INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1954-55

1956

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APPENDICES

INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR

ANNUAL REPORT FOR THE FINANCIAL YEAR 1954-55

ADMINISTRATIVE AND GENERAL

General — The Institute pursued its research and other activities as usual. Dr. S. V. Puntambekar, Ph.D. (Ill.), F.A.Sc., joined the Institute as its new Director on 8th November 1954. During the period following the resignation of Dr. P. K. Bose in December 1953 and until the assumption of office by Dr. Puntambekar, Shri P. S. Negi, Entomologist, had acted as the Director of the Institute and Shri M. Venugopalan, Shellac Utilization Officer, had held charge of the Chemical Section.

As before, the Institute continued to attract throughout the period numerous visitors from all walks of life, including a few from foreign countries. The most important of these, deserving special mention are listed below:

1. Shri R. G. Bhatawadekar, Joint Director, Ministry of Railways, Government of India
2. Mr. R. Sobol, Coppal & Co., Brussels
3. Dr. H. Bachmayer, Siemens Department
4. Dr. R. V. Rao, Deputy Director of Industries, Assam
5. Shri Poli Reddi, Deputy Director, Industries & Commerce, Andhra
6. Mr. J. H. Whitaker, Professor, University of Connecticut, U.S.A.
7. Prof. D. N. Karve, Member, Planning Commission, Government of India
8. Shri V. Kalyana Sundaran, Planning Commission, Government of India
9. Shri A. Nanu, Deputy Secretary, Ministry of Production, Government of India
10. Shri Basudeva Prasad Sinha, Member, A.I.C.C.

The following members of the Governing Body of the Indian Lac Cess Committee also visited the Institute:

1. Shri S. M. Saksaria
2. Shri S. P. Agarwal
3. Shri S. Sharma

Shri Gopalakrishnan, I.C.S., Secretary, Ministry of Food & Agriculture (Agri.), President, Indian Lac Cess Committee, paid his maiden visit to the Institute in March 1955.

Roads and Buildings — The proposed renovation of the water-works of the Institute was taken up and partly finished during the period. New cast-iron pipes, 4 in. in diameter, could be procured and laid, and supply of water through this new line started in March 1955 to the great relief of all concerned. It may be noted that the question of replacing 3 in. G.I. pipes which had been laid over 25 years back, had been pending for well over 3 years, and there were frequent interruptions in water supply during all this time as the line needed almost daily repairs.

Library — The number of books and bound volumes of journals accessioned during the year was 225. In addition, miscellaneous scientific publications numbering 90 were also received.

The Institute distributed during the period over 6,000 of its own publications: in addition, over 300 publications were sold, and some 100 copies transferred to Special Officer for Lac Cultivation's office for sale/distribution.

It may be noted that the library has already grown big and continues to grow fast on account of constant addition to its stock of books and journals: the available space is proving inadequate to properly accommodate the existing stock, and its expansion by the addition of one room has been sanctioned recently.

Training — Total number of trainees on the roll under Lac Cultivation during the period was 16, of whom 6 were from Bihar, 3 from U.P., 2 from Bhopal, 1 each from West Bengal, Vindhya Pradesh, Andhra, Bombay and S.O.L.C.s staff. Eight trainees completed the full one year's course; the trainees from Bhopal and Bombay left only after going through a part of the course. Five trainees were on the roll at the close of the year.

There were in the Chemical Section 4 regular trainees (6 months' course) under the Industrial Uses of Lac, and one casual trainee deputed by a commercial firm for one month's training in the analysis of lac.

Staff — The following staff joined the Institute during the year:

1. Dr. S. Krishnaswami, Ph.D., as Biologist (Entomological Section, on 19-6-54)
2. Shri N. S. Chauhan, M.Sc., as temporary Research Assistant, Entomological Section, on 10-5-54
3. Shri V. S. Gupta, M.Sc., as temporary Research Assistant, Chemical Section, on 10-10-54
4. Shri B. B. Khanna, M.Sc., as temporary Research Assistant, Chemical Section, on 1-11-54
5. Shri R. K. Verma, B.A., as temporary Senior Clerk, on 12-10-54
6. Shri S. Prasad, as temporary Junior Clerk, on 1-12-54
7. Shri P. K. Choudhury, as temporary Junior Clerk, on 10-1-55

The following members resigned or were discharged during the period:

1. Shri. K. K. Sarkar, M.Sc., Research Assistant (Analytical Chemist), resigned in October 1954
2. Shri R. P. Mehrotra., B.Sc., Junior Research Assistant, resigned (released on 18-1-55),
3. Shri M. Lakra, Senior Clerk, resigned (released on 12-10-54)
4. Shri R. K. Verma was discharged on 12-1-55
5. Shri A. K. Biswas, B.A., Museum Assistant *cum* Insect Setter, resigned (released on 1-7-54)
6. Shri Alam Singh, Peon, discharged on 1-6-54

Shri T. P. Bhowmik, M.Sc. (Chemical Section), was promoted as Scientific Officer (S.O.), with retrospective effect from 6-7-53 *vice* Shri M. Venugopalan, S.O., promoted as Shellac Utilization Officer.

Shri S. C. Sen Gupta, M.Sc., Research Assistant, Chemical Section, was promoted to the Selection Grade (Rs. 250-500), with retrospective effect from 6-7-53 *vice* Shri T. P. Bhowmik, promoted as temporary Scientific Officer.

Shri S. N. Gupta, M.Sc., Liaison Officer under S.O.L.C., reverted to the Entomological Section in April 1954 to be promoted as temporary S.O.

Shri P. R. Bhattacharya, M.Sc., who had been away to the U.S.A., since July 1953 under the award of a foreign scholarship, rejoined the Institute on 1-10-54.

Shri A. Bhattacharya, M.Sc., Research Assistant, Entomological Section, proceeded to U.K. in September 1954 for advanced study under the Colombo Plan. He is expected to remain abroad for 2 years.

Shri S. N. Srivastava, Research Assistant (Physicist), had been away to the Indian Institute of Science, Bangalore, from 4-6-54 to 23-10-54 to receive training in high-voltage technique.

Staff Club — The condition of the staff club remains much the same as in the last few years. Following the drastic cut in the Committee's grant to the club since April 1951, the club has not accepted any grant from the Committee.

ENTOMOLOGICAL SECTION

(P. S. Negi, Entomologist)

I. RESEARCH AND INVESTIGATIONS

1. 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 forest of the Forest Department of Bihar*

Baisakhi *crop* — The Forest Department continued to carry on lac work in the Kundri forest under the technical guidance of the Institute. As reported in the last *Annual Report*, owing to the paucity of broodlac caused by extreme summer of 1953, only 3,237 trees were infected after partial defoliation in October 1953 to grow the *Baisakhi* 1953-54 crop. This year, too, the summer was extremely hot and practically rainless with the result that within 10-20 miles of Kundri, lac has practically become extinct; however, in Kundri, because of the improved methods of cultivation employed, the damage was very much smaller, the lac insects having died in large numbers only on about 21 per cent trees. Thus partial defoliation greatly reduced mortality of lac insects from heat on about 79 per cent trees. But these good results achieved were spoiled by the hitherto undiscovered enemy or enemies. The nature of damage by this agency has already been described in some previous reports. It played havoc with the living lac insects in the month of June and ate them up in very large numbers by breaking open the lac tests. This has resulted in extreme shortage of surplus broodlac and wastage in sticklac, the latter being due to the fact that to get at, and eat, the lac insects, the unknown enemy or enemies break open the lac tests of individual living insects and the broken pieces of lac, which form the larger portion of the lac produced, either fall to the ground or along with the lac insects are eaten up by the enemy itself.

However, inspite of heavy mortality due to extreme heat and damage caused by the unknown enemy or enemies, due to the beneficial effect of partial defoliation, it had been possible to leave sufficient broodlac on 79 per cent trees for their self-infection to grow the succeeding *Katki* crop and to obtain 1,211 lb. of surplus broodlac to artificially infect 205 *palas* trees.

Further, as a result of the past effect of partial defoliation from 2,632 *palas* trees, which could not be brought under regular cultivation from 1951, it was possible to obtain 1859 lb. of *ari* sticklac. From 28 *ber* trees, 91·5 lb. of *ari* sticklac was harvested. The yield of sticklac obtained from brood and rejected lac, cut from *palas* in June-July, was 457 lb.; out of this, 60 lb. was from the surplus broodlac (1,211 lb.), infected to grow the *Katki* 1954 crop. The total yield of sticklac from crop cut at different stages was 2,407·5 lb.

