potassium acid phthalate using phenolphthalein as indicator, and was adjusted to nearly 0·1*N* by dilution with water.

Procedure — Weighed about 1 gm. of the sample to an accuracy of 1 mg. and dissolved in 50 cc. of the neutral alcohol. Dissolution was hastened by warming on a water-bath for a few minutes. When dissolution was complete, the solution was cooled, 10 drops of the indicator were added, and the whole was titrated against the standard alcoholic or

TABLE VII

Sl. No.	Sample No.	Colour ratio using Dubosque colorimeter	Mean colour ratio	Bleach index from graph	Deflection in photo-electric colorimeter	Mean deflection
1	I	(a) 6·00	6·20	58	11·0	11·00
		6·40			11·0	
		(b) 5·70	5·65	62	14·0	14·00
		5·60			14·0	
2	IA_2	(a) 5·70		62	14·0	14·00
		5·60	5·65	62	14·0	
		(b) 5·70	5·80	61	14·0	
		5·90			14·0	
3	IA_1	(a) 4·90	4·93	67	14·0	14·00
		4·96			14·0	
		(b) 5·20	5·25	64	16·0	16·00
		5·30			16·0	
4	Ph_7	4·80	4·80	67	15·0	15·00
		4·80			15·0	
5	W	4·84	4·72	68	22·0	22·00
		4·60			22·0	
6	V	(a) 4·50	4·55	70	20·0	20·00
		4·60			20·0	
		(b) 4·08	4·04	74	24·0	24·00
		4·00			24·0	
7	Ph_1	(a) 3·80	3·85	75	22·0	22·50
		3·90			23·0	
		(b) 3·70	3·75	76	22·0	22·25
		3·80			22·5	
8	N	(a) 3·60	3·65	76	22·0	22·50
		3·70			23·0	
		(b) 3·70	3·75	76	22·5	22·75
		3·80			23·0	
9	Ph_5	3·52	3·52	78	25·0	25·00
					25·0	
10	O	(a) 3·80	3·70	78	25·0	25·00
		3·60			25·0	
		(b) 3·70	3·55	79	28·0	28·00
		3·40			28·0	
11	K	(a) 3·60	3·66	77	29·0	29·00
		3·72			29·0	
		(b) 3·60	3·65	77	25·0	25·00
		3·70			25·0	
12	S	2·96	3·02	83	34·0	34·00
		3·08			34·0	
		2·84	2·78	86	33·0	33·00
		2·72			33·0	

TABLE VII — (*Contd.*)

Sl. No.	Sample No.		Colour ratio using Dubosque colorimeter	Mean colour ratio	Bleach index from graph	Deflection in photo-electric colorimeter	Mean deflection
13	Ph_2		2·78	2·80	86	36·0	36·00
			2·82			36·0	
14	J	(a)	2·70	2·72	87	35·0	34·50
			2·74			34·0	
		(b)	2·76	2·78	86	31·0	30·75
			2·80			30·5	
15	G	(a)	2·40	2·35	92	44·0	44·00
			2·30			44·0	
		(b)	2·40	2·46	90	41·0	41·00
			2·52			41·0	
16	L	(a)	1·90	2·00	98	53·0	53·00
			2·10			53·0	
		(b)	2·30	2·35	92	42·5	42·50
			2·40			42·5	
17	IB_1	(a)	2·20	2·25	93	49·0	49·00
			2·30			49·0	
		(b)	2·10	2·00	98	51·0	51·50
			1·90			52·0	
18	U		2·00	1·95	99	57·0	57·00
			1·90			57·0	
19	C		2·15	2·17	95	44·0	44·00
			2·20			44·0	
20	72		1·83	1·87	100	50·0	50·50
			1·92			51·0	
			1·92			45·0	45·00
			2·12		98	45·0	
21	18	(a)	1·78	1·84	101	50·0	50·00
			1·90			50·0	
		(b)	1·70	1·75	102	55·0	55·00
			1·81			55·0	
22	D	(a)	1·61	1·66	104	56·0	56·00
			1·70			56·0	
		(b)	1·70	1·68	103	54·0	54·00
			1·66			54·0	
23	IIA_1	(a)	1·86	1·85	101	55·0	55·00
			1·84			55·0	
		(b)	1·70	1·65	104	60·0	60·50
			1·60			61·0	
24	P	(a)	2·00	1·98	98	58·0	58·00
			1·96			58·0	
		(b)	1·88	1·89	100	63·0	63·00
			1·90			63·0	

TABLE VII — (*Contd.*)

Sl. No.	Sample No.	Colour ratio using Dubosque colorimeter	Mean colour ratio	Bleach index from graph	Deflection in photo-electric colorimeter	Mean deflection
25	M	(a) 1·54	1·64	104	60·0	59·00
		1·74			59·0	
		(b) 1·46	1·54	105	70·0	70·00
		1·62			70·0	
26	80	1·52	1·57	105	58·0	58·00
		1·62			58·0	
27	17	1·54	1·57	105	59·0	58·50
		1·60			58·0	
28	A	1·52	1·56	106	60·0	60·00
		1·60			60·0	
29	79	(a) 1·58	1·61	105	65·0	65·00
		1·64			65·0	
		(b) 1·62	1·63	104	63·0	63·00
		1·64			63·0	
30	Ph_{11}	(a) 1·30	1·40	109	75·0	75·00
		1·50			75·0	
		(b) 1·30	1·30	111	70·0	70·00
		1·30			70·0	
31	8	(a) 1·00	1·05	117	84·0	84·00
		1·10			84·0	
		(b) 1·04	1·05	117	87·0	87·00
		1·06			87·0	
32	E	(a) 0·94	0·98	119	101·5	101·25
		1·02			101·0	
		(b) 0·94	0·99	119	88·0	88·00
		1·03			88·0	
33	Ph_{12}	(a) 1·16	1·23	113	83·0	83·00
		1·30			83·0	
		(b) 1·45	1·35	110	80·0	80·00
		1·25			80·0	
34	Ph_{13}	(a) 1·25	1·15	115	80·0	80·00
		1·05			80·0	
		(b) 1·20	1·30	111	84·0	84·00
		1·40			84·0	
35	Ph_3	1·22				
		1·20	1·20	114	94·0	93·50
		1·18			93·0	
36	I	(a) 0·90	0·93	120	117·0	116·50
		0·96			116·0	
		(b) 1·00	1·05	118	103·0	103·00
		1·10			103·0	

TABLE VII — (*Contd.*)

Sl. No.	Sample No.	Colour ratio using Dubosque colorimeter	Mean colour ratio	Bleach index from graph	Deflection in photo-electric colorimeter	Mean deflection
37	4	(a) 0·84	0·83	123	117·0	117·00
		0·82			117·0	
		(b) 0·92	0·94	120	99·0	99·00
		0·96			99·0	
38	X	(a) 0·85	0·87	121	106·0	106·00
		0·90			106·0	
		(b) 0·82	0·86	121	102·0	102·00
		0·90			102·0	
39	73	(a) 0·86	0·84	122	134·0	134·00
		0·82			134·0	
		(b) 1·00	1·03	119	104·0	104·00
		1·06			104·0	
40	2	(a) 0·92	0·91	121	109·0	109·00
		0·90			109·0	
		(b) 0·86	0·88	122	108·0	108·00
		0·90			108·0	
41	Q	(a) 0·66	0·69	128	157·0	157·00
		0·72			157·0	
		(b) 0·76	0·77	125	139·0	139·00
		0·78			139·0	
42	66	(a) 0·64	0·64	128	165·0	165·00
		0·64			165·0	
		(b) 0·70	0·68	128	156·0	156·00
		0·65			156·0	
43	Ph_9	(a) 0·60	0·61	131	190·0	190·00
		0·62			190·0	
		(b) 0·58	0·60	131	192·0	192·00
		0·62			192·0	
44	F	(a) 0·52	0·53	134	230·0	230·00
		0·54			230·0	
		(b) 0·54	0·56	133	200·0	200·00
		0·58			200·0	
		(c) 0·57		133	194·0	194·00
		0·60	0·56		194·0	
		0·52				
45	IIB_1	(a) 0·48	0·48	137	245·0	245·00
		0·48			245·0	
		(b) 0·57	0·57	133	198·0	197·00
		0·58			196·0	
46	Ph_8	(a) 0·48	0·49	136	241·0	240·50
		0·50			240·0	
		(b) 0·45	0·46	138	248·0	248·00
		0·47			248·0	

TABLE VII — (*Contd.*)

Sl. No.	Sample No.	Colour ratio using Dubosque colorimeter	Mean colour ratio	Bleach index from graph	Deflection in photo-electric colorimeter	Mean deflection
47	H	(a) 0·36	0·365	144	330·0	330·00
		0·37			330·0	
		(b) 0·38	0·385	142	272·0	272.50
		0·39			273·0	
48	B	0·43	0·44	138	283·0	283·50
		0·45			284·0	
49	Ph_{10}	(a) 0·32	0·335	145	360·0	360·00
		0·35			360·0	
		(b) 0·33	0·33	146	355·0	355·00
		0·33			355·0	
50	Y	(a) 0·30	0·305	148	395·0	395·00
		0·31			395·0	
		(b) 0·30	0·305	148	425·0	425·00
		0·31			425·0	
		(c) 0·28				
		0·29	0·29	150	445·0	445·00
		0·30			445·0	

aqueous potassium hydroxide. The end point was considered to have been reached when a faint colour remained even after continuous swirling for 30 seconds.

The values obtained are given in Table VIII (p. 57). It will be noted that practically the same values are obtained by the use of either of the reagents.

(iii) *A rapid method for the determination of iodine value of lac* — Apart from its utility in the study of constitution, the degree of unsaturation expressed in terms of the iodine value of lac is particularly interesting to the shellac analyst, because this forms the basis of one of the (two) methods of estimation of rosin, a common adulterant of lac. The current method for this, namely, Wij's method, estimates volumetrically the amount of iodine consumed by a known weight of the substance when treated with a solution of iodine monochloride in acetic acid solution. The conditions of the experiments, however, are rather exacting, in particular, iodine monochloride appears to be far too reactive a substance to be used with such a delicate material as lac. Hence a number of other methods known for the determination of iodine value of organic compounds were tried on lac, and are described below:

The method, first tried, was that developed recently by Mukerji for the iodine value of oils and fats using hypochlorus acid as the reagent (Mukerji, *J. Am. Oil Chem. Soc.* 1955, **32**, 351). The chief attractive features of this method are: (i) the estimation involves the use of an aqueous solution of the reagent (in all the methods currently employed, the reagents used must be perfectly anhydrous), (ii) the method is a quick one, a reaction time of only 4 to 5 minutes being necessary, and (iii) the reagent used is much milder than iodine monochloride. According to the author, the results obtained compare favourably with those by other standard procedures. Details of the method as applied to lac were as follows:

Glacial acetic acid was first employed as the solvent for lac. The sample was weighed out into a glass-stoppered conical flask and the requisite volume of glacial acid added. The

TABLE VIII — ACID VALUES OF BLEACHED LAC

Sl. No.	Sample No.	Acid value using alcoholic potash (normality 0·1058)		Acid value using aqueous potash (normality 0·1041)	
1	BL_8	(a) 62·00 (b) 61·46	Mean 61·73	(a) 62·12 (b) 62·37	Mean 62·25
2	BL_9	(a) 62·29 (b) 62·32	62·31	(a) 62·18 (b) —	62·18 —
3	22	(a) 68·42 (b) 68·58	68·50 —	(a) 68·37 (b) 68·89	68·63 —
4	18	(a) 68·98 (b) 69·15	69·07 —	(a) 69·40 (b) 69·04	69·22 —
5	24	(a) 69·83 (b) 69·37	69·60 —	(a) 69·74 (b) 68·92	69·33 —
6	BL_6	(a) 69·65 (b) 69·92	69·79 —	(a) 70·21 (b) 69·81	70·01 —
7	BL_4	(a) 70·03 (b) 70·26	70·15 —	(a) 70·82 (b) 70·70	70·76 —
8	17	(a) 70·73 (b) 70·73	70·73 —	(a) 71·91 (b) 71·71	71·81 —
9	BL_5	(a) 71·03 (b) 70·92	70·98 —	(a) 71·91 (b) 71·32	71·72 —
10	BL_3	(a) 72·44 (b) 72·41	73·43 —	(a) 72·73 (b) 73·26	73·00 —
11	XXX	(a) 72·47 (b) 72·57	72·52 —	(a) 72·46 (b) 71·91	72·10 —
12	XXIX	(a) 75·50 (b) 76·07	75·79 —	(a) 75·43 (b) 76·43	75·93 —

flask was thoroughly shaken so as to dissolve the sample in the acid. Aqueous solution of sodium hypochlorite of requisite strength was then added, and the mixture shaken well and allowed to stand in the dark for 5 minutes at room temperature. Twenty cc. of 15 per cent potassium iodide solution were then added. The flask was shaken well, and after 1 minute, the liberated iodine was titrated with standard sodium thiosulphate solution.

