INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1952-53

1954

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ADMINISTRATIVE AND GENERAL

General — The Institute pursued its research and other activities as programmed. A major change in the administrative set-up in the Institute during the period was the transfer of accounts and certain other items of administrative work to the Office of the Secretary, Indian Lac Cess Committee. The new set-up had been in contemplation for some time past, and was finalized during the year.

Dr. P. K. Bose, Director of the Institute, had been away from Namkum for about 3 weeks in June-July 1952 leading the Indian delegation to the meetings of the International Organization for Standards, held in New York, to finalize the international draft specifications on lac. While abroad, the Director contacted important sections of lac trade and lac-consuming industries in the U.S.A. and the U.K. to learn first-hand of the present conditions and the future prospects of lac in those countries. He submitted a report to the Committee on his return to Namkum. The Director had also been absent from Namkum on a few weeks' leave during February-March 1953. In the absence of the Director, Dr. A. P. Kapur, Entomologist, held charge of the current administrative duties of the Institute.

The new UNESCO coupons scheme (scientific materials) proved very helpful in the procurement of scientific apparatus, particularly from the hard-currency areas. The Institute had purchased under this scheme a laboratory hydraulic press, which would have been difficult to obtain otherwise.

As usual, the Institute attracted a large number of visitors from all over the country. A few of the distinguished visitors, deserving special mention, are named below:

1. His Excellency Sri R. R. Diwakar, Governor of Bihar
2. Hon'ble Sri M. P. Sinha, Minister for Industries, Bihar
3. Sri Q. Huda, Development Secretary, Bihar
4. Sri S. M. Ali, Director of Industries, Bihar
5. Sri M. P. Sinha, Deputy Commissioner, Ranchi
6. Sri R. K. Rao — Members, Finance Commission
7. Sri N. K. Mehta — Members, Finance Commission
8. Sri B. K. Madan — Members, Finance Commission
9. Sri M. V. Rangachari — Members, Finance Commission
10. Sri M. P. Misra, M.P.
11. Sri A. P. Sinha, M.P.

Roads and Buildings — Minor petty repairs to roads and buildings during the monsoon were done by the C.P.W.D. Annual whitewashing of the office and laboratory buildings as well as of the staff quarters was done by the same body. Minor repairs to the roads were also carried out.

The construction of four staff quarters and a trainees' hostel, sanctioned in 1951, commenced during the latter half of the period. The work had not been finished by the end of March 1953. Meanwhile, the shortage of staff quarters continued to be acute. It is feared that the position is not likely to improve substantially even when these quarters are completed, for a considerable number of new posts has been created following the recommendation of the Reviewing Committee (*vide* previous report). Construction of additional quarters appears essential if new employees, about to join, are to be accommodated at Namkum.

Following a directive from the Committee, Director's office has been shifted to a residential building and the rooms so vacated have been allotted to the Entomological Section. The Director and his Technical Assistant continue to occupy the same rooms as before. Plans for the new Administrative Block are being prepared by the C.P.W.D. Till the new block is constructed, the present arrangement would continue.

Water Supply — The question of renovating the water works of the Institute, which was to be given priority, is still pending. The C.P.W.D. is understood to have submitted a detailed plan after an on-the-spot survey; but the actual work of assembling materials, laying pipelines, etc., is yet to commence. The urgency of changing the pipeline should be apparent from the fact that the old pipes have corroded so badly as no longer to be able to stand even the strain of occasional repairs.

Library — After remaining vacant for well over two years, the post of the Librarian was filled in September 1952. Till the recruitment of the Librarian, the library had been looked after by Sri B. Mukhopadhyay, Technical Assistant to the Director, at first alone, and later on with the assistance of a temporary Junior Clerk, especially appointed for the purpose.

The library registered during the period a total accession of 178 volumes of books and bound volumes of journals in addition to a large number of miscellaneous pamphlets, received in exchange and otherwise from various sources. 3,300 copies of Institute's own publications were sold or distributed during the period.

A revised (second) edition of *A Handbook of Shellac Analysis* was published during the period, all copies of its previous edition having been exhausted. As would appear from its reviews in various journals, the new edition has been well received by the technical press of the world.

Training — An important change to note under this is the introduction of a uniform scale of fees for all trainees in the industrial uses of lac. The fee for the complete course, which was Rs. 25/- only for nominees of shellac trade and Rs. 150/- for others, has now been fixed at Rs. 50/- for all. This reduced scale of fees, coupled with accommodation facilities which will be offered soon on completion of the hostel, will go a long way towards popularizing the course.

The number of candidates who underwent full or partial training in lac cultivation during the year was 19; of these ten qualified themselves for the Committee's certificate of proficiency, awarded on completion of successful training.

One student completed his full course of training in the industrial uses of lac. A few industrial concerns deputed their staff to undergo training in the analysis and grading of lac for short periods. In addition, a State scholar from Burma received three months' training in the Chemical Section of the Institute.

Staff — With the transfer of accounts work to the office of the Secretary, Indian Lac Cess Committee, the post of Head Clerk for the Institute has been abolished, and a post of Assistant-in-charge on a reduced pay scale created in its place. The post of Accounts Clerk has also been abolished, resulting in the net reduction of the ministerial cadre by one post.

The following appointments were made during the period:

1. Sri G. Patra, M.Sc., Research Assistant (Physical Chemist), on 5-1-53.
2. Sri B. Purakayastha, B.Sc., Arboricultural Assistant, on 10-1-53.
3. Sri B. N. Sen, B.Sc., Librarian, on 16-9-52.
4. Sri Amrit Lal Paul, Temporary Junior Clerk (Library), on 4-8-52.
5. Sri Ram Lakhan Singh, Artist and Photographer, on 15-9-52.
6. Sri Bimal Chandra Sen Majumdar, Temporary Junior Clerk, on 20-2-53.

7. Sri Bimalendu Sen Gupta, Temporary Junior Clerk, on 4-3-53.
8. Sri Abdul Motalib, Night Chowkidar, on 17-6-52.
9. Sri Prayag Mahto, Chowkidar (Plantation), on 21-10-52.
10. Sri Daniel Tirkey, Chowkidar (Plantation), on 21-10-52.
11. Sri Budhua Uraon, Temporary Peon, on 15-12-52.
12. Sri Sadho Uraon, Temporary Bullock Keeper, on 26-4-52.

The following persons left the services of the Institute during the period :

1. Dr. G. N. Bhattacharya, D.Sc., Scientific Officer, on 4-8-52.
2. Sri B. V. Somayajulu, M.Sc., on 1-5-52.
3. Sri S. C. Das, Instrument Maker, on 16-3-53.
4. Sri S. K. Chatterjee, Temporary Clerk (Library), on 27-7-52.
5. Sri Amrit Lal Paul, Temporary Clerk (Library), on 16-9-52.
6. Sri Sadho Uraon, Temporary Bullock Keeper, 28-6-52.
7. Sri S. P. Roy Chowdhury, B.A., Stenographer to the Director, I.L.R.I., expired on 9-10-52 at Calcutta. Noted as much for his friendliness towards all as for his efficiency in the discharge of his official duties, his death was deeply mourned by all members of staff.

Staff Club — A drastic cut in the Committee's grant to the Namkum Staff Club has already been reported. While the possibility of restoring the cut is being explored, the club has completely exhausted its previous savings. It appears doubtful if without substantial aid from the Committee, the club will at all be able to function in the future.

ENTOMOLOGY SECTION

(Dr. A. P. Kapur, Entomologist)

INTRODUCTION

The approved revised programme of research for the Entomology Section was received during the period under report and efforts were made to switch over to this programme as early as possible. Additional accommodation, made available in the early part of 1953, removed much of the congestion in the entomological laboratory. The post of Artist and Photographer, which had remained vacant for six months, was filled up in September 1952 and the temporary post of Arboricultural Assistant in January 1953. Sri P. S. Negi, Scientific Officer, returned from leave in August 1952.

1. TRAINING AND ADVISORY SERVICE

Training — In all 19 persons had been receiving training in lac cultivation during the period under report. Of these, three trainees (Demonstrators) from Bihar left the course incomplete after attending for about a month. One Lac Inspector from Bihar was deputed to attend a short course of 6 months and the rest full one year's course. Ten trainees completed the course successfully and have since taken up duties in their respective States as follows:

Madhya Pradesh	Forest Range Officer	1
	Dy. Forest Range Officers	2
	Foresters	2
Bihar	Lac Inspector (6 months' course)	1
	Lac Demonstrators	3
Uttar Pradesh	Lac Demonstrator	1

At the end of March 1953, six trainees were left on the rolls: four from Bihar, and one each from Uttar Pradesh and the Jammu and Kashmir State.

Advisory service — Advice was given to various institutions and persons interested in lac cultivation, whenever asked for. Advice and assistance in technical matters were given to the Special Officer for Lac Cultivation, including reports on examination of lac samples, and forecast of emergence for the various crops. Scientific staff of the Section were also deputed on tours to help him in lac extension work in Uttar Pradesh.

Exhibits and specimens of lac and related insects were sent to some educational and other institutions. Nearly 500 visitors were shown round the Museum, etc., and a few college and school parties (including Forest Schools) given lectures and taken round the plantation and laboratories. Part was also taken in several rural exhibitions held in the lac-growing areas of Bihar.

2. RESEARCH AND INVESTIGATIONS

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

(i) *Large-scale experiments on preserving* Baisakhi *broodlac on* palas *by partial defoliation at Kundri plantation of the Forest Department, Bihar* — Cultivation of lac by the coupé system and large-scale trial of the method of preserving broodlac from the *Baisakhi* crop by partial defoliation of *palas* were continued by the Forest Department under the technical assistance of this Institute. The area containing nearly 30,000 trees is divided into a *Katki* (smaller : No. II) and two *Baisakhi* (large : Nos. I and III) coupés, the last two being brought under lac cultivation in alternate years. In July 1952, 107 maunds 20 seers of broodlac were obtained and a substantial quantity of the same left on such trees as had infectable shoots, with a view to getting extra broodlac in October 1952. Nearly 20 maunds of broodlac were sold and the rest utilized in infecting 2,451 trees in the *Katki* coupé II. The rejected lac and the *phunki* (brood left after the swarming was over) gave a total of 80 maunds 8 seers of scraped lac.

Of the *Katki* crop obtained in October 1952, 63 maunds 32 seers of broodlac were obtained from coupé II and 168 maunds 28 seers from coupé III referred to above, and the entire quantity used in infecting trees in coupé I for the next (1952-53) *Baisakhi* crop. Scraped lac obtained from *phunki* and the rejected lac amounted to 21 maunds and 21 seers. Thus an all-round progress was maintained at Kundri.

(ii) *Residual effect of repeated partial defoliation of* palas *on lac production* — Experiments have been laid out at the Institute's plantation, Namkum, and at Kundri. At Namkum 20 trees of *palas* were selected for growing *Baisakhi* 1952 crop and the same number selected in another plot for *Baisakhi* 1953 crop. Subsequent *Baisakhi* crop would be grown alternately in these two plots. Of the 20 trees in the former plot ten trees, chosen at random, were partially defoliated prior to infection and the other ten infected without defoliation on 23rd October 1952, and the crop harvested on 27-28th June 1952. The results obtained were as follows:

Particulars	Undefoliated	Defoliated
No. of trees infected	10	10
Quantity of brood used	10 srs.	18 srs. 10 ch.
Quantity of total yield of lac	1 md. 11 ch.	2 mds. 2 srs. 4 ch.
Ratio: brood applied to yield obtained	1:4·06	1:9·53
Quantity of broodlac obtained	37 srs. 2 ch.	1 md. 35 srs. 13 ch.
Percentage of selected broodlac	91·25	92·17

At Kundri, two blocks, each containing 100 trees of *palas*, were marked for the *Baisakhi* 1952 crop and, as in the above case, one block of 100 trees was infected after partial defoliation and the other infected without defoliation in October 1951. The crop was harvested in July 1952 and the following results obtained:

Particulars	Undefoliated	Defoliated
No. of trees infected	100	100
Quantity of broodlac used	1 md. 19 srs. 12 ch.	1 md. 10 srs. 8 ch.
Quantity of total yield of crop	7 mds. 8 srs. 10 ch.	5 mds. 8 srs. 10½ ch.
Ratio: brood applied to yield obtained	1:4·83	1:3·80
Percentage of selected broodlac	10·90	26·26

Kundri being a notoriously hot and dry place during summer, there the problem of preserving *Baisakhi* broodlac is rather acute. Moreover, these trees have been partially defoliated for the past several years. The differences as regards the percentage of selected brood in the two treatments are rather marked and the yield figures are also different from those obtained at Namkum. Both these experiments will have to be repeated for a number of years before the residual effect of partial defoliation on lac production could be determined.

(b) Finding of, and Trials on, Suitable Lac Hosts for *Baisakhi* Crop Including Certain *Ficus* and *Albizzia* Species

At Namkum *Albizzia lucida* (*galwang*), *Ougeinia dalbergioides* (*pandan*), *Ficus cunia* (*porho*) and *Samanea saman* (rain tree) were under trial for the purpose of determining their brood preserving qualities during the hot weather. The results obtained were as follows:

Particulars	*A. lucida* (6 trees)	*O. dalbergioides* (26 trees)	*F. cunia* (5 trees)	*S. saman* (1 tree)
Ratio of broodlac used to yield of lac	1 : 8·0	1 : 4·9	1 : 8·87	1 : 2·8
Ratio of scraped lac from brood to yield of scraped lac	1 : 8·9	1 : 10·9	1 : 8·6	1 : 3·0
Percentage of selected broodlac in the total yield of lac	52·27	63·09	77·08	76·37

A. lucida and *O. dalbergioides* have been under trial for the last seven years and have given satisfactory results. *Ficus cunia* has also given good results for the last two years and is being further tried for the current *Baisakhi* crop. The progeny of broodlac obtained from these hosts also takes well on the common *Katki* hosts, namely *ber* and *palas*. It is recommended that wherever possible *galwang*, *pandan* and *porho* should be put under *Baisakhi* crop.

(c) DETERMINATION OF THE MOST SUITABLE PRUNING METHODS AND SEASONS FOR *Kusum* (*Schleichera trijuga*)

The object of this study is to evolve a pruning method by which suitable shoots for cultivating lac on them would be produced in the shortest possible time. Four treatments are under trial: (I) 'Apical pruning' (cutting the main branches near the apices) with 18 months' interval of rest between pruning and infection; (II) in the second treatment this interval has been reduced to 12 months. Another kind of pruning designated as 'surface pruning' (*Annual Report*, 1947-48) was tried to see if suitable number and kind of branches could be produced. In treatments III and IV surface pruning was practised with 12 and 6 months' interval of rest respectively.

(i) *Shoot study*: *Number and growth of shoots from January-February* 1952 *to January-February* 1953 — Observations were taken fortnightly on the number of buds that appeared and developed into shoots on a previously marked branch to be referred to hereafter as the "main shoot". Length and girth of these shoots were also recorded at fortnightly intervals and a summary of the observations made during the period mentioned above is given in the following paragraphs and in Table I (pp. 7-8).

Treatment I: 18 *months' interval of rest — apical pruning* — For this treatment four trees are under observation, two (tree Nos. 14 and 134) being cropped in January-February and two (tree Nos. 180 and 124) in June-July each year. In the former set of trees, tree No. 134 was cropped in January 1952 and No. 14 in January 1951. During the active period of growth, March and April 1952, the secondaries attained some length in tree No. 14 and tertiaries also developed and attained their maximum length by September 1952. In tree No. 134 (cropped in January 1952) primary buds started coming out in late February and early March and the shoots arising from these attained their maximum length by the end of March 1952. Due to damage to primaries, 3 secondary shoots developed during the second active period from July to September. Though some tertiary buds developed during the latter period, these did not form shoots. Fresh set of tertiaries, however, developed in February 1953.

Behaviour of the shoots on trees cropped in June-July was as follows: In tree No. 124, which was cropped in July 1951, the primary shoots did not show any further growth during February-April 1952. However, the secondary shoots appeared towards the end of the first week of April 1952 and continued to grow up to the third week of June 1952 when most of the thin tip-buds had fallen. The tertiaries started coming up in the middle of August and practically all of these attained their maximum lengths by the end of September 1952. In tree No. 180 (cropped in July 1952) buds appeared on the main branch at the end of August and all the five buds developed into shoots, the growth of which continued up to the middle of September. There was practically no linear growth up to the end of November when a few secondary buds developed on damaged portions of some primaries. Simultaneously four more primary buds appeared, but neither these nor the fore-mentioned buds had developed into shoots up to the end of February 1953.

TABLE I — RESULTS OF SHOOT STUDY FROM JANUARY-FEBRUARY 1952 TO JANUARY-FEBRUARY 1953

Tree No.	Date of cropping	Primaries: Buds sprouted and developed into shoots, %	Primaries: No. of shoots	Primaries: Length in inches, average (range)	Secondaries: Buds sprouted and developed into shoots, %	Secondaries: No. of shoots	Secondaries: Length in inches, average (range)	Tertiaries: Buds sprouted and developed into shoots, %	Tertiaries: No. of shoots	Tertiaries: Length in inches, average (range)	Remarks on larval settlement and lac encrustations
1	2	3	4	5	6	7	8	9	10	11	12
Treatment I											
14	3-2-51	100·5	5	6·55 (2·25-12·6)	61·5	8	2·15 (0·25-8·0)	100·0	6	4·16 (0·5-7·5)	*Tree No.* 14: *Cropped in Jan.* 1953 — None of the primaries have got any encrustation, neither the secondaries. Tertiaries also do not have any because all lac insects which had settled were at an early stage.
124	4-7-51	45·7	16	4·61 (0·75-10·5)	94·4	17	7·9 (0·5-19·0)	100·0	10	3·25 (0·25-11·0)	*Tree No.* 124: *Infected in Jan.* 1953 — Three primaries are covered with lac larvae. Only 6 secondaries have got sparse and scattered settlement. Only one tertiary has very sparse settlement.
134	24-1-52	23·8	5	3·4 (2·25-5·5)	60·0	3	7·9 (6·5-9·75)	Few tertiary buds developed at the end of May but did not grow into shoots			*Tree No.* 114: *Cropped in Jan.* 1953 — Only 3 primaries have got encrustation in one of which it is good and in the other two dead and immature cells excepting few well-developed cells. Five secondaries have fairly good encrustation and one has scattered.
180	1-7-52	55·5	5	4·15 (2·25-6·75)	8 secondary buds noticed						
Average				4·65			6·25			3·59	
Treatment II											
36	28-6-52	100·0	4	3·8 (3·25-4·5)	No secondaries						*Tree No.* 161: *Infected in Jan.* 1953 — Three primaries have got partial settlement of lac larvae. Very good settlement has taken place on all the secondaries. Only 1 tertiary has got no settlement.
114	5-7-51	21·05	8	3·37 (1·0-8·0)	77·0	10	6·4 (2·25-18·5)	No tertiaries			*Tree No.* 128: *Cropped in Jan.* 1953 — Only 1 primary has got about half a dozen immature cells. Two secondaries have good encrustation though partial. No encrustation on the tertiaries.
161	21-1-52	41·6	5	10·9 (3·25-23·5)	55·5	5	6·1 (1·5-10·25)	75·0	3	5·08 (2·5-7·75)	
Average				5·43			6·3			5·08	
Treatment III											
42	25-5-52	100·0	5	11·05 (0·5-27·5)	No secondaries						*Tree No.* 190: *Infected in Jan.* 1953 — Exceptionally good settlement of lac larvae has taken place on all the primaries and secondaries.
128	8-7-51	100·0	2	5·75 (3·0-8·15)	83·3	5	10·4 (2·25-18·5)	83·3	5	2·9 (1·0-6·25)	*Tree No.* 70: *Cropped in Jan.* 1952 — Three primaries have got encrustation of which in one it is quite good and in the other two parts is dead and immature.
190	22-1-52	100·0	4	4·56 (3·0-8·75)	100·0	6	3·75 (2·5-5·5)	Only one tertiary bud developed			*Tree No.* 214: *Infected in Jan.* 1953 — No settlement of lac larvae has taken place.
Average				7·72			6·77				
Treatment IV											
70	18-1-52	100·0	5	2·6 (1·0-4·75)	No secondaries						
214	26-6-52	40·0	2	4 (3·75-4·25)	No secondaries						

Treatment II: 12 *months' interval of rest — apical pruning* — For this treatment 3 trees are under observation. In tree No. 36 (cropped on 28-6-52), four buds appeared on the main branch in late August and developed into 4 primary shoots which attained their maximum length by the middle of September. In tree No. 114 (cropped on 5-7-51, earlier growth of shoots already reported), there was no further growth of primaries in the active period, March-April 1952, but the secondary shoots developed and attained their maximum length by the end of March 1952. No further growth took place in any shoots and no tertiary shoot appeared. In tree No. 161 (cropped on 21-1-52), 3 primary shoots attained their maximum length by the end of April. Two more primary shoots appeared at that time and continued to grow till the end of June when the secondary shoots began to develop. Their growth continued till the second week of September. The tertiary shoots came out at the end of August and ceased to grow after the middle of September.