(ii) *Residual effect of repeated partial defoliation of* palas *on lac production* — The problem for investigation is to test how repeated partial defoliation affects the lac-producing capacity of *palas*. As pointed out in the last *Annual Report*, the experiments, as laid down, required remodelling. It will be possible to do so for operations to be conducted from 1955-56, when equal number of comparable trees that have been under defoliation for some years now and those that have not been defoliated, will be pruned and infected under similar conditions and the crop yield obtained compared. Trees for this purpose have been selected and marked in Kundri.

In the meantime, the data obtained from experiments as laid down since 1952, only confirm the results already established, namely, that partial defoliation reduces the mortality in summer due to heat and thus preserves more broodlac in summer than otherwise, and it effects saving in broodlac required to grow *Baisakhi* crop for brood purposes (*see* Table I, p. 4).

TABLE I — CROP DATA

Locality	Number of trees and treatment	Brood used				Part crop yield obtained				% of selected brood obtained or the lac sticks with less heat affected mortality	Ratio of infected to yield obtained (scraped lac)	Remarks
		Lac sticks		Scraped lac		Lac sticks		Scraped lac				
		lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.			
Namkum	10 undefoliated	23	12	4	11	56	14	7	9	83·3	1:1·6	—
	10 defoliated	18	7	3	8	37	14	6	1	100·0	1:1·7	—
Kundri	50 undefoliated	94	0	11	10	180	0	19	0	11·1	1:1·6	—
	50 defoliated	58	8	6	14	85	0	7	0	50·6	1:1·10	Trees smaller than undefoliated ones. Unknown enemy destroyed living insect and lac

In hot areas growing of *Katki* crop by self-infection is essential and it may be adopted in other areas too. Hence, to judge the effect of partial defoliation on production of lac in terms of sticklac (scraped lac) on both the crops (*Baisakhi* and *Katki*) taken together, some broodlac was left for self-infection on 10 partially defoliated as well as on 10 undefoliated hosts at Namkum, and it was found that the ratio of scraped lac obtained from broodlac used in October 1954 to scraped lac yield produced in June and October was 1:5·22 in the case of undefoliated trees and 1:5·34 in the case of defoliated trees, i.e. it was slightly higher from the defoliated trees.

It has been stated under (i) that in Kundri in June, the unknown enemy heavily damaged the living lac insects that escaped death from extreme heat and hot winds. Although lac insects survived heat and drought in much larger numbers on defoliated trees than on undefoliated ones, due to damage caused to lac insects by the unknown enemy, the actual yield of sticklac and broodlac obtained from defoliated trees was very adversely affected this year.

To find out the unknown enemy that damages the broodlac, some birds and squirrels visiting the defoliated trees were shot down and collected. Results of examination are given elsewhere.

To provide alternative food to suspected unknown enemies in summer, 85 cuttings of *pakur* (*Ficus infectoria*) and 70 cuttings of *putkal* (*Ficus glabella*) were planted in coupé I of Kundri. The ripe fruits of these trees are expected to attract the unknown enemies in preference to living lac insects and thus save the enormous devastation of living lac insects and the lac produced by them. The actual benefit to be derived would be known only some years hence when these cuttings developed into trees and began to fruit, but unfortunately due to extreme heat and due to white ant attack all the cuttings planted have died.

2. (i) Economics of Utilizing *Palas* (*B. monosperma*) for *Baisakhi* Crop Only and *Ber* (*Z. mauritiana*) for *Katki* Crop

Experiments have been laid out and operations will start in the succeeding year.

(ii) Comparative Preservation of Broodlac on *Ber* (*Z. mauritiana*) by Partial Pruning before Infection in October-November and after Infection in December-January in the *Baisakhi* Crop

It was proved many years ago that partial pruning of *ber* helps in a large measure to preserve broodlac in the *Baisakhi* crop and the results have been published. Experiments have now been taken up to find out the difference in preservation of broodlac when partial pruning is carried out before and after infection of the crop. In the first case, the tree is partially pruned before it is infected with broodlac, hence all the lac insects that settle on it remain on it till the crop is cut. On the other hand, in the second case, the tree is partially pruned after the lac insects have settled on it and are growing; hence during partial pruning some of the shoots bearing lac have to be cut down. If the first method gives as good results as the second, on which a detailed paper has already been published, then it is definitely to be preferred as it would not only economize in the quantity of broodlac to be used but make available to cultivator the maximum produce of lac that each insect might be able to secrete in its lifetime. To study the problems, three treatments were effected and under each treatment there were five trees. At crop maturity only a portion of the crop was cut from each tree and the rest left to grow the succeeding *Katki* crop by self-infection so that maximum yield of sticklac obtained by each treatment might be available.

Treatment 'A'—Partial pruning in October-November (21-10-54), before infection.

Treatment 'B'—Partial pruning in December-January (5-1-54), after infection.

Treatment 'C'—Control, i.e. without partial pruning.

In all the three cases, part crop was cut from the trees in June-July from the *Baisakhi* crop and rest left for self-infection to produce the succeeding *Katki* crop.

The data given in Table II show that Treatment 'B' was superior to Treatment 'A' in *Baisakhi* as well as in *Katki* crop and that both these treatments were superior to 'C' which served as control to both of them.

TABLE II — EFFECT OF PARTIAL PRUNING ON PRODUCTION OF BROODLAC FROM *BER* BEFORE AND AFTER INFECTION OF *BAISAKHI* CROP

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

Treatment and number of trees	Brood used		Selected brood obtained			Total yield			Percentage of selected brood obtained
	lb.	oz.		lb.	oz.		lb.	oz.	
'A' 5	5	6	B	3	9	B	7	7	B 47·9
			K	6	14	K	36	13	K 16·9
'B' 5	11	4	B	3	14	B	6	15	B 55·8
			K	7	15	K	43	8	K 18·9
'C' 5	9	12	B	2	5	B	11	13	B 19·6
			K	5	6	K	70	15	K 7·6

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

The experiments were conducted on *Albizzia lucida* (*galwang*), *Ficus cunia* (*porho*) and *Ougeinia dalbergioides* (*pandan*) at Namkum. Data given in Table III indicate that broodlac survived on all the three hosts, and that best results were obtained from *Albizzia lucida* and *Ficus cunia*.

TABLE III — COMPARATIVE DATA ON YIELDS OF SUMMER BROOD FROM VARIOUS HOSTS

Host and No. of trees	Kind of brood used: *Palas* — *A. lucida* 5	*Palas* — *O. dalbergioides* 5	*Ber* — *F. cunia* 2	*Ber* — *A. lucida* 3	*Ber* — *O. dalbergioides* 3
	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Brood used	5 8	12 13	3 13	1 13	4 9
Scraped lac from brood used	1 2	2 1	0 12	0 9	1 6
Total yield of lac sticks	14 9	21 13	17 2	23 5	22 5
Total scraped lac yield	1 11	3 2	2 1	3 13	4 9
Broodlac yield	14 10	12 1	17 3	17 11	11 9
Scraped lac from brood yield	1 11	1 15	2 1	3 4	3 5
Percentage of selected brood yield	100·0	55·3	100·0	75·8	51·1
Brood to yield ratio of lac sticks	1: 2·63	1: 1·70	1: 4·47	1: 13·00	1: 0·8
Brood to yield ratio of scraped lac	1: 1·40	1: 1·50	1: 2·67	1: 6·55	1: 3·27
Brood used to brood yield ratio as lac sticks	1: 2·65	1: 0·94	1: 4·47	1: 9·86	1: 2·50

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

It has already been stated (*Annual Report*, 1953-54) that the problem, at this advanced stage of investigation at the Institute, has only some regional importance and cannot be further studied in the absence of Research Field Stations in different parts of the country. However, the results obtained at Namkum are given in Table IV.

TABLE IV — BROOD-CARRYING CAPACITY OF MAJOR LAC HOSTS

Locality	Crop	Hosts and No. of trees	Brood used for infection lb.	Brood used for infection oz.	Brood yield obtained lb.	Brood yield obtained oz.	Ratio of brood to brood yield
Namkum	*Jethwi* 1954	*Kusum* 10	24	10	69	7	1: 2·82
Hesal	*Jethwi* 1954	*Kusum* 20	252	2	1,014	12	1: 4·03
Namkum	*Baisakhi* 1953-54	*Palas* 10	24	6	47	6	1: 1·94 only surplus brood cut from the trees
	Katki 1954	*Palas* 10	18	14	40	2	1: 2·2
	Baisakhi 1953-54	*Ber* 5	9	12	2	5	1: 0·23 only surplus brood cut from the trees
	Katki 1954	*Ber* 10	13	8	31	4	1: 2·30
	Katki 1954	*Khair* 10	12	12	nil	nil	1: 0
	Aghani 1954-55	*Khair* 10	19	2	10	8	1: 0·54

5. Proper Time of Harvesting for Maximizing Yields

Experiments have been laid at Namkum and will come into operation from 1955-56. But being a problem of regional importance, hostwise regional field stations are required.