It was noticed that the shellac precipitated out when the hypochlorite solution was added, and so with a view to finding out at what stage coagulation could be avoided, the experiment was repeated using 10, 25, 50, 75 and 100 cc. of glacial acetic acid. Using 25 cc. of 0·1*N* sodium hypochlorite it was found that precipitation could be avoided only when 100 cc. of acetic acid were used. (The iodine value was found to increase with the amount of acetic acid used.)

As 100 cc. of acetic acid would be far too expensive, the possibility of using ethyl alcohol in place of acetic acid was investigated. Experiments were repeated using different amounts of alcohol. When 75 cc. of (over 95 per cent) alcohol were used together with 20 cc. of 0·1*N* sodium hypochlorite solution, no precipitation was noticed. Under these conditions, a sample of shellac gave an iodine value of 9·3 and a sample of rosin, 133. It was found

that for every 1 per cent rosin present, there was a rise of about 1·2 in the iodine value of the shellac, the theoretical rise being $1{\cdot}24 = \frac{(133 - 9{\cdot}3)}{100}$. It was also found that with a more concentrated solution of hypochlorite ($0{\cdot}25N$) and correspondingly smaller volume of the solution, the volume of alcohol could be reduced to 50 cc.

A number of further experiments were carried out in which various factors, viz. the strength and amount of sodium hypochlorite solution, time of reaction, strength and amount of alcohol, temperature of reaction, etc., were altered one after the other. Iodine value was observed to change with every individual factor, and for obtaining reproducible results, all the factors had to be strictly controlled. The value increased with an increase in the strength or amount of sodium hypochlorite solution and also by allowing more time for the reaction. It also increased when temperature was raised, as well as with an increase in the strength of alcohol.

In all the above experiments, the same sample of shellac had been used. To ascertain the range of variation of iodine value from sample to sample even under the same set of conditions, a number of shellac samples were examined for their iodine values. The values were found to vary from 7·8 to 15·4. This range, unfortunately, is too wide and hence renders the method unsuitable for iodine value estimations. This may be due to the fact that sodium hypochlorite which is known to have a bleaching action on lac acted under the conditions of the experiment more as a bleach than as an additive compound for the unsaturation. It is significant that in these experiments, the iodine values obtained were more or less dependent upon the colour index of the sample and increased with increasing colour index.

II. APPLIED

1. Varnishes, Lacquers and Paints

(i) *Ageing properties of shellac-linseed oil paints* — It is now nearly eight years since the wood and steel work of the Institute and staff quarters were painted with shellac-linseed oil paints. The painted surfaces indoors do not show any visible sign of deterioration so far.

(ii) *Oil cloth* — An officer of this Institute visited the factory of Bhor Industries, near Poona, with the necessary shellac composition to prepare large-scale samples of oil cloth of the usual commercial widths, viz. 52-54 inches. The authorities of the factory were kind enough to allow use of their machinery. About 50 yards of oil cloth (52-54 inches) were made and embossed under the usual conditions. It was roughly estimated that per running yard the shellac-based oil cloth would cost about 3-4 annas more than the material they are manufacturing at present. Their technician and Director, however, admitted the superiority of the shellac compositions in some respects and expressed their desire to manufacture about a thousand yards of the material and put it on sale to study the market reaction. The latest report from the party indicates that an adverse price differential of 3-4 annas per yard would not be acceptable to the market.

(iii) *Shellac-based anti-corrosive and anti-fouling paints* — Samples of anti-corrosive and anti-fouling paints submitted some time back to the Indian Naval and Chemical and Metallurgical Laboratories (I.N.C.M.L.) at Bombay have now undergone sea-water immersion tests. It has been reported that whereas the anti-fouling compositions showed poor performance, the only anti-corrosive paint supplied showed promise inasmuch as with an approved anti-fouling coat on top, the shellac paint withstood sea-water satisfactorily for about 5 months as against a minimum requirement of six months. An officer of this Institute was deputed to see, and have discussions with, the officers of I.N.C.M.L., as a result of which a programme of work has been drawn up to be taken up early.

(iv) *Shellac-rosin-glycerine varnish* — The test report on a clear baking oil insulating varnish, prepared from linseed oil and shellac-rosin-glycerine modified resin, was reproduced in the Institute's *Annual Report* 1954-55 (pp. 62-63). In view of its satisfactory performance, a semi-large scale production *cum* demonstration of the varnish was carried out in the factories of two of the leading paint and varnish manufacturers of Calcutta. In both the cases, the batches consisted of one maund* of rosin, half a maund of shellac and the corresponding quantity (4 seers)† of glycerine in stainless steel kettles without however any provision for continuous mechanical stirring. The preparation was found to proceed smoothly and did not present any difficulty. A sample of the varnish produced in one of the factories was sent for testing to the Government Test House, Alipore, Calcutta. The report since received indicates that the samples proved satisfactory in all respects except oil resistance. Another sample sent to the Indian Telephone Industries also met with the same complaint. Our laboratory sample, however, had passed this test. This is being looked into.

(v) *Lac*-kamala *oil combinations* — The possibility of plasticizing lac with *kamala* oil was investigated.

Kamala oil is a quick drying vegetable oil of outstanding properties and is being recommended as a substitute for *tung* oil. Unfortunately, lac is not compatible with *kamala* oil nor does this oil lend itself to manipulations like linseed oil. So the prospect of preparing lac-*kamala* oil combinations under the usual conditions is negligible.

Lac, however, has been found to be compatible with the mixed fatty acids of the oil. The mixed fatty acids obtained from a sample of the oil received through the kind courtesy of the Forest Research Institute, Dehra Dun, had the appearance of a waxy solid with an acid value of 177·1, saponification value of 194·8, iodine value of 133·85 and hydroxyl number 99·1. The parent oil itself had an acid value of 7·2, saponification value of 225·0, iodine value of 145·4 and hydroxyl number 24·996. The fatty acids were readily soluble in alcohol, aromatic hydrocarbons, esters, ketones and like solvents.

Heat tests were carried out to determine the gelation time of both the oil and the fatty acids and it was found that the oil gelled in 9 minutes and the fatty acids in about 19 minutes.

A shellac varnish with varying proportions of *kamala* fatty acids in alcohol or alcohol-toluene mixture, gave films which were dull and translucent, presumably owing to the waxy nature of the mixed fatty acids. When, however, the mixed fatty acids were heated at about 150°C. or better still at 200°C., a clear reddish-brown resinous material was obtained which did not set to a waxy solid. There was a drop in acid value during this treatment, which corresponded almost exactly to a simultaneous fall in hydroxyl number also. This material had an acid value of 94-96 and hydroxyl number 11-13. Determination of molecular weights by Rast's method indicated that an inter-molecular reaction was taking place. The final product was soluble in practically all the solvents in which the parent material was soluble and showed a tendency to air-dry. Films of shellac containing different proportions of this material in alcohol or alcohol-toluene mixture, however, were not clear and bright, although air-drying. The material is obviously unsuitable for use as a plasticizer for lac.

The possibility of chemically combining this material with shellac was then investigated. As a preliminary, the life under heat of shellac containing varying proportions of this material was determined at two different temperatures, viz. 150°C. and 200°C. The results obtained are tabulated in Tables IX and X (p. 60).

As *kamala* oil fatty acids and shellac, when heated together, polymerize rather too rapidly to allow of sufficient amount of the former to combine with the latter the possibility of combining them through the monoglycerides was investigated.

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*1 maund = 82 lb. nearly; †1 seer = 2 lb. nearly.

TABLE IX — LIFE UNDER HEAT OF SHELLAC AND *KAMALA* OIL FATTY ACIDS: TEMP. 150°±1°C.

Sl. No.	Shellac	*Kamala* oil fatty acid	Time for gelation	Condition of the polymerized mass
1	10	—	50 mins.	Soft and brittle
2	8	2	87 ,,	Very tough and elastic
3	6·6	3·3	121 ,,	Soft and elastic
4	6·0	4·5	173 ,,	,,
5	5·0	5·0	194 ,,	Very soft and elastic
6	—	10	More than 6 hrs.	Not polymerized and also not solidified on cooling.

TABLE X — LIFE UNDER HEAT OF SHELLAC AND *KAMALA* OIL FATTY ACIDS: TEMP. 200°±1°C.

Sl. No.	Shellac	*Kamala* oil fatty acid	Time for gelation	Condition of the polymerized mass
1	10	—	12 mins.	Very hard
2	8	2	16 ,,	Hard and tough
3	6·6	3·3	24 ,,	Tough but slightly flexible
4	6	4·5	30 ,,	Elastic, rubber-like
5	5	5	30 ,,	Elastic, soft powdery mass
6	—	10	210 ,,	Jelly-like elastic mass

The preparation of monoglycerides, starting from *kamala* oil was not successful as the material gelled far too rapidly. So, monoglycerides of *kamala* oil were prepared, starting from the fatty acids of the oil by heating with glycerine and 0·5 per cent catalyst (on the weight of the acid). Here sodium hydroxide was used as the catalyst. In about 4 hrs. at a temperature of 190 ± 5°C., the product obtained had an acid value of about 4 and was soluble in alcohol. When heated with dewaxed shellac in different proportions, it gave clear resinous material but the films from alcoholic solutions were soft and hazy with no improvement even on baking for a few minutes. The work is to be continued.

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

(i) ***Making of shellac from lac by alkali extraction method*** — As reported earlier (*Annual report, I.L.R.I.*, 1954-55, p. 71) shellac made from ammonia-lac solution had a very poor life and flow due to prolonged heat treatment involved. So extraction of lac by dissolving seedlac in some other alkali and precipitating with acid was tried.

To start with, *Kusmi* seedlac was dissolved in water containing sodium carbonate 10 per cent on the weight of seedlac, and precipitated with dil. HCl (1: 4); it was then washed free from acid and dried in shade. The product had practically no life and flow. Efforts to revive the life and flow by dissolving in spirit proved abortive. However, to find out the extent of deterioration, lac was extracted from the same grade of seedlac by spirit and made into sheets. The product had a life of 40 mins. and a flow of 70 secs. (for 5 in.). Obviously, the method of alkali extraction needs to be modified.

Towards this end, the method of dissolution in alkali followed by precipitation with dilute sulphuric acid as adopted in the preparation of bleached lac (*Practical Applications of Recent Lac Research*, 2nd Ed., pp. 16-17) was tried. A sample of lac prepared accordingly had a life of 58 mins. and a flow of 130 secs.; the yield was 88·9 per cent. In this case, though the life was good, the flow was not. To improve the flow, the precipitated lac, after washing, was ground in ball mill, and again washed very thoroughly with tap water till free

from sulphate. The product thus obtained registered a flow of 80 secs. Different methods of drawing sheets by melting this lac were next tried. Best results were obtained by melting the dry precipitated lac with a little water (10 per cent on its weight) in an open pan heated on oil bath at 130°-135°C. (the temp. of the melt was 90°-95°C.), for about an hour till the melt was moisture-free. The sheets made from this melt by passing through cold rollers had good life and flow but did not have a satisfactory colour. The colour varied from light green to deep amber, depending upon the concentration of alkali solution used for dissolving lac and the extent of washing the precipitated lac. This might be due to one or several of the following causes: (1) Contamination with traces of iron present in tap water, (2) action of alkali on nitrogenous matter, (3) action of alkali on colouring matter present in seedlac and (4) the effect of the heat treatment during sheet making. As however, the colour did not improve either by the addition of a little oxalic acid (0·1 per cent) or by carrying out the whole process with distilled water in glass or porcelain vessels, the unsatisfactory colour was presumably *not* due to contamination with iron. That the dark colour was not due to nitrogenous matter was proved by the observation that shellac which is free from nitrogenous matter or water-soluble dye, when dissolved in alkali and precipitated with acid, showed the same unsatisfactory amber colour. This also proves that the water-soluble colouring matter is not responsible. Further, shellac made from the same seedlac by the country method, when melted with little water in a pan on oil bath at 130°C. till moisture-free, and drawn into sheets did not show any appreciable change in colour. This proves that the heating operation [cause (4)] is not responsible for the undesirable colour. Evidently the only possibility left is the action of alkali on erythrolaccain, the water-insoluble dye, present in seedlac. The action seems to be irreversible as the colour is not regained by precipitation with acid.