Treatment III: 12 *months' interval of rest — surface pruning* — For this treatment also 3 trees are under observation. In tree No. 42 (cropped on 25-6-52), the primary shoots developed in early part of August and in most cases attained their maximum length by the middle of August. The secondary shoots have not appeared till the end of February 1953. In the case of tree No. 128 (cropped on 8-7-51), a report on the earlier growth period was given in last year's report. During March 1952 there was a slight increase in the length of primary and secondary shoots. Due to damage to tip-buds of the secondaries, a set of tertiary shoots developed in later part of March and attained their maximum length by the first week of April. In tree No. 190 (cropped on 22-1-52), primary shoots developed in the middle of March and continued to grow till the end of first week of April. Further growth took place in the later part of May when two more primary shoots also appeared and continued to grow till the middle of June. Secondary shoots started coming out in the first week of September and attained their greatest length by the end of the month.

Treatment IV: 6 *months' interval of rest — surface pruning* — For this treatment 2 trees are under observation. In tree No. 70 (cropped on 18-1-52), buds appeared on the main shoot towards the end of April and primary shoots developed very late towards the end of May 1952. By the middle of June three more new shoots had developed and all the five primaries continued to grow till July 1952 and the shoots remained short. No secondary shoots developed. In tree No. 214 (cropped on 26-6-52), the buds on the main shoots were not noticed until the middle of September and the two primary shoots appeared in the middle of October and continued to grow till the end of the month, the total growth being $3\frac{3}{4}$ and $4\frac{1}{4}$ in. At the end of October one bud, and at the end of November, three buds were noticed, but these did not develop into shoots. No secondary shoots were observed.

(ii) *Yield of lac* — The ratio of broodlac used to yield of lac based upon weights of scraped lac in each case obtained for the *Jethwi* 1952 and *Aghani* 1953 crops from the trees receiving the above-mentioned four treatments is given in Table II.

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

Treatment		*Jethwi* (1952) crop		*Aghani* (1953) crop	
No.	Interval of rest and type of pruning	No. of trees	Ratio of broodlac used to yield	No. of trees	Ratio of broodlac used to yield
I	18 months: apical	18	1: 3·18	23	1: 0·90
II	12 months: apical	16	1: 1·96	15	1: 1·80
III	12 months: surface	13	1: 2·18	17	1: 2·06
IV	6 months: surface	15	1: 1·16	19	1: 1·30

A similar experiment with statistical layout was commenced in February 1951 and continued during the period under report. These trees compared favourably with one another in size, etc. The results together with their statistical analysis, kindly undertaken by the Crop Statistician of the Indian Lac Cess Committee, are given in Table III.

TABLE III — CROP COMPARISON ON THE BASIS OF YIELD

Treatment No.	Treatment: Interval of rest and type of pruning	*Jethwi* (1952) crop: No. of Trees	*Jethwi* (1952) crop: Ratio of broodlac used to yield	*Aghani* (1953) crop: No. of Trees	*Aghani* (1953) crop: Ratio of broodlac used to yield
I	18 months: apical	172	1: 3·69	19	1: 0·4659
		173	1: 4·21	22	1: 1·1312
		175	1: 5·57	25	1: 0·8621
		176	1: 1·90	27	1: 0·6250
		Total	15·37	Total	3·0842
		Mean	1: 3·8425	Mean	1: 0·77105
II	12 months: apical	35	1: 2·41	113	1: 3·2592
		38	1: 2·20	115	1: 0·6875
		39	1: 2·49	117	1: 0·2727
		40	1: 1·28	118	1: 1·4000
		Total	8·36	Total	5·6194
		Mean	1: 2·09	Mean	1: 1·40485
III	12 months: surface	31	1: 0·99	129	1: 2·3636
		43	1: 1·00	130	1: 0·9545
		48	1: 0·91	131	1: 0·2857
		50	1: 2·00	133	1: 0·4545
		Total	4·96	Total	4·0583
		Mean	1: 1·24	Mean	1: 1·01453
IV	6 months: surface	203	1: 1·04	61	1: 0·1875
		207	1: 0·94	63	1: 0·0000
		208	1: 1·53	75	1: 0·0000
		209	1: 0·84	79	1: 0·2424
		Total	4·35	Total	0·4299
		Mean	1: 1·0875	Mean	1: 0·10750

Jethwi 1952

Analysis of variance

	S.S.	D.F.	M.S.	F.
Between treatments	19·18505	3	6·395016	8·5281
Within treatments	8·94180	12	0·74515	—
Total	28·12685	15	—	—

Conclusion: Treatment effects are highly significant at 5 and 2 per cent levels; treatment I is significantly superior to the remaining three which do not differ significantly among themselves. At 1 per cent level treatment I is superior to III and IV only. 5 and 2 per cent level: I, II, III, IV. 1 per cent level: I, II, III, IV.

Aghani 1953

Analysis of variance

	S.S.	D.F.	M.S.	F.
Between treatments	3·5596	3	1·1815	1·7353
Within treatments	8·2036	12	0·6836	—
Total	11·7632	15	—	—

Conclusion: Treatment effects are insignificant at both 5 and 1 per cent levels. The S.E. of difference between means of any two treatments=0·5846. There is a significant difference only between treatments II and IV. At 5 per cent level: II, III, I, IV. At 1 per cent level: II, III, I, IV. There is no evidence of any beneficial effect due to treatments though treatment II appears to be slightly superior to treatment IV.

(iii) *Yield of broodlac: percentage of broodlac in the total yield of crop in the four treatments* — Successful pruning aims at producing shoots that would not only produce more lac but also more broodlac because any shortage of brood in one crop would seriously affect the production in the next crop. It has been often observed that the lac encrustations towards the apex of tender shoots contain mostly dead insects and the resulting crop yields relatively lesser quantity of broodlac. In order to judge the effect of the four different pruning treatments from the above-mentioned point of view, careful selection of broodlac was made from the crop obtained from each tree. The data collected and the analysis of the results are shown in Table IV. It may be remarked that both the *Jethwi* and *Aghani* crops were poor in Chota Nagpur during the period under report and the same condition was observed on some of the experimental trees.

TABLE IV — PERCENTAGE OF SELECTED BROODLAC

Treatment	*Jethwi* (1952) crop		*Aghani* (1953) crop	
	Tree No.	Percentage brood	Tree No.	Percentage brood
I	172	31·57	19	11·11
	173	59·01	22	40·00
	175	54·70	25	20·63
	176	22·44	27	8·00
	Total	167·72	Total	79·74
	Mean	41·93	Mean	19·935
II	35	17·41	113	50·00
	38	23·57	115	26·66
	39	14·75	117	0·00
	40	20·52	118	46·15
	Total	76·25	Total	122·81
	Mean	19·0625	Mean	30·725
III	31	17·24	129	39·13
	43	29·31	130	18·51
	48	19·11	131	0·00
	50	13·10	133	0·00
	Total	78·76	Total	57·64
	Mean	19·69	Mean	14·41
IV	203	19·40	61	0·00
	207	4·91	63	0·00
	208	14·75	75	0·00
	209	16·00	79	0·00
	Total	55·06	Total	0·00
	Mean	13·765	Mean	0·00

Jethwi 1952 *crop* (*yield of broodlac*)

	Analysis of variance			
	S.S.	D.F.	M.S.	F.
Between treatments	1874·3703	3	624·7901	6·0259
Within treatments	1244·2003	12	103·6834	—
Total	3118·5706	15	—	—

Conclusion: Treatment effects are highly significant. Treatment I is significantly superior to other treatments which do not differ significantly among themselves. At 5 and 1 per cent levels: I, III, II, IV.

For the *Aghani* (1953) crop (yield of broodlac), it was not considered possible to undertake an analysis of variance on account of a large number of zero values in the results obtained. The value of the various treatments is, however, obvious from the mean percentages given above.

(d) Growing of Lac Hosts under Crop and Bush Conditions

(i) *Under crop condition*: Cajanus cajan (*syn.* C. indicus): arhar — A small number of *arhar* plants, some of which were about two years old and others only 12-15 months old, were infected at Namkum for both the *Baisakhi* (1951-52) and *Katki* (1952) crops. Unfortunately irrigation facilities were inadequate. The death rate of plants under the *Baisakhi* (8-9 months) crop was to the tune of 40 per cent, especially in the later months of insect maturity, while for the *Katki* (3-4 months) crop it was practically negligible. The results obtained are summarized below:

Baisakhi (1951-52) *crop*

Age of plants	2 years old	1 year old
No. of plants	10	31
Kind of broodlac used	*Rangeeni*, from *ber*	*Rangeeni*, from *ber*
Quantity of broodlac used	1 sr. 4 ch.	1 sr.
Broodlac obtained	10 ch.	8½ ch.
Rejected lac obtained	4 srs. 7½ ch.	3 srs. 4½ ch.
Total yield	5 srs. 1½ ch.	3 srs. 13 ch.
Ratio: brood applied to yield obtained	1: 4·07	1: 3·81

Katki (1952) *crop*

No. of plants (15 months)	20
Kind of broodlac used	*Rangeeni* from *O. dalbergioides*
Quantity of broodlac used	1 sr. 4 ch.
Broodlac obtained	1 sr. 11 ch.
Rejected lac obtained	4 srs. 5 ch.
Total yield	6 srs.
Ratio: brood applied to yield obtained	1: 4·80

In Assam where *arhar* is used extensively as lac host the plants have a longer life (3 years) than is the case in the plains (1-2 years). With the help of proper irrigation and by employing a suitable variety, it is hoped that more vigorously growing plants would be obtained in the plains also for lac cultivation. Seeds of a promising variety have already been collected from a private estate near Ranchi, and would be given trials in the coming years.

(ii) *Under bush condition*: Zizyphus jujuba (ber), Inga dulce, Flamingia congesta *and* Albizzia lucida (galwang) — Attempts are in progress to grow these plants under bush condition, where, with proper manuring and irrigation, it may become possible to induce vigorous growth of shoots for lac cultivation, especially with a view to preserving broodlac from the *Baisakhi* (summer) crop. The two last-named species have already been infected, but here again lack of irrigation facilities has been a serious handicap. Seeds of *Butea superba*, a climber type of lac host, have also been obtained for the same purpose in view.

(e) PESTS OF HOST TREES

(i) *Tessaratoma javanica* (Thunberg) — RYNCHOTA: PENTATOMIDAE — Observations on the incidence, nature of damage and life-history of this bug were continued. As was the case last year, this year also the bug appeared in smaller numbers; the peak period of its activity also remained June-July, as in the previous years.

During 1952 an adult female bug was first noticed in the field on 20-2-52 and the first two batches of 14 and 15 eggs were collected from the field on the 29th March. In the experimental cages where the various stages of the bugs were being reared, the first two batches of 4 and 12 eggs were laid on the 22nd March 1952. During the subsequent months, the population increased gradually, when in June-July, it reached its maximum and bugs were found in various stages of development. The adult bugs continued to appear in the field all through the winter. In 1953 the first batch of seven eggs in the process of hatching was collected in the field on 9th April 1953. In the experimental cages the first batch of 13 eggs was collected on 13th March 1953.

During the winter months, the adult bugs as well as the nymphs in various instars were found in the field and the same was true in the case of field cages where the life-history was under study. No eggs were laid in either case during the period between the end of October and the greater part of March. Pre-oviposition period varied considerably depending mostly upon the season when the bugs reached the adult stage. In cases where this stage was reached in the period between October and December 1951, the pre-oviposition period varied between 111 and 247 days (average for 9 = 162·4 days). In cases where the adult stage was reached between the middle of March and the middle of August 1952, the pre-oviposition period was usually short and varied between 23 and 72 days (average for 12 = 38·3 days). There were, however, two exceptions where adults emerging on 25-6-52 and 13-8-52 laid the first batch of eggs on 31-3-53 and 13-3-53, i.e. after 279 and 212 days respectively. It will be observed that in cases where the winter season intervened, the pre-oviposition period was about four times that in cases where the adults usually emerged in early part of summer.

Oviposition period and the number of eggs laid per female practically remained the same for bugs that completed egg-laying in the same summer, when they were born, and the bugs that passed through winter during the pre-oviposition period. The actual data obtained in this connection are as follows: (a) In cases where the winter intervened during the pre-oviposition period, maximum oviposition period = 97 days; minimum period = 12 days; average for 9 females = 42·0 days; (b) in cases where the winter did not intervene, maximum oviposition period = 85 days; minimum period = 11 days; average for 10 females = 52·7 days.

The fecundity or number of eggs laid per female in the two categories mentioned above was also noted. The results obtained were as follows: (a) Maximum number of eggs laid per female = 294; minimum number = 38 eggs; average for 9 females = 97·3 eggs; (b) maximum number of eggs laid per female = 200; minimum number = 28 eggs; average for 10 females = 115·9 eggs. Although the females collected from the field also laid in general the same number of eggs as the reared females referred to above, in one case a female collected from the field (after over-wintering) laid 406 eggs. Sexes were represented in the ratio of 4 females to 3 males in the reared specimens (56 examples) while in the specimens collected in the field the sexes were almost equally represented (158 females, 153 males).

Development of various stages — It was observed that majority of the bugs passed through 5 nymphal instars before reaching the adult stage. However, out of 60 individuals under observation four passed through an additional, i.e. sixth instar. Details of the duration

TABLE V — DURATION OF VARIOUS STAGES IN THE LIFE-HISTORY OF *T. JAVANICA*

Dates: Egg laying	Dates: Emergence of adults	No.	Egg to adults	Egg stage	1st	2nd	3rd	4th	5th	6th
5-4-52	7 to 21-6-52	5	63-77	9	20-26	6-9	4-7	7-9	6-25	—
7-4-52	19-6-52	1	73	14	11	11	7	13	17	—
9-4-52	11-6-52	1	63	12	9	7	10	9	10	—
10-4-52	17-6-52 13-8-52	9	68-125	13-14	16-14	6-8	5-7	7-58	16-50	—
10-4-52	11-7-52	1	92	13	16	8	7	11	6	31
14-4-52	12 to 18-6-52	3	59-65	13	8-11	8	6-7	8	15-19	—
15-4-52	21-6-52 25-8-52	5	67-132	13	8-21	5-11	5-10	9-12	19-77	—
17-4-52	26-6-52 4-7-52	3	70-78	12	11	5	9	13-14	20-27	—
23-4-52	17-6-52 3-7-52	3	55-71	11	11-13	5-7	5-9	5-8	14-28	—
23-4-52	2-7-52	1	70	11	13	5	6	8	5	—
29-4-52	21-6-52 7-7-52	7	53-69	11	9-10	4-6	6	7-15	16-22	—
5-5-52	5 to 15-7-52	5	61-71	10-11	8-15	5-10	7-8	7-19	17-21	—
9-5-52	10-7-52 29-8-52	4	62-111	11	8	3-6	9-11	10-60	17-19	—
10-5-52	14 to 18-7-52	2	96-100	10	22-24	10-12	9	16-27	20-27	—
21-5-52	18-7-52	1	58	8	9	5	7	8	21	—
14-8-52	—	1	—	8	12	5	14	7	3	Died in 6th instar
20-8-52	27-10-52 to 1-12-52	2	68-103	10-12	8-25	6-8	7-12	7-9	21-46	—
22-8-52	26 to 27-10-52	2	35-68	10	11	10-13	3-4	7-9	21-22	—
27-8-52	28 to 31-10-52	2	62-65	10	10	3-5	10-12	8-9	19-21	—
12-9-52	31-3-53	1	200	15	7	16	65	75	22	—
27-9-52	24-3-53	1	178	13	7	8	46	44	31	—

of various stages are given in Table V. At the most two generations of the bug were reared in a year, the first from April to June and the second from June to October, the adult from the latter becoming rather inactive and not laying eggs during the winter. For the majority of bugs winter intervened in the second generation.

T. javanica *and the drying up of the young shoots of* kusum — Owing to the simultaneous occurrence of this bug in large numbers and the drying up of the young shoots of *kusum* it was suspected earlier that this pentatomid may be solely or partly responsible for such damage. Trials were made to investigate this point by confining the bug in various stages of development on young and healthy shoots in field cages. It was observed that from the spot where the bug thrust its proboscis small quantity of sap oozed out and, if the shoot was too tender, the leaves and/or the buds started drying up. Different nymphal instars and the adult bugs were tried separately in field cages. The nymphs in various instars as well as the adult bugs were equally capable of causing the drying up of the young leaves, buds or shoots as will be seen from Table VI. Two cages were used as control for the above experiment, i.e. without any bugs; the drying up of shoots was very little and was due to causes other than the injuries by the bugs. First signs of injury to leaves were noticed after 15 and 18 days. The colour of dried leaves and the brown patches in these cages were of lighter colour than was the case when portions were injured by the bugs. Moreover, the portions of leaves which withered due to injuries by bugs invariably possessed wrinkles.