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

The experiments have been modified and were conducted on *kusum, palas, ber* and *khair*. There were three treatments and three coupés in each case. For *kusum*, each coupé was divided into 7 blocks and in each block there were 3 trees. For other species of hosts, each coupé was divided into 5 blocks and in each block there were 3 trees.

Treatment 'A' used one-third of the actually required broodlac on each tree.

Treatment 'B' used half of the actually required broodlac on each tree.

Treatment 'C' used full quantity of broodlac required on each tree.

The results obtained are tabulated in Table V (pp. 8-11).

The data offered in Table V indicate that in the case of *Rangeeni* lac in the *Katki* crop, Treatment 'A' is better than Treatment 'C' on *khair* only and Treatment 'C' is better than 'A' on *ber* and *palas*; Treatment 'B' is better than 'A' and 'C' on *khair* and *palas* but is inferior to both on *ber*. In the case of *Kusmi* lac, Treatment 'A' is better than Treatment 'C' in the *Aghani* and *Jethwi* crop on *kusum* as well as on *khair*; Treatment 'B' is better than 'A' and 'C' on *khair* in *Aghani* crop and on *kusum* in *Jethwi* crop but is inferior to both in *Aghani* on *kusum*.

However, the statistical analysis of variance in the *Katki* crop does not show any difference of significance between the three treatments on any of the three hosts. But in the case of *Kusmi* lac in the *Jethwi* crop on *kusum*, both Treatments 'A' and 'B' are highly significant and superior to Treatment 'C'; in *Aghani* crop, Treatment 'B' is significantly superior to 'A' at 5 per cent level on *kusum* but it is not so on *khair*.

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

It has already been stated in the *Annual Report* for 1953-54 that it is a long-range problem and can be adequately studied only if sufficient number of each kind of host are available in one or more areas. However, results of experiments conducted with the few available plants at Namkum are given in Table VI (p. 12).

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

The chief object of this study is to evolve a pruning method by which suitable shoots for cultivating lac on them could be produced in the shortest possible time without affecting the vitality of the host or the optimum crop yields. For this purpose, two types of pruning are under study, namely, "Apical pruning" (cutting the branches or shoots near the apices) and "Surface pruning" (tips of main branches and shoots are not cut, but only the lateral shoots and branches arising from them are cut flush at the point of their origin).

(i) *Shoot study* — The number and growth of shoots from January-February 1954 to January-February 1955 are recorded. Field observations in each case have been extended from one to three branches.

Treatment I: 18 *months' interval of rest, "Apical pruning"* — Four trees forming two sets of each were under observation, the first set (tree Nos. 14 and 134) being cropped in January-February and the second set (tree Nos. 180 and 124) in June-July of successive years.

First set — From tree No. 14, crop was cut on 9-1-53 and it was reinfected in June-July 1954 to grow *Aghani* 1954-55 crop.

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

Weight of lac sticks without brackets; weight of scraped lac within brackets.

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio
Rangeeni Blocks *Katki* crop 1954												
I	1 0	1 9	7 11	1: 7·68	1 8	5 14	15 2	1: 10·08	3 0	5 2	18 7	1: 6·14
	(0 4)	(0 7)	(1 5)	(1: 5·25)	(0 6½)	(1 4)	(2 4)	(1: 5·54)	(0 13)	(1 3)	(4 0)	(1: 4·92)
Khair (*palas* and *khair*)												
II	1 0	3 13	14 1	1: 14·06	1 8	11 4	22 8	1: 15·00	3 0	7 3	16 7	1: 5·48
	(0 4½)	(0 14)	(2 11)	(1: 9·55)	(0 6½)	(2 9)	(4 6)	(1: 10·77)	(0 11)	(1 11)	(3 8)	(1: 5·09)
III	1 0	1 0	7 14	1: 7·87	1 8	7 14	14 0	1: 9·33	3 0	8 11	15 14	1: 5·29
	(0 4)	(0 4)	(1 0)	(1: 4·00)	(0 7)	(2 11)	(4 1)	(1: 9·28)	(0 11)	(2 4)	(3 10)	(1: 5·27)
IV	1 0	1 9	5 11	1: 5·69	1 8	0 8	4 14	1: 3·25	3 0	4 10	10 4	1: 3·41
	(0 4½)	(0 7)	(0 15)	(1: 3·33)	(0 6)	(0 2)	(0 12)	(1: 2·0)	(0 10)	(0 14)	(1 10)	(1: 2·60)
V	1 0	—	3 9	1: 3·56	1 8	2 9	8 11	1: 5·79	3 0	3 5	13 9	1: 4·52
	(0 5)	—	(0 6)	(1: 1·20)	(0 6)	(0 10)	(1 10)	(1: 4·33)	(0 12)	(0 12)	(2 5)	(1: 3·08)
Treatment Total	5 0	7 15	38 14	1: 6·52	7 8	28 1	65 3	1: 8·69	15 0	28 15	74 9	1: 4·97
	(1 6)	(2 0)	(6 5)	(1: 4·59)	(2 0)	(7 2)	(13 1)	(1: 6·53)	(3 9)	(6 12)	(15 1)	(1: 4·24)
Ber (*ber* × *ber*)												
I	0 14	1 13	7 15	1: 9·07	1 5	—	3 1	1: 2·33	2 10	7 14	19 2	1: 7·28
	(0 2½)	(0 5)	(0 15)	(1: 6·00)	(0 5½)		(0 6)	(1: 1·09)	(0 8)	(1 11½)	(3 4½)	(1: 6·56)
II	0 14	—	3 1	1: 3·50	1 5	2 11	7 5	1: 5·57	2 10	1 4	6 14	1: 2·62
	(0 3)	—	(0 6)	(1: 2·00)	(0 5½)	(0 10½)	(0 6½)	(1: 4·09)	(0 10)	(0 6)	(1 2)	(1: 1·80)
III	0 14	1 4	7 6	1: 8·43	1 5	—	2 1	1: 1·57	2 10	0 12	6 6	1: 2·43
	(0 3)	(0 4½)	(1 2½)	(1: 6·16)	(0 5)	—	(0 4)	(1: 0·80)	(0 9)	(0 2½)	(0 10½)	(1: 1·17)
IV	0 14	1 4	6 2	1: 7·00	1 5	—	1 9	1: 1·19	2 10	6 2	14 5	1: 5·45
	(0 3)	(0 3½)	(0 13½)	(1: 4·50)	(0 6)	—	(0 4)	(1: 0·66)	(0 10)	(1 12)	(3 7)	(1: 5·50)

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

Weight of lac sticks without brackets; weight of scraped lac within brackets.

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio	Broodlac used	Broodlac obtained	Total yield	Brood and yield ratio
	lb. oz.	lb. oz.	lb. oz.		lb. oz.	lb. oz.	lb. oz.		lb. oz.	lb. oz.	lb. oz.	
(*ber* × *ber*)												
V	0 14	0 8	3 5	1: 3·38	1 5	3 9	7 11	1: 5·85	2 10	7 14	16 9	1: 6·31
	(0 3½)	(0 1½)	(0 7½)	(1: 2·14)	(0 4½)	(1 1)	(1 9)	(1: 5·56)	(0 8)	(1 13½)	(3 3½)	(1: 6·44)
Treatment Total	4 6	4 13	27 13	1: 6·36	6 9	6 4	21 11	1: 3·30	13 2	23 14	63 4	1: 4·82
	(0 15)	(0 14½)	(3 12½)	(1: 4·03)	(1 10½)	(1 11½)	(3 13½)	(1: 2·32)	(2 13)	(5 13½)	(11 11½)	(1: 4·16)
Palas												
Palas (*ber*) × *palas*												
I	0 10	2 0	6 3	1: 9·90	0 15	—	1 9	1: 1·66	1 14	—	3 1	1: 1·63
	(0 2)	(0 8)	(0 14)	(1: 7·00)	(0 2)	—	(0 8)	(1: 4·0)	(0 4)	—	(0 12)	(1: 3·00)
II	0 10	—	1 0	1: 1·60	0 15	2 5	6 7	1: 6·86	1 14	0 12	2 13	1: 1·50
	(0 1½)	—	(0 4)	(1: 2·66)	(0 2½)	(0 13)	(1 9)	(1: 10·00)	(0 5)	(0 3)	(0 9)	(1: 1·80)
III	0 10	—	1 9	1: 2·50	0 15	1 9	5 11	1: 6·40	1 14	3 1	11 4	1: 6·00
	(0 1½)	—	(0 6)	(1: 4·00)	(0 2)	(0 6)	(1 2)	(1: 9·00)	(0 4)	(0 12)	(2 5)	(1: 9·25)
IV	0 10	—	0 10	1: 1·00	0 15	1 0	5 6	1: 5·75	1 14	7 5	11 11	1: 6·23
	(0 1½)	—	(0 2)	(1: 1·33)	(0 2½)	(0 4)	(0 14)	(1: 5·60)	(0 4½)	(2 5)	(3 7)	(1: 12·22)
V	0 10	—	1 4	1: 2·00	0 15	—	4 2	1: 4·40	1 14	3 1	4 5	1: 2·30
	(0 2)	—	(0 4)	(1: 2·00)	(0 2)	—	(0 6)	(1: 3·00)	(0 5)	(0 12)	(1 6)	(1: 4·40)
Treatment Total	3 2	2 1	10 10	1: 3·40	4 11	4 14	23 3	1: 4·94	9 6	14 3	33 2	1: 3·53
	(0 8½)	(0 8)	(1 14)	(1: 3·53)	(0 11)	(1 7)	(4 7)	(1: 6·55)	(1 6½)	(4 0)	(8 7)	(1: 6·00)
Jethwi crop 1954												
I	1 0	3 1	6 3	1: 6·19	1 8	3 1	10 4	1: 6·83	3 0	1 13	8 7	1: 2·81
	(0 7)	(1 4)	(2 1)	(1: 4·71)	(0 13)	(1 4)	(3 9)	(1: 4·38)	(1 10)	(0 10)	(2 13)	(1: 1·72)
Kusum												
II	1 0	2 9	5 0	1: 5·00	1 8	—	4 10	1: 3·08	3 0	1 0	5 2	1: 1·71
	(0 7)	(1 2)	(1 15)	(1: 4·45)	(0 10)	—	(1 9)	(1: 2·50)	(1 9)	(0 7)	(2 0)	(1: 1·28)