Attempts were,, therefore, made to see if this could be checked or made reversible to gain the original colour.

Dilute alcoholic solutions of both the precipitated lac and shellac (both made from the same seedlac) (5 gms. in 100 cc.) were prepared; it was found that the solution of acid-precipitated lac, though lighter in shade, had still the characteristic amber colour. An alcoholic seedlac solution of the same strength was heated with KOH (equivalent to Na_2CO_3, 10 per cent on the weight of lac) at 80°C. for $\frac{1}{2}$ hr., cooled, and equivalent amount of dil. H_2SO_4 was added. (Thus the actual process of making precipated lac was simulated in alcoholic medium.) On adding the acid, the pink colour of the alkali solution vanished and the characteristic colour of shellac in alcoholic solution reappeared. The change in colour due to alkali treatment at 70°-80°C. followed by acid precipitation as found in aqueous medium, does not, therefore, occur in alcoholic solution. It appears, therefore, that the colour is due to irreversible change of erythrolaccin in aqueous medium.

Different alkalies and acids were next tried for extracting lac from seedlac by the usual method, and the precipitated lac in some cases, was left overnight in dilute acid or water, to see if thereby the colour of the final shellac melt would be regained. The observations are recorded in Table XI (p. 62).

Since the action of excess acid or immersing the precipitated lac overnight in dilute acid solution failed to improve the colour, the quantities of acid added were varied to see if this would achieve the purpose. Dilute solutions of sulphuric, oxalic and acetic acids were made and titrated against the Na_2CO_3 used for dissolving seedlac. In three separate lots same amount of seedlacs (50 gms.) was dissolved in a measured volume of the alkali solution and the requisite amounts of acid were added.

Acid	*Yield of pptd. lac*	*Colour of the shellac sheets*
No. 1 dil. H_2SO_4	44 gms.	Amber
No. 2 dil. oxalic	45 ,,	,,
No. 3 dil. acetic	45 ,,	,,

Evidently this also did not improve the colour.

TABLE XI — PROPERTIES OF LAC PREPARED BY ALKALI EXTRACTION METHOD

Alkali used	Acid used	Any other treatment of the pptd. lac	Life of shellac melt	Flow	Colour of the shellac made
1. Na_2CO_3	Dil. H_2SO_4	Left overnight in acid soln.	30 mins.	90 secs.	Amber
2. KOH*	,,	,,	30 ,,	125 ,,	,,
3. ,,	,,	Left in water after washing	40 ,,	70 ,,	,,
4. Sodi bicarb	,,	,,	—	—	,,
5. Sodi bicarb	Dil. acetic acid	,,	—	—	Amber but lighter than above
6. Sodi bicarb + CO_2 passed in soln.	Dil. H_2SO_4	,,	45 mins.	105 secs.	Amber
7. Ammonia	Dil. H_2SO_4	,,	45 ,,	—	,,
8. Triethanolamine	Dil. H_2SO_4	,,	45 ,,	—	,,

*Pptd. lac left overnight in dilute acid solution developed reddish-brown colour which on melting gave the same amber colour.

It will be noticed from the above that all manipulations regarding the use of different alkalies and acids, resorted to so far, failed to improve the colour of the final shellac melt. Attempts to dissolve seedlac powder in Na_2CO_3 solution of different concentrations at room temperature (and thereby to eliminate the action of hot alkali which might be responsible for the change in colour) also failed, as this only softened the outer surface of the seedlac grains, most of which, therefore, remained undissolved. However, the undissolved grains were separated by filtration and dissolved in hot Na_2CO_3 solution as before. Both the cold and hot alkali-dissolved, fractions were separately precipitated with dilute H_2SO_4, washed, and sheets were drawn. The portion which dissolved in cold alkali gave dark amber-coloured sheets and the other fraction had a green colour, i.e. they had the same type of colour but of different depth.

Different concentrations of Na_2CO_3 solution were next tried for dissolving the seedlac at 70°C. and the colour of the final shellac melt was examined: the data are given in Table XII.

TABLE XII

	I	II	III
Shellac	10 gms.	10 gms.	10 gms.
Na_2CO_3	1 gm.	1 gm.	1 gm.
Water	100 cc.	200 cc.	300 cc.
Weight of residue after filtration	0·42	0·40	0·69
Colour of the acid pptd. lac	Light brown	Very light brown	Cream coloured

The precipitated lac, though found to be of a different colour, developed the same amber colour on melting and being drawn into sheets. Cold extraction with alkali or use of dilute solution of Na_2CO_3 did not, therefore, improve the colour. Work is being continued.

(ii) *Making seedlac and shellac of low bleach number* — As reported earlier (*I.L.R.I. Annual Report*, 1954-55, pp. 73-75), seedlacs having bleach numbers lower than usual can be made by washing lac with caustic soda. It was also reported that A.V., life under heat and flow of the resulting seedlac are quite up to the mark. In continuing the work, the wax contents of the samples obtained by washing respectively without, and with, 3·5 gms. and 7 gms. of caustic soda for each pound of lac were determined and found to be 3·88, 2·98 and 2·94 per cent respectively. To determine whether the seedlac washed with caustic soda would retain the low bleach index over a reasonably long period, three samples were examined after nine months (April to December 1955) and found to have their bleach indices unaltered. Results are given in Table XIII.

TABLE XIII

Seedlac washed with NaOH (in gm./lb. of lac)	Bleach indices	
	April 1955	December 1955
0	95	98
3·5	78	77
7	68	67

In the previous experiments with old lac NaOH used was 3·5 gms. per pound of lac which corresponds to 5 chataks per maund. In the case of fresh lac this amount was considered too much as the colouring matter in fresh lac is soft and comparatively easy to remove.

The fresh *Rangeeni* lac was washed with varying quantities of caustic soda to find the minimum amounts of the reagent required to produce best quality seedlac with minimum loss. Washing was done in vats as in the country process. Results are given in Table XIV.

TABLE XIV

NaOH used per md. of lac	Yield %	Bleach index
0	77·0	100
2·0 ch.	71·0	78
2·5 ch.	70·0	77
5 ch.	57·5	63

So 2·5 chs. of NaOH per maund of lac was considered sufficient to reduce the bleach index effectively, consistently with minimum loss in yield.

As compared with the yield when no NaOH is used, the yield of seedlac when NaOH is used in washing, is somewhat less. Investigations were continued with other reagents, particularly oxidizing agents, to see if the yield could be increased. Results are given in Table XV (p. 64).

TABLE XV

Oxidizing agents used	Yield %	Bleach index	Remarks
Nil (control)	55	111	—
Sodium hypochlorite	55	105	Grains are not clean
Nitric acid	55	105	,,
Acidic potassium dichromate	55	105	Grains become yellow
Acidic potassium permanganate	55	100	Grains become blackish
Hydrogen peroxide	55	103	Grains are not clean

Subsequent experiments were done with *ber* lac (100 gms.) using acidic potassium permanganate in varying amounts. Results are given below:

TABLE XV(a)

Amount of $KMnO_4$ (cc. of *N* solution)	Bleach index	Remarks
0	98	—
5	89	The grains become blackish
10	85	
10 (acidic)	81	

The above experiment was repeated with *palas* lac and 10 cc. of $KMnO_4$ solution: the bleach index was not reduced and the grains became blackish.

To remove the blackish tint, the seedlac washed with $KMnO_4$ was re-washed with $NaHSO_3$ solution and NaOH. The results with *palas* lac were as follows:

TABLE XVI

Mode of washing	Bleach index	Remarks
1. With water only	140	—
2. With acidic $KMnO_4$	140	Grains become blackish
3. With $NaHSO_3$ after washing with acidic $KMnO_4$	130	Slightly improved in colour
4. With NaOH before washing with acidic $KMnO_4$. Followed by $NaHSO_3$	106	Much improved

On repeating experiment (4) with *ber* lac, bleach index was lowered from 96 to 84.

These experiments were then carried on with bigger lots of seedlac, washing being done either in vats or in washing barrels. But results obtained were different from those from small-scale experiments, most probably due to the presence of iron in water and precipitated manganese dioxide. (In small-scale experiments distilled water was used.) So experiments using potassium permanganate were discontinued.

The Institute's *Annual Report* (1936-37) mentions that lac particles become lighter in colour on treatment with $NaBO_3$ (Sodium perborate), which was, therefore, tried in next experiments: In a preliminary experiment with *palas* lac bleach index was lowered from 120 to 99. The minimum quantity of this reagent for efficient washing was determined from the following experiments: (1 kg. *palas, phunki* lac was used).

TABLE XVII

Quantity of sodium perborate in gm.	Yield %	Bleach index	Remarks
0	67·9	118	—
2	67·0	104	—
4	66·5	97	—
6	65·0	87	—
10	64·5	87	—

From the above the minimum quantity of $NaBO_3$ required to reduce the bleach index sufficiently appears to be 6 gm./kg. Accordingly experiments with bigger lots of lac (10 srs. each) with 6 gms. and 8 gms. of perborate per kg. of lac were done. Results are given below in Table XVIII.

TABLE XVIII

Perborate gm./kg.	Yield	Bleach index	Colour index	Hot alc. ins. %
0	7 srs. 10 chs.	119	8·5	3·884
6	7 srs. 6 chs.	96	6·0	3·196
8	7 srs. 6 chs.	92	6·0	2·724

The above data show that sodium perborate can reduce the bleach index of seedlac effectively, but that judging from its price, the quantity required is rather too much. Subsequent experiments were done to see if the quantity of perborate could be reduced by using it in conjunction with other chemicals so that the overall cost would come down. It was found that by using 5 gms. of perborate along with 1 gm. of NaOH for each kg. of lac the bleach index of the product came down from 119 to 93 with a simultaneous reduction in the yield by some 3 per cent. Obviously, the result is not encouraging.

Subsequent experiments were done with the idea of replacing perborate by a mixture of borax and sodium carbonate or sodium hydroxide. Ten seers of lac were washed in each experiment. Results follow in Table XIX (p. 66).

The use of a mixture of borax and sodium hydroxide as the washing reagent may, therefore, be considered satisfactory, and its possibility in large-scale washing is being explored.

Along with the experiments on the determination of a suitable washing reagent, attention was paid to the designing of a suitable washing barrel. The barrel used so far, and consisting of 2 drums, one inside another, was modified to simulate washing by feet. Though the performance of the modified barrel was good, its capacity to wash lac was reduced, as much of its inner volume was rendered ineffective due to the position of inner

TABLE XIX

Quantity of lac	Reagent	Yield Sr.	Yield ch.	Bleach index	Colour	Hot alc. ins. %
PALAMAU						
Palas, phunki (1955)	Water (control)	7	10	119	8·5	3·884
,,	Borax 50 gms. + Na_2CO_3 10 gms.	7	4	90	7	2·592
,,	Borax 50 gms. + NaOH 10 gms.	7	6	86	6	2·228
MANBHUM						
Palas, phunki	Water	7	10	102	6·5	3·102
,,	Borax 50 + Na_2CO_3 10	7	0	86	5	2·264
,,	Borax 50 + NaOH 10	7	0	80	5	2·260
SINGHBHUM						
Palas, phunki	Water (control)	7	8	106	10	3·980
,,	Borax 50 + Na_2CO_3 10	7	0	86	8	3·352
,,	Borax 50 + NaOH 10	7	0	82	7·5	2·840

drum being eccentric. A further modification was made in which the eccentric drum was replaced by a number of long blades fixed horizontally on an eccentric axle. The capacity was thus increased to 4 times, but the washing efficiency was impaired. Further work is being done to modify the washing barrel and improve the method otherwise.

(iii) *Separation of sand from seedlac* — To separate sand from seedlac which is left with it after washing, the washed lac is winnowed after drying. In all factories this job is done by women labour and accounts for a good part of the production cost. So experiments were initiated to find out a mechanical process. Previously some work was done by Thakur (*I.L.R.I. Bulletin* No. 27), and Bhowmik and others (*I.L.R.I. Tech. Note* No. 4) towards this end, in which seedlac was treated with brine either in a centrifuge or a stationary drum. Though the results were satisfactory, the method was not favoured by the industry, because brine was not readily available and also subsequent washing to free from brine meant added cost. In the present experiments, advantage has been taken of the substantial difference in specific gravity of lac and sand particles in working out a method of separation: this is based on the fact that because of the difference in sp. gr., different centrifugal forces come into operation during rotation. Thus when seedlac with sand is stirred up by a mechanical stirrer in a beaker containing water, sand particles settle down at the central portion of the bottom of the beaker while the grains of lac continue in motion and tend to rise up. In an actual experiment a conical vessel tapering towards the bottom was used: particles of sand collected at the bottom cone and seedlac particles floated in water while in motion. A device could be made to take out the seedlac particles while in motion and leave behind the sand particles inside the vessel. To run the operation continuously, an arrangement

for continuous feeding of seedlac and water, and continuous discharge of clean seedlac and settled sand particles had to be made.