(ii) *Termite control*: Butea monosperma (palas) *and* Zizyphus jujuba (ber) — The two most common host trees of lac insects are often attacked by the termites. The extent of damage caused to *palas* in the Institute's plantation at Namkum by the mound-building

TABLE VI — *T. JAVANICA* AND INJURY TO YOUNG SHOOTS OF *KUSUM*

No. of cage	Date of caging	Total period of caging (days)	No. and stage of bug	Injury first observed after (days)	Nature of damage
1	26-2-52 to 6-4-52	40	2, V instar	25	1 leaflet dried
2	29-3-52 to 3-5-52	36	2 adults	13	4 leaflets dried
3	1 to 15-4-52	15	2 adults	4	1 leaflet and 4 buds dried
4	9-4-52 to 5-5-52	27	1 adult	24	3 leaflets dried
5	21-4-52 to 8-5-52	18	13, I instar	11	1 leaflet and 4 buds dried
6	24-4-52 to 3-5-52	10	8, I instar	10	3 buds dried
7	27-4-52 to 3-5-52	7	13, I instar	6	3 leaflets and 2 buds dried
8	28-4-52 to 5-5-52	8	14, I instar	4	1 leaflet dried
9	1 to 9-5-52	9	4, II instar	2	1 leaflet dried
10	2 to 19-5-52	18	2 adults	1	2 leaflets and 1 bud dried
11	5 to 13-5-52	9	2, II instar	2	1 leaflet dried
12	6 to 16-5-52	11	5, II instar	3	1 bud dried
13	21-11-52 to 20-2-53	91	3, III and 1, II instar	7	3 leaflets dried and fallen, 6 leaflets partly dried, 8 leaflets with brown spots
14	21-11-52 to 20-2-53	91	3, III and 2, IV instar	7	5 leaflets dried and fallen, 7 leaflets partly dried, 4 leaflets with injury and fungus at midribs
15	21-11-52 to 20-2-53	91	4, V instar	5	15 leaflets dried and fallen, 3 leaflets partly dried, 3 buds dried
16	20-11-52 to 20-2-53	90	4 adults	8	20 leaflets dried and fallen, 2 leaflets partly dried

species *Odontotermes obesus* (Rambur) was stated in the *Annual Report* for 1950-51. While during the succeeding year the position remained much the same, the termites were satisfactorily controlled in the period under report. 0·5 per cent Gammexane wettable powder in lime wash was applied to the trunk to a height of 4-5 ft., and for the past several months and up to the time of reporting not a single tree has been attacked. The cost of ingredients (Gammexane and lime) worked out to be one anna per tree.

(iii) *Miscellaneous insects* — (a) *Sathrophyllia rogosa* Linn. (ORTHOPTERA: TETTICONIDAE) which appeared in pest form on *palas* last year was scarce during the year under report in the Namkum plantation. (b) Attack of *Myllocerus cardoni* Marshall (COLEOPTERA: CURCULIONIDAE) was also less severe on *kusum*. (c) However, during the summer the pentatomid *Cyclopelta siccifolia* Distant appeared gregariously on shoots of certain *palas* and *arhar* (*Canjanus cajan*) and was easily netted and killed. (d) *Hieromantis foxysta* Meyrick (LEPIDOPTERA: SCHRECKSTINEIDAE) was less common this year. (e) Another leaf-roller of *kusum*, *Argyroploce aprobata* Meyrick, was also found damaging leaves both at Namkum and Hesal. (f) The small caterpillars, which were reported to tunnel through tender shoots of *kusum* and cause the drying up of the central young shoots, were identified as belonging to *Ascalevia* sp.

(f) DETERMINATION OF THE VARIOUS RACES, STRAINS, SPECIES, ETC., OF THE LAC INSECTS; THEIR PERFORMANCE, SELECTION OF GOOD STRAINS, CROSS-INFESTATION, ETC.

(i) *Systematic study of the lac insects* — Determination and classification of the various species, strains and varieties of the lac insects were recently commenced. The existing collection of the lac insects in the department is being worked out. A preliminary catalogue of the family LACCIFERIDAE, in which are included all the lac-producing insects of the world, has been prepared.

(ii) *Breeding of yellow variety of the lac insect* — Yellow variety of the *Rangeeni* strain of the common lac insect is being bred on a small scale. The original stock of this variety found mixed up with the usual crimson variety was obtained from a fig tree in New Delhi. The first generation was completed at Namkum in July 1952, and the second in October 1952. The third generation is progressing. After trial on various hosts in the first generation it was observed that smaller plants (potted or in nursery bed) of *Albizzia lucida* and *Zizyphus jujuba* were more suitable for rearing the insects and for examination under a binocular microscope. At the time of infecting the second generation care was taken to breed the progeny of mostly single cells on separate plants. This was repeated for the third generation also and the progeny remained true to its colour (yellow) as far as the lac insects were concerned. In the males, however, the lac resin secreted was slightly reddish and could be easily mistaken for the usual crimson cells by a casual observer. On breaking open a cell the yellow males (both winged and apterous forms) could be easily seen. Since the males live a much shorter life than the females and contribute very little towards the total resin secretion in the crop, the slightly darker colour of their secretion does not appear to matter much. Green (1922), who recorded the crimson and yellow varieties in a related species *Laccifer albizziae* (Green) from Ceylon, stated that he " did not observe any yellow males ". It is hoped that given proper care and adequate facilities it would be possible to breed this variety on a large scale also.

(iii) *Performance of the* Rangeeni *strain* (Baisakhi) *on rain tree* (Samanea saman) *in Chota Nagpur* — Intimately connected with the systematic studies of the lac insects is the question of host relationship of the various species, strains and varieties. In view of the report that in Thailand, rain tree (*Samanea saman*, previously referred to under the generic name *Enterologium* or *Pithocolobium*) is employed commonly as a lac host and gives thick encrustations and heavy yield, it was desired that possibilities of utilizing this host in India should be investigated. A large tree in the Institute compound was infected with the *Rangeeni* strain and some observations were also taken on this host in certain other parts of Chota Nagpur.

Trial at Namkum

Date of infection — 17th October 1951
Weight of selected brood used = 4 srs. 2 ch.
Period of infection (in wire gauze baskets) = one month
Weight of *phunki* (broodlac after swarming is over) = 2 srs. 8 ch.
Weight of scraped *phunki* = 14 ch.
Date of harvesting — 25th June 1952
Weight of total yield obtained = 11 srs. 10 ch.
Weight of selected broodlac = 8 srs. 14 ch.
Weight of scraped lac from rejected lac = 7 ch.
Weight of scraped lac from *phunki* = 2 srs. 4 ch.
Weight of scraped lac from total yield = 2 srs. 11 ch.
Ratio — broodlac (with sticks) used to total yield of lac (with sticks) = 1: 2·15
Ratio — broodlac used to broodlac obtained = 1: 2·15
Ratio — scraped lac from brood applied to total yield = 1: 3·07

These results indicate that the performance of rain tree in respect of yield of lac crop is almost the same as that of common hosts of *Rangeeni* strain such as *palas* and *ber*. The encrustations were also similar and it seemed that our common *Rangeeni* strains would not show any improvement or deterioration when cultivated on this host.

At Jamshedpur and Latehar in Chota Nagpur division, observations were taken on certain rain trees bearing lac. At both these places the trees were situated on the road-side and were only partly harvested at irregular intervals with the result that they suffered from a continuous strain from the lac insects and from lopping. The latter act, perhaps, cannot be avoided because the wood is weak and the branches must be cut thick for the safety of men harvesting the crop. The regeneration of the branches, as observed under the climate of Chota Nagpur, did not appear to be very quick or vigorous (the length of new shoots becoming hardly 8-10 ft. compared to about 30 ft. reported in the case of trees in Thailand). The lac encrustations on new shoots were similar to those obtained from the infected rain tree mentioned above or from an average *palas* or *ber* tree. However, some 1¼ in. thick branches (generally old) were found partly covered with lac.

Examinations of lac insects and their encrustation on rain trees from Thailand, Vizagapatam and Chota Nagpur were made. Some believe that Thailand lac is produced mainly, if not exclusively, by *Laccifer chinensis* (Mahadihassan, 1923). An examination of the material from Thailand indicated that *L. chinensis* is distinct from our common Indian species *L. lacca*. Without going into details of structure at this stage, it may be mentioned that the best of lac encrustation of *L. chinensis* from Thailand and of *Laccifer lacca* from Chota Nagpur were 12 mm. and 6 mm. thick respectively. Another example of lac encrustation on rain tree from Paravatipore, Vizagapatam district, was examined and it was observed that in regard to the thickness of the encrustation and the shape of the insects it resembled more the examples from Thailand than the example of the common *Rangeeni* strain occurring in India. This might be a distinct species or only a subspecies of the Thai lac insect which has been recorded by Mahadihassan from Nepal and Bhutan also. It is probable that future surveys and studies of the different species may prove it to be more widely distributed.

(g) Influence of Various Environmental Conditions on the Lac Insect

Studies on the effect of constant temperature and known humidity on the life-history of the *Rangeeni* and *kusmi* strains have been initiated in the laboratory. Since the life-history of the lac insects extends over a period of several months it became necessary to evolve a technique to grow suitable species of host plants for use in the incubators. This object was achieved satisfactorily by employing potted plants of *Albizzia lucida*, *Acacia farnesiana* and *Zizyphus jujuba* for the *Rangeeni*, and *Schleichera trijuga* (*kusum*) and *Z. jujuba* for the *kusmi* strain. The studies were started in November 1952 for the *Rangeeni* strain, and in early February 1952 for the *kusmi* strain at 27°C. and 20°C. and humidity range 50-80 and 50-90 per cent respectively. Though the life cycles have not been completed up to the end of the period covered by this report, observations on earlier stages of life-history showed that at 27°C. controlled temperature the development was proceeding at a faster rate than that of others in the field conditions where the average minimum and maximum temperatures were 14·5°C. and 30·8°C. respectively. At 20°C. controlled temperature, on the other hand, the rate of development was much slower than that under the field conditions. *Kusmi* and *Rangeeni* strains developing under the same conditions (27°C.) showed slightly different rate of growth in the early stages. Further observations are in progress and it is hoped that when several generations have passed and more data have been gathered interesting results would be obtained.

(h) Insect Enemies of Lac

(i) Chrysopa *spp.*—There are definitely two species of *Chrysopa* that attack the lac insects locally. The smaller one (*Annual Report*, 1951-52) is referred to as *Chrysopa* sp. No. 2 for want of proper identification. Specimens sent abroad have been returned unnamed in one case while in the other these have not yet been identified.

Chrysopa *sp. No.* 1 — Various stages of this lace-wing fly continued to appear on both the *Rangeeni* and *kusmi* crops and were collected during the period under report from *Baisakhi* (1952) on *Ougeinia dalbergioides*, *Katki*, (1952) crop on *palas* at Namkum, *Jethwi* (1952) crop on *kusum* at Namkum and Hesal, *Baisakhi* (1953) on mango, *boga*, litchi *O. dalbergioides*, *Flemingia congesta*, *A. lucida* and *ber* and *Jethwi* (1953) crop on *kusum* at Namkum. Table VII gives details of its life-history.

TABLE VII — DATES AND DURATION OF VARIOUS STAGES IN LIFE-HISTORY OF *CHRYSOPA* SP. No. 1

Date of		Duration in days					
Egg-laying	Emergence of adult	Egg to adult	Egg stage	1st instar	2nd instar	3rd instar	Pupa
8-8-52	8-9-52	31	3	7	5	9	7
4-9-52	29-9-52	25	3	5	5	7	7
4-9-52	29-9-52	25	3	5	4	6	7
12-9-52	6-10-52	24	2	3	7	5	7
24-12-52	16-2-53	54	4	9	8	18	15

In the first four cases a cocoon was spun up by the third instar larva two days, and in the fifth case seven days, before reaching the pupa stage.

Parasites (Ichneumonid and Chalcid) of the pupae of this species have also been collected. Its life-history studies are concluded; control measures could be considered only after its identification has been received.

The number of immature (44-113 days old) lac cells fed upon or damaged by the larvae in various instars are given in Table VIII.

TABLE VIII — FEEDING RECORDS OF *CHRYSOPA* LARVAE

Larvae		No. lac cells		No. fed per day by single larva		
Instar	No. observed	Offered	Fed	Minimum	Maximum	Average
I	5	802	292	2	20	6·5
II	3	535	246	1	24	11·0
III	9	1358	954	1	74	14·9

Chrysopa *sp. No.* 2 — This species also appeared on *Jethwi* (1952) crop on *kusum* and the *Katki* (1952) *Rangeeni* crop both at Namkum and at Hesal.

(ii) *Survey and collection of insect enemies and their associated parasites occurring in different lac-growing areas* — Although the insect enemies of lac in Chota Nagpur, the main lac-growing tract in the country, were fairly well known, those from other lac-growing areas were less adequately known and poorly represented in the reserve collection at the Institute. As a preliminary step towards making a more complete survey of the insect enemies, samples of freshly mature lac sticks were obtained from several places and kept in parasite and predator emerging cages. The insects obtained were being duly preserved for future studies. Efforts will be made to continue this work till a truly representative collection is built up.

(i) Cultural and Preventive Methods of Control of Insect Enemies

At Hesal wire-net baskets are being used since July 1950, and it has been possible to have an idea of the serviceable life of such baskets. In July 1952, of the 329 new baskets used for the first season, 87 per cent remained serviceable after use: of the 758 baskets used for the second season, nearly 94 per cent remained serviceable; of the 521 used for the third season, 80 per cent remained serviceable and of the 109 baskets used for the fourth season, nearly 97 per cent remained serviceable. During January 1953 a total of 1,320 wire-net baskets and 88 hollow bamboo containers were used for infection. Seven wire-net baskets were lost and in the remainder the percentage of serviceable baskets left after use were as follows: 71 per cent serviceable baskets out of 267 used for the second season; 70 per cent left serviceable out of 662 used for the third season; and 51 per cent left serviceable out of 384 used for the fourth season.

The results of examination for trapped parasites and predators from 18 baskets, each of which contained two chataks of locally produced broodlac from the *Aghani* 1953 crop, are given below:

NAME AND NUMBER OF INSECTS TRAPPED

Chalcids:	*Erencyrtus dewitzi* Mahd.	57
	Eupelmus tachardia Howard	53
	Parechthrodrymus calvicornis Cam.	12
	Tachardiaephagus tachardiae Howard	87
	Tachardiaephagus somervilli Mahd.	162
	Tetrastichus purpureus Cam.	6
Braconids:	(different)	
Predators:	*Eublemma amabilis* Moore	
	Eggs	726
	Larvae	4
	Pupae	5
	Moths	59
	Holcocera pulverea Meyr.	
	Eggs	138
	Larvae	28
	Pupae	7
	Moths	33
Miscellaneous insects:		
	Coleoptera	18
	Other Orders of insects	36

The object of using hollow bamboo pieces and wire-net as brood containers was to see if these could serve the same purpose as the wire-net baskets which would cost 10 annas each as compared to 3 annas, the cost of bamboo (7-8 in. and wire-net 2 pieces of 4-5 in. square) baskets. Laboratory trials and closer observations on emergence of lac larvae had shown the two devices to be equally satisfactory. During *Katki* 1952 crop grown on *palas*, a small-scale field trial was made in the Institute's plantation where the settlement of larvae and the ensuing crop were as satisfactory as in cases where wire-net baskets had been used. Trials on *kusum* for *Jethwi* 1953 crop have also been conducted. The crop is still in progress.

(j) Biological Control of Lac Predator *Eublemma amabilis* Moore

(i) *Breeding of* Bracon greeni *on alternative hosts in the laboratory* — An all-the-year-round supply of the alternative (unnatural) host *Etiella zinckenella* was obtained this year also by systematic cultivation of *Crotolaria saltiana*, etc., in the Institute's plantation. Small numbers of caterpillars of *Torchylepida fructicassiella* (the *Cassia fistula* or *amaltas* pod borer) that were available were also used as alternative hosts for the purpose. The results of breeding *B. greeni* on these alternative hosts are given in Table IX (p. 20). It will be noted that maximum parasitization recorded during the period under report was: (1) for *E. zinckenella*, 57·1 per cent during December 1952; (2) for *T. fructicassiella*, 75 per cent in November 1952. Maximum number of *B. greeni* bred per host was 1·64 for *E. zinckenella* and 2·3 for *T. fructicassiella* in July and November 1952 respectively.

TABLE IX — LARGE-SCALE BREEDING OF *B. GREENI* ON ALTERNATIVE HOSTS (APRIL 1952 TO MARCH 1953)

Month	No. of host larvae: Introduced	Parasitized: No.	Parasitized: %	Living	Dead	Pupated	Host and parasite contact (in days)	Adults emerged: Males	Females	Total	% females	Adults emerged per host
1	2	3	4	5	6	7	8	9	10	11	12	13
Etiella zinckenella (pod borer of *Crotolaria saltiana*)												
April 1952	1100	177	16·0	200	719	4	3	21	66	87	75·86	0·49
May 1952	1140	68	5·9	421	645	6	3	14	39	53	73·5	0·7
June 1952	1100	140	12·72	406	530	24	3	44	88	132	66·6	0·93
July 1952	1130	233	20·53	223	666	8	3	38	131	169	77·5	1·64
Aug. 1952	1140	319	27·9	116	687	18	3	41	143	184	77·7	0·57
Sept. 1952	1100	229	20·8	104	734	33	3	23	65	88	73·8	0·3
Oct. 1952	1140	210	18·4	86	840	4	3	26	117	143	81·8	0·67
Nov. 1952	1100	556	50·54	24	520	—	3	118	609	727	83·76	1·3
Dec. 1952	1130	646	57·1	7	477	—	3	156	399	555	71·8	0·85
Jan. 1953	1140	383	33·5	30	727	—	3	111	152	263	57·7	0·6
Feb. 1953	1030	232	22·52	65	733	—	3	115	151	266	58·9	1·4
March 1953	1130	223	19·7	333	567	7	3	40	84	124	67·7	0·5
TOTAL	13380	3416	25·5	2015	7845	104	...	747	2044	2791	73·2	...

REMARKS — From December 1952 in two cages yeast hydrolysate with 3 sugar solutions being supplied, but no such particular changes noted so far.

Month	Introduced	No.	%	Living	Dead	Pupated	Contact (days)	Males	Females	Total	% females	Per host
T. fructicassiella (pod borer of *Cassia fistula*)												
April 1952	100	26	26·0	31	42	1	3	3	5	8	62·5	0·3
May 1952	100	8	8·0	46	44	2	3	2	3	5	60·0	0·6
June 1952	100	13	13·0	48	34	5	3	1	5	6	83·3	0·4
July 1952	100	18	16·3	46	46	—	3	11	18	29	62·0	1·6
Aug. 1952	100	36	36·0	34	30	—	3	17	24	41	58·5	1·13
Sept. 1952	100	25	25·0	41	34	—	3	9	16	25	64·0	1·0
Oct. 1952	100	43	43·0	26	31	—	3	25	64	89	71·9	2·06
Nov. 1952	100	75	75·0	4	21	—	3	49	125	174	71·8	2·3
Dec. 1952	110	67	60·9	8	35	—	3	40	52	92	56·5	1·37
Jan. 1953	100	39	39·0	37	24	—	3	16	23	39	58·9	1·0
Feb. 1953	90	26	28·8	38	26	—	3	11	25	36	69·4	1·3
March 1953	110	22	20·0	44	41	3	3	8	9	17	52·9	0·7
TOTAL	1220	398	32·6	403	408	11	...	192	369	561	65·9	...