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

Weight of lac sticks without brackets; weight of scraped lac within brackets.

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'				Treatment 'B'				Treatment 'C'			
	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio	Broodlac used lb. oz.	Broodlac obtained lb. oz.	Total yield lb. oz.	Brood and yield ratio
(*kusum* × *kusum*)												
III	1 0	3 1	8 12	1: 8·75	1 8	—	3 5	1: 2·21	3 0	2 5	4 6	1: 1·46
	(0 8)	(0 14)	(2 11)	(1: 5·37)	(0 11)	—	(0 14)	(1: 1·27)	(1 9)	(0 13)	(1 3)	(1: 0·76)
IV	1 0	2 9	5 2	1: 5·12	1 8	2 1	9 4	1: 6·16	3 0	1 4	8 3	1: 2·73
	(0 8)	(1 0)	(1 15)	(1: 3·89)	(0 11)	(0 11)	(3 8)	(1: 5·09)	(1 14)	(0 8)	(2 5)	(1: 1·23)
V	1 0	3 9	6 5	1: 6·31	1 8	1 0	11 4	1: 7·50	3 0	1 4	5 6	1: 1·79
	(0 6)	(1 4)	(2 1)	(1: 5·50)	(0 12)	(0 6)	(5 8)	(1: 7·33)	(1 14)	(0 9)	(1 10)	(1: 0·89)
VI	1 0	2 9	6 11	1: 6·69	1 8	—	22 9	1: 15·04	3 0	6 7	18 11	1: 6·23
	(0 8)	(0 14)	(2 3)	(1: 4·37)	(0 11)	—	(8 3)	(1: 11·91)	(1 14)	(1 13)	(5 6)	(1: 2·87)
VII	1 0	2 3	5 4	1: 5·25	1 8	1 0	9 4	1: 6·17	3 0	2 5	8 5	1: 2·77
	(0 6)	(0 12)	(0 9)	(1: 4·17)	(0 12)	(0 6)	(3 7)	(1: 4·58)	(1 5)	(0 11)	(2 4)	(1: 1·71)
Treatment Total	7 0	19 9	43 5	1: 6·18	10 8	7 2	70 8	1: 6·71	21 0	16 6	58 8	1: 2·49
	(3 2)	(7 2)	(14 7)	(1: 4·62)	(5 0)	(2 11)	(26 10)	(1: 5·32)	(11 10)	(5 7)	(17 9)	(1: 1·51)
Kusmi Blocks												
I	1 0	1 4	5 12	1: 5·75	1 8	1 13	4 14	1: 3·25	3 0	2 13	5 10	1: 1·87
	(0 7)	(0 10)	(1 11)	(1: 3·85)	(0 10)	(0 12)	(1 9)	(1: 2·50)	(1 0)	(1 3)	(2 7)	(1: 2·44)
Aghani crop 1954-55												
II	1 0	1 0	6 2	1: 6·12	1 8	0 12	4 7	1: 2·96	3 0	2 1	4 8	1: 1·50
	(0 6)	(0 7)	(2 4)	(1: 6·00)	(0 9)	(0 5)	(1 4)	(1: 2·22)	(1 0)	(0 14)	(1 11)	(1: 1·69)
Kusum												
III	1 0	1 0	5 6	1: 5·37	1 8	1 0	5 6	1: 3·58	3 0	3 9	6 4	1: 2·08
	(0 7)	(0 7)	(2 0)	(1: 4·57)	(0 9)	(0 8)	(1 10)	(1: 2·79)	(1 0)	(1 9)	(2 10)	(1: 2·06)
(*kusum* × *kusum*)												
IV	1 0	1 0	4 1	1: 4·06	1 8	1 0	5 2	1: 3·41	3 0	4 10	8 12	1: 2·69
	(0 6)	(0 6)	(0 15)	(1: 2·50)	(0 10)	(0 6)	(1 10)	(1: 2·60)	(1 1)	(2 4)	(4 1)	(1: 3·84)

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

Weight of lac sticks without brackets; weight of scraped lac within brackets.

CROP DATA OF TREATMENTS

Blocks	Treatment 'A'						Treatment 'B'						Treatment 'C'					
	Broodlac used		Broodlac obtained		Ttoal yield	Brood and yield ratio	Broodlac used		Broodlac obtained		Total yield	Brood and yield ratio	Broodlac used		Broodlac obtained		Total yield	Brood and yield ratio
	lb.	oz.	lb.	oz.	lb. oz.		lb.	oz.	lb.	oz.	lb. oz.		lb.	oz.	lb.	oz.	lb. oz.	
kusum × *kusum*																		
V	1	0	2	1	4 12	1: 4·75	1	8	1	9	4 6	1: 2·91	3	0	5	6	10 0	1: 3·33
	(0	7)	(1	0)	(1 12)	(1: 4·00)	(0	10)	(0	11)	(1 2)	(1: 1·82)	(1	1)	(2	7)	(4 6)	(1: 4·70)
VI	1	0	1	0	2 4	1: 2·25	1	8	1	4	5 6	1: 3·58	3	0	4	2	7 11	1: 2·56
	(0	4)	(0	9)	(0 15)	(1: 3·75)	(0	9)	(0	7)	(1 11)	(1: 3·00)	(0	15)	(1	14)	(3 8)	(1: 3·73)
VII	1	0	0	12	2 5	(1: 2·31	1	8	0	8	3 1	1: 2·04	3	0	4	10	7 9	1: 2·52
	(0	6)	(0	6)	(0 13)	(1: 2·17)	(0	9)	(0	4)	(0 11)	(1: 1·22)	(0	15)	(2	1)	(2 13)	(1: 3·00)
Treatment Total	7	0	8	1	30 10	1: 4·37	10	8	7	14	32 10	1: 3·10	21	0	27	3	50 6	1: 2·39
	(2	11)	(3	13)	(10 6)	(1: 3·86)	(4	2)	(3	5)	(9 9)	(1: 2·32)	(7	0)	(12	4)	(21 8)	(1: 3·07)
Aghani crop 1954-55																		
I	1	0	3	1	7 3	1: 7·18	1	8	3	1	7 3	1: 4·79	3	0	3	5	8 7	1: 2·81
	(0	7)	(1	9)	(3 6)	(1: 7·71)	(0	12)	(1	4)	(2 6)	(1: 3·16)	(1	6)	(1	2)	(2 6)	(1: 1·73)
Khair																		
II	1	0	—		1 13	1: 1·81	1	8	0	12	8 7	1: 5·62	3	0	1	13	10 0	1: 3·33
	(0	8)	—		(0 8)	(1: 1·00)	(0	11)	(0	6)	(1 12)	(1: 2·54)	(1	6)	(0	9)	(2 10)	(1: 1·91)
(*kusum* × *khair*)																		
III	1	0	1	9	3 10	1: 3·62	1	8	—		2 1	1: 1·37	3	0	3	9	7 11	1: 2·56
	(0	7)	(0	10)	(1 6)	(1: 3·14)	(0	11)	—		(0 6)	(1: 0·54)	(1	9)	(1	4)	(2 2)	(1: 1·36)
IV	1	0	3	1	6 10	1: 6·62	1	8	5	10	12 0	1: 8·00	3	0	2	5	7 7	1: 2·46
	(0	8)	(1	2)	(1 14)	(1: 3·75)	(0	12)	(1	14)	(3 11)	(1: 4·08)	(1	6)	(0	15)	(2 8)	(1: 1·82)
V	1	0	1	0	5 10	1: 5·62	1	8	4	6	21 12	1: 14·50	3	0	2	9	9 12	1: 3·25
	(0	8)	(0	7)	(1 9)	(1: 3·12)	(0	12)	(1	9)	(5 11)	(1: 7·58)	(1	7)	(1	0)	(2 13)	(1: 1·91)
Treatment Total	5	0	8	11	24 14	1: 4·97	7	8	13	13	51 7	1: 6·86	15	0	13	9	43 5	1: 2·88
	(2	6)	(3	12)	(8 11)	(1: 3·66)	(3	10)	(5	1)	(13 14)	(1: 3·83)	(7	2)	(4	14)	(12 7)	(1: 1·74)