The system was found to work satisfactorily under the following conditions: (1) The stirrer is rotated at such a speed that by the revolution of the water, the seedlac is kept floating and water just overflows the edge carrying down seedlac with it; (2) the cone of the vessel is about 32°, and (3) the ratio of seedlac to water at the feed is 1: 6. In a vessel with 10 in. diameter and 18 in. depth, one maund of seedlac could be treated. The rate of feed may be increased by increasing the volume but keeping the angle of cone constant. Results of some experiments with this device are given in Table XX. (The efficiency of the arrangement was assessed by determining the ash content of the samples before and after treatment.)

TABLE XX

Sample No.	Ash content before treatment %	Ash content after treatment %
1	1·516	0·818
2	1·523	0·836
3	1·523	0·876
4	1·523	0·843

The samples thus treated, though free from sand particles contain some woody matter. The ash content of pure seedlac, prepared by hand-picking of particles of lac from a lot of seedlac was found to be 0·84 per cent.

As the seedlac washed in barrel contains more sand than that washed in stone-vats, two experiments were done with seedlacs containing admixtures of sand to the extent of 5 and 20 per cent respectively. After treatment in the apparatus described above, the sand content of the samples was found to have been reduced to 0·85 and 0·80 per cent respectively. A few quantitative experiments were also done to separate sand particles from *molamma* (fine grains of lac): Partial separation could be effected.

Following success in the small-scale experiment, a bigger plant to process 15 mds. of seedlac per hour has been fabricated in the Institute workshop and given several trials already. Promising results have been obtained and arrangements are in progress to carry on experiments with this plant in some commercial factory.

(iv) *Studies on bleached lac*

(a) *Preparation and distribution of samples* — Mention was made in the last *Annual Report* about the preparation of a number of samples of bleached lac under a variety of conditions. It was stated that most of them retained their solubility and also remained good otherwise till the time of that report. All these samples are now nearly 20 months old and most of them are still in good condition and retain their solubility. A few, however, have become rather slow filtering, which is perhaps a prelude to their becoming insoluble.

Meanwhile at the request of a local shellac manufacturer, nearly 1½ mds. of bleached lac were prepared for him under our controlled conditions out of seedlac supplied by him. It is understood that he has sold the entire quantity portion-wise to different consumers and that no complaint has been received from any of them regarding quality. A 3-lb. sample of bleached lac was sent to a pharmacological laboratory in Bombay for experimental use to fix kymograph records for pharmacological studies. The laboratory has now reported that the sample worked " excellently ". Another 5-lb. sample was supplied to a firm of prospective manufacturers in Calcutta at their request, to explore the possibilities of this material

both inland and abroad. They have since reported that they had sent portions of this sample to their overseas connections and also used some of the material themselves, and that as a result they are convinced about the possibilities of this kind of lac as a small-scale industry. They also requested for technical advice for the erection of a plant to produce 200-250 mds. per month. It was pointed out to them that the Institute itself might erect soon a pilot plant at a cost of Rs. 75,000 and hence the party had better wait till the successful working of this plant. They have agreed to this and have promised their support to the successful marketing of the output from this plant.

(b) *Stability during export* — Advantage was taken of the visit of Dr. Jordan to this Institute to know more about the qualities of this product. In order to ascertain the stability of this bleached lac on exposure to marine atmosphere, such as it would encounter during export, a 7-lb. sample prepared in December (1955) last was sent along with him in course of his return journey by sea in January. Reaching England during the second week of February and keeping it there for another two weeks, Dr. Jordan was kind enough to return a portion of the sample by parcel post (also by sea). This sample which was received back here on the 14th April 1956, did not show on examination any change as regards either colour or solubility, indicating that the product can be safely transported by sea without risk of deterioration.

Dr. Jordan had also been requested to distribute the sample to some of the leading manufacturers and consumers of bleached lac in his country for their views on the quantity of the product. His report is still awaited.

(c) *Preparation of refined (i.e. wax-free) bleached lac* — It will be noted that all the experiments so far were carried out only on what is known as the " regular " variety of bleached lac, i.e. bleached lac which retains its full complement of wax. The other variety known as " refined, i.e. wax-free bleached lac is, however, of equal importance and hence experiments were directed towards preparation of this adopting our improved method. After a series of experiments, it was ascertained that the " dewaxing " part of the operation could be conducted as follows:

To 350-400 parts of water are added 10 parts of anhydrous sodium carbonate and the solution heated to 60°-70°C. 100 parts of seedlac are then added little by little, taking care that the solution does not froth over due to rapid addition. After addition of all the lac, the solution is kept stirred at about 90°C. for another 15 mins. to complete the dissolution and then strained through muslin. The residue is worked with hot water at about 70°C. The collected filtrate is then heated to boiling and allowed to stand undisturbed. The wax, molten due to the temperature of the solution, rises to the surface and sets, on cooling, to a hard crust. After the solution has cooled to practically room temperature, this crust of wax is removed and some filter paper (which serves very well as filter aid) stirred into the solution, which is then filtered through bags made of drill cloth. The first runnings from the bag are generally " cloudy " and may be returned for re-filtration. When the filtrate becomes clear, it is collected, subjected to the bleaching process under exactly the same condition as for " regular " bleached lacs.

A typical sample of refined bleached lac prepared under the above conditions when properly air-dried, had the following properties:

Moisture	Less than 0·5%
Acid value	57-77
Colour index	0·4-0·5
Wax	0·02%

It dissolves readily in rectified spirit in the cold giving a clear solution unlike the regular variety which gives a cloudy solution due to the suspended wax. A

number of samples have been prepared and these are being preserved for studying their ageing properties.

(d) *Bleaching lac with alternative bleaching agents* — The bleaching of seedlac with sodium chlorite and the properties of bleached lac obtained therefrom have been reported already (*I.L.R.I. Annual Report* 1954-55, p. 77). Continuing this study it was found that by increasing the amount of sodium chlorite used, the life and flow of the resulting bleached lac could be appreciably improved. For example, in an extreme case, when 52 gms. of sodium chlorite were used for 119 gms. of seedlac, the bleached lac obtained had a life under heat of 88·5 mins. at 150°C. as against 50 mins. for fresh high-grade shellac at the same temperature. The flow was 345 secs. as compared with 115 secs. for shellac. This bleached lac, however, was excessively soft and when powdered readily coalesced into blocks and adhered to containers.

A comparison of the properties of this bleached lac tabulated below with those of the " foreign " dewaxed decolourized lac mentioned in the last *Annual Report* is interesting.

TABLE XXI

Property	Chlorite-bleached lac	' Foreign ' dewaxed decolourized lac	Regular hypochlorite-bleached lac
Appearance	Brittle, rather softish, the powdered solid readily coalescing into a block and sticking firmly to container	Quite similar to the chlorite bleached lac	Dry sandy powder with no tendency to block or soften
Acid value	137·6	117·2	Below 70-72
Saponification value	284·7	291·4	About 250
Colour index	—	0·45	0·3-0·4
Hydroxyl value	229·7	234·0	—
Flow	345 secs.	180 secs.	Does not flow the 5 in.
Life at 150°C.	88·5 mins.	118 mins.	10-15 mins.

(e) *Colour retention of bleached lac varnishes* — Following the preparation of bleached lacs of satisfactory keeping qualities in the dry condition, colour stability of varnishes made from these was investigated. Ten per cent solutions of a few of these lacs in re-distilled spirit were made and stored in glass containers fitted with cork stoppers in the laboratory cupboard. The colour indices were determined after filtering off the wax. The acid values were also determined to watch the fall, if any, in these. The results are given in Table XXII (p. 70).

It will be seen that there is hardly any change either in colour or in acid value during a period of 6-18 months although there is some drop in both the values in course of the first few months.

(f) *Variation in pH during the bleaching of lac* — The value of *p*H determination as a means of controlling a production-reaction carried out in one or more stages, is now well recognized. Since the Institute's new method of lac bleaching involves several operations, the feasibility of their successful control through a recording of the *p*H values at various stages was explored. Results of experiments with details follow:

TABLE XXII — KEEPING QUALITY OF BLEACHED LAC VARNISHES

Varnish	Colour index				Acid value			
	When fresh	After 6 months	After 15 months	After 18 months	When fresh	After 6 months	After 15 months	After 18 months
1	0·43	0·38	0·38	0·40	6·531	6·186	6·284	6·426
2	0·43	0·42	0·43	0·42	6·528	6·416	6·466	6·482
3	0·33	0·30	0·31	0·35	6·552	6·413	6·482	6·424
4	0·50	0·45	0·42	0·42	6·723	6·413	6·494	6·521

It is relevant to mention that the actual process of lac bleaching is mainly a three-stage one, namely (1) preparation of the bleach liquor, (2) use of this bleach liquor for the bleaching and (3) reclaiming the lac from the bleached solution. A brief description of the processes as carried out is given below. The values of *p*H recorded at various stages will be found in Table XXIII (p. 71).

(1) *Preparation of bleach liquor* — 1,200 gms. of I.C.I. bleaching powder was stirred with 6 litres of water for half an hour, decanted and filtered. 900 gms. of soda were separately dissolved in 2,400 cc. water and slowly added to the bleaching powder extract, with constant mechanical stirring. Then approximately 150 cc. of 4·5*N* NaOH solution or, more economically, a few gms. of calcium hydroxide cake obtained by filtering the bleaching powder extract, were added to adjust the alkalinity, which should be just sufficient to hold for 5 secs. the colour obtained by 2-3 drops of phenolphthalein. The strength of the bleach liquor was controlled to $3 \pm 0{\cdot}05$ per cent available chlorine before use.

(2) *Use of bleach liquor for bleaching lac* — 1,200 gms. of seedlac were made to dissolve in three times its weight of water containing 120 gms. of soda, the extract being maintained at about 80°-90°C. It was filtered through muslin cloth and ice was added to cool it to 35°C.

Bleach liquor was added in small portions at a time, the last portion of 250 cc. having been added when the previously added chlorine had been consumed, as tested by starch-iodide paper. The total amount of bleach liquor to be added was determined by the bleach index of lac.

When bleaching was complete as determined by the colour ratio ranging between 3 and 4, (the total volume of the bleached extract at the time of determining the colour ratio should be 12 litres, i.e. 10 times the weight of seedlac) equal amount of cold water and sufficient ice were added so as to cool the bleached extract to or below 20°C.

(3) *Reclaiming lac from the solution* — Dilute sulphuric acid (approx. 1*N*) was sprayed into the bleached extract with constant agitation. White precipitates of bleached lac were obtained. Precipitation is complete when the extract turns blue litmus paper red.

The bleached lac thus obtained is then washed in a rotary drum with an intermittent spray of cold water. When the washing is free from sulphate ions ($BaCl_2$ test), bleached lac is taken out in a glass jar, kept immersed under water overnight and then dried in air on cloth trays. It is powdered and packed, when dry.

The yield from the bleaching experiment was satisfactory both in quantity and quality. It follows that in course of actual manufacture *p*H values corresponding to various stages should closely approximate those recorded in the above table.

TABLE XXIII — VARIATION OF *p*H DURING THE BLEACHING OF LAC

Solution No.	Solutions at various stages	*p*H values		Remarks
		Determined immediately	After ½ hr.	
	(i) During preparation of bleach liquor			
1	Bleaching powder extract	11·8	—	—
2	Soda soln.	10·2	—	—
3	Soda soln. added to bleaching powder extract	9·4	—	—
4	NaOH added to control alkalinity	10·5	—	—
	(ii) During the use of bleach liquor for bleaching lac			
5	Seed lac extract	9·5	8·4	1,200 gms. of seedlac and 120 gms. soda in 3·6 litres of water
6	Partially bleached extract when 1 litre bleach liquor is consumed*	9·5	9·0	—
7	Partially bleached extract when 2 litres bleach liquor are consumed*	9·5	9·2	—
8	Partially bleached extract when 3 litres bleach liquor are consumed*	9·5	9·45	Becomes 9·2 after 18 hrs.
9	Partially bleached extract when 3½ litres bleach liquor are consumed*	9·45	9·45	—
10	Partially bleached extract when 4 litres bleach liquor are consumed*	9·45	9·45	—
	(iii) During reclaiming bleached lac			
11	Approx. 1*N* sulphuric acid solution	1·9	—	—
12	After putting 1 litre of acid solution No. 11	7·6	—	—
13	After putting 2 litres of acid solution No. 11	6·5	—	—

* The consumption of bleach liquor was tested with starch iodide paper. Complete consumption is indicated by no or slight blue colouration of the test paper.