TABLE X — DEVELOPMENT OF *B. GREENI* IN RELATION TO ITS NATURAL AND ALTERNATIVE (UNNATURAL) HOSTS

History of generations of *B. greeni*: food and host offered	Period of observations (1952)	No. of pairs	Longevity (days)		Preoviposition period (days), average range	Oviposition period (days), average range	No. of eggs laid, average range	Adults emerged				% survival (egg-pupa)
			Male, average range	Female, average range				Male	Female	Total	% of female	
1	2	3	4	5	6	7	8	9	10	11	12	13
Sugar solution: Etiella												
6th generation	18-3-52 to 2-5-52	3	21 20-23	40·3 31-45	18·3 17-20	3·3 1-5	10·6 5-17	3	6	9	66·6	28·12
7th do	17-4-52 to 26-6-52	4	35 17-43	36 24-42	11·47 9-14	3·5 1-11	9·25 5-13	0	6	6	100·0	16·2
8th do	20-5-52 to 26-6-52	1	37	37	25	6	28	5	12	17	70·5	60·7
9th do	25-6-52 to 11-7-52	3	11-6 11-12	15 14-16	5·3 2-11	5·3 1-9	11·3 3-20	11	13	24	54·1	70·5
10th do	10-7-52 to 2-8-52	2	16 15-17	20 17-23	7 5-9	3·5 2-5	11 3-5	6	4	10	40·0	45·5
11th do	3-8-52 to 3-9-52	2	25·5 20-31	26·5 23-30	6 4-8	10·5 7-14	34 2-20	2	2	4	50·0	5·8
12th do	19-8-52 to 25-9-52	2	35·5 34-37	35·5 34-37	18 18	8 3-13	17 16-18	1	3	4	75·0	11·7
13th do	25-9-52 to 25-11-52	2	28·5 27-30	28·5 27-30	5 5	8·5 1-16	6·5 5-6	4	9	13	69·2	100·0
14th do	20-10-52 to 16-11-52	2	26 18-34	19·5 26-33	7·5 4-11	3·5 1-6	12·5 7-10	5	3	8	37·5	32·0
15th do	16-11-52 to 20-12-52	2	27·5 21-34	32 30-34	12·5 12-13	13·5 11-16	16 1-6	7	8	15	53·3	46·8
16th do	28-12-52 to 9-2-53	1	23·0 23	43 43	7 7	21 21	24 24	0	3	3	100·0	12·5

TABLE X — DEVELOPMENT OF *B. GREENI* IN RELATION TO ITS NATURAL AND ALTERNATIVE (UNNATURAL) HOSTS (*continued*)

History of generations of *B. greeni* : food and host offered	Period of observations (1952)	No. of pairs	Longevity (days) Male, average range	Longevity (days) Female, average range	Pre-ovi-position period (days), average range	Ovi-position period (days), average range	No. of eggs laid, average range	Adults emerged Male	Adults emerged Female	Adults emerged Total	Adults emerged % of female	% survival (egg-pupa)
1	2	3	4	5	6	7	8	9	10	11	12	13
17th generation	30-1-53 to 17-3-53	2	43 42-44	45 44-46	17·5 8-27	3·0 2-4	7·0 5-9	1	2	3	66·6	21·4
18th do	13-3-53 to 8-4-53	2		No oviposition at all by these two pairs								
Greeni bred on *Etiella* for 8 generations; food and host offered — sugar solution: *Eublemma*												
1st generation	6-5-52 to 9-6-52	3	24·6 20-34	24·6 20-34	7·3 6-10	10·3 1-22	23·6 2-59	15	24	39	61·5	54·9
2nd do	30-5-52 to 30-6-52	4	21·5 15-28	23·7 18-24	12·25 6-18	3·75 2-6	22·5 12-34	14	44	58	75·8	64·4
3rd do	25-6-52 to 11-7-52	3	15·3 14-16	16 16	2 2	10 10	28·3 15-36	49	13	62	20·9	72·9
4th do	9-7-52 to 14-8-52	2	17 17	19 19	6 2	10 7-12	15 13-17	10	6	16	37·5	53·3
5th do	26-7-52 to 14-8-52	3	15·6 11-20	16 15-17	4 3-5	6·3 3-13	21·60 14-30	6	34	40	85·0	61·5
6th do	11-7-52 to 22-9-52	3	38·0 38	41 38-43	10·3 5-20	19·6 9-29	38·6 2-16	15	12	27	44·4	23·2
7th do	17-9-52 to 9-10-52	3	19·6 19-20	20·3 19-22	4·2 3-5	12·6 11-14	25·3 2-16	11	51	62	82·2	58·4
8th do	6-10-52 to 28-10-52	3	17·0 10-22	21·6 19-23	2·3 2-3	14·0 10-18	35·3 1-12	32	46	78	58·9	73·5

(ii) *Development of* B. greeni *in relation to its natural and alternative host* — The object of this study was to know whether the development and fecundity of the parasite *B. greeni* is affected by its being continuously bred on the alternative host *E. zinckenella*. The details of the experiments as well as the results obtained in regard to the longevity of the adults, pre-oviposition and oviposition periods and the fecundity of the parasites are given in Table X. The results confirm the tentative conclusions reported last year that though the fecundity of the parasites decreases when it is bred on the alternative (unnatural) host, it shows an increase when the natural host (*E. amabilis*) is offered to the parasite which had been bred on the unnatural host for as many as eight generations. Preoviposition period, which usually increased when the alternative host was offered to the parasite, showed a decrease when the natural host was again offered to the progeny bred on unnatural host. These observations indicated that rearing the parasites for a number of generations on the alternative host does not make its progeny indifferent to the natural host when the same is presented to it for oviposition. Viability of the immature stages (egg to pupa) also shows a general improvement when the natural host is offered for development of the parasite, viability figures being (i) for parasite given *Etiella* as the host for 17 generations = 39·9 per cent and (ii) for progeny of parasites bred on *Etiella* for 8 generations and subsequently reared for 8 generations on *Eublemma* larvae = 57·7 per cent which is about the same when *B. greeni* is all through bred on *Eublemma.*

3. INSTITUTE PLANTATION, NAMKUM

General upkeep of the plantation was maintained according to funds available.

Young trees and seedlings were given farmyard manure. Green manuring was carried out throughout *khair* and *palas* plots with *Boga* (*Tephrosia candida*) in order to suppress the growth of wild grasses and also to improve the soil texture. Hoeing and weeding operations round the younger plants were regularly carried out. Young plants required for the laboratory and plantation work were raised in the small nursery started in the plantation itself. For experimental purposes, a limited number of trees were infected and the statement showing the gross yield of lac from Namkum and from the leased plantation at Hesal is given in Table XI.

TABLE XI — A STATEMENT OF LAC PRODUCED AND ITS DISPOSAL

Crop, locality and kind of lac		Lac produced, Md. sr. ch.	Disposal: Under use in the Dept., Md. sr. ch.	Disposal: Driage, Md. sr. ch.	Disposal: Supplied to Chem. Sec., Md. sr. ch.	Disposal: Sold, Md. sr. ch.
Baisakhi, 1951-52						
Namkum:	Yield	8 7 12	8 7 12	—	—	—
	Scraped	2 33 2½	—	1 4 4½	1 28 14	—
Jethwi, 1952						
Namkum:	Yield	1 12 8	1 12 8	—	—	—
	Scraped	0 12 15	—	0 4 11	0 8 4	—
Hesal:	Yield	32 22 10	32 22 10	—	—	—
	Scraped	8 31 5	—	0 34 2	7 37 3	—
Katki, 1953						
Namkum:	Yield	4 28 8	4 28 8	—	—	—
	Scraped	0 16 0	—	0 0 3	0 13 10	—
Aghani, 1952-53						
Namkum:	Yield	0 3 5	0 3 5	—	—	—
	Scraped	0 0 2½	0 0 2½	—	—	—
Hesal:	Yield	9 0 14	9 0 14	—	—	—
	Scraped	2 17 5	2 17 5	—	—	—

N.B. — Yield = brood and rejected lac sticks together.

TABLE XI — STATEMENT OF LAC PRODUCED AND ITS DISPOSAL (*continued*)

	Quantity, Md. sr. ch.	Value, Rs. as. ps.
1. By supply of broodlac for use as samples from Institute plantation	0 4 0	5 9 9
2. By supply to Chemical Section, I.L.R.I., of scraped laç from Institute plantation	1 28 14	68 14 0
	0 8 4	12 6 0
	7 37 3	475 12 6
	0 15 13	15 13 0
	10 10 2	572 13 6
3. By supply of scraped lac for use in the department	0 0 2½	0 2 6
	2 17 5½	97 5 6
	2 17 8	97 8 0
4. By supply of scraped lac to the Chemical Section, I.L.R.I.,		
from purchased *ari* lac (*Katki*, 1950) ...	1 3 4	43 4 0
from Namkum plantation — *Rangeeni* lac (*Katki*, 1950)	0 15 0	15 0 0
from Namkum plantation (*Baisakhi*, 1950-51) ...	0 9 8	9 8 0
from Hesal plantation — *kusmi* lac (*Aghani*, 1951-52)	18 19 6	924 3 6
	0 10 4	15 6 0
from Namkum plantation — *Rangeeni* lac (*Katki*, 1951)	0 23 12	23 12 0
from purchased *ari palas* lac from Kundri (*Baisakhi*, 1951-52)	0 5 1	5 1 0
from purchased *kusmi* lac from Kundri (*Jethwi*, 1952)	0 3 13	5 11 6
from purchased *Rangeeni* lac from Kundri (*Katki*, 1952)	0 7 3	7 3 0
from purchased *kusmi* lac from Kundri (*Aghani*, 1952-53)	0 3 7¼	3 7 3
from miscellaneous lac from Kundri (*Aghani*, 1952-53)	0 0 8	0 8 0
	21 21 2¼	1053 0 3
Grand Total		Rs. 1727 15 6

CHEMICAL SECTION

The posts of Analyst, Junior Research Assistant and Physical Chemist (Research Assistant) remained vacant for most of the period.

1. VARNISHES, LACQUERS AND PAINTS

Lac-linseed oil paints — During the year under report, an Officer of the Central Standards Office, Ministry of Railways, evinced great interest in these paints and paid visits to the Institute in order to ascertain personally the possibility of using some of our products in the railways. Impressed with the indoor performance of our shellac-linseed oil paints he requested for samples for trials in railway buildings and coaches. A number of samples were supplied and an interim report recently received indicates that paints containing shellac, linseed oil, lime and cashew-nut shell liquid-formaldehyde resin (in the proportion of 20, 100, 3, 100 and 15 respectively) "have given very good results. The gloss has been retained to a remarkable extent after four months' exposure." Requests have come for further samples of similar compositions containing polymerized cashew-nut shell liquid (but without formaldehyde) and these would be despatched as soon as possible. The Central Standards Office expressed preference for similar lead-free paints, and work on these was taken up (*vide infra*).

Lac-linseed oil compositions using zinc oxide as the incorporating agent — Lead-free shellac oil paints were prepared by using zinc oxide as the incorporating agent in place of litharge. The composition was prepared as follows:

200 gm. of linseed oil were heated to 170°C., and 4·5 gm. zinc oxide added. The temperature was raised to 290°C. and maintained for 10 min. Shellac powder (80 gm.) was now added in small lots at a time maintaining the temperature at 290°C. during the addition. A clear melt was obtained. After keeping the product at the same temperature for another 10 min., further 200 gm. of linseed oil (or other drying oil) were added taking care that the temperature did not fall below 270°C. during the addition. After 10 min., the product was cooled to about 150°C. and thinned with white spirit (200 cc.).

This vehicle, without pigment, dried to a smooth glossy film in 72 hr. In the presence of 0·4-0·5 per cent cobalt naphthenate the drying time was reduced to less than 24 hr.

Ageing properties of shellac-linseed oil paints — It will be recalled that about five years back, all the wood and steel works of the Institute laboratories and staff quarters were painted with our new shellac-oil paints. After five years, the painted surfaces indoors are still keeping quite well. No deterioration of any kind has been noticed so far.

Shellac-based anti-corrosive and anti-fouling paints — References to earlier books reveal the use of shellac as a vehicle in anti-fouling and anti-corrosive paints for ships' bottoms, though it is not clear how far it is still being used for the purpose. In order to revive this use of shellac and particularly to ascertain the suitability of some of the recent modifications of shellac in this field, experiments were commenced in the early part of the year. Promising results have been obtained.

2. MOULDING COMPOSITIONS

Lac-dimethylol urea — Lac-dimethylol urea compositions were made both by the wet and dry processes, and tests carried out to determine the optimum (1) quantity of dimethylol urea (DU), (2) temperature and (3) moulding pressure were reported on page 16 of our *Annual Report* for the year 1946-47. These experiments have been repeated using technical grade of DU (U.S.A.). This material was practically insoluble in alcohol, whereas freshly made laboratory samples were soluble. The earlier procedure of making the moulding powders was to mix the ingredients in a Baker-Perkin's mixer for 3-4 hrs. A simpler method of mixing the ingredients (without solvents) by means of hot rollers was explored.

The following composition was first tried: shellac (100 parts), *haldu* wood flour (100 parts), DU (tech., 15 parts)*, aluminium stearate (3 parts) and pigment (4 parts).

These ingredients were mixed on the hot rollers (90°-95°C.) for 10 min. and then taken out in the form of a soft sheet. On cooling and powdering this was found to be rather soft and unsuitable for hot moulding. No improvement was noticeable even when this was cured for a further period of 9 hr. at 90°-95°C.

The experiment was then repeated under somewhat different conditions. The ingredients were mixed in a Baker-Perkin's mixer at 90°-95°C. for 3 hr. in order to see if this increased time of hot mixing would have any beneficial effect. The product was still unsatisfactory and a further hot rolling for 17 min. and curing for 6 hr. at 90°-95°C. did not result in any improvement. It was quite evident, therefore, that the technical grade of DU used in these experiments was not a satisfactory accelerator for the preparation of shellac moulding powders at least under these conditions.

The effect of hardeners was then investigated. For this purpose an old sample of laboratory-made DU was used. Ingredients were mixed on hot rollers as before for 5-10 min. and the hardeners were then added. The mixing was continued till the material came out in the form of a sheet. The results of moulding experiments with these products are shown in Table I (p. 27).

It will be clear from Table I that a mixture of maleic acid and lime (2 and 1 per cent respectively on the weight of lac) proved quite satisfactory as hardeners. As these results were obtained by using an alcohol-insoluble sample of DU, the experiments were repeated with (i) freshly made alcohol-soluble DU and (ii) a technical grade (insoluble) of the same material both with and without hardeners. The findings are shown in Table II (p. 29).

From Table II, it is evident that satisfactory moulding powders can be prepared from shellac using technical grade dimethylol urea if only hardeners such as maleic acid (2 per cent) and lime (1 per cent) are also incorporated. In the case of fresh DU (alcohol-soluble variety), which gives a satisfactory shellac-moulding powder even without any hardener, the use of these hardeners results in improved strength and gloss and reduced curing time.

Further work regarding, (i) use of other hardeners, both organic as well as inorganic, (ii) the water absorption and heat resistance of the moulded products and (iii) the film properties of lac-dimethylol-urea resin is in progress.

3. MODIFICATION OF LAC AND ITS DERIVATIVES

Fluidity, life under heat, and softening point are some of the essential characteristics of a resin for use in the moulding industry. Scratch hardness, water resistance and elasticity are some of the important considerations for resins to be used in protective coating. Although shellac possesses these characteristics to an appreciable extent and as such is finding suitable use in these industries, a shellac with a better flow and life, higher elasticity and water resistance has always been sought by a large section of shellac consumers. Some work has already been carried out in the past to attain these objectives but with limited success. The present investigations were undertaken in order to see how far modifications of shellac with common or inexpensive materials, like rosins and esters of lac, will result in improvement of the essential characteristics of the resin.

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* The optimum quantity of DU in such compositions was reported to be 15 per cent on the weight of shellac (*Annual Report*, 1946-47, p. 16). Incidentally this quantity is equivalent to 9 per cent urea and 25 per cent formalin which were the proportions found most satisfactory for lac-urea-formaldehyde powders.

TABLE I — LAC-DIMETHYLOL UREA (TECHNICAL QUALITY) MOULDING COMPOSITIONS

Hardeners used (gm. per 100 gm. of shellac)	Duration of initial hot rolling at 90°-95°C.	Time of hot rolling after the addition of hardeners	Total time	Remarks	Drying time (at 90°-95°C.)	Moulding results and remarks
1. —	20 min.	—	20 min.	No smell of formaldehyde came out from the soft sheet form	9 hr.	Could not be moulded at 145°C. The product was very soft and came out in a pasty form from the moulds.
2. Oxalic acid, 3·0	5 min.	5 min.	10 min.	No smell of formalin came out from sheet form	3 hr.	Moulded at (1) 145°C. and 1·5 T/sq. in. for 5 min. — blister-free but very dull in appearance; (2) 145°C.— 2 T/sq. in. for 5 min. — blister-free but very dull in appearance; (3) 145°C.— 1·5 T/sq. in. for 3 min.— slightly better in gloss; blisters appeared.
3. Phthalic anhydride, 3·0	10 min.	16 min.	26 min.	do	4 hr.	145°C.—1·5 T/sq. in.—3 min.— blister-free but dull in appearance.
4. Cinnamic acid, 3·0	10 min.	2 min.	12 min.	do	3½ hr.	145°C.— 1·5 T/sq. in.— 3 min.— blister-free but dull in appearance.
5. Maleic anhydride, 3·0	10 min.	13 min.	23 min.	No smell of formalin came out from sheet form; the sheet was harder than others	3 hr.	145°C.— 1·5 T — 3-5 min.; does not fuse properly; cracks during ejection: sticks to the mould.
6. Maleic acid, 3·0	10 min.	6 min.	16 min.	No smell of formalin came out in sheet form;	1½ hr.	145°C.— 1·5 T/sq. in. — 3 min.; blister-free but dull in appearance. 145°C.— 1·5 T/sq. in.— 5 min.; blister-free but dull in appearance; slightly better in gloss.