TABLE VI — EFFECT OF CHANGE OF HOST PLANT

Brood history	No. of trees	Lac sticks								Scraped lac from				
		Brood used		Brood yield		Total yield		Brood to yield ratio	Selected brood-lac %	Brood used		Total yield		Brood to yield ratio
		lb.	oz.	lb.	oz.	lb.	oz.			lb.	oz.	lb.	oz.	
Rangeeni *strain* —Katki 1954 (*June-July to Oct.-Nov.* 1954)														
Albizzia lucida ($P \times A. L \times P \times A. L \times P$) $\times$ *palas*	6	14	10	7	12	29	11	1 : 2·03	26·1	1	12	6	0	1 : 3·43
Pandan ($P \times S \times P \times S \times P$) $\times$ *palas*	7	12	0	17	15	43	8	1 : 3·62	41.2	1	15	10	0	1 : 5·16
Porho ($P \times Po \times P \times Po \times P$) $\times$ *palas*	10	17	2	7	7	39	15	1 : 2·33	18·6	2	1	8	5	1 : 4·03
Pandan (*ber*) $\times$ *ber*	3	3	14	12	5	28	11	1 : 7·40	42·9	0	14	6	2	1 : 7·00
Albizzia lucida (*ber*) $\times$ *ber*	6	6	10	18	3	48	6	1 : 7·30	37·6	0	13	8	6	1 : 10·3
Kusmi *strain* — Jethwi 1954 (*Jan.-Feb. to June-July* 1954)														
Ber (*kusum*) $\times$ *kusum*	6	22	5	16	11	52	9	1 : 2·36	31·7	9	8	15	10	1 : 1·64
Khair (*kusum*) $\times$ *kusum*	6	24	5	47	7	84	0	1 : 3·45	56·4	9	6	31	10	1 : 3·4
Pakur (*kusum*) $\times$ *kusum*	3	14	2	22	0	22	0	1 : 1·56	100·0	8	1	9	8	1 : 1·17
Aghani 1954-55 (*June-July* 1954 to *Jan.-Feb.* 1955)														
Kusum ($K \times B$) $\times$ *ber*	5	9	6	4	1	29	3	1 : 3·11	13·9	3	5	7	2	1 : 2.15
Kusum ($K \times Kh$) $\times$ *khair*	5	19	10	22	4	83	12	1 : 4·26	26·6	8	3	17	12	1 : 2·16
Kusum ($K \times Pk$) $\times$ *pakur*	3	22	0	40	8	97	5	1 : 4·42	41·6	9	7	32	13	1 : 3·47

Branch I — Only one secondary shoot had some linear growth. There was no growth in primaries, other secondaries and tertiaries.

Branch II — Only one secondary showed some linear growth. Tertiary buds appeared in March and developed into shoots.

Branch III — Secondary and tertiary shoots developed and their linear growth ceased in March. However, one tertiary continued to grow slowly till the end of September.

From tree No. 134, crop was cut on 8-2-54.

Branch I — Primary shoots appeared in February and all continued to grow in length till April. In one shoot, however, linear growth occurred in August-September also.

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

Branch III — Primary shoots appeared in February and stopped linear growth in April, however, one continued to grow till middle of June and attained a length of 30 inches. Secondary shoots appeared only from those primaries whose tips got damaged.

Second set — From tree No. 180, crop was cut on 1-7-54.

Branch I — Primary shoots began to appear in late July and stopped linear growth in August. One secondary shoot appeared in September.

Branch II — Primary shoots appeared in third week of July and grew in length till August. However, one primary shoot appeared in early September and one secondary in November.

Branch III — Primary shoots appeared in third week of July and continued to grow in length till the middle of August. Secondary shoots grew in September-October only from those primaries whose tips had dried or had been damaged.

From tree No. 124, crop was cut on 28-6-53.

Branch I — New secondary and tertiary shoots that came up in February 1954 continued to grow till March after which their growth stopped.

Branch II — Some linear growth occurred in March-April in previous years' primary and secondary shoots. From tips of damaged primaries and secondaries, new secondary and tertiary, shoots appeared respectively.

Branch III — Linear growth occurred in March-April only in two primary and two secondary shoots of previous year. New secondary and tertiary came up in middle of March and grew till April; after that linear growth continued only in two secondary shoots till June.

Treatment II: 12 *months' interval of rest, "Apical pruning"* — Three trees were under observation.

From tree No. 36, crop was cut on 8-1-54.

Branch I — Primary shoots appeared soon after crop cutting and grew in length till March. From tips of damaged primaries appeared secondary shoots and some of them continued to grow in length till July.

Branch II — Primary shoots appeared in early March but they stopped growing in April, and again resumed growth in July and have luxuriant growth.

Branch III — Primary shoots appeared in March. Secondary shoots appeared only from the tips of the damaged primaries and grew till July.

From tree No. 114, crop was cut on 30-6-54.

Branch I — Primary shoots appeared in July and also in September, their linear growth continued at a slow rate up to October.

Branch II — Primary shoots appeared in July but only two of them continued to grow in length up to September.

Branch III — Primary shoots appeared in July and secondary shoots developed from the damaged primaries only.

From tree No. 161, crop was cut on 1-7-53.

Branch I — Primary shoots of previous year did not grow further but one new primary shoot appeared and continued to grow till March. From the tips of damaged primaries, secondary shoots appeared and continued to grow till May. Secondary shoots gave rise to tertiary shoots and tertiary shoots gave rise to sub-tertiaries.

Branch II — Only one of the primary shoots of previous year showed some linear growth. Secondary shoots appeared and continued to grow till May but one secondary shoot appeared as late as in September. Tips of damaged secondary shoots gave rise to tertiaries and sub-tertiaries.

Branch III — Primary of previous year did not grow in length but gave rise to secondary shoots which grew in length till April and then tertiary shoots appeared and grew till middle of May. A few sub-tertiaries appeared in late July.

Treatment III: 12 *months' interval of rest, "Surface pruning"* — Three trees were under observation.

From tree No. 42, crop was cut on 4-2-54.

Branch I — Primary shoots appeared in March and ceased to grow in length after April.

Branch II — Primary buds that appeared in March dried up and new primary shoots again developed in June.

Branch III — Only one primary shoot appeared in March and linear growth stopped in April.

From tree No. 128, crop was cut on 30-6-54.

Branch I — New buds did not appear.

Branch II — Primary shoots appeared in June but growth was poor.

Branch III — Primary shoots appeared but growth was poor.

From tree No. 190, crop was cut on 3-7-53.

Branch I — Primary shoots of previous year did not grow in length. But two new primary shoots appeared in March and grew till April. From broken tips of primaries, secondary shoots appeared, and tertiary shoots appeared from broken tips of secondary shoots and they grew in length till middle of May.

Branch II — Secondary shoots appeared from primary shoots of previous year and their growth in two shoots continued up to June while in others it stopped in April.

Branch III — Secondary shoots appeared from primaries of previous year and their linear growth stopped in May.

Treatment IV: 6 *months' interval of rest, "Surface pruning"* — Two trees were under observation.

From tree No. 70, crop was cut on 4-2-54.

Branch I — One shoot appeared in March and continued to grow till April.

Branch II — No shoot appeared.

Branch III — One primary shoot appeared in March and grew, and it gave rise to a secondary shoot in July 1954.

From tree No. 214, crop was cut on 3-7-54.

Branch I — One primary shoot appeared and grew till August.

Branch II — Primary shoot did not appear.

Branch III — One primary shoot appeared in July and continued to grow till August.

Details are given in Table VII (*see* pp. 15 and 16).