TABLE XXIII — VARIATION OF *p*H DURING THE BLEACHING OF LAC (*Contd.*)

Solution No.	Solutions at various stages	*p*H values		Remarks
		Determined immediately	After ½ hr.	
14	After putting 2½ litres of acid solution No. 11	5·0	—	—
15	After putting 2¾ litres of acid solution No. 11	3·7	—	Precipitation is complete. Blue litmus turns red after immersion for 5-10 secs.
16.	After putting 3 litres of acid solution No. 11	2·8	—	Excess acid, blue litmus turns red immediately
17.	Tap water	6·5	—	—
18.	After washing for 20 mins. under spray of cold water	5·7	—	Washing is complete no turbidity with $BaCl_2$ solution

(v) *Bleaching of shellac wax* — In order to find out some cheap method of bleaching shellac wax, a few experiments were conducted: The following processes were tried:

(a) Shellac wax was treated repeatedly with boiling water for various lengths of time.

(b) Wax was continuously boiled in a 5 per cent H_2SO_4 solution for different periods.

(c) Process (b) was repeated with addition of a little HNO_3 conc.

(d) Molten wax was spread in films and exposed to sunlight for 15 days.

But none of these processes (a) to (d) brought about any improvement in colour.

(e) Next, molten wax was treated with alkaline hydrogen peroxide for about half an hour, when an improvement in colour was noticed. The treated wax was neutralized, washed and melted.

(f) Shellac wax was emulsified in 3 per cent Na_2CO_3 solution, and bleach liquor containing about 3 per cent chlorine was added. The emulsion was neutralized with dilute H_2SO_4, and wax precipitated on warming. The wax was filtered and the filtrate washed till acid-free: the resulting wax was white but the colour re-appeared to some extent on melting in water-bath. The process appears to be promising and will be further investigated.

3. Miscellaneous Uses of Lac and Associated Products

(i) *Modification of shellac wax* — It has been pointed out by some carbon paper manufacturers that certain inherent characteristics of shellac limit its use in their industry. One such characteristic is its tendency to crystallize out from solutions in solvents like naptha, turpentine, etc. To reduce or eliminate this tendency, it was sought to mix or combine it with different proportions of such materials, as bees wax, dammar and rosin oils, etc. In some compositions pure palmitic acid was used. In

all cases of attempted chemical combination the temperature of reaction was kept between 210°-240°C. For effective combination *p*-toluene sulphonic acid was used as catalyst in some cases and the period of reaction was varied from 30 mins. to 4 hrs. None of these combinations, however, compared favourably with carnauba wax. It may be noted that a good of variety carnauba wax behaved similarly to shellac wax in regard to its property of crystallizing from solvents, as could be judged from their saturated solutions in toluene. It was noticed that shellac wax flows twice as rapidly as carnauba wax under similar conditions, i.e. 90°C.; whether this is a defect of shellac wax from the industrial point is to be further examined.

(ii) *Cement for electric bulb caps* — Composition of these cements had to be modified several times as the technical requirements for a proper cement as specified by the Secretary, Indian Lamp Factories Association, were being changed from time to time. Thus, the original specifications as laid down by the Association in June 1951, required that a cement cured at 200°-250°C. for 4 mins. should be hard on removal under a torque of 25 lb.-in. with B-22 (ordinary Bayonot caps). Further, the caps should not become loose on long storage particularly in moist atmosphere. The composition reported earlier stood all the tests for bulbs up to 100 watts, but when the cement was sent to one of the Lamp factories under the Association, an additional specification was insisted upon, namely that the cement after capping would have to stand boiling water test preferably for 2 hrs. (i.e. bulbs should not become loose if kept in boiling water for 2 hrs.). The 'bakelite' cement then available in the market, however, did not satisfy this test: it stood boiling water only for ½ hr.

Modifications of the earlier composition were, therefore, made with the aim of making it more thermosetting and water-resistant. The Institute's standard lac-urea-formaldehyde varnish was modified with aluminium chloride, maleic acid, lime, etc. Different types of lac (e.g. shellac heated at 140° for 1 hr., mixture of such heat-treated lac with saponified lac 20 per cent on the weight of lac) were also tried. Precipitated chalk was then mixed with varnishes thus prepared in proportions of lac: chalk = 20: 80, forming a paste, which was then used for capping bulbs. Electric bulbs cemented with each of these were tested in boiling water. Two of the compositions were found satisfactory and sent to "Pradip Lamp Works", Patna and "Bengal Lamp Works", Calcutta, for test and report. Samples were reported to work better in the capping machine but could not stand the boiling water test. Meanwhile a new condition was introduced; namely, that the cement should stand a torque of 25 lb.-in., immediately on removing bulbs from boiling water in which they were kept for 2 hrs. Attempts at further modification of the above cement failed, as use of more hardener converted the varnishes into a thick gell which could not be conveniently mixed with chalk to form a good paste, capable of remaining soft for 24 hrs. Incorporation of a thermosetting resin along with lac was, therefore, considered necessary.

Compositions were next made by using different proportions of lac and phenol formaldehyde (P-F) resin. It is interesting to note that though P-F resin is thermosetting, a composition containing only P-F resin (without lac) did not work satisfactorily. Several compositions containing different proportions of lac and P-F resin were made by hot-rolling the resins with chalk and bulbs cemented with each of them were tested according to the new specifications. A torque testing apparatus was also fabricated in our machine shop for this purpose. A proportion of lac: P-F resin = 60: 40 was found to be most satisfactory. Some of the usual hardeners of lac were next tried to modify the above composition and best results so far have been obtained with a composition made by hot-rolling shellac 60 parts, line 0·6 part, P-F resin 40 parts and precipitated chalk 200 parts. Bulb caps cemented with this composition stood the torque test after immersing in boiling water for ½ to 1 hr. A sample of the above composition was sent to Bengal Lamp Works, Calcutta for their test and report. Though this sample failed to stand the torque test after immersion in boiling water for 2 hrs., its performance otherwise was found excellent and even better than that of the imported bakelite cement now being used by

them: it was slightly inferior to a cement obtained from Japan which is used for high wattage lamps. It was also reported that in their search for a good cement, they have, in the course of the last few years, tested quite a good number of bulb cements both local and foreign-make, and except the above-mentioned Japanese composition, none was found better than our composition. This composition also formed better type of paste with alcohol than compositions made earlier and a trial experiment with 10 lb. of the above cement in the automatic kneading and capping machine of the Bengal Lamp Works worked quite satisfactorily.

The above composition also proved to be a very good adhesive for broken porcelain articles. Broken cups and saucers fixed up by a paste of the above composition with alcohol, followed by baking at 120°C. for 2 hrs. stood the temperature of boiling water. In the Laboratory, several items of broken porcelain apparatus have been made serviceable by using this cement.

(iii) *Micanite boards and micanite V-rings* — A number of enquiries were received from several firms at Calcutta regarding a suitable adhesive for making micanite V-rings and micanite boards of about $\frac{1}{16}$ in. thickness. The boards or rings should stand moulding, sawing, punching, drilling and such other mechanical operations. Layers of mica flakes were coated with a dilute alcoholic shellac solution 20-30 per cent so that on air-drying, the final resin content was 15-20 per cent on the weight of the flakes. These were arranged and pressed into a board, which, however had a poor adhesion, as most of the lac was squeezed out in the course of pressing. A thicker solution of shellac in alcohol (100 gms. in 200 cc.), however, worked satisfactorily. Mica flakes spread in the form of a sheet were coated by brush in this way, till thickness of $\frac{1}{8}$ in. was obtained. Roughly 25-30 laminae were required for this thickness. The board thus obtained was air-dried, baked at 90°C. for 2-3 hrs. and pressed between tin or aluminium sheets in a hydraulic press (120 lb./sq. in., 130°C., 5 mins.) and cooled down to 45°-50°C. before removal. A little of the shellac was found to have squeezed out but most of it remained behind, spread in uniform layers in between the mica flakes. The board thus prepared had an average thickness of $\frac{1}{16}$ in. and the total quantity of resin was found to be 15-20 per cent on the weight of the mica flakes. Some adhesive promoters were also tried, and boards made with each of them were sent to one of the Calcutta firms for test and report. An adhesive composition made by refluxing shellac: 100 parts, spirit: 200 parts, oxalic or tartaric acid: 2 parts worked very satisfactorily. Further work on micanite tubes and V-rings is being done.

(iv) *Adhesive for brush bristles* — On receiving an enquiry from a firm in Calcutta for a suitable adhesive for fixing bristles of shaving brushes a few compositions were sent for their test, out of which the following was reported to be working satisfactorily:

Lac — 100 gms.
Spirit — 300 cc.
Formalin — 50 cc.
Urea — 15 gms.
} Refluxed for 2 hrs. on water bath
and
Maleic acid (1 gm.) — further refluxed for $\frac{1}{2}$ hr.

When cold, the above varnish was mixed with wood flour (specific vol. 90 cc.) 20 per cent on the weight of lac.

Work has also been started for formulating suitable adhesive compositions for setting bristles of paint and varnish brushes. Such brushes are generally of flat type, in which the bristles are fitted in a tin ferrule. The general procedure of fixing such bristles is to pour the adhesive into the ferrule so that part of the bristles inside the ferrule gets soaked in the varnish which is allowed to penetrate a distance of about $\frac{1}{2}$ in. to 1 in. down the bristles. The excess varnish is then poured back from the ferrule to which fire is now set; the extra solvent is thus burnt out and the resin is also "set". Lac varnishes refluxed with or without hardeners failed to work satisfactorily by the above

method as such heat-treated varnishes have high viscosity and, therefore, do not penetrate among the bristles. Encouraging results have been obtained with alcoholic solution of lac mixed in the cold with some hardeners and used immediately thereafter. The work is being continued.

4. *Ad hoc* Work

(i) *Varnish for the prevention of tarnishing of brass and copper* — The following lac varnish, prepared after a number of trials, in reply to a commercial enquiry, was found useful for preserving gloss and preventing tarnishing of brass and copper wares: 20 gms. dewaxed decolourized lac were dissolved in 180 gms. rectified spirit. To this were added 0·1 gm. maleic acid, 10 gms. butyl alcohol (to reduce blushing), 0·5 gm. sextol phthalate or castor oil, and 2 drops phosphoric acid.

Copper plates and brass rods were coated with this varnish by dipping. The thin single coat so produced could prevent tarnishing of the brass and copper wares for more than a year, while the same surface without the lac film tarnished within a month, when exposed to the atmosphere of the Chemical laboratory.

(ii) *Lacquering sticks for wooden toys* — Light-coloured lacquering sticks for wooden toys were made by fusing bleached lac with an equal weight of rosin and 2-5 per cent plasticizer. These sticks by themselves or pigmented with titanox were tried on wooden toys and found to work satisfactorily.

(iii) *Tailoring cloth* — Water-proof muslin cloth (tailoring cloth) was made by dipping muslin in bleached lac/spirit solution. The sample prepared in the laboratory compared favourably with an English sample as regards stiffness, water resistance and glaze. It was, however, slightly inferior to the latter in regard to heat resistance, and in addition, required more careful handling under the hot iron press.

(iv) *Coloured sand* — According to an enquiry received in the Institute, it was required to dye sand into different colours that should be resistant to ordinary tap water as also to sea-water.

For this purpose, sand from the river bed was first decolourized by treatment with strong hydrochloric acid. Subsequent thorough washing removed both the acid and other soluble impurities. The dyeing solution was prepared by dissolving 5 gms. dewaxed shellac in 100 gms. rectified spirit to which was added 0·2 to 0·5 per cent alcohol-soluble (water-insoluble) dye. The treated sand was kept immersed in this shellac lacquer for half an hour, then filtered and dried. The colour of the sand so dyed was not altered or affected even after 15 days' immersion (at 40°C.) in sea or tap water.