TABLE I — LAC-DIMETHYLOL UREA (TECHNICAL QUALITY) MOULDING COMPOSITIONS — (*continued*)

Hardeners used (gm. per 100 gm. of shellac)	Duration of initial hot rolling at 90°-95°C.	Time of hot rolling after the addition of hardeners	Total time	Remarks	Drying time (at 90°-95°C.)	Moulding results and remarks
7. Maleic acid, 1·5	10 min.	12 min.	22 min.	No smell of formalin; came out in sheet form	3 hr.	145°C.— 1·5 T/sq. in.— 3 min.; blister-free but dull.
8. Maleic acid, 0·5	10 min.	20 min.	30 min.	No smell of formaldehyde; came out in sheet form which was soft	7½ hr.	Moulded at 145°C.— 1·5 T/sq. in.— gloss fair, but the composition was too soft for hot moulding.
9. Hexamine, 1	10 min.	4 min.	14 min.	No smell of formaldehyde; came out in sheet form which was soft; the sheet was still softer	8 hr.	145°C.— 1·5 T/sq. in.— 3 min.—gloss and flow satisfactory, composition was soft; blisters appeared.
10.* Lime, 1	10 min.	2 min.	12 min.	do	6½ hr.	145°C.— 1·5 T/sq. in.— 3 min.— very good gloss and flow, but blisters appeared which could not be cured even by longer drying.
11. Maleic acid, 2 and lime, 1	10 min.	5 min. after adding maleic acid and 3 min. after adding lime	18 min.	No smell of formalin; came out in a sheet form which was fairly hard	1½ hr.	145°C.— 1·5 T/sq. in. — 3 min.—good flow and gloss; could easily be removed hot.
12. Maleic acid, 1 and lime, 1	10 min.	5 min. and 5 min.	20 min.	do	2 hr.	145°C.—1·5 T/sq. in.— 3 min.— good flow and gloss; very slightly softer.
13. Maleic acid, 3 and lime, 1	10 min.	5 min. and 3 min.	18 min.	do	1½ hr.	145°C.—1·5 T/sq. in.—3 min.— good flow and gloss; gloss slightly less than composition No. 11.

TABLE II — LAC-DU MOULDING POWDERS USING DIFFERENT GRADES OF DU

Quality of dimethylol urea used	Hardener used	Total time of hot rolling, min.	Curing time (at 90°-95°C.)	Impact strength, cm. kg./cm.^{2}	Moulding results
1. Lab.-made alc.-soluble quality	None	5	2 hr.	4·30	Good moulding at 145°C.— 1·5 T/sq. in.— 3 min.
2. do	2% maleic acid and 1% lime	10	45 min.	4·33	Good moulding at 145°C.— 1·5 T/sq. in.— 3 min. Slightly better gloss
3. Technical quality (alc.-insol.)	do	11	30 min.	4·33	do
4. do	None	8	3 hr.	—	Could not be moulded at 145°C. nor could it be improved by baking at 90°-95°C. for a longer time

(i) *Shellac and rosin* — Shellac mixed with varying proportions of rosin (0-10 per cent) was melted in an oil bath at 125°C. for 1 hr. After cooling and powdering, the products were examined for acid value, life under heat, flow as well as softening and melting points. Films of these modified shellac were made on glass slides and polished tin sheets in the usual manner. After air-drying for 10 days the scratch hardness, elasticity and water resistance of these films were determined. The corresponding values of untreated shellac as well as shellac heated alone at 125°C. for 1 hr. have been shown in Table III.

TABLE III — SHELLAC AND ROSIN HEATED IN DIFFERENT PROPORTIONS AT 125°C. FOR 1 HR.

No.	Shellac, %	Rosin, %	Acid value	Fluidity for 5·0″, sec.	Life at 150°C., min.	Softening point, °C.	Melting point, °C.	Scratch hardness : load in gm. on 1 mm. steel ball
1	Untreated shellac	0	74·52	47	48	69·0	78·0	2,000
2	100	0	71·87	101	48	68·0	76·0	750
3	99	1	73·67	94	54	66·4	76·0	1000
4	98	2	74·82	91	55	68·3	78·0	900
5	97	3	76·99	89	57	71·4	81·0	850
6	96	4	77·52	81	59	71·0	81·5	900
7	95	5	78·66	72	62	71·0	82·0	900
8	94	6	79·98	70	65	68·0	80·0	800
9	93	7	81·03	68	69	69·0	79·0	800
10	92	8	82·25	64	72	68·0	81·0	800
11	91	9	83·96	62	76	67·8	78·5	750
12	90	10	85·50	60	79	64·2	77·0	600

No. 1 : blush after 3-4 hr. on immersion in water. Recovery in 30 min.
Nos. 3 to 12 : sign of blush after 7 hr. Recovery in 3½ hr. for Nos. 3 to 8. No recovery for rest.

From Table III it is clear that, as expected, the acid value, flow and life progressively increased with increasing proportions of rosin. The softening and melting points, however, were not appreciably affected. The scratch-hardness of rosinated shellac films was considerably lower than that observed in the case of untreated shellac. Rosinated shellac films showed first signs of blush after about 7 hours' immersion as against 3-4 hours in the case of untreated shellac. Rosinated shellac films (1-6 per cent rosin) required about 3½ hr. for recovery and those containing higher percentage of rosin did not recover at all whereas untreated shellac films under same conditions recovered within half an hour.

(ii) *Shellac and methyl esters of lac* — Similar experiments were carried out using methyl ester of lac in place of rosin, the expectation being enhanced flexibility and fluidity of the products. The heating in this case was conducted at three different temperatures. The results are summarized in Table IV.

TABLE IV—PROPERTIES OF SHELLAC + METHYL ESTER OF LAC AFTER HEATING FOR 1 HR.

Temperature of heating, °C.	Shellac, %	Methyl ester of lac, %	Acid value	Softening point, °C.	Melting point, °C.	Life under heat at 150°C., min.	Fluidity for 5·0″ (Westinghouse), sec.	Scratch hardness test: load in gm. on 1 mm. steel ball
—	Untreated shellac	—	74·52	69	78	48	47	2000
110	100	0	74·91	67	76	47	80	750
—	99	1	74·29	64	74	61	51	750
—	98	2	73·65	64	74	54	63	950
—	96	4	73·65	66	74·5	50	67	1000
—	93	7	71·86	65	74	64	61	850
—	90	10	70·60	64	73	53	55	750
125	100	0	71·87	68	76	48	101	750
—	99	1	71·52	69	79	44	117	750
—	98	2	71·49	68·5	78·5	43·5	108	800
—	96	4	71·19	65	74	43	92	1000
—	93	7	69·43	67	76	44	92	800
—	90	10	66·74	68	79	47	90	750
135	100	0	71·41	69	78	28	301	800
—	99	1	70·82	71	80	31	219	1250
—	98	2	69·39	69	80	31·5	201	900
—	96	4	68·79	68	79	32	181	750
—	93	7	67·24	67	78	35	156	950
—	90	10	66·07	66	75	39	137	1,250

It will be seen from Table IV that fluidity and life under heat were inferior to those of parent shellac except for the products obtained at 110°C. There was not much change in the softening and melting points. The films obtained from the melts had inferior scratch hardness; elasticity did not appreciably improve. The time for initial appearance of blush on immersion, in water was about 7 hr. Recovery of the blushed film, on 24 hours' immersion, was 3½-4 hr. It would thus be seen that shellac and rosin or shellac and lac esters do not give better performance than shellac in regard to flow or life or film properties.

4. FUNDAMENTAL RESEARCHES

(a) Chemical Constitution of Shellac

The work on the constitution of shellac was continued (*Annual Report*, 1951-52, p. 23) and further attempts were made to determine the position of the hydroxyl group in butolic acid.

(i) *Butolic Acid*

Oxidation of methyl butolate — Methyl butolate (2 g.) was oxidized with 10 per cent chromic acid (16 cc.) dissolved in 90 per cent acetic acid at room temperature, and methyl ketobutolate (1·5 g.) was obtained as a liquid.

Preparation of mixed oximes and the Beckmann transformation — Oximation of methyl ketobutolate (1·5 g.) was effected with hydroxylamine hydrochloride and sodium acetate in boiling 80 per cent alcohol for 2 hr. The mixed (cis- and trans-) oximes (1·6 g.) were obtained as a liquid. To the unpurified liquid oximes concentrated sulphuric acid (10 cc.) was added and the mixture heated on a water bath for an hour. After cooling, it was poured over powdered ice and the precipitated amides were separated. A brown solid product (1·23 g.) was obtained.

Hydrolysis of mixed amides — The mixed amides (1·17 g.) were heated in a bomb at 165°C. for 5 hr. with 20 per cent alcoholic caustic potash solution (5 cc.). After cooling, the bomb was opened and the contents were taken out, acidified with sulphuric acid and steam-distilled. About 1·5 l. of distillate (A) were collected and kept aside for extraction of steam-volatile acid. The residual liquid was extracted with ether and the ethereal extract (B) retained for examination. The aqueous residue was neutralized with caustic potash solution and again steam-distilled. About 2 l. of distillate (C) were collected which contained the steam-volatile amine. The distillate residue (D) was expected to contain the amino acid.

(A) Steam-volatile acid: The distillate (A) (1·5 l.) was extracted with ether and a slightly pungent-smelling brown liquid (0·2 gm.) was eventually obtained. It did not solidify even at 5°C.

(B) The ethereal extract (B), which was supposed to contain the dibasic acid, practically gave no residue on drying and decolourization.

(D) No amino acid also could be obtained from the distillate residue.

The processes were once more repeated with a larger amount of methyl butolate (7 gm.). Pure mixed amides, m.p. 88°-89°C., were hydrolysed with 46-48 per cent hydrobromic acid at 160°-170°C. in a sealed tube for 6 hr. The products are being investigated.

(ii) *Examination of Salt Fractions of Hydrolysed Lac*

Treatment of brown barium salt — The brown barium salt, after extraction with absolute ethyl alcohol (*Annual Report*, 1949-50, p. 21), was further extracted with hot absolute methyl alcohol when a part dissolved. The insoluble residue was then extracted successively with hot water and hot methyl alcohol-water mixture (50 : 50).

Methyl alcohol-soluble barium salt — Methyl alcohol was distilled off and water added to the residue giving water-soluble and water-insoluble fractions.

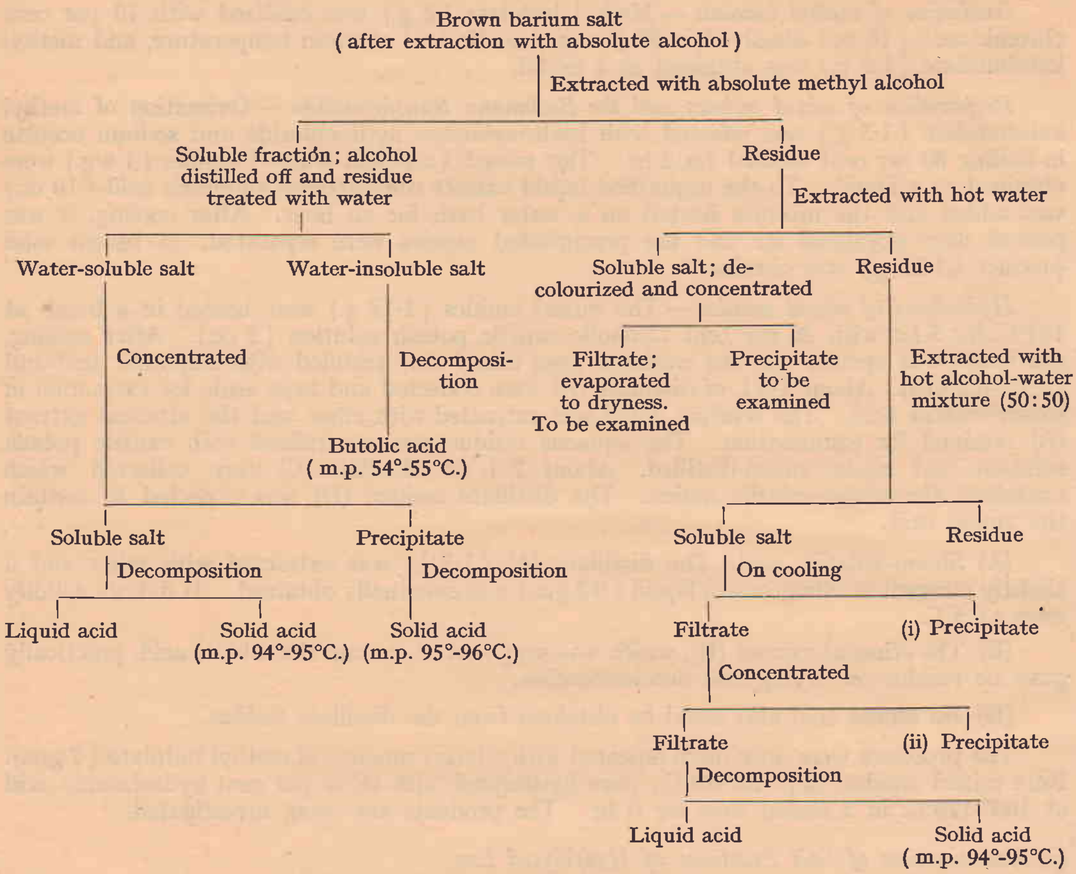
The water-insoluble fraction on decomposition gave butolic acid.

The water-soluble fraction was concentrated, and, on cooling, a precipitate was obtained which, when decomposed with acid, gave a solid acid melting at 95°-96°C. The filtrate containing the soluble barium salt, on decomposition, gave a solid acid melting at 94°-95°C. and a liquid acid.

Hot water-soluble barium salt — The hot water extract was decolourized and concentrated. A small amount of barium salt separated on standing. The filtrate was then evaporated almost to dryness on the water bath and then left at room temperature. This is being investigated further.

Hot methyl alcohol-water extract — The hot alcohol extract, on cooling, gave a precipitate. The filtrate was concentrated and a second crop was obtained on cooling. The mother liquor on decomposition gave a solid acid melting at 94°-95°C. and a liquid acid.

The whole procedure is briefly shown in the following schematic diagram:



Treatment of violet barium salt — The absolute alcohol extracted violet barium salts (*Annual Report*, 1949-50, p. 19), both minor and major fractions, were similarly extracted successively with hot absolute methyl alcohol, hot water and hot methyl alcohol-water mixture (50 : 50).

The methyl alcohol-soluble but water-insoluble salts obtained from the minor and major salt fractions gave butolic acid on decomposition.

The alcohol and water-soluble salt from the minor salt fraction gave only a solid acid melting at 94°-95°C. while that from the major fraction gave a solid acid melting at 95°-96°C. and a liquid acid.

Fractionation of cream-coloured zinc salt — Attempts were made to fractionate the zinc salt (*Annual Report*, 1948-49, p. 17) with solvents as follows:

The finely powdered salt was digested several times with hot absolute methyl alcohol. The extract on cooling gave a precipitate. The filtrate on dilution with methyl alcohol gave a second precipitate. Alcohol was then distilled off as far as possible from the filtrate and water added, by which process a soluble and an insoluble fraction were obtained.

The residue, left after methyl alcohol extraction, was digested with hot methyl alcohol-water mixture (50 : 50). The extract on cooling gave a precipitate of zinc salt. These are being further studied.

(b) Oxidation of Shellac with Periodic Acid

As has been reported already (*Annual Report*, 1951-52, p. 25) the percentage of dihydroxy compound, resulting from oxidation of shellac with periodic acid, gradually increased from 13·36 per cent in half an hour to 40·1 per cent in 5 days. The oxidation was allowed to proceed up to a period of 15 days and it was found that the value gradually increased with time and reached 60·67 per cent in 11 days, remaining thereafter practically constant. The value for saponified shellac, when oxidation was carried out for 30 min., was found to be 35·3-36·5 per cent. In this case also, the value increased with time and reached the maximum of 59·8 per cent in 4 days. In the above two cases the maximum values are in close agreement. Aleuritic acid was also completely oxidized within 30 min. with periodic acid. Hence, presumably aleuritic acid residue, having free adjacent -OH groups is present in shellac to the extent of about 15 per cent. In hydrolysed shellac dihydroxy compounds registered a value of 35 per cent in terms of aleuritic acid.

It was suggested (loc. cit.) that the increase in value with time might be due to the fact that more adjacent OH groups present in shellac in bound condition are liberated under the experimental conditions. To determine whether acetic acid was responsible for the increased values, shellac was dissolved in acetic acid and kept for different periods of time and then the percentage of dihydroxy compound was determined by adding the reagent solution as usual. It was found that the value instead of increasing, as was expected, gradually decreased with time from 13·55 to 8·24 per cent within a period of 1 hr. to 6 days.

Hence it follows that acetic acid is in no way responsible for the increased values and the increase might be due to slow or secondary oxidation of some other groups in shellac or saponified shellac.

It was further observed that the volume of the reagent solution and the volume and the nature of the solvents had practically no effect on the determination of the percentage of the dihydroxy compound. Addition of 5 cc. chloroform following the addition of potassium iodide solution to the reaction mixture helped to get the correct end point as the precipitated oxidized shellac remained dissolved in chloroform.

Results obtained with different grades of shellac at different periods of time are given in Table V.

TABLE V — PERCENTAGE OF DIHYDROXY COMPOUND IN TERMS OF ALEURITIC ACID FOR ISI GRADES OF SHELLAC

Time of reaction in min.	Special	A	B	C	D	E	ILRI *kusmi*
5	11·66	10·68	11·14	10·96	11·00	11·00	12·10
10	12·88	11·26	11·56	11·51	11·79	11·79	12·10
20	13·13	11·38	12·12	11·56	12·57	11·79	12·56
30	13·75	11·52	12·74	12·09	12·54	11·79	13·36
60	13·96	11·46	13·77	12·23	12·57	12·57	13·36

The following are some of the values obtained in a number of commercial and authentic samples of seedlac and shellac (Table VI; p. 34).

(c) Caustic Potash Fusion of Aleuritic Acid

Le Seuer (*J. Chem. Soc.*, 79, 1313, 1901) studied the action of fused potassium hydroxide on 9,10-dihydroxystearic acid (m.p. 131°C.). Carrying out the reaction at 250°C., he obtained a C_{18}-dibasic monohydroxy acid (m.p. 111°-111·5°C.) as the main product in a yield of 58 per cent from the fused mixture. The other products obtained in poor yields were pelargonic acid, azelaic acid and an acid, $C_{18}H_{34}O_3$, melting at 78·5°-79°C. In a like manner, the fusion of aleuritic acid with caustic potash, it was thought, might lead to some interesting results.

TABLE VI — DIHYDROXY VALUES OF SOME SPECIMENS OF SEEDLAC AND SHELLAC

Types of seedlac or shellac	% dihydroxy compound in terms of aleuritic acid
1. Assam seedlac	15·92
2. Burma seedlac	12·87
3. Golden *Baisakhi* seedlac (Ranchi)	13·30
4. *Kusmi* seedlac (I.L.R.I.)	14·30
5. Siam seedlac	9·80
6. Assam shellac	14·81
7. Burma shellac	13·81
8. *Kusmi* shellac (I.L.R.I.)	13·36
9. Bleached regular shellac (I.L.R.I.)	12·71
10. Bleached refined shellac (I.L.R.I.)	14·35
11. T.N. shellac	9·20
12. Superfine shellac (Daltongunj)	12·76
13. Dead shellac	10·08
14. *Baisakhi* shellac (1940)	8·34

Accordingly, aleuritic acid (25 gm.) was fused with caustic potash (100 gm.) at 230°-240°C. till effervescence ceased. The fused mass was cooled, dissolved in water (500 cc.) and kept in cold to see whether any unchanged aleuritic acid precipitated out as sodium aleuritate. As there was no precipitation, the solution was acidified with dilute sulphuric acid. A brown soft mass, having an unpleasant rancid odour, which did not solidify even at 5°C., was obtained. The soft mass was steam distilled and 6 l. of distillate having a rancid odour were collected. The distillate residue on cooling gave some crystals together with a brown semi-solid mass. The solid matter was filtered off and washed with ether giving an insoluble crystalline substance (4·0 gm.) and an ether-soluble brown semi-solid mass (5·3 gm.).