(ii) *Yield of lac* — The data given in Table VIII below show that in the *Jethwi* 1954 crop, best results were obtained from Treatment I (18 months' rest, "Apical pruning") and in *Aghani* 1954-55, Treatment III (12 months' rest, "Surface pruning") yielded the best results. Taking both the crops (*Jethwi* and *Aghani*) together, the best results are indicated from Treatment III ("Surface pruning" 1 year's interval), and surface pruning with an interval of 6 months' rest gave better results than Treatment II (1 year's rest, "Apical pruning").

TABLE VIII — CROP DATA

Treatment No.	Interval of rest and type of pruning	*Jethwi* 1954			*Aghani* 1954-55			*Jethwi & Aghani* combined		
		No. of trees	Ratio of brood-lac used to yield of lac		No. of trees	Ratio of brood-lac used to yield of lac		No. of trees	Ratio of brood-lac used to yield of lac	
			Lac sticks	Scraped lac		Lac sticks	Scraped lac		Lac sticks	Scraped lac
I	18 months: 'Apical'	20	1:6·23	1:5·60	23	1:1·33	1:0·75	43	1:3·09	1:2·59
II	12 months: 'Apical'	19	1:4·93	1:4·39	18	1:1·70	1:1·24	37	1:3·26	1:2·83
III	12 months: 'Surface'	17	1:6·15	1:4·93	16	1:2·43	1:1·92	33	1:4·09	1:3·43
IV	6 months: 'Surface'	15	1:4·64	1:3·71	10	1:1·38	1:0·93	25	1:3·62	1:3·01

For statistical analysis, a set of 4 comparable trees under each treatment in *Jethwi* as well as in *Aghani* were laid. The ratios of crop data obtained from them together with the statistical analysis, kindly undertaken by the Statistician of the Indian Lac Cess Committee, are given in Table IX (p. 17).

TABLE VII — RESULTS OF SHOOT STUDY FROM JANUARY-FEBRUARY 1954 TO JANUARY-FEBRUARY 1955

Branch No.	Date of cropping	Primaries			Secondaries			Tertiaries			Condition of shoots	Larval settlement and lac encrustation
		Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)	Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)	Buds sprouted and developed into shoots %	No. of shoots	Length in inches average (range)		
2	3	4	5	6	7	8	9	10	11	12	13	14
						Treatment I						
I	9-1-53	83·30	5	5·40 (2·75-9·0)	72·72	8	3·28 (0·50-6·75)	70·00	7	2·39 (0·75-6·50)	1 pr., 2 sec. and 1 tert. shoot dried up; 1 pr. shoot fallen	*Tree No.* 14 — *Cropped in January* 1955 Br. I — No encrustation on primaries because all lac larvae that had settled died and damaged at the early stage. Partial encrustation on 2 secondaries and 2 tertiaries — The rest of the shoots have no encrustation.
II	9-1-53	—	6	4·37 (1·0-11·0)	—	8	2·59 (1·25-5·25)	44·44	4	2·56 (1·50-4·25)	1 pr. and 1 sec. dried up; 2 prs. and 1 sec. damaged and broken, 2 terts. fallen down	Br. II — The primaries had settlement but all died at the larval stage. One secondary shoot has sparse encrustation. The tertiary shoots do not have lac encrustation.
III	9-1-53	—	5	9·15 (1·50-15·0) 6·18	—	12	2·29 (0·50-7·50) 2·66	100·00	3	3·67 (1·25-4·25) 2·71	2 sec. shoots dried and fallen. Upper portion of 1 pr. dried up	Br. III — Dead and immature lac cells on 2 primaries. No encrustation on secs. and terts.
I	28-6-53	94·44	17	5·89 (1·0-13·0)	77·78	21	2·11 (0·50-6·50)	75·00	6	2·83 (0·75-5·0)	1 sec. dried up, 5 prs. dried up and broken	*Tree No.* 124 — *Infected in January* 1955 Br. I — Settlement on all primaries continuous, all-round and very good. 7 secs. have no settlement and the rest have excellent settlement — complete and all-round. On 3 tertiaries, settlement on the ventral side of the basal portion of the shoots and all others have all-round continuous and very good.
II	28-6-53	—	8	6·66 (2·25-13·75)	—	13	2·50 (0·25-5·50)	66·67	2	3·37 (0·75-6·0)	1 pr. and 1 tert. dried up. Top of 3 sec. shoots dried up	Br. II — Sparse settlement and in patches on 5 primaries. A few secondaries have lac larvae fairly settled on them but the others do not have any settlement.
III	28-6-53	—	6	14·58 (13·0-16·25) 7·77	—	13	3·63 (1·0-10·50) 2·64	100·00	3	1·08 (0·25-1·75) 2·45	Apex of 1 pr. dried up, 3 sec. dried up; 2 shoots damaged by insects at tender stage	Br. III — All the primaries have scattered settlement and in patches but very good. Some of the secondaries have good settlement in the mid-ventral position of the shoots. No settlement on tertiaries.
I	8-2-54	85·71	6	3·12 (1·50-6·0)	No secondaries and tertiaries						1 pr. broken and lost	*Tree No.* 180 — *Cropped in July* 1954 Br. I — Encrustation on 1 primary only about middle and all-round, on 3 secondaries all-round and good, and on 2 excellent, other shoots have patchy healthy lac.
II	8-2-54	100·00	6	9·17 (5·0-21·50)	Three secondary buds appeared but dried up				No tertiaries		1 pr. shoot damaged by insects at tender stage and broken	Br. II — Encrustation on 2 primaries only excellent and on 3 secondaries good encrustation on lower surface, 2 have patches, others have on encrustation.
III	8-2-54	80·00	8	8·44 (2·50-30·0) 7·06	50·00	1	0·25 0·25		No tertiaries		1 pr. shoot dried up and broken; 4 shoots broken by strong winds	Br. III — Continuous all-round, good encrustation on 2 primaries, 7 secondaries have encrustation of which 4 have continuous good and on lower side very good.
I	1-7-54	100·00	2	7·62 (7·0-8·25)	100·00	1	3·50		No tertiaries			*Tree No.* 36 — *Infected in January* 1955 Br. I — Poor settlement in patches on the primaries, other shoots have no settlement.
II	1-7-54	100·00	6	12·08 (1·25-18·75)	50·00	1	6·0		No tertiaries		1 pr. shoot broken. Upper portion of 3 prs. dried up	Br. II — No larval settlement
III	1-7-54	80·00	4	10·06 (3·50-19·25) 10·66 7·71	100·00	2	5·62 5·18 2·74		No tertiaries	2·60	Top of 2 prs. dried up	Br. III — Only 2 secondaries have partial settlement but not good.
						Treatment II						
I	8-2-54	75·00	3	10·08 (2·50-14·75)	100·00	9	4·11 (0·75-9·0)	50·00	1	0·75	Apical portion of 1 pr. and 2 sec. shoots dried	*Tree No.* 114 — *Cropped in July* 1954 Br.I — Encrustation on 2 primaries, very good,

				10·00 7·71			5·18 2·74			2·60
					Treatment II					
I	8-2-54	75·00	3	10·08 (2·50-14·75)	100·00	9	4·11 (0·75-9·0)	50·00	1	0·75
II	8-2-54	66·67	2	35·75 (35·50-36·0)	60·00	3	1·33 (0·50-3·0)		No tertiaries	
III	8-2-54	100·00	3	10·08 (5·0-17·0) 16·50	50·00	5	8·00 (0·75-20·50) 4·76	100·00	1	22·0 11·37
I	30-6-54	62·50	5	1·90 (0·50-3·25)			No secondaries and tertiaries			
II	30-6-54	75·00	3	10·58 (1·0-15·75)			No secondaries and tertiaries			
III	30-6-54	100·00	3	1·92 (1·0-3·50) 4·27	100·00	2	1·88 (1·0-2·75) 1·88		No tertiaries	
I	1-7-53	100·00	8	9·22 (2·0-18·50)	48·61	11	4·52 (0·75-9·50)	85·71	18	4·39 (0·75-9·50)
II	1-7-53	—	4	10·00 (6·50-15·0)	83·33	5	6·45 (1·50-13·75)	100·00	5	3·17 (1·50-5·0)
III	1-7-53	—	5	7·90 (3·50-15·0) 9·02 9·23	83·33	5	2·70 (1·0-5·50) 4·54 4·50	55·55	5	3·30 (0·50-5·0) 4·04 4·56
					Treatment III					
I	4-2-54	100·00	2	8·50 (1·0-16·0)			No secondaries and tertiaries			
II	4-2-54	75·00	3	5·08 (1·0-7·50)	66·67	2	1·38 (1·0-1·75)	—	—	—
III	4-2-54	33·33	1	2·00 5·71			No secondaries and tertiaries 1·38			
I	30-6-54	No response from this branch						—	—	—
II	30-6-54	100·00	2	2·12 (0·50-3·75)			No secondaries and tertiaries			
III	30-6-54	100·00	2	1·37 (0·25-2·50) 1·74			No secondaries and tertiaries			
I	3-7-53	80·00	4	8·06 (3·75-13·0)	83·33	5	1·80 (0·50-2·50)	100·00	3	4·33 (1·50-9·50)
II	3-7-53	—	5	3·95 (1·50-5·50)	71·43	5	6·05 (2·75-9·50)	—	—	3·33 (3·0-4·0)
III	3-7-53	—	3	5·92 (4·50-8·25)	75·00	3	3·17 (1·50-4·50)	—	—	—