(v) *Shellac metal lacquers* — Ordinary shellac films on aluminium foils usually crack or peel off when the foils are bent or stamped into various shapes. An enquiry for an improved varnish that would give more flexible and firmly adhering films was received. Of the various compositions tried so far the following appears to be the best.

30 gms. shellac (dewaxed 'platina') are dissolved in 100 gms. rectified spirit and refluxed with 2·5 gms. maleic acid for 3 hrs. 5 gms. pine oil are added to it as plasticizer, and 0·2 to 0·5 per cent alcohol-soluble dye of desired shade is thoroughly stirred into it. Aluminium foils were coated by dipping and air-dried. The films were rather slow-drying and had a tendency to soften with the result that when the foil was kept tightly folded, the folds sometimes stuck to each other in patches.

5. Experimental Regional Testing Laboratory

During the 12 months from 2 April 1955 on which day the scheme was officially put into operation till the end of March 1956, 282 samples were received from 40 parties for 377 tests, which comprised the following:

Hot alcohol insolubles (impurities) test	220
Bleach index/bleachability	55
Rosin	78
Colour index	10
Orpiment	3
Cold alcohol solubles	3
Life under heat	3
Flow	3
Sugar	1
Wax	1

The results of these analyses were sent to various parties. Although it was explicitly made clear that they were required to give the test results of commercial analysts as soon as they received ours, our requests had been complied with only in the case of 102 samples, consisting of 86 for hot alcohol insolubles and 16 for bleach index/bleachability. The commercial analysts' results agreed with ours within the following limits:

	Hot alcohol insolubles	
Within	± 0·2 %	34 cases
Within	± 0·3 ,,	7 ,,
Within	± 0·4 ,,	10 ,,
Above	± 0·4 ,,	51 ,,

Bleach index/bleachability: Of the 16 samples (*vide supra*) for which bleach test results from commercial analysts were available, there was agreement with our findings in 9 cases, while their results were higher than ours in 5 cases and lower in 2 cases.

III. PROPAGANDA AND PUBLICITY (UTILIZATION OF LAC)

Work proceeded more or less on the same lines as before, albeit with added emphasis on the possibilities of increased internal consumption. Close contact was maintained throughout the period with actual and potential consumers of lac in different fields of its application. Thus, the Railways and Defence Departments of the Government of India, Varnish and Paint manufacturing concerns, small-scale manufacturers of sealing waxes, French polish and adhesive compositions, manufacturers of rubber and leather goods, potters interested in the coating of earthenware, were frequently contacted, and supplied with relevant literature and samples and other particulars. Wherever necessary, factories were visited and actual demonstration of the processes given. An itemwise description of activities is given below:

Varnish and paint — In addition to the notes and other information regarding the manufacture, properties, performance, various uses, etc. of the several lac-drying oil compositions which were freely circularized last year among the interested parties, detailed information regarding another newly developed composition namely, shellac-rosin-glycerine ester combinations with better performance in some respects was also freely distributed; and parties were requested to give trials and to take up the manufacture of the products if found satisfactory. Samples of this new varnish composition and also the modified resin were sent to some parties for tests. Large batches of this resin and the varnish were also made in the premises of some manufacturers who expressed satisfaction at the performance of the products. The chief uses of this composition are: (1) as clear baking insulating varnish and (2) for the manufacture of insulating cloth ('Empire cloth'). The behaviour of these products in both the applications is being tested at the India Electric Works, Calcutta and by Messrs Bhor Industries near Poona. Both these firms desire to take up the manufacture of insulating cloth and are at present engaged in the procurement and erection of the

necessary equipment. Messrs Indian Electric Works is already making and using insulating varnish and insulating cloth based on lac in small quantities. The varnish has also been tested at the Government Test House, Calcutta and found to pass both B.S. and I.S.I. specifications. There is, however, a slight defect in the varnish in that it does not possess fully the property of ' drying through ' and this is expected to be shortly overcome by further modification.

It may perhaps be mentioned that although the performance of the shellac compositions in their various applications is satisfactory, the manufacturers and industrialists are unanimous that the present ruling price of lac is very high, and unless reduced substantially, say to the level of Re. 1 to 1-4 per pound, will prevent its greater utilization.

Oilcloth — Another important use of shellac-drying oil composition is in the manufacture of oilcloth. Two firms: (1) the Bhor Industries, near Poona, and (2) the Strawboard Mfg. Company, Saharanpur, who have got the necessary equipment are interested in the manufacture of this material. Of these, the former as a regular manufacturer of such products using different compositions, has given large-scale trials to the shellac composition and is satisfied with the quality of the products. Actual demonstration of the whole process including the making of the coating composition from raw materials to the finished product was also carried out at the firm's factory. Several yards of the cloth of width 52-54 in. were made and tested, and lac-based oilcloth proved superior to those based on their present composition as regards pliability, toughness, surface hardness, etc. The only drawback, as the management observed, lies in the high price of shellac as mentioned earlier, the cost of production being higher by 3-4 annas per yard than that using their present composition. Nevertheless, the firm manufactured 1,000 yards of oilcloth in the first instance and put it on the market to study the public reaction, which however was not favourable solely because of price difference.

Another firm, namely, the Mysore Lac and Paint Works, Mysore, has also expressed its desire to take up the manufacture of oilcloth, and all possible technical assistance is being given.

Attempts are also being made through the National Research Development Corporation (N.R.D.C.) of the Government of India to get parties interested in the manufacture of oilcloth and insulating cloth, and necessary details together with samples as regards process, equipment required, etc., have been given to them. A large sample of oilcloth prepared in a factory was displayed at Indian Industries Fair, New Delhi with the co-operation of National Research Development Corporation. As a result, number of enquiries from interested parties for supply of information regarding manufacturing details, type of equipment required, etc., were received and these were attended to.

Adhesives and cements — The process of making Gasket Shellac cement was communicated to the Mysore Lac and Paint Works, and the Technical Development Establishments of the Defence Services at Bangalore and Ahmednagar; samples also were sent to these parties for test and report. Ten pounds of electric bulb cap cement based on shellac were sent on request to a Military Establishment at Delhi to meet their immediate requirements. At the same time work is in progress to improve further the quality of the cement so as to extend its use for bulbs of higher wattage. Considerable success has already been achieved towards increasing the heat-resistance of the cement and fresh samples are being sent to various Electric Lamp Manufacturing concerns for factory tests. Details of making water-proof abrasive papers, emery cloth, abrasive wheels, etc., were sent to parties in Calcutta and Poona. Both of them are keen in taking up the manufacture of these products and a representative from the Calcutta firm visited the Institute to learn the process.

A firm in Kanpur is satisfied with a shellac adhesive sent to them for fixing bristles in shaving brush handles. Manufacturing details of the adhesive together with the approximate cost of production have been supplied to the firm on request.

Samples of shellac adhesives were also sent to a few firms interested in the manufacture of micanite products such as hard micanite, commutator micanite, flexible micanite, mica tapes, etc. These are reported to be satisfactory, and one firm in Calcutta, namely, Messrs B. M. Singh & Sons, is using the shellac composition for making micanite rings for their use.

Sealing wax — Methods of making superior quality sealing waxes, the improvements in the technique of the process, etc., were given to some of the small-scale manufacturers. A technical note on the subject has been published for distribution to interested parties.

Bleached lac — The demand for bleached lac is gradually increasing and large number of samples of improved quality bleached lac prepared at the Institute were sent to several parties on request. These were favourably commented upon and larger demands are envisaged. Messrs Leather Chemicals and Industries, Calcutta have reported that the samples were quite suitable for making superior quality leather finishes. Bleached lac is also found to be quite good for some pharmacological purpose and for finishing sports goods. Further samples of the material have been sent to different furniture dealers and cabinet makers for eliciting their opinion regarding quality and performance.

A Commercial firm in Calcutta was given complete details of the process of manufacture of bleached lac on a large scale. In the meantime a proposal is afoot to put up a pilot plant at the Institute at an approximate cost of Rs. 75,000 and to study all factors involved in the large-scale process. It is only after successful production in the pilot plant that the process will be recommended to large-scale manufacturers.

Details regarding the preparation of practically colourless lacquer for application on art metalwares to prevent tarnishing were given on request to art brassware manufacturers and to the Government Schools of Arts and Crafts in Madras and Uttar Pradesh.

Experiments are being conducted at the Central Food & Technological Institute, Mysore, on the preservation of foodstuffs, more especially fruits and eggs by coating these with shellac compositions. Preliminary results having given encouraging results, the Director of the Institute asked for and has been supplied with larger quantities of bleached lac for carrying out more exhaustive trials. Report from the Director is awaited.

Lac coating on earthenware — The use of shellac in coating earthenware is actively pursued with the co-operation of the All-India Village & Khadi Industries Board, Bombay. Regular demonstrations were held at the various Pottery Training Centres of the Board and also at the many Khadi & Village Industries Exhibitions organized by the Board from time to time. To all these places, a potter especially trained in the art at the Institute was sent for giving the demonstration.

Demonstrations were arranged, among others, at (1) All-India Village & Khadi Industries Emporium, Bombay, (2) Potters Training Centre at Khanapur near Belgaum, (3) Potters Co-operative Society at Dharavi, (4) Khadi & Village Industries Exhibition at Naini Tal and Meerut (5) All-India Potters Conference, Sevagram, etc. Apart from the above, details of the process together with samples were sent on request to Kasturaba Seva Mandir, Rajpura (PEPSU), the Director of Industries and Commerce, Madras and to several parties in Madhya Bharat and Madhya Pradesh. It may be mentioned that the shellac coating on earthenware has become a part of the programme of All-India Khadi & Village Industries Board in their scheme for the development of village industries.

Shellac is also used in leather industry to a certain extent, chiefly in the form of leather finishes and polishes. Suggestions were given to a party in Calcutta for overcoming some of the defects, namely, " crusty break " and " loss of lustre " observed in some of the leather finishes containing shellac.

Enquiries made from Messrs Bata Shoe Co., Calcutta, have revealed that they are satisfied with the performance of the shellac compositions they are using at present. Their consumption at present is 6 cwt. of shellac per month or nearly 100 mds. per year.

Miscellaneous enquiries — Schemes for the reorganization of the lac factory under the management of the Madras Government and for starting lac industries by the Madhya Bharat Government have been submitted to the respective Governments on request with a view to increasing the consumption of lac in these States.

Information regarding physical and chemical properties of various grades of shellac, seedlac, etc., were given to the Ministry of Defence in response to their enquiry.

A minor use for shellac for colouring sand to various shades required in some hydraulic experiments was suggested to the Central Water & Power Research Station, Government of India, near Poona.

Enquiries made at Technical Development Establishment at Poona and Kanpur revealed that they were using shellac for a number of purposes including some new ones for which shellac was not used before, particularly in the form of modified coating compositions, adhesives, cement, etc. They suggested that if the heat resistance or the melting point of shellac could be raised to about 100° or 110°C., its use might be further extended. Experiments to increase the melting point of shellac without sacrificing its other properties are in progress.

Improved varnishes obtained by the combination of shellac with cashew-nut shell liquid and other chemicals have been recommended to firms in Gujrat and Bombay for use as Bobbin Enamels and for enamelling copper wires for electrical purposes. Wherever necessary, samples together with details of manufacture were sent to the interested parties.

Consumption of shellac in India — Further figures were collected on the amount of shellac utilized in India. In Rajasthan alone about 750 mds. of shellac are consumed in bangle making and about 250 mds. in lacquering art brassware, thus bringing the total to about 1,000 mds. In Punjab and PEPSU, the figures total to about 4,200 mds. being made up as follows:

French polish	about	1,400	mds.
Lacquer ware	,,	1,400	,,
Jewellery	,,	700	,,
Miscellaneous	,,	700	,,

Publicity through Exhibitions — Samples of lac and lac products were sent to the following exhibitions during the period under review. Printed pamphlets, notes, etc., containing brief descriptions of the various processes and other information were also sent:

1. The Silver Jubilee Fair, Addis Ababa, Ethiopia
2. St. Ericks International Trade Fair, Stockholm, Sweden
3. The Third International Djakorta Fair, Indonesia
4. Rama Krishna Mission Vidya Mandira Museum
5. Indian Industries Fair, New Delhi
6. Pakistan International Industries Fair, Karachi
7. Royal Agricultural & Food Exhibition at Colombo, Ceylon
8. All-India Plastics Exhibition, Bombay
9. Leipzig Spring International Trade Fair, Leipzig, E. Germany
10. Village Industries Seminar Exhibition, Community Project
11. Lakh Udyog Prasikshan Kendra, U.P.
12. All-India Congress Exhibition, Amritsar
13. The Patent Centenary Exhibition, Calcutta
14. Indian Trade Exhibition, Gold Coast, West Africa

It may be mentioned that the All-India Handicrafts Board had arranged for televising daily at the Indian Industries Fair, New Delhi, the art of making bangles from lac with a view to popularizing the use of shellac in this industry.