The crystalline mass on decolourization and recrystallization from aqueous methyl alcohol melted at 105°-106°C. Mixed m.p. with pure azelaic acid (m.p. 107°C.) was 95°C. The acid and saponification values were found to be equal, being 395·2. This acid is being further investigated. Attempts to crystallize the semi-solid mass from chloroform did not succeed.

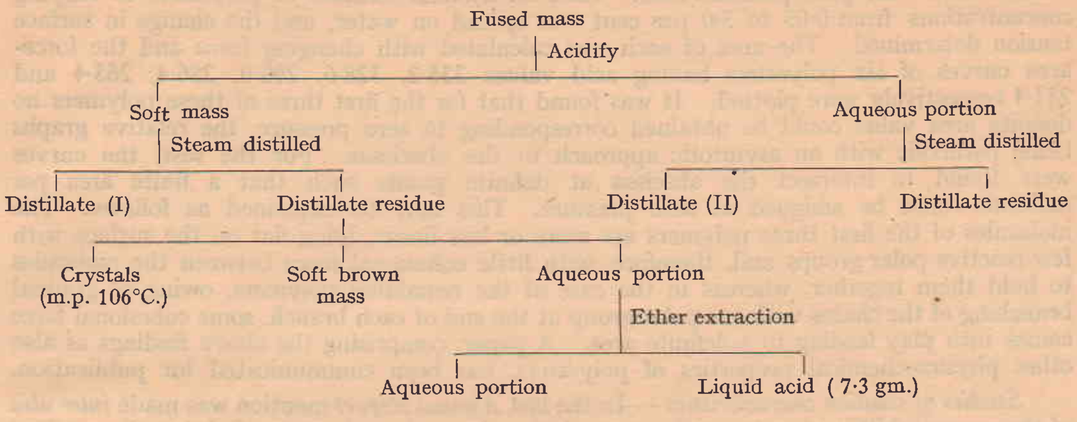
The filtrate from the distillation residue was extracted with ether. On removal of ether from the dried extract, a thick liquid (7·3 gm.) was obtained having an A.V. 414·9 and refractive index 1·4670 at 32°C.

The mother liquor remaining over after the separation of the soft mass also possessed rancid odour and was steam distilled yielding 2 l. distillate. The two distillates were taken together and extracted with ether. Removal of ether gave a slightly pungent-smelling liquid (4·87 g.) having refractive index 1·4445 at 32°C., A.V. 386·9 and S.V. 411·1. The various steps are indicated diagrammatically on p. 39.

(a) Fractionation of Shellac

Shellac is known to consist of two parts: (i) an ether-insoluble part called pure or hard resin and (ii) an ether-soluble part called soft resin. These can be conveniently separated by ether or some other organic solvents. Schaeffer, Weinberger and Gardner (*Ind. Eng. Chem.*, **30**, 451, 1938) divided the hard lac into four fractions by means of different solvents. These results indicate that hard resin is not a single compound but a mixture of at least four components. For a correct appreciation of the nature of shellac complex, it is necessary to know the chemical nature of physically or chemically separable units that make up hard resin. Venugopalan and Sen (*J. Soc. Chem. Ind.*, **57**, 371, 1938) developed a process for the preparation of hard resin taking advantage of the precipitation of hard resin in an acetone solution of shellac in the presence of urea, the soft resin being left unaltered in the acetone solution itself.

Alkali fusion of aleuritic acid



An attempt was made to fractionate shellac by progressive precipitation of shellac-urea complex from acetone solution according to Venugopalan and Sen's procedure as follows:

Angelo's dewaxed and decolourized shellac (200 gm.) was dissolved in dry acetone (1 l.) by warming. A solution of urea (16 gm.) in acetone (500 cc.) to which a few drops of water had been added was made by warming. These two solutions were mixed and refluxed on the water bath. After 15 min. a solid began to separate and was immediately filtered off through cotton wool (F I). The filtrate gave a second solid product (F II) on slight cooling and a third (F III) on cooling to room temperature. The mother liquor was again refluxed for a further period of 2 hr. and on cooling overnight another product (F IV) was obtained. These fractions were then individually extracted with acetone to remove the adhering soft resin. The acetone extract on cooling gave a precipitate (F V). The acetone solutions were taken together and a coloured thick syrup (F VI) was left when acetone was distilled off. The products were then washed repeatedly with boiling water to decompose the urea complex and remove urea. The properties of the resultant products are as shown in Table VII.

TABLE VII — FRACTIONATION OF HARD RESIN THROUGH UREA COMPLEX

Fractions	Wt. obtained, gm.	Acid value	Sap. value	Ester value
I	22·0	74·0	232·6	158·6
II	34·0	70·2	252·5	182·3
III	44·8	60·9	224·2	163·3
IV	11·8	64·4	224·5	160·1
V	35·6	49·2	171·5	122·3
VI (soft resin)	48·7	100·8	187·3	86·5
Control	Shellac	74·8	220·4	145·6

(e) POLYESTERIFICATION OF 9,10-DIHYDROXYHEXADECANE 1,16-DICARBOXYLIC ACID

After studying the various physico-chemical properties such as refractive index, molecular weights, viscosity and fractionation of polyesters of the above di-acid, the properties of monomolecular layers during progressive polyesterification were studied. The surface tension of pure distilled water was determined by means of Cenco-Dunouy tensiometer, standardized with pure palmitic acid. Then an acetone solution of polyesters of varying concentrations from 0·05 to 5·0 per cent was spread on water, and the change in surface tension determined. The area of each was calculated with changing force and the force-area curves of six polyesters having acid values 335·2, 328·6, 298·0, 286·4, 263·4 and 251·4 respectively were plotted. It was found that for the first three of these polymers no definite area value could be obtained corresponding to zero pressure, the relative graphs being parabolic with an asymtotic approach to the abscissae. For the rest, the curves were found to intersect the abscissa at definite points such that a finite area per molecule could be assigned at zero pressure. This may be explained as follows: The molecules of the first three polymers are more or less linear, lying flat on the surface with few reactive polar groups and, therefore, with little cohesional force between the molecules to hold them together, whereas in the case of the remaining polymers, owing to gradual branching of the chains with one polar group at the end of each branch, some cohesional force comes into play leading to a definite area. A paper, comprising the above findings as also other physico-chemical properties of polyesters, has been communicated for publication.

Studies of solution characteristics — In the last *Annual Report* mention was made *inter alia* of the precipitability of a few polyesters of the above di-acid while studying the various physico-chemical properties of the polyesters formed by the heat polymerization of the di-acid. Further work was continued, particularly on the quantitative aspects of the subject. Precipitability and solubility of four polyesters of the above di-acid having different degrees of polymerization were investigated for the purpose, and the applicability of two equations of G. V. Schulze was examined on the basis of the experimental results obtained. It was found that Hibbert's equation (a modification of G. V. Schulze's) was in better agreement with the results and reasons for this were given. The solubility experiments were carried out in acetone solution using water as the non-solvent. A slightly modified form of Hibbert's apparatus was used during titrations; the end point could be sharply determined by noting the first sign of turbidity against a black paper screen background, while a strong beam of light illuminated the titration tube. The precipitability was observed in dioxane-water system at 25°C. A paper embodying the results has been communicated for publication.

(f) Alcoholysis of Polycondensed Products of Aleuritic Acid

A preliminary study of alcoholysis of some polycondensed products of aleuritic acid prepared according to the method described by Basu, Bhowmik and Bose (*J. sci. industr. Res.*, **7B**, p. 153, 1948) was done. Alcoholysis was done by heating the polycondensed product (2·5 gm.) on a water bath for 4 hr. with 95 per cent ethyl alcohol (10 cc.) and concentrated hydrochloric acid (0·5 cc.). The products of alcoholysis were isolated by pouring the above solution into cold water and extracting with ether. The ethereal extract was washed with 2 per cent NaOH and water. The washings were acidified, and a white precipitate obtained which was found to be aleuritic acid. The residue obtained after evaporation of the ether solution was examined.

Results of the experiments done so far are given below:

Nature of polyaleuritic acid used	Product of alcoholysis	
	S.V.	-OH.V
1. Insoluble and infusible	183·3	396·4
2. Insoluble in alcohol but soluble in alcohol-benzene mixture (1: 1)	172·4	436·0
3. Soluble in alcohol (A.V. 17·5)	180·9	449·5
4. Soluble in alcohol (A.V. 95)	171·0	564·4

Calculated S.V. and -OH.V of ethyl ester of aleuritic acid and its chain polymers are as follows:

Ethyl ester of	S.V.	-OH.V
1. Aleuritic acid	169·0	507·0
2. Dimer	181·5	453·0
3. Trimer	186·1	434·2
4. Tetramer	188·5	424·1

From the above it appears that a polycondensed product of aleuritic acid can be alcoholysed to a lower stage of condensation by heating with alcohol containing hydrochloric acid.

The importance of the presence of acid (HCl) was revealed by the following experiment: Infusible and insoluble polycondensed aleuritic acid was heated with 95 per cent alcohol on a water bath for 4 hr. The mass did not dissolve. Then HCl was added and heating continued for another 4 hr., when the mass dissolved to a clear solution. The product of alcoholysis was found to have the properties as stated above.

(g) Hydrolysed Lac

The product of saponification of the lac resin is a sticky mass consisting essentially of a mixture of hydroxy acids. This hydrolysed lac has been found suitable for use as an adhesive for the manufacture of flexible micanite and also for electric bulb capping cement. The ethylene glycol ester of hydrolysed lac has also been found to be remarkable for its low temperature flexibility.

In the preparation of hydrolysed lac (also known as saponified lac) from shellac, a yield of only 50-60 per cent on the weight of shellac has been reported. This obviously refers only to the water-insoluble fraction which readily separates out on the addition of mineral acid to saponified lac. Very little is known about the remaining 30-40 per cent (which is obviously present in water-soluble form) beyond the statement, unsupported by experimental evidence, that this fraction consists largely of aleuritic acid for which it has been recommended as a source (cf. Kamath, N. R., *London Shellac Research Bur., Bull. No.* 6, 1944, p. 5).

As this fraction constitutes a substantial proportion of the lac, it was considered of interest to study it more thoroughly. Accordingly shellac was hydrolysed as follows: 160 gm. of caustic soda were dissolved in 300 cc. water. The solution, on cooling, measured 335 cc. 5 cc. portion of this was transferred by means of a pipette to a 100 cc. measuring flask and was set aside for determining the acid equivalent. To the remaining caustic solution, 1,000 gm. of powdered shellac were added and the mixture was boiled under reflux on a sand bath for 6 hr. On cooling, the wax that had risen to the surface hardened to a thick crust. The saponified mass was then diluted to about 3 l. and filtered and the insoluble wax residue washed thoroughly. The crude wax, after drying, weighed 45-50 gm.

The clear filtrate was diluted still further to a total volume of 5 l. and cautiously acidified with efficient stirring, with the calculated amount (as determined by titration) of 10 per cent sulphuric acid. After some time the precipitated viscous mass was separated from the mother liquor by decantation and washed thrice with boiling water. It was then dried by heating up in a shallow basin to about 140°C. A sticky stiff mass was obtained in a yield of 735-800 gm.

The aqueous mother liquor and washings were then concentrated by evaporation in a shallow basin over a low flame. A pale orange-red resinous material (having the appearance of soft resin) was obtained. This was collected and the mother liquor further concentrated almost to the point of crystallization of sodium sulphate contained in the solution. More of the resinous material separated out. This product was transferred to a 250 cc. beaker and mixed with the earlier lot and heated to boiling with a small amount of water. A clear solution was obtained which, on cooling, separated into two layers, the bottom one being the resinous acid. The clear aqueous supernatant layer was decanted off and the acid washed twice with small amounts of water in the same manner. The product was dried by heating in a shallow basin to about 140°C. During this heating the acid thickened considerably which was not the case with the water-insoluble fraction. On cooling, the product set to a hard brittle mass. The yield of this fraction varied from 120 to 150 gm.

The sodium sulphate-saturated aqueous mother liquor was then evaporated to dryness on a boiling water bath and the residue extracted with alcohol in a soxhlet. On evaporation of the alcoholic extract only a negligible amount of a tarry matter was obtained. The properties of the two fractions of hydrolysed lac, insoluble and soluble in water respectively, are tabulated below:

PROPERTIES OF HYDROLYSED LACS

Properties	Parent shellac	I Portion precipitated on the addition of mineral acid to shellac saponified with caustic alkali	II Portion recovered from the aqueous mother liquor from I
1. Appearance	—	Soft sticky resin	Hard brittle resin
2. Colour	—	Dark reddish-brown	Pale orange-red
3. Yield on the weight of shellac	—	73-80%	12-15%
4. Acid value	72-75	150-160	210-220
5. Saponification value	—	—	273·8
6. Life at 150°C.	52 min.	108 min.	Gradually but steadily thickens until after 2-2½ hr. it becomes too hard to stir
7. Appearance of the polymerized product	Horny brittle resin	Tough elastic mass; rubber-like; slightly tacky	Extremely hard and brittle
8. Solubility of the "polymerized" product in alcohol	Mostly insoluble	Soluble with difficulty	Completely soluble even in the cold
9. Acid value of the polymerized product	—	91·47	183·7
10. Aleuritic acid (by allowing to stand in contact with 30% NaOH)	—	22% yield	Nil

From the above it will be seen that contrary to the expectations of Kamath and Gidvani, there appears to be no aleuritic acid in the acid fractions recovered from the aqueous mother liquor. Practically the whole of the aleuritic acid appears to be present in the water-insoluble portion of the hydrolysed lac.

It was observed that the drying out of the resinous acid from the aqueous mother liquor by direct heating resulted in continuous thickening of the product. It was considered probable, therefore, that in addition to drying, polymerization was also taking place due to raising of temperature. In order to eliminate this possibility, a small amount of the wet product was smeared on the surface of a shallow basin and allowed gradually to air-dry. When thoroughly dry, it was scraped off, powdered and again allowed to air-dry for a few days. A pale pinkish brittle resinous powder was obtained having an A.V. of about 260 and S.V. of 274·5 indicating that during heating some chemical change did take place with elimination of water.

It will be noted that the above acid fractions were obtained by saponifying lac with caustic alkali by boiling under reflux. In another experiment, the saponification was carried out in the cold. For this purpose 100 gm. of lac (Angelo's dewaxed superblonde) were dissolved in 100 cc. of a 20 per cent caustic soda solution and allowed to stand for 10 days when sodium aleuritate was precipitated. The mixture was then diluted with 400 cc. of 20 per cent solution of sodium chloride and filtered under suction and the residue washed with a further 100 cc. of the same sodium chloride solution. The filtrate was neutralized with dilute hydrochloric acid with stirring in the cold when a resinous semi-solid mass insoluble in water separated. The clear supernatant portion was decanted off and the insoluble product was separated. The decanted layer together with the wash-water was extracted successively with ether, chloroform and ethyl acetate. Solid sodium carbonate was then added in excess to the extracted liquor which was then evaporated to dryness. The residue was powdered and extracted with absolute ethyl alcohol. Evaporation of alcohol after decolourization gave sodium salt of some organic acid.

The ether, chloroform, and ethyl acetate extracts were dried and the solvents distilled off. The last traces of the solvents were removed under high vacuum when fluffy powders were obtained.

The water-insoluble acid was boiled twice with water with mechanical stirring. The water extract was successively extracted with ether, chloroform and ethyl acetate. No alcohol-soluble sodium salt could be obtained in this case from the extracted liquor.

The amounts of different acid fractions obtained were as shown in Table VIII.

TABLE VIII—ACIDIC FRACTIONS OBTAINED FROM 100 GM. OF SAPONIFIED SHELLAC

Acid fractions	Weight obtained, gm.	Acid value	Remarks
1. Ether soluble	5·8	305·8	Fractions 1-4 are obtained from water-soluble shellac acids
2. Chloroform-soluble	0·5	173·0	—
3. Ethyl acetate-soluble	7·5	283·3	—
4. Water-soluble as sodium salt	17·0	—	25·3% Na
5. Aleuritic acid	23·0	186·0	—
6. Insoluble acid	42·0	—	—

5. GRADING AND ANALYSIS

(a) Bleachability of Seedlacs

An improved method for the determination of the bleachability of seedlacs has been already described (*Annual Report*, 1950-51, pp. 29-33). This method consists in treating all samples of seedlac, irrespective of grade or kind, under exactly identical conditions and determining the colour of the resulting solution after filtering off the wax, in terms of N/1000 iodine by matching in a Dubosq comparator. The bleach index is then directly read from a curve. The dependability (accuracy) of this curve and the influence of temperature on the results obtainable by this method have now been examined.

Effect of temperature — It is well known that temperature has considerable influence upon the speed of hypochlorite bleaching. It was, therefore, considered necessary to determine how far the results of this modified method will be affected by temperature at which the bleaching is allowed to proceed. With this end in view, the determinations were carried out on a number of samples of seedlac, the solutions in contact with the bleach liquor being allowed to stand overnight (i) at the laboratory temperature (30°-35°C.) and (ii) in a refrigerator at 3°-5°C. and in a few cases in a thermostat at 35°C. For the sake of completeness, the colour ratios of some of the solutions before the final addition of the 4 cc. bleach liquor were also determined. The results obtained are given in Table IX.

TABLE IX — COLOUR RATIO

Experiment No.	Sample	Before the addition of the last 4 cc.		½ hr. after the addition of the 4 cc.		
		At 30°-35°C.	At 3°-5°C.	At 30°-35°C.	At 3°-5°C.	At 35°C.
1	P	4·30	4·56	5·64	5·32	—
2	Q	—	2·61	3·12	2·64	—
3	Q	0·81	2·91	2·77	2·94	—
4	R	1·24	3·48	4·27	4·27	—
5	S	0·51	1·05	1·39	1·41	—
6	S	0·45	1·22	1·25	1·44	—
7	S	0·56	1·40	1·47	2·19	—
8	T	2·24	6·24	8·84	8·90	—
9	T	1·98	7·74	8·98	8·94	—
10	a	—	—	3·40	3·49	3·40
11	b	—	—	3·35	3·49	3·37
12	c	—	—	2·74	3·06	2·75
13	d	—	—	0·95	0·88	0·80
14	e	—	—	3·00	3·48	3·52
15	f	—	—	3·17	3·24	3·00

It will be seen from the above table that laboratory temperature (at least up to 35°C.) has no appreciable influence on the final results.

Another point of interest has emerged from these experiments. It will be noted that in the case of the solutions maintained in the refrigerator the colour ratios both before and after addition of the 4 cc. were not very different. In the case of solutions maintained at higher temperature, however, the same ratios were obtained only after the addition of the 4 cc. and not before. This would indicate that in cases where the bleaching is conducted at low temperatures, even though the rate of bleaching might be slow, there is no reversion of colour on keeping. Therefore, the additional 4 cc. added next morning are without effect. In the case of batches allowed to stand at higher temperatures, the bleaching is faster and after the bleach liquor has already exhausted itself, i.e. when there is no further bleaching, the solution starts regaining colour. The 4 cc. of bleach liquor added next morning only eliminates the colour thus regained. The solution is thereby brought back to the same shade which it had at the time when the bleaching was complete, but reversion of colour had not commenced.