Apical portion of 1 pr. and 2 sec. shoots dried up
3 sec. shoots fallen at the tender stage
2 prs. broken and fallen at the tender stage; 2 sec. shoots dried up and fallen

1 pr. shoot damaged and fallen

1 pr., 1 sec. and 1 tert. broken and lost. Top of 1 tert. shoot dried up
Apex of 2 pr. shoots dried up

1 pr. shoot dried up and broken
1 pr. shoot damaged and broken

2 pr. shoots dried up and broken; 1 tert. and top of 2 sec. shoots dried up
Apical portion of 2 sec. and 2 tert. dried up; 1 tert. broken and lost

Tree No. 114 — *Cropped in July* 1954
Br.I — Encrustation on 2 primaries, very good, all-round, one secondary on lower surface.
Br. II — Encrustation on primaries, very good and all-round, on 2 secondaries partial.
Br. III — Encrustation on 4 primaries (3 all-round and good, 1 lower surface), on 3 secondaries of which lac on 2 dead at early stage and on 1 sparse and in patches.

Tree No. 161 — *Cropped in July* 1954
Br. I — One primary is covered with a few living lac cells, the others have no encrustation, on 3 secondaries encrustation good — with well-developed cells and 3 covered with dead cells. All tertiaries have lac encrustation of which 7 have shown very good encrustation continuous, all-round.
Br. II — Scattered encrustation and in patches on 2 primaries and on others at the mid-portion of the shoots but good quality. On 3 secondaries partial encrustation with well-developed lac cells.
Br. III — Except 1 primary all have encrustation of which 1 has shown continuous excellent encrustation. Some of the secondaries have scattered encrustation throughout. Dead lac cells on 1 tertiary and others continuous, all-round encrustation — excellent.

Tree No. 42 — *Infected in January* 1955
Br. I — Poor settlement.
Br. II — No larval settlement.
Br. III — The primaries are covered with lac larvae but not the secondary shoots.

Tree No. 128 — *Cropped in July* 1954
Br. I — A few dead cells are found.
Br. II — Primary shoots have sparse and patchy encrustation.
Br. III — Primary shoots have sparse but healthy encrustation.

Tree No. 190 — *Cropped in January* 1955
Br. I — The mid-portion of the primary shoots covered with healthy lac cells. No lac on secondaries. Partial lac encrustation on tertiaries — not good quality.
Br. II — Scattered encrustation and in patches on all primaries except one which covered with a few living cells. All secondaries have encrustation, of which one, excellent continuous encrustation. On 1 tertiary shoot scattered living cells.
Br. III — On 3 primaries, partial encrustation with living and dead cells. Good encrustation at basal portion of secondary shoots.

Tree No. 70 — *Cropped in January* 1955
Br. I — Poor encrustation with a few healthy lac cells.
Br. III — Poor encrustation on the lower side of shoots.

Treatment III											
I	4-2-54	100·00	2	8·50 (1·0-16·0)			No secondaries and tertiaries				1 pr. shoot dried up and broken 1 pr. shoot damaged and broken
II	4-2-54	75·00	3	5·08 (1·0-7·50)	66·67	2	1·38 (1·0-1·75)	—	—	—	
III	4-2-54	33·33	1	2·00 5·71			No secondaries and tertiaries 1·38				
I	30-6-54	No response from this branch						—	—	—	
II	30-6-54	100·00	2	2·12 (0·50-3·75)			No secondaries and tertiaries				
III	30-6-54	100·00	2	1·37 (0·25-2·50) 1·74			No secondaries and tertiaries				
I	3-7-53	80·00	4	8·06 (3·75-13·0)	83·33	5	1·80 (0·50-2·50)	100·00	3	4·33 (1·50-9·50)	2 pr. shoots dried up and broken; 1 tert. and top of 2 sec. shoots dried up
II	3-7-53	—	5	3·95 (1·50-5·50)	71·43	5	6·05 (2·75-9·50)	—	—	3·33 (3·0-4·0)	Apical portion of 2 sec. and 2 tert. dried up; 1 tert. broken and lost
III	3-7-53	—	3	5·92 (4·50-8·25) 5·81 5·04	75·00	3	3·17 (1·50-4·50) 3·75 3·43	—	—	— 3·83 3·83	
Treatment IV											
I	4-2-54	50·00	1	1·75	—	—	—	—	—	—	
II	4-2-54	No response from this branch						—	—	—	
III	5-2-54	100·00	1	1·25 1·50	100·00	1	0·75 0·75	—	—	—	Top dried up
I	3-7-54	100·00	1	1·00	50·00	1	0·25	—	—	—	
II	3-7-54	No response from this branch						—	—	—	
III	3-7-54	100·00	1	5·50 3·25 2·38			No secondaries and tertiaries 0·25 0·50				

Tree No. 128 — *Cropped in July* 1954
Br. I — A few dead cells are found.
Br. II — Primary shoots have sparse and patchy encrustation.
Br. III — Primary shoots have sparse but healthy encrustation.

Tree No. 190 — *Cropped in January* 1955
Br. I — The mid-portion of the primary shoots covered with healthy lac cells. No lac on secondaries. Partial lac encrustation on tertiaries — not good quality.
Br. II — Scattered encrustation and in patches on all primaries except one which covered with a few living cells. All secondaries have encrustation, of which one, excellent continuous encrustation. On 1 tertiary shoot scattered living cells.
Br. III — On 3 primaries, partial encrustation with living and dead cells. Good encrustation at basal portion of secondary shoots.

Tree No. 70 — *Cropped in January* 1955
Br. I — Poor encrustation with a few healthy lac cells.

Br. III — Poor encrustation on the lower side of shoots.

Tree No. 214 — *Cropped in July* 1954
Br. I — All primaries have encrustation but majority bear unhealthy lac cells.
Br. II — Primaries bear unhealthy and undeveloped encrustation. Unhealthy and scattered encrustation on secondaries.
Br. III — Encrustation healthy on primaries, on 2 at the basal portion only. On secondaries no encrustation.

Tree No. 214 — *Infected in January* 1955
Br. I — Very poor settlement on all shoots.

Br. III — Poor settlement and in patches.

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

Treatment No.	Interval of rest and type of pruning	*Jethwi* 1954		*Aghani* 1954-55	
		Tree No.	Ratio of broodlac used to yield	Tree No.	Ratio of broodlac used to yield
I	18 months: 'Apical'	172	1: 9·16	19	1: 0·72
		173	1: 7·80	22	1: 0·95
		175	1: 5·15	25	1: 1·08
		176	1: 6·43	27	1: 0·54
	Total		28·54		4·06
	Mean		7·13		1·01
II	12 months: 'Apical'	13	1: 6·00	159	1: 1·18
		115	1: 4·18	162	1: 0·49
		117	1: 5·90	164	1: 0·70
		118	1: 3·73	223	1: 0·80
	Total		19·81		3·17
	Mean		4·95		0·79
III	12 months: 'Surface'	129	1: 12·36	189	1: 5·16
		130	1: 6·22	192	1: 5·18
		131	1: 2·25	193	1: 1·19
		133	1: 8·88	198	1: 0·52
	Total		29·71		12·05
	Mean		7·43		3·01
IV	6 months: 'Surface'	203	1: 9·78	60	1: 0·75
		207	1: 2·82	63	1: 0·73
		208	1: 10·15	67	1: 1·00
		209	1: 2·00	71	1: 0·43
	Total		24·75		2·91
	Mean		6·19		0·73

Analysis of variance for *Jethwi* 1954 crop

Source	S.S.	D.F.	M.S.	F.
Between treatment	40·3470	3	13·449	1·28
Within treatment	126·5061	12	10·522	—
Total	166·8531	15	—	—

Conclusion: The 'F' value is not significant, and hence the treatment effects are not significant. The S.E. of differences between means of treatments is 2·29. None of the individual differences shows any differential effects due to treatments.

In this experiment, both individual and total differences are insignificant even at 5 per cent level (*see also* Table XII, p. 21).

(iii) *Yield of broodlac* — Percentage of broodlac obtained from the yield of lac crop in the 4 treatments is given in Tables X and XI, (pp. 18 and 19).