IV. METEOROLOGICAL DATA

The average meteorological data for each month during 1955-56 are given in the following table:

Month & year		Mean wind speed (miles/hr.)	Mean max. temp. °F.	Mean min. temp. °F.	Mean dry bulb temp. °F.	Mean humi-dity %	Mean sunshine (hrs./day)	Total rainfall in.	Highest max. temp. °F.	Lowest min. temp. °F.
April	1955	2·59	98·60	68·80	86·03	24·40	10·42	0·05	104	62
May	1955	2·07	102·90	77·16	89·68	39·19	8·85	0·09	110	68
June	1955	1·83	97·20	76·83	85·23	66·13	6·66	11·69	110	73
July	1955	1·85	87·19	74·35	80·26	81·16	3·45	12·34	92	72
August	1955	1·22	89·39	73·84	80·00	79·52	5·87	9·81	94	70
September	1955	1·21	88·30	72·90	80·20	78·67	7·17	7·90	94	70
October	1955	1·17	85·19	67·81	76·48	73·58	7·08	3·17	92	56
November	1955	1·40	80·37	52·87	70·20	55·10	9·07	0·52	88	48
December	1955	0·92	76·16	46·29	64·13	55·26	9·92	nil	82	37
January	1956	1·12	78·32	48·45	65·97	47·55	9·81	0·55	84	42
February	1956	1·21	79·10	49·79	68·20	40·62	9·12	1·20	90	40
March	1956	1·99	90·68	61·39	76·52	48·19	9·69	4·55	96	54

The highest maximum temperature recorded during the year was 110°F. and was recorded on the 12th of May and 4th and 5th of June. The lowest temperature was 37°F. and was touched only on one day, viz. the 28th December. The total rainfall during the year amounted to 51·81 in. and the monsoon rainfall 41·74 in. as against 44·82 and 39·91 in. respectively during the corresponding periods of the previous year.

As our thermometer housing was reported to be not exactly in conformity with the Indian Meteorological specifications, a standard Stevenson screen approved by the Directorate of Agricultural Meteorology, Poona was purchased and installed along with a set of new thermometers conforming to the above specifications and tested and approved by the above Directorate. These are expected to yield more accurate meteorological data. The rest of our requirement were also examined and approved as quite satisfactory.

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Director
Indian Lac Research Institute
Namkum

APPENDIX I

Tabulated Statement of Progress of Investigations

ENTOMOLOGICAL

Item	Year of commencing the experiments	Progress	Future work/Remarks
I. Research & Investigations			
1. Improving crop production on *palas* by partial defoliation			
(i) Preservation of *Baisakhi* broodlac on *palas*	1948-49	Despite *Kundri* being an extremely hot area, it has been possible to bring progressively increased number of trees under lac cultivation as a result of better preservation of broodlac by adopting partial defoliation of *palas;* last year almost the entire coupé III (with 11,526 trees) was infected for the *Baisakhi* season. Total quantity of sticklac obtained during 1955-56 was 3,752 lb. In addition, 2,569 lb. of surplus broodlac from *Katki* crop (1955) was sold out for Rs. 1,462/14/6. Damage of living lac insects by birds and squirrels was observed towards crop maturity both in *Baisakhi* and *Katki* crops.	To be continued for demonstration purpose
(ii) Residual effect of repeated partial defoliation of *palas* on lac production	1952-53	The effect of partial defoliation in brood production is being compared with cultivation practices without partial defoliation and according to the villager's method at *Kundri.* Theft of lac during infection interfered with the results. At Namkum, no significant difference in yield of broodlac was obtained for defoliated and undefoliated trees. In order to assess the residual effect of this practice, 100 trees defoliated and used for lac cultivation for 10 years already and another 100 trees not defoliated at all are being compared for their maximum lac production.	To be continued at least 2 more seasons to *confirm results*
2. (i) Economics of utilizing *palas* for *Baisakhi* and *ber* for *Katki* crop only	1955-56	The experiment has been started only in this year and in *Baisakhi* season *ber* has given better results than *palas*, the brood to yield ratio of scraped lac being 1 : 4·18 for *ber* and 1 : 3·16 for *palas*.	To be continued
(ii) Comparative preservation of broodlac on *ber* by partial pruning before and after infection	1953-54	Percentage of selected broodlac obtained was nearly double from trees pruned partially before infection in October than from trees pruned after infection in December. The control trees which did not receive any partial pruning treatment did not yield any broodlac.	To be continued for one more year

APPENDIX I (*Contd.*)

Item	Year of commencing the experiments	Progress	Future work/Remarks
3. Finding of, and trials on, lac hosts for *Baisakhi* crop including certain ficus species	1945-46	*Albizzia lucida*, *Ficus cunia* and *Ougeinia dalbergioides* were tried at Namkum and *F. cunia* gave the best results, the brood used to brood yield ratio being 1: 5·48 and brood to yield (scraped lac) ratio being 1: 9·35.	
4. Determination of brood-carrying capacity of the major lac hosts	1952-53	*Kusum*, *ber*, *palas* and *khair* hosts were infected for all the four crops. This year broodlac yields were not satisfactory except for *palas* in the *Baisakhi* season.	This item should be extended to Regional field stations when they are set up .
5. Proper time of harvesting for maximizing yield	...	The experiment has not so far been taken up, but will be taken up after the regional field stations are set up.	
6. Determination of optimum density of larval settlement on various hosts	1953	The experiment was carried out on *kusum*, *palas*, *ber* and *khair*. Of the three treatments $\frac{1}{3}$ and $\frac{1}{2}$ the quantity of brood usually required were better than the full usual quantity used for *palas* and *ber* in the *Baisakhi* season, and for *palas* only in the *Katki* season, for *ber* and *khair*, the usual full quantity was better than the other two treatments in *Katki* season, and also for *kusum* in *Jethwi* season. Statistical analysis of the crop data, however, were significant only for *kusum* in *Jethwi* season, the treatment effect at 5 per cent level being in the order. A B C:	To be continued
7. Effect of change of host plant on crop production	1952-53	*Kusum* was alternated with *ber*, *khair*, and *pakur* in the case of *kusmi* strain. Similarly *palas* with *Albizzia lucida*, *sandan* and *porho*; and *ber* with *A. lucida* and *Sandan* in the case of *Rangeeni* strain. Best results were obtained with *pakur* × *kusum* and *A. Lucida* × *ber* in the *Kusmi* and *Rangeeni* strains respectively	
8. Determination of the most suitable pruning method and seasons for *kusum*	1951	As usual the four treatments, i.e. apical pruning (i) with 1½ years' rest, and (ii) one year's rest, and surface pruning (iii) with one year's rest and (iv) 6 months' rest were under investigation. Measurement of growth of shoots indicated that growth was best with treatment I and most retarded with treatment IV. Judging by the yield of lac, treatment II was the best in *Jethwi* 1955 crop and treatment III in *Aghani* 1955-56. Statistical analysis of figures per tree, however,	

APPENDIX I (*Contd.*)

Item	Year of commencing the experiments	Progress	Future work/Remarks
		indicated that in *Jethwi* crop, treatment II differed significantly from treatment IV although, on the whole no difference exists. The treatment effects in the *Aghani* crop were not significant at 5 per cent level.	
9. Growing of lac hosts under bush and crop conditions	1952-53	*Arhar* hosts raised under crop conditions for the *Baisakhi* season died in large numbers in summer, only 10·5 per cent of the plants carrying lac till maturity and the brood to yield ratio (scraped lac) of the crop being 1 : 3·66. *A. Lucida, F. Congesta* and rose bushes were infected in the *Baisakhi* season. Larvae on rose did not survive after settlement. Between the other two bushes, *A. Lucida* gave better results, and the ratio of brood to yield of lac (scraped) was 1 : 7·68.	*Arhar* and *Flemingia* seem to be suitable only for raising an *ari* crop of lac and not for broodlac
10. Collecting pests of host trees, noting their parasites and control operations against various pests	1950	Investigations on the large-scale control of *T. Javanica,* a pest of *kusum* shoots were carried out, when a severe out-break of the pest was noticed at Hesel-Berwari. Both mechanical and chemical methods of control were tried. Sweeping the bugs with hand nets and killing them in kerosenated water proved effective and cheap. Use of sticky paste cloth was fairly satisfactory. Among chemicals, BHC 5 per cent dust was not so satisfactory as the emulsion and suspension sprays of BHC at 0·3 per cent and 0·6 per cent respectively. Kerosene emulsion was only partially effective while lime-sulphur scorched foliage without giving any control of the bugs. Life-history studies of *Coptosoma ostensum* and *Lampides boeticus* pests of leaves and flowers respectively of *palas* trees are under progress.	To be continued
11. Determination of the various races, strains, species, etc., of lac insects, their performances, cross-infestations, etc.	...	Collection of specimens was continued.	To be continued
12. Influence of various environmental conditions on lac insects	1952-53	Work received a set-back due to both refrigerators maintaining constant temperatures below 20°C., and about 24°C. going out of order, one in September and another in October, 1955. Both *Rangeeni* and *Kusmi* strains were under investigation. None of the females completed the life-cycle. The males of the *Rangeeni* strain in the *Katki*	To be continued

APPENDIX I (*Contd.*)

Item	Year of commencing the experiments	Progress	Future work/Remarks
		crop completed the life-cycle only under the field conditions, and the total life-cycle was 45·3 days on *A. Lucida* and 52·4 days on *A. farnesiana*.	
13. Survey of lac enemies and their parasites	1950	Emergence of insects from 14 samples of lac caged during the year did not show any new enemies or their parasites except for 3 miscellaneous chalcids of unknown role. Detailed investigations on the damage done by squirrels and birds were carried out. It has been ascertained that up to 58·4 per cent of the living lac cells that barely survived the summer heat were damaged by these enemies in June-July 1955. A paper on these enemies was prepared and read at the Science Congress 1956.	
14. Cultural and preventive methods of control of lac enemies	1945	Use of wire-net baskets for infection to reduce infestations of insect enemies in the field was continued. Bamboo baskets used to enclose the wire-net baskets gave cent per cent protection to both wire-net baskets and the broodlac. It was also observed that most of insect enemies get trapped during infection, and only few insects emerge during *phunki* stage. Lac produced from crops with the use of wire-net baskets for infection were less infested with parasites and predators.	
15. Control of enemies of lac by use of insecticides	...	Insecticides D.D.T. and B.H.C. as 5 per cent dust and 0·1 to 0·3 per cent spray do not seem to be harmful to the lac insect. Their effect on the control of the enemy insects is also not convincing. D.D.T. sprays at 0·3 per cent of weekly or tri-weekly or 6-weekly intervals seemed to give some promising results in *Katki* 1955 crop. Treatment of lac sticks and scraped lac after harvest gave some control of the enemies, with D.D.T. and B.H.C. dusts and sprays; carbon disulphide among fumigants gave best results.	(The experiment may be modified to include other insecticides)
16. Biological control	1942	(i) Mass breeding of *Bracon greeni* was continued on the natural host *Eublemma* and the unnatural alternative host *Etiella*. (ii) A scheme for biological control of lac enemy predators has been sanctioned for 5 years and in that	

APPENDIX I (*Contd.*)

Item	Year of commencing the experiments	Progress	Future work/Remarks
		connection areas at Berwari and Maheshpur-Sirka were selected, trees surveyed and marked. Two temporary sheds have been put up at Berwari. The final settlement of trees on lease from the owners is under way. In one of the areas, trees have already been infected. An air-conditioning room has been set up for mass breeding of parasites.	
		(iii) Work on the life-history studies of *Perisierola pulveriae* (Bethylid), *Elasmus claripennis* and *Apantales tachardiae* and *A. fakrulhajiae* were continued and breeding techniques were developed. They can still be improved.	
II. Institute plantation (Namkum)	...	The general upkeep of the plantation was looked after as usual. *Palas, khair, ber* and *kusum* seeds were sown to fill up gaps caused by death of plants in the plots. Green manuring was carried out. *C. saltiana* was raised to provide alternative hosts for breeding *B. greeni*. Seedlings of host plants required for laboratory studies were raised in the nursury.	
III. Training and advisory service	...	(a) *Training* — 15 trainees were on the roll, of whom 4 left on completion of the full course and 3 after doing a part of the course only. Eight trainees were left on the roll at the end of the year who are continuing their course.	
		(b) *Advisory Service* — Advice on lac cultivation was tendered to various Institutions and Community Projects and National Extension Service Administrations. A large number of samples of lac were examined on behalf of the Special Officer for lac cultivation, who was also offered technical advice on various matters.	
CHEMICAL SECTION			
I. Fundamental			
1. Chemical constitution of lac	1947		
(i) Synthesis of butolic acid	1954	One more intermediate, ethyl chloroadipate was prepared.	To be continued