Verification of the curve — It was realized that the validity of the new method depends entirely on the dependability or accuracy of the curve, i.e. on whether seedlacs would all be bleached to the standard shade (colour ratio 3-3·6), if treated with equivalent quantities of bleach liquor as indicated by the curve. This was, therefore, investigated. The bleach indices of a number of seedlacs were determined according to the new method with reference to the curve. These samples (37·5 ± 0·1 gm.) were then extracted with soda as usual and filtered. The filtrate, after cooling, was made up to a volume of 375 − x cc.; where x = (bleachi ndex of the sample − 4) × $\frac{5}{4}$. It was then treated with x cc. of bleach, thus making the total volume 375 cc. and allowed to stand overnight. 300 cc. of the resulting mixture were treated with a further 4 cc. of bleach liquor, allowed to stand for ½ hr. and the colour ratio determined after filtering off the wax. The results are given in Table X.

TABLE X

Expt. No.	Sample	Colour ratio found with 80 cc. bleach	Bleach index read from curve	Colour ratio after bleaching with equivalent of bleach index
1	a	3·95	73	4·01
2	a	3·84	74	3·94
3	b	6·25	56	3·82
4	b	6·52	55	3·42
5	c	2·45	92	3·92
6	c	2·50	92	3·64
7	d	1·40	109	3·7
8	d	1·40	109	2·96
9	e	1·64	105	3·09
10	e	1·64	105	3·42
11	f	0·87	120	3·34
12	f	0·64	127	3·62

These values are not very wide off the expected 3-3·6 and may be considered to be within the limits of experimental error.

A note comprising the results of these investigations is being prepared for publication.

(b) Heat Resistance of Shellac Plastics

The work on the determination of the heat resistance of shellac plastics by various methods was continued (*Annual Report*, 1951-52). To start with, the determination was carried out both by Marten's oven test and by A.S.T.M. method.

The A.S.T.M. method, in principle, consists in the determination of temperature at which a stress of 5·5 lb. will produce a deflection of 10 mils when the stress is applied to the top of a horizontal moulded bar (½″ × ½″ × 5″) at a point midway between two supports, spaced 4 in. apart. The apparatus as suggested by A.S.T.M. was made in the Institute machine-shop with slight modifications and set up inside the Marten's oven, where the temperature could be raised gradually at a rate of 2°C./min. Deflections of the specimen rods were observed at regular intervals, with a micrometer gauge, corrections being applied for thermal expansion of the metal part in contact with the specimen. The value of heat resistance (in temperature) was determined from a graphical plot of the deflections against temperature. The temperature resistance as determined thus by A.S.T.M. method came out to be 65°-66°C. as against 81·5°-82°C. given by the Marten's oven test method. The work will be continued.

6. MAKING OF SHELLAC BY AUTOCLAVE

The pilot plant fabricated by a Calcutta firm was installed and experiments with different qualities of seedlac were done. Time required to melt 30 seers of seedlac was found to be 1½ to 1¾ hr. depending upon the quality of the seedlac. The time increases with the age and the hot alcohol-insoluble contents of the seedlac. The moist molten lac obtained from the autoclave was further heated in a double-walled steam-heated open enamelled pan to dry. If transferred in small lots, as the molten lac comes out of the autoclave, to the steam-heated pan, the entire product from 30 seers of seedlac can be dried in 30 min. from the time of completion of the melting in autoclave.

The dry molten lac obtained from the drying vat was made into sheets by a hand-driven machine. The machine consists of a moving hollow roller made of mild steel, 10 in. in diameter and 20 in. in length, and with arrangements to heat by steam and to cool by circulating water through the roller. On the top of this roller is placed another roller, 3 in. in diameter, and of same length which acts as " spreader ". A blade is put underneath to release the shellac sheet from the surface of the moving roller. The machine could make in 15 min. 30 seers of shellac from dry molten lac.

To make sheets of shellac the dry molten lac was somewhat cooled and poured on to the moving hot roller. The molten lac passing through the combination of the moving and the fixed rollers takes the form of a sheet which is drawn by hand from the bottom of the moving roller.

A comparative statement showing the yields of shellac and *kiri*, and the properties of shellac made respectively by the country and the autoclave methods is given in Table XI (p.43).

From the table it can be seen that for better grades of seedlac, the average yield from the autoclave is lower than that by the country process by 2-3 per cent. For relatively poor grades of seedlac, the yield by the former method may be lower by as much as 5-6 per cent. The reduced yield is partly due to the fact that the product from the autoclave invariably contains less insolubles and wax, and partly to the fact — particularly in the case of the poorer grades of seedlac — that no pressure was applied on the seedlac in the autoclave to force out the lac through the filtering medium, which naturally raised the amount of lac left behind as adhering to the impurities.

To see if the yield of shellac from seedlac containing a relatively high amount of impurities could be improved, the following experiments were performed: (1) the seedlac was heated in the autoclave at a higher pressure and (2) for a longer period. The yield, however, did not increase in either case; in addition, the products obtained were darker in colour.

While working with *Baisakhi* seedlac, it was observed that as compared with *kusmi* seedlac the average grains of *Baisakhi* seedlac were smaller in size and passed through the wire net used in the autoclave. So it was necessary to put first a layer of seedlac of bigger grains obtained by previously sieving the seedlac over the same wire net.

Apart from the experiments referred to already on the drying of molten lac in a double-walled steam-heated pan, a few preliminary experiments were done to dry the moist lac obtained from the autoclave by heating for 4 hr. in vacuum of 23 in. at 70°-75°C. Molten lac from the same batch was also dried in steam-heated open pan for comparison. Results are as given below:

	Open pan	At reduced pressure
Moisture, %	2·23	2·13
Flow (Westinghouse), 5 in.	75 sec.	70 sec.
Life under heat at 150°C.	48 min.	50 min.
Colour index	10·9	9·7

7. "*AD HOC*" RESEARCHES

(a) *White cement for low-watt electric bulb* — An enquiry was received from a Calcutta firm for a suitable white cement from lac for binding brass caps to low-watt electric bulbs such as car lamps and pilot lamps. A few compositions made from lac and saponified lac in varying proportions with titanium oxide as white pigment were made, and tested at the above firm. Among these, the compositions containing 25 per cent saponified lac on the weight of lac and 50 per cent pigment on the total weight were found to be satisfactory in that the cement remained white after fixing and baking, and the adhesion also was good. The effect of storage on these lamps under ordinary atmospheric conditions is being examined.

TABLE XI — COMPARISON OF YIELDS OF SHELLAC PREPARED BY COUNTRY AND AUTOCLAVE PROCESSES

Seedlac taken 30 *srs. in each case*

	1	2	3	4	5	6	7	8	9	10	11	12
Method of melting	Auto-clave	Auto-clave	Auto-clave	Country	Auto-clave	Country	Auto-clave	Country	Auto-clave	Country	Auto-clave	Country
Quality of lac	*Kusmi* 1952	*Kusmi* 1952	*Kusmi* 1952	*Kusmi* 1952	*Baisakhi* golden 1953	*Baisakhi* golden 1953	*Baisakhi* fine 1953	*Baisakhi* fine 1953	*Baisakhi* ordinary 1953	*Baisakhi* ordinary 1953	*Baisakhi* 5% 1953	*Baisakhi* 5% 1952
Weight of seedlac	30 srs.	30 srs.	30 srs.	—	—	—	—	—	—	—	—	—
Yield of shellac	26 srs. 4 ch.	26 srs. 12 ch.	26 srs. 12 ch.	27 srs. 2 ch.	26 srs. 12 ch.	27 srs.	25 srs. 8 ch.	26 srs.	23 srs. 4 ch.	24 srs.	21 srs.	22 srs. 8 ch.
Weight of *kiri* obtained	2 srs. 12 ch.	2 srs. 6 ch.	2 srs. 4 ch.	1 sr. 2 ch.	2 srs.	1 sr. 4 ch.	3 srs.	1 sr. 4 ch.	3 srs. 8 ch.	2 srs.	5 srs. 4 ch.	2 srs. 10 ch.
Analytical data												
Hot alcohol insolubles	0·46	0·35	0·38	0·92	0·29	0·66	0·19	0·66	0·23	0·93	0·28	1·24
Life under heat, min. (150°)	38	37	37	47	34	43	46	53	40	48	37	54
Flow 5, in. (Westing-house), sec.	80	72	78	55	131	113	97	87	170	121	240	175
Wax content, %	2·7	2·4	2·6	4·7	3·2	5·6	2·9	4·7	2·57	5·2	3·8	4·8

(b) *Gasket shellac compound* — A firm in Bombay was interested in the details of preparation of gasket shellac compound and sent a sample of foreign make for examination. On analysis, the sample was found to contain 30-35 per cent lac dissolved in a mixture of alcohol and a small quantity of high boiling solvent. A few compositions from shellac similar to the one sent by the firm but with improved adhesive properties were made and sent to the firm for testing. The firm has not yet reported about the results and a reminder has been issued.

(c) *" Water-soluble " lac* — An interesting observation has been made on the action of ammonia on lac and shellac. It has been noted that mere exposure of lac and shellac to ammonia vapours under specified conditions makes them water-soluble. From a preliminary examination, it has been found that the absorption of ammonia by lac is nearly equivalent to or a little over the amount of alkali required to neutralize the acidity of lac. In one estimation, ammonia actually absorbed by lac amounted to 2·54 per cent. This figure, however, requires confirmation.

The properties of the films obtained from an aqueous solution of lac containing the minimum amount of ammonia were also examined. These films were found defective in that they lacked lustre and gloss, and also cracked on simple air-drying. These defects could be overcome by the addition of 10-15 per cent of extra ammonia and refluxing the solution for 4-5 hr. Further study on the development of " water-soluble " lac is in progress.

(d) *Silicone fluids with shellac varnish* — This investigation was taken up to see if water-repelling silicone fluids could suppress blushing properties of shellac films. The sample of silicone fluid (D.C. 200) used in these experiments was received through the courtesy of the Dow Corning Corporation, Midland, Michigan. It was completely soluble in toluene. Its solubility in rectified spirit was negligible (0·3-0·4 per cent), and in alcohol-toluene mixture (2 : 1 by volume) about 4-5 per cent. Ordinary and dewaxed shellac varnishes were separately prepared in rectified spirit as well as in alcohol-toluene mixture (2 : 1) saturated with D.C. 200. The properties of the air-dried films from these varnishes after ageing for 5 days and one month were studied. The films obtained were rather dull and uneven, especially those from the alcohol-toluene varnish (which contained the larger amount of silicone fluid). There was no improvement in the blushing properties (water resistance) of these films and their adhesion was also poor.

(e) *Decolourization of shellac wax* — An attempt was made to bleach shellac wax (yellow) by dispersing it in 3 per cent sodium carbonate solution and adding to it 3 per cent sodium hypochlorite. Although the wax could thus be bleached, the colour reappeared on melting. Attempts were then made to remove colour from a solution through adsorption by means of decolourizing charcoal. Decolourization from an alcoholic solution of the wax which was first employed for the purpose was not successful; the colour, however, could be adsorbed by charcoal from an ethyl acetate solution of the wax. A typical experiment is described:

100 gm. of yellow shellac wax were dissolved in 1,000 cc. ethyl acetate by heating. Then 20 gm. of decolourizing charcoal were added and the whole was refluxed for $1\frac{1}{2}$ hr. and then filtered while hot. The solvent was recovered by distillation and the residue was heated in an open pan to 105°C. Decolourized wax, thus obtained, had the following data:

	Decolourized wax	Original wax
Acid value	17·53	20·67
Saponification value	74·42	124·20
Softening point	71°-72°C.	75°-76°C.
Melting point	78°-79°C.	83°-84°C.

8. MISCELLANEOUS WORK

(a) *Yield of seedlac and shellac* — As in the last year (*Annual Report,* 1951-52), samples of *Baisakhi* sticklac were collected from Daltonganj and converted into seedlac and shellac with the following results. The amount of sticklac used in each case was one maund.

Sample No.	Yield of seedlac	Yield of shellac (single bag)	Yield of shellac (double bag)
1	21 srs. 10 ch.	19 srs. 11 ch.	18 srs. 8 ch.
2	21 srs. 12 ch.	19 srs. ½ ch.	18 srs. 8 ch.
3	23 srs. 10 ch.	21 srs. 4 ch.	20 srs. 3 ch.

A sample of sticklac had been received from the Department of Cottage Industries, Assam, with a request for assessment of its quality as regards yield of shellac and seedlac and their properties. The results are given below:

1. Yield of seedlac per md. of sticklac	32 srs. 11 ch.
2. Yield of shellac (single bag)	30 srs. 4 ch.
3. Yield of shellac (double bag)	29 srs. 10 ch.
4. Colour index of seedlac	23·5
5. Bleach index of seedlac	120 cc.
6. Hot alcohol insoluble of seedlac (No. 1)	3·772%
7. Hot alcohol insoluble of shellac (No. 2)	0·984%
8. Hot alcohol insoluble of shellac (No. 3)	0·492%

(b) *Compilation of literature on chemical investigations on lac* — A compilation is being made of up-to-date literature dealing with the chemical investigations of lac and its associated materials with a view to publishing the same in the form of a comprehensive review. The preliminary draft is practically complete.

9. DEMONSTRATION AND PUBLICITY

Work under this head was continued as before. Information was supplied mostly through correspondence in answer to various technical and general enquiries from interested parties; in some instances, before replying to specific enquiries, e.g. those relating to gasket shellac compound, waterproof coloured inks, waterproof varnishes, etc., certain amount of *ad hoc* research had to be undertaken. Requests for samples of bleached lac and details for the preparation of bleached lac, shoe polishes from lac wax, etc., were also received from a few parties and these were complied with. A few pounds of bleached lac were supplied to the Department of Anthropology, Indian Museum, Calcutta, for preserving some of their specimens.

In response to a particular enquiry from the Central Standards Office, Ministry of Railways, Chittaranjan, on the possibilities of utilizing by the Indian railways some of the products developed from lac, a few samples of lac-oil varnishes, oilcloth compositions, sealing waxes, lac-oil paints, waterproof coloured inks were sent for trials and examination. Some of these products are reported to be undergoing inside and outside exposure tests and the final reports are expected in due course. Among the compositions sent, those containing cashew-nut shell liquid and lac are reported to be better in some ways as compared with lac-linseed oil compositions. An officer from the Central Standards Office also visited the Institute to acquaint himself with the details of preparation of some of these compositions and took with him a few more samples for further trials. Samples of lead-free lac-oil paints and varnishes were also made and sent to the Central Standards Office on request.

Samples of lac-oil varnishes were also sent to the Indian Standards Institution, Delhi, to see if these could be used for making fuel pump diaphragms able to withstand the action of petrol and petrol-alcohol mixtures. A report from the Institution on these samples is awaited.

About 25 gallons of lac-oil compositions for making oilcloth and bookbinding cloth were sent to a firm in Saharanpur for giving manufacturing trials. The firm sent us samples of some of the manufactured products. On examination, these were found to have some defects in that the coating applied was too thick and there was also soaking of the composition on the other side of the cloth. Suggestions were given to overcome these defects and the party promised to continue the trials and report.

In response to another enquiry from the same firm some details regarding the preparation of " empire cloth "-like materials, suitable for wrapping on tyres and tubes, were supplied. The firm is reported to be now engaged in making about 40 yards of such cloth based on our formula for trials by National Rubber Works, Katni, M.P.

Samples of modified lac moulding powder sent to the Technical Development Establishment of the Armed Services Wing, Dehra Dun, have been found after exhaustive trials to be suitable for making radio knobs. The compositions, however, did not prove satisfactory for making binocular eye-cups. Attempts are being made to supply a suitable moulding composition for making these cups.

A few injection moulding compositions made from lac were sent to Central Telegraph Workshops, Bombay, for making telegraph plugs. None of these proved satisfactory as the flow and finish were not good. Besides, the strength of the plugs made from the compositions was rather poor.

A few compositions of white cement made from lac for fixing brass caps to low-watt bulbs (motor-car lamps, pilot lamps, etc.) were sent to an electric lamp manufacturing firm. The adhesive property of the cement was found to be good. The effect of storage on these bulbs is being watched.

Two gallons of an adhesive compound made from lac have been sent on request to the Radio Engineer, Government of Madras, for stiffening loudspeaker cones as also for fixing them to metal frames. Trial samples sent earlier were found to be satisfactory for the purpose.

Advice regarding the setting up of a garnet lac manufacturing factory together with full details about the preparation of garnet lac from *kiri* was given to the Director of Industries, Bihar, on request.

Many parties were interested to know the process of making cheap and good-quality sealing waxes and the design of suitable moulds for casting 20 sealing wax sticks at a time. These have been supplied and a non-technical note on the manufacture of good-quality sealing waxes is being prepared for distribution to interested parties.

Information regarding the manufacture of micanite, micafolium, insulating cloth, etc., using shellac was supplied to various parties.

Demonstration on the new method of making shellac by autoclave process was given at the Institute to persons interested in the process.

Apart from the above, wide publicity to some of the important recent developments on lac and its industrial applications arising out of the researches conducted at the Institute was given in several English and Indian language papers by the Dy. Principal Information Officer, Press Information Bureau, Government of India. As a result of this publicity various enquiries were received for supply of more detailed information on most of the items. Particular mention may be made of the article on the " Use of Shellac in Coating Earthenware " which evoked numerous enquiries both from the public and from various State Governments. For the benefit of such enquirers a non-technical note on the subject was published and widely distributed. Practical demonstration was given of the whole process before a large gathering at the All India Sarvodaya Sammelan Exhibition held recently at Chandil in Manbhum district, Bihar. The President of the Indian Union and the Governor of Bihar, who were both present at the demonstration, took keen interest in the process. The public also were largely impressed by the demonstration. As a result of all this, it is hoped that the country's internal consumption of lac may increase to a certain extent.