APPENDIX I (*Contd.*)

Item	Year of commencing the experiments	Progress	Future work/Remarks
(ii) Periodic acid oxidation of aleuritic acid and shellac	1955		
(a) Oxidation of aleuritic acid	...	Oxidation is expected to yield an acidic and a neutral part: a semi-carbazone (perhaps azelaic semi-aldehyde — the acidic part) was separated.	To be continued
(b) Separation of oxidation products from shellac	1955	Semi-carbazone of an aldehydic acid appears to have been separated.	To be continued
(c) Total amount of aleuritic acid present in shellac	1955	Percentage of aleuritic acid was 33-36 for shellac and 31-36 for seedlac. Results suggest that adjacent -OH groups of aleuritic acid do not undergo change in contact with excess of alkali.	To be continued
(iii) Fractionation of aleuritic acid	1955	Existing data suggest aleuritic acid to be a mixture of isomeric acids. Two crops of crystals have been obtained and are under study.	To be continued
(iv) Separation of aldehydo-lactonic acid and shellolic acids from *Kusmi* shellac	1955	Following separation by solvent extraction, further separation through insoluble- and soluble-lead salts effected. An aldehydic acid reported to have been separated elsewhere appears to be not a single acid, but a mixture. Kamath's claim regarding separation of a component of lac resin containing a carbonyl group is being investigated.	To be continued
(v) Paper chromatography	1954		
(a) Hydroxy acids	...	R_f values determined.	Circular paper chromatography started
(b) Shellac and rosin	1955	R_f values so far recorded do not appear to be very different.	
(vi) Loss on acid precipitation of shellac from alkali carbonate solution	1955	Loss amounted to 8-10% and is found to be due in part to the removal of acidic part (a highly soluble aldehydic acid) from shellac.	To be continued
2. Physico-chemical studies on lac			
(i) Osmotic pressure of shellac solutions	1955	Measured with cellophane membranes: reproducible results not obtained.	To be continued
(ii) Dissociation constants of free acids contained in shellac, and hard and soft lac resin	1955	Neutralization curves obtained with electronic *p*H meter, and values recorded.	
(iii) Specific heat of shellac	1938-40 Measurements *de novo* 1954	A newly designed rectangular calorimeter which is superior to the cylindrical type used previously in some respects, was employed: sp. heat over the range 20°-105°C. and m.p. determined.	Complete

APPENDIX I (*Contd.*)

Item	Year of Commencing the experiments	Progress	Future work/Remarks
(iv) Fractionation of polyesters of diacid from aleuritic acid	1955	Diacid prepared and purified as a preliminary to thermal polymerization.	
3. Standardization, grading and Analysis			
(i) Determination of the bleach-index/bleachability of seedlac	1952		
(a) The (new) Institute method	1955	Bleach-index determined by using 60, 70, 80, 100 and 120 cc. of bleach liquor. Bleach-index against colour ratio plotted on a semi-log scale.	
(b) Use of Photo-electric colorimeter	1955	Photo-electric colorimeter can be used and has some advantages, e.g. elimination of eye-fatigue, personal element, and the necessity to prepare repeatedly standard iodine solution.	
(ii) Acid value of bleached lac using aqueous alkali	1955	Practically same values are obtained by using either aqueous or alcoholic alkali.	
(iii) A rapid method for the determination of the iodine value of lac	1955	A new method using hypochlorous acid as reagent and having certain advantages over the current method has proved successful in case of many organic compounds. When applied to lac, it did not work satisfactorily, probably because of the bleaching action of HOCl on lac.	
II. Applied			
1. Varnishes, lacquers and paints			
(i) Ageing properties of shellac linseed oil paints	1946	Indoor surfaces painted 8 years back keeping quite well.	
(ii) Oil cloth	1946-47	Oil cloth of usual commercial widths (52-54 in.) prepared in a factory. Though better in several respects, it costs 3-4 annas more per yard, and hence not favoured in the market.	
(iii) Shellac-based anti-corrosive and anti-fouling paints	1953	Anti-fouling composition failed on sea-immersion tests. Anti-corrosive composition appears to be promising.	To be continued
(iv) Shellac-rosin-glycerine varnish	1953-54	Large-scale preparation gave composition satisfactory in every respect except oil resistance. Laboratory samples satisfied this also. The matter is being looked into.	To be continued
(v) Lac-*Kamala* oil combination	1955	Lac is not compatible with *Kamala* oil but combines with the fatty acids from *Kamala* oil: Too rapid polymerization on heating lac and *Kamala* oil fatty acid prevents sufficient amounts of fatty acid from combining with lac. Using monoglycerides in place of fatty acids, clear resin was obtained, film property of which was not good.	To be continued

APPENDIX I (*Contd.*)

Item	Year of Commencing the Experiments	Progress	Future Work/Remarks
2. Improvements of manufacture of seedlac, shellac, bleached lac, etc.			
(i) Making shellac by alkali extraction method	1953	Dissolution of seedlac in 10 per cent soda solution followed by acid (HCl) precipitation gave a product with rather bad flow and poor life. Using H_2SO_4 in place of HCl, life improved, but flow worsened. Flow could be improved by grinding in a ball mill followed by thorough washing, but the colour deteriorated. Attempts to improve colour did not quite succeed. Different acids/alkalis were tried also.	To be continued
(ii) Making seedlac and shellac of low bleach number	1954	Use of small quantity of NaOH in washing gave a seedlac of low bleach number. This had good keeping quality (9 months' observed). Various oxidizing agents were also tried (H_2O_2, $KMnO_4$, Na perborate). Use of borax with NaOH also gives good results, and is to be tried on large-scale production. A new washing barrel also designed.	
(iii) Separation of sand from seedlac	1955	Previous experiments used brine, which is not easily available everywhere. A mechanical system using a conical vessel with a rotating stirrer inside has been devised which effects separation, taking advantage of the different sp. gr. and hence different centrifugal forces coming into play. Large-scale trials are being arranged in a factory.	To be continued
(iv) Studies on bleached lac			
(a) Distribution of samples for different uses	1955	(i) Use in fixing kymograph successful. (ii) Uses in other fields also reported satisfactory (inland and abroad).	
(b) Stability of bleached lac during export	1955	A few lb. sent to U.K. by sea and also returned by sea did not suffer any deterioration in course of journey of some 3 months.	
(c) Preparation of refined (i.e. wax-free) bleached lac	1955	Seedlac is dissolved in soda solution, heated to 60°-70°C. Wax floats on the surface and is removed. "Dewaxing" operation finished, bleaching schedule may be followed as usual.	
(d) Bleaching lac with alternative bleaching agents (sodium chlorite)	1955	The product could be improved by increasing the amount of sodium chlorite, in respect of flow and life under heat. It was, however, soft, and tended to coalesce and adhere to containers.	

APPENDIX I (*Contd.*)

Item	Year of Commencing the Experiments	Progress	Future Work/Remarks
(e) Colour retention of bleached lac varnishes	1955	Spirit varnishes tested at intervals of 6, 15 and 18 months found to retain colour and A.V. practically unchanged. Some drop in A.V. occurs during the first few months.	To be continued
(f) Variation in *p*H during the bleaching of lac	1955	*p*H values determined in course of the several operations involved in bleaching. Optimum values corresponding to each stage have been found as a result.	To be continued
(v) Bleaching of shellac wax	1955	The wax was treated with various acids (H_2SO_4, HNO_3), exposed to sunlight but to no effect. H_2O_2 or chlorine bleaching improved the colour: the latter is to be further tried.	To be continued
3. Miscellaneous uses of lac and associated products			
(i) Modification of shellac wax	1955	To improve it to the level of carnauba wax, shellac wax was sought to be mixed or combined with bees wax, damar, rosin, oils, etc. Satisfactory results not obtained.	To be continued
(ii) Cement for electric bulb-caps	1951	Frequent changes in specifications necessitated several modifications of the composition. The latest composition stands boiling water *cum* torque test for ½ to 1 hr. It is better than imported bakelite cement, and slightly inferior to a Japanese one. This is being tried in some firms. The cement proved very good for joining (mending) broken porcelain articles: few apparatuses have been successfully mended.	
(iii) Micanite boards and micanite V-rings	1955	A shellac adhesive for micanite boards with details as to the mode of its use has been worked out.	To be continued (micanite V-rings and tubes)
(iv) Adhesive for brush bristles	1955	Alcoholic solution of lac mixed in the cold with some hardener has given promising results.	To be continued
4. *Ad hoc* work			
(i) Varnish for prevention of tarnishing of brass and copper	1955	A varnish based on dewaxed decolourized lac worked satisfactorily (observation so far more than a year).	
(ii) Lacquering sticks for wooden toys, from bleached lac	1955	Bleached lac fused with rosin (& plasticizer) and pigmented. Worked satisfactorily.	
(iii) Tailoring cloth	1955	Waterproof muslin cloth made by dipping in bleached lac/spirit solution. It is slightly inferior to an English make.	
(iv) Coloured sand	1955	Lac-based composition could be evolved (The colour resists sea or tap-water).	

APPENDIX I (*Contd.*)

Item	Year of Commencing the Experiments	Progress	Future work/Remarks
(v) Shellac metal lacquers	1955	The lacquer for aluminium foils formulated. The films are rather slow-drying and folds get stuck in patches.	
5. Experimental regional testing lab.	1955	282 samples from 40 parties for 377 tests received. Results compared with those of commercial analysis.	
III. Propaganda and Publicity (Utilization of lac)		Work continued on the previous lines by S.U.O.	

APPENDIX II

List of publications during 1955-56

1. Hindi Prachar Patra No. 3 — Indian Lac Cess Committee: Activities and Achievements.
2. Lac and Lac Products: 3rd reprint with revision.
3. I.L.R.I. Bulletin No. 85 — Polyesterification of Polyhydroxy-polybasic acid: Part II — Studies on physico-chemical properties, by P. R. Bhattacharya (*J. sci. industr. Res.*, Vol. **14B**, No. 8, 1955).
4. Bionomics and Control of *Tessaratoma javanica* (Thunberg), a sporadic pest of *Kusum* (*Schleichera oleosa*) in Chota Nagpur, by B. P. Mehra & A. P. Kapur (*Indian Journal of Entomology*, Vol. **XVII**, Pt. I, April 1955).
5. I.L.R.I. Bulletin No. 86 — Polyesterification of Polyhydroxy-polybasic acid: Part III — Solution Characteristics, Precipitability and Solubility, by P. R. Bhattacharya (*J. sci. industr. Res.*, Vol. **14B**, No. 9, 1955).
6. Research Note No. 38 — Oxidation of shellac by Periodic acid, by S. C. Sen Gupta (*J. sci. industr. Res.*, 1955, Vol. **14B**, No. 10).
7. Technical Note No. 11 — Manufacture of sealing wax, by T. Bhowmik.
8. Bulletin No. 87 — A simple method for the forecast of emergence of lac larvae, by P. S. Negi (Reprinted).
9. Bulletin No. 23 — Some simple methods of reducing the damage done by insect enemies to the lac crop, by P. M. Glover (Reprinted with revision).
10. Bulletin No. 51 — Directions for the demonstration staff, by P. S. Negi (Reprinted with revision).
11. On some serious seasonal and forced predatory enemies of lac, by S. Krishnaswami, N. S. Chauhan & P. S. Negi (*Proc. 43rd Ind. Sci. Cong.*, Part III, Abstracts).
12. Separation and Identification of hydroxy acids present in shellac by paper chromatography, by S. C. Sen Gupta (*Proc. 43rd Ind. Sci. Cong.*, Part III, Abs. No. 204).

APPENDIX III

Production of sticklac in India during 1955-56 (in maunds).

Year	*Baisakhi*	*Jethwi*	*Katki*	*Aghani*	*Total*
1955-56	8,13,000	41,000	2,93,000	61,000	12,08,000
1954-55	6,00,000	45,500	2,29,000	1,58,000	10,33,000
1953-54	4,26,500	15,500	1,61,000	51,000	6,54,000

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