Exhibits of various types of lac and lac-based articles were sent to the following places during the period under review:

1. Principal, L. D. College of Engineering, Ahmedabad
2. Aboriginal Exhibition, Jagdalpur
3. Lord Reay Maharashtra Indian Museum, Poona
4. Indian Industries Exhibition and Trade Fair, Ranchi
5. The Professor of Zoology, Government Degree College, Naini Tal
6. Mahabodhi Fair at Sanchi, Bhopal
7. The Principal, Goenka College of Commerce & Business Administration, Calcutta
8. The President and Principal, St. Berchman's College, Madras
9. Indian National Congress Exhibition, Hyderabad
10. Government Khasmahal Exhibition at Simdega, Nagri and Gumla, Bihar
11. Republic Day Exhibition, Nagpur, M.P.
12. Rashtrapati Bhavan, New Delhi
13. National and International Agricultural Exhibition, Rome
14. Silver Jubilee Exhibition, Indian School of Mines, Dhanbad
15. All India Sarvodaya Sammelan Exhibition, Chandil, Manbhum, Bihar
16. Canadian International Trade Fair, Toronto (Canada)

10. METEOROLOGICAL REPORT

The average meteorological data for each month during the year 1952-53 are given in the following table:

Month and year		Dry bulb temp. (°F.)	Max. temp. (°F.)	Min. temp. (°F.)	Relative humidity %	Sunshine (hr./day)	Wind speed (miles/hr.)	Rainfall (in.)
April	1952	84·1	100·5	71·1	44·3	9·3	2·40	3·69
May	1952	86·5	102·8	76·4	57·5	8·6	1·00	3·63
June	1952	85·4	98·6	78·6	60·9	5·8	2·40	2·58
July	1952	79·6	88·0	72·5	84·0	3·8	2·30	21·76
Aug.	1952	78·3	87·1	72·5	87·7	4·9	1·75	13·00
Sept.	1952	78·9	88·3	74·8	84·7	5·2	1·14	7·68
Oct.	1952	77·0	88·2	68·1	61·2	8·0	0·83	4·86
Nov.	1952	70·7	83·1	55·3	54·0	9·7	0·63	Nil
Dec.	1952	65·9	80·0	49·0	51·8	9·9	0·45	0·04
Jan.	1953	62·0	76·2	49·0	61·5	8·4	0·77	0·99
Feb.	1953	67·4	85·0	56·3	49·1	9·7	0·90	0·65
March	1953	86·3	98·5	65·9	30·8	10·6	1·80	Nil

The highest maximum temperature attained during the year under report was 110°F. and was recorded on 28th May 1952 and again on 13th and 14th June 1952. The lowest minimum temperature was only 40°F. and was observed on three days in January 1953, namely 18th, 25th and 26th.

The total rainfall during the year was 58·88 in. and the monsoon rain 45·02 in. as against 51·8 in. of total rainfall and 42·06 in. monsoon rainfall during 1951-52, thus showing a slight improvement over the previous year's figures.

P. K. Bose
Director
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Namkum

APPENDIX I

Tabulated Statement of Progress of Investigations

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
1. (i) Improving crop production on *palas* by partial defoliation	1948-49	Experiments continued at Kundri. In July 1952, 107½ mds. of broodlac obtained excluding quantity left on trees for self-infection. This quantity *minus* 20 mds. sold out used to infect 2,451 trees in *Katki* coupé II. Total of 80 mds. 8 srs. scraped lac obtained. *Katki* (1952 October) yield = 63 mds. 32 srs. broodlac from coupé II *plus* 168 mds. 28 srs. brood from coupé III (self-infected). Total scraped from *Katki* = 21 mds. 21 srs.	To be continued.
(ii) Residual effect of repeated partial defoliation of *palas* on lac production	1952-53	(a) At Namkum, 10 partially defoliated and 10 undefoliated trees infected in October 1951. The defoliated trees gave very much better total crop as well as broodlac. Brood to yield ratio for the two groups respectively 1 : 4·06 and 1 : 9·53. (b) At Kundri, experiment was done with 100 defoliated and 100 undefoliated trees. Undefoliated trees gave higher total crop as well as brood yield; percentage of selected brood from defoliated group was more than double that from the undefoliated group.	To be continued.
2. Finding of, and trials on, suitable lac hosts for *Baisakhi* crop including certain *Ficus* and *Albizzia* species	1945-46	6 *Albizzia lucida*, 26 *Ougeinia dalbergioides*, 5 *Ficus cunia* and 1 *Samanea saman* tried at Namkum. The first 3 species gave satisfactory results in respect of both broodlac and total yield. Their use as *Baisakhi* hosts is recommended.	To be continued.
3. (i) Determination of the most suitable pruning method and seasons for *kusum*	1951	Treatment I — Apical pruning with 18 months' rest between cropping and infection developed primary, secondary and tertiary shoots. Treatment II — Apical pruning with 12 months' rest: few secondaries but no tertiaries appeared. Treatment III — Surface pruning with 12 months' rest: few secondaries but no tertiaries appeared. Treatment IV — Surface pruning with 6 months' rest: some growth of primaries only.	

APPENDIX I (*continued*)

ITEM	COMMENCED	PROGRESS	FUTURE WORK PROPOSED
(ii) Yield of lac	...	For *Jethwi* 1952, effect of treatments may be graded in the order I, III, II, IV. *Aghani* 1953: effect of treatments may be graded in the order III, II, IV, I. Statistical analysis of data for 4 trees shows treatment I for *Jethwi* to be best. For *Aghani* there is no clear indications though treatment II appears to be slightly better than treatment IV.	
(iii) Yield of broodlac	...	*Jethwi* 1952 crop: Treatment effects highly significant. Treatment I superior to treatments II, III, IV. *Aghani* 1953 crop: Method of statistical analysis could not be applied, because of too many zeroes in the results.	
4. Growing of lac hosts under crop and bush conditions			
(i) Under crop condition	1952-53	*Cajanus cajan* (*arhar*) tried. Ten plants 2 years old each and 31 plants 1 year old each infected with *ber* broodlac. For the resulting *Baisakhi* (1951-52) crop, brood to yield = 1: 4·07 for the first, and 1: 3·81 for the second group. 20 plants, 15 months old each, infected for *Katki* 1952: Brood to yield ratio = 1: 4·80. Mortality among *Baisakhi* carrying plants 40 per cent, that among *Katki* carrying plants nil.	Long-life varieties of *arhar* will be grown and infected with lac.
(ii) Under bush condition	1952-53	*Z. jujuba, Inga dulce, Flemingia congesta* being grown under bush condition. The two last-named hosts already infected with lac.	To be continued. *B. superba* to be grown for the experiment.
5. Pests of host trees			
(i) *Tessaratoma javanica* (Thunberg) Rhynchita: *Pentatomaiadae*	1950	This is a sporadic pest of *kusum*. Detailed study of life-history has been made.	Concluded.
(ii) *T. javanica* and drying up of young shoots of *kusum*	1950	The nature of the damage and the manner in which it is caused were studied: the bug in nymphal adult stage punctures shoots, buds and leaves and causes them to dry up.	
(iii) Termite control	1950	Termite attack on *ber* and *palas* (at Namkum) could be controlled by applying to tree trunks up to a height of 4-5 ft. 0·5 per cent Gammexane wettable powder in lime wash. The cost of ingredients per tree = one anna.	

APPENDIX I (*continued*)

ITEM	COMMENCED	PROGRESS	FUTURE WORK PROPOSED
(iv) Miscellaneous insects	...	Insects attacking hosts were: *Sathrophyllia rugosa* Linn. (*palas*), *Myllocerus cardoni* Marshall (*kusum*), *Hieromentic foxysta* Meyrick; *Cyclopelta siccifolia* Distant (*palas* and *arhar*) could be netted and killed; *Argyropolce aproba* Meyrick, leaf-roller of *kusum*. Caterpillars (tunnellers) reported last year identified this year as belonging to *Ascalevia* sp.	To be continued.
6. Determination of the various races, strains, species, etc., of the lac insects, their performance, etc.			
(i) Systematic study of lac insects	...	Preliminary catalogue of the family LACCIFERIDAE completed. Classification of the various species, etc., collected already started.	
(ii) Breeding of yellow variety of the lac insect	1952-53	A yellow variety obtained from Delhi being bred on *A. lucida* and *Z. jujuba* plants in pots and in the nursery for purposes of isolation and study. 3rd generation is developing. Male is slightly crimson and liable to be mistaken for the usual crimson variety, but it is not so.	
(iii) Performance of the *Rangeeni* strain (*Baisakhi*) on rain trees (*Samanea saman*) in Chota Nagpur	1951	One rain tree in the Institute tried. For *Baisakhi* June 1952, ratio of brood used to brood obtained = 1:2·15; ratio of brood used to yield (scraped in either case) = 1:3·07. Performance at par with other *Rangeeni* hosts in Chota Nagpur.	To be continued.
		Examination of lac insects from Thailand suggests that the lac-secreting species there is perhaps *L. chinensis* Mahadihassan 1923 and not *L. lacca.*	
7. Influence of various environmental conditions on lac insects: temperature effect	1952-53	*Kusmi* and *Rangeeni* strains were grown on suitable potted plants under conditions of controlled temperature and known humidity. Controlled temperatures were 20°C., 27°C. and R.H. 50-80 and 50-90 per cent. Growth faster than under ordinary field conditions at 27°C. and poorer at 20°C. Initial rate of growth was slightly different for the two strains.	To be continued.
8. Insect enemies of lac			
(i) *Chrysopa* sp.	1950	Two species not yet identified.	
Chrysopa sp. No. 1		Life cycle studied. The insect passes through 3 instars before pupation, the period for maturity varying from 24 to 31 days generally. Feeding habits studied and parasites of these collected.	

ITEM	COMMENCED	PROGRESS	FUTURE WORK PROPOSED
Chrysopa sp. No. 2		Incidence noticed on *Jethwi* and *Katki* crops.	
(ii) Survey and collection of insect enemies and their associated parasites occurring in different lac-growing areas	...	Samples of lac obtained from several parts of the country and kept in cages for emergence of predators and parasites, to be studied subsequently.	
9. Cultural and preventive methods of control of insect enemies			
(i) Use of wire-net baskets as brood containers	1945	Serviceable life of baskets was assessed. Percentage of serviceable baskets left after use was as follows: In one group, 87 per cent after one season's use, 94 per cent after use for second season, 80 per cent after use for third season. In another group, 71 per cent after second season's use, 70 per cent after third season's use and 51 per cent after fourth season's use.	To be continued.
(ii) Hollow bamboo containers with two ends closed with wire net	1951-52	Laboratory trials were followed by small-scale field trials for *Katki* 1952 crop. Appear to be as satisfactory as all-wire baskets.	To be continued.
		A large number of enemy and other (non-lac) insects were trapped in these baskets. Actual counting of these was done.	To be continued.
10. Biological control of the lac predator *Eublemma amabilis* Moore			
(i) Breeding of *Bracon greeni* on alternative hosts in the laboratory	1942	*Crotolaria saltiana* and certain other plants cultivated continued to supply throughout the year *Etiella zinckenella*, an alternative host for *B. greeni*. *Trachylepida fructicassiella* (*Cassia fistula* pod borer) was also available for use as alternative host. Maximum parasitization for *E. zinckenella* 57·1 per cent, for *T. fructicassiella* 75 per cent. Maximum of *B. greeni* bred per host = 1·64 for the former and 2·3 for the latter.	To be continued.
(ii) Development of *B. greeni* in relation to its natural and alternative host	...	Bred on alternative host for several generations, fecundity of *B. greeni* decreases, and period of oviposition increases, but the progeny bred once again on natural host shows improvement in fecundity and preoviposition period. Viability of parasite in its immature stages also improves when the natural host is offered.	

APPENDIX I (*continued*)

ITEM	COMMENCED	PROGRESS	FUTURE WORK PROPOSED
11. Other activities of the Entomology Section			
(i) Training	1940	19 persons were receiving training in lac cultivation. 10 completed the course; 5 of them were from M.P., 4 from Bihar and 1 from U.P.	To be continued.
(ii) Advisory service	...	Advice was given to various parties on request. Technical assistance given to S.O.L.C. in his work on extension of lac cultivation.	To be continued.
(iii) Namkum Plantation	...	General upkeep maintained. *Boga* cultivated as a source of green manure. A small nursery continued to be maintained for raising plants required for research.	
12. Varnishes, lacquers and paints			
(i) Lac-linseed oil paints	1948	Paints containing shellac, linseed oil, lime and cashew nut shell liquid (CNSL)-formaldehyde resins have given good indoor performance. Railways have tried the paints and taken further samples for repeat trials.	To be continued.
(ii) Lead-free lac-linseed oil paints	...	At the suggestion of the Railways, paints have been formulated using zinc oxide in place of litharge. The paint vehicle can be thinned with white spirit, and air-dried to a glossy film in 72 hr. With 0·4-0·5 per cent cobalt naphthenate in it, the drying time comes down to less than 24 hr.	To be continued.
(iii) Ageing properties of lac-linseed oil paints	...	Wood and iron-work of the Institute buildings and staff quarters were painted 5 years back. Painted surfaces indoors have been keeping quite well.	Observations to be continued.
(vi) Shellac-based anti-corrosive and anti-fouling paints	1952-53	Work started to evolve shellac-based compositions to be used for painting ships' bottoms.	Some of the recent formulations of shellac paints will also be tried.
13. Moulding compositions: Lac-dimethylol urea compositions	1946	Lac-dimethylol urea (DU) moulding powders sought to be reformulated using technical quality DU in place of laboratory-made alcohol-soluble DU. Use of technical quality DU found feasible, if hardeners (maleic acid 2 per cent and lime 1 per cent) are included in the composition. Technique of production also simplified. Use of these hardeners also improves the powders made with alcohol-soluble DU.	Other hardeners will be tried and study of various properties of these moulding powders will be made.

APPENDIX I (*continued*)

Item	Commenced	Progress	Future work proposed
14. Modification of lac and its derivatives			
(i) Shellac and rosin	1952	Shellac mixed with rosin in proportions varying from 0 to 10 per cent and treated at 125° for 1 hr. The films were studied for water resistance and scratch hardness. No improvement over shellac films was noted.	To be continued.
(ii) Shellac and methyl ester of lac	1952	Shellac and methyl ester (0-10 per cent) mixed and heated at different temperatures (110°, 125°, 135°C.). Films had inferior scratch hardness, no improvement in elasticity; water resistance also not improved.	
15. Fundamental researches			
(a) Chemical constitution of shellac	1947		
(i) Butolic acid	...	Experiments continued to determine position of -OH group in butolic acid. Butolic acid was converted into methyl ketobutate. Mixed amides were obtained from ketobutate by oximation. The amides were hydrolysed to yield various fractions for further study.	To be continued.
(ii) Salt fractions of hydrolysed lac	...	(1) Brown barium salt, (2) violet barium salt and (3) cream-coloured zinc salt, already separated, were further fractionated to yield a number of liquid and solid acids. Butolic acid was one of the fractions.	To be continued.
(b) Oxidation of shellac with periodic acid	...	Both shellac and saponified shellac were oxidized with periodic acid. The observed percentage of dihydroxy compound in either case increased with time, reaching a maximum of nearly 61 per cent. This suggests the presence in shellac of aleuritic acid residue having free -OH groups to the extent of about 15 per cent. Acetic acid used in these experiments had no effect on the values, as could be determined by a different experiment.	
(c) Caustic potash fusion of aleuritic acid	...	Aleuritic acid was fused with caustic potash, and the fused mass on treatment gave several fractions (crystals, liquid acid and a brown mass).	

APPENDIX I (*continued*)

Item	Commenced	Progress	Future work proposed
(d) Fractionation of shellac	...	Shellac-urea complex, made from dewaxed, decolourized lac, was fractionated, giving 6 fractions with distinct A.V., S.V. and E.V.	
(e) Polyesterification of 9, 10-dihydroxyhexadecane 1, 16-dicarboxylic acid	...	6 poly-esters were prepared and force-area curves plotted (using a Cenco-Dunouy tensiometer). The data were interpreted as throwing light on the branching of, and cohesional force between, the molecules. Solution behaviour (precipitability) of the poly-esters in dioxane water system at 25°C. was also studied.	
(f) Alcoholysis of poly-condensed products of aleuritic acid	...	Alcoholysis effected by heating the polycondensed product with (95 per cent) ethyl alcohol. The poly-condensed product was alcoholysed to a lower degree of condensation.	
(g) Hydrolysed lac	...	(i) The mother liquor remaining behind after evaporation of hydrolysed lac is believed by some to contain aleuritic acid. The residue, on actual test, is found to be a different resin (not aleuritic acid) which is under study.	To be continued.
		(ii) Saponification (hydrolysis) was carried out in the cold, and several acid fractions separated from the residue, which are under study.	To be continued.
16. Grading and analysis			
(i) Bleachability of seed-lacs	1951	A new method for determining bleach index, developed and reported already, was further tested as to whether temperature of determination would affect the results, and how far the method was accurate. Within the range 3°-35°C., temperature had no effect; values deduced from the curve were also consistent and reasonably accurate.	To be continued.
(ii) Heat resistance of shellac plastics	1951	Heat resistance (in terms of temperature) was measured for test bars by Marten's oven method and A.S.T.M. method. The values by the respective methods were 65°-66°C. and 81·5°-82°C.	
17. Improvements in the manufacture of shellac, seedlac, etc.			
Making of shellac by autoclave	1947	Experiments were conducted with the pilot plant installed last year. Time required to melt 30 srs. of seedlac varied from 1½ to 1¾ hr. depending on the quality of seed-lac.	

APPENDIX I (*continued*)

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
		A hand-driven machine was designed and fabricated to convert molten seedlac (after drying) into shellac. With this, 30 srs. of shellac could be made in 15 min. The final yield is somewhat lower, owing partly to less insolubles and wax content of the final product.	
18. *Ad hoc* researches			
(i) White cement for low-watt electric lamps	...	Effect of ageing is being studied.	
(ii) Gasket shellac	1952	Gasket shellac compounds of an improved type formulated and sent to a firm for test and report.	
(iii) Water-soluble shellac	1952	Mere exposure of shellac to ammonia vapour renders it water-soluble. The films of such shellac solution were prepared and tested. Product resulting from refluxing of water-soluble shellac with extra ammonia shows better film properties.	To be continued.
(iv) Bleaching/decolourizing shellac wax	1952	Colour of shellac wax, bleached with hypochlorite, reappears on keeping. Decolourization with charcoal is permanent. Details of the method have been worked out.	
19. Miscellaneous work			
(i) Testing of samples	...	Sticklac samples from the bazar were tested for quality. Samples of sticklac sent by Assam Government were tested for quality (yield of seedlac, shellac).	
(ii) Compilation of chemical literature on shellac	1952	A preliminary draft is complete and is being scrutinized.	
20. Demonstration and publicity	...	Various enquiries were replied to and demonstrations given. Participation in exhibitions helped popularization of lac and lac products, in particular the recently developed method of coating earthenware with shellac.	

APPENDIX II

List of Papers Published during the Year 1952-53

1. Constituents of Shellac: Part I—Butolic Acid, by S. C. SEN GUPTA & P. K. BOSE (*J. sci. industr. Res.*, Vol. 11B, 1952)
2. Polyesterification of Polyhydroxy-polybasic Acid, by P. R. BHATTACHARYA (*J. sci. industr. Res.*, Vol. 11B, 1952)
3. The Use of Shellac in Coating Earthenware, by M. VENUGOPALAN & P. K. BOSE (*J. sci. industr. Res.*, Vol 11A, 1952)
4. Hindi translation of the above
5. Handbook of Shellac Analysis, Second Edition, revised by G. N. BHATTACHARYA & P. K. BOSE

APPENDIX III

Statistics of Lac Production in India during 1952-53 (in maunds)

	Baisakhi	*Jethwi*	*Katki*	*Kusmi*	Total
1952-53	8,90,000	29,000	1,06,500	38,500	10,64,000
1951-52	8,81,400	9,000	2,65,500	63,500	12,19,400
1950-51	6,88,050	5,000	2,49,500	40,800	9,83,350

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