TABLE X — PERCENTAGE OF SELECTED BROODLAC

Treatment No.	Interval of rest and type of pruning	*Jethwi* (1954) crop		
		Tree No.		Percentage of broodlac
I	18 months: 'Apical'	172		84·73
		173		73·93
		175		68·66
		176		65·93
			Total	295·25
			Mean	73·31
II	12 months: 'Apical'	113		54·24
		115		60·34
		117		72·29
		118		34·96
			Total	221·83
			Mean	55·44
III	12 months: 'Surface'	129		52·60
		130		43·90
		131		17·82
		133		46·67
			Total	160·99
			Mean	40·25
IV	6 months: 'Surface'	203		48·44
		207		61·24
		208		59·32
		209		23·91
			Total	192·91
			Mean	48·23

Analysis of variance

Source	S.S.	D.F.	M.S.	F.
Between treatment	2388·65	3	796·2	3·77
Within treatment	2529·6102	12	210·80	—
Total	4918·2602	15	—	—

Conclusion: Treatment effects are not significant even at the 5 per cent level. The S.E. of difference between means of treatments is 10·26. At 5 per cent level, Treatment I is superior to Treatments III and IV individually though as a whole no differences exist. At 5 per cent level: I, II, III, IV.

TABLE X — PERCENTAGE OF SELECTED BROODLAC (*Contd.*)

Analysis of variance for *Aghani* 1954-55 crop

Source	S.S.	D.F.	M.S.	F.
Between treatment	14·28	3	4·76	2·82
Within treatment	20·27	12	1·69	—
Total	34·55	15	—	—

Conclusion: The 'F' value is not significant at the 5 per cent level and hence the treatments cannot be supposed to have had a differential effect on yield of lac.

S.E. of difference between means of treatments = 0·73.

Conclusion: The differences between Treatments I and III, II and III, and III and IV are real, i.e. Treatment III is significantly different from others. At 5 per cent level: III, I, II, IV.

Analysis of variance for *Jethwi* 1954 and *Aghani* 1954-55 combined

Source	S.S.	D.F.	M.S.	F.
Between seasons	1	204·5253	204·5253	33·44
Treatments	3	24·2973	8·0991	1·324
S.X.T.	3	5·3258	1·7753	0·2902
Error	24	146·7776	6·1157	—
Total	31	380·9260	—	—

S.E. of mean = 2·452692. S.E. of difference of any two treatments = 1·226.

Conclusion: The effect of seasons is highly significant. None of the treatment effects or the treatment differences is significant.

TABLE XI — PERCENTAGE OF SELECTED BROODLAC FOR BOTH CROPS COMBINED

Treatment No.	Interval of rest and type of pruning	*Jethwi* (1954) crop		*Aghani* (1954-55) crop	
		Tree No.	Percentage of broodlac	Tree No.	Percentage of broodlac
I	18 months: 'Apical'	172	84·73	19	2·86
		173	73·93	22	14·00
		175	63·66	25	Nil
		176	65·93	27	15·66
	Total		293·25		32·52
	Mean		73·31		8·13
II	12 months: 'Apical'	113	54·24	159	Nil
		115	60·34	162	11·43
		117	72·29	164	Nil
		118	34·96	223	22·22
	Total		221·83		33·65
	Mean		55·44		8·41

TABLE XI — PERCENTAGE OF SELECTED BROODLAC, ETC. (*Contd.*)

Treatment No.	Interval of rest and type of pruning	*Jethwi* crop		*Aghani* crop	
		Tree No.	Percentage of broodlac	Tree No.	Percentage of Broodlac
III	12 months: 'Surface'	129	52·60	189	35·71
		130	43·90	192	40·35
		131	17·82	193	Nil
		133	46·67	198	Nil
	Total		160·99		76·06
	Mean		40·25		19·01
IV	6 months: 'Surface'	203	48·44	60	Nil
		207	61·24	63	Nil
		208	59·52	67	Nil
		209	23·91	71	Nil
	Total	-	192·91		—
	Mean		48·23		—

Analysis of variance for *Jethwi* crop

Source	S.S.	D.F.	M.S.	F.
Between treatment	2388·65	3	796·2	3·77
Within treatment	2592·6102	12	210·80	—
Total	4918·2602	15	—	—

Conclusion: Treatment effects are not significant even at 5 per cent level. The S.E. of difference between means of treatments is 10·26. At 5 per cent level, Treatment I is superior to Treatment III and IV individually though as a whole no difference exists.

Analysis of variance for *Aghani* crop

There are all zeros in Treatment IV and there are zeros in others also hence no analysis is possible.

9. Growing Lac Hosts under Crop and Bush Conditions

(i) *Under crop conditions — Arhar* (*C. cajan*) seeds from Namkum plantation were sown. The growth of seedlings was satisfactory; 241 plants were infected with *Rangeeni* broodlac in October 1954 for the *Baisakhi* 1954-55 crop. The settlement of lac larvae was good and the crop is in progress.

(ii) *Under bush conditions — Flemingia congesta, Albizzia lucida, Inga dulce,* rose and *ber* (*Zizyphus mauritiana*) were raised in the plantation and care is being taken to convert them into bush form. *A. lucida* and *F. congesta* were infected and the results are given in Table XIII (p. 22).

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

A paper on *Tessaratoma javanica,* a bug pest of *kusum* (*S. oleosa*) is under publication. An annotated list of some of the pests of well-known lac hosts and their control is being made ready for publication.

TABLE XII — CROP COMPARISON AND STATISTICAL ANALYSIS OF INDIVIDUAL TREES

Crop and No. of trees infected	Treatment No.	Mean ratio	Standard deviation	Standard error of mean	Limits between which values can lie at 5% level		Percentage of trees falling				Mean of L_1 and L_2 for both crops for each treatment
					Lower limit L_1	Upper limit L_2	Below L_1	Above L_2	Between L_1 and L_2	Total of L_1+L_2	
Jethwi 1954; 20	I	6·330	1·202	0·269	5·77	6·89	35·0	40·0	25·0	65·0	61·0
Jethwi 1954; 19	II	5·110	1·801	0·413	4·24	5·98	36·8	31·6	31·6	63·2	62·3
Jethwi 1954; 17	III	6·740	2·634	0·639	5·39	8·09	35·3	29·6	35·3	64·9	60·5
Jethwi 1954; 15	IV	4·310	1·937	0·500	3·24	5·38	26·6	26·6	31·8	58·8	64·4
Aghani 1954-55; 23	I	1·490	0·854	0·178	1·02	1·86	43·6	21·7	34·3	56·0	—
Aghani 1954-55; 18	II	1·560	0·976	0·230	1·08	2·04	38·8	22·2	38·8	61·6	—
Aghani 1954-55; 16	III	2·896	2·125	0·531	1·76	4·02	43·5	37·5	18·7	56·2	—
Aghani 1954-55; 10	IV	1·479	0·5083	0·161	1·12	1·84	20·0	20·0	60·0	80·0	—

Conclusion — The trees with values of brood to yield above the upper limit (L_2) are significantly superior to those with values below the lower limit (L_1) and that the trees with values between L_1 and L_2 can lie at 5 per cent level of significance.

TABLE XIII

Host No.	*A. lucida* 8	*F. congesta* 20
Crop	*Baisakhi* 1953-54	*Katki* 1954
Brood used	11 lb. 12 oz.	4 lb.
Brood obtained	4 lb. 9 oz.	13 lb. 1 oz.
Total yield of lac sticks	8 lb. 7 oz.	34 lb. 10 oz.
Ratio of brood to yield lac sticks	1:4·71	1:8·65
Ratio of brood to yield scraped lac	1:3·12	1:6·50
Percentage of selected brood	55·56	37·72

(i) *Pests of* Kusum (S. oleosa)

Serinatha augur — This bug is a pest on dry as well as on green fruits of *kusum* and it is suspected to adversely affect germination of seeds of *kusum*. Eggs are laid singly or in batches of 2-16. The maximum number of eggs laid by a female was 203 in 11 days. Egg stage from June-September varies from 5 to 9 days, average being 7 days. During winter, egg stage was 16-17 days. There are 5 instars. The total life-history period depending on the season and food supplied varied from 31 to 146 days. Dimorphic adults are found especially from November to January. The dimorphism is in wings only, some have fully formed wings, in others the wings (forewing) do not reach the tip of abdomen. The population of hemiwinged adults was 0·16 per cent. The bug exhibits cannibalism. The nymphs and adults freely feed on the eggs. The older forms feed on the younger.

(ii) *Pests of* Palas (B. monosperma)

(a) *Captosma* sps., fam. Pentotomidae, sub-fam. *Plataspidinae*. It is a pest of *palas* leaves. The attack is prominent on new buds in February and continues at a slower rate up to May-June, and again increases in September. The nymphs and adults of the Coccinellid *Synia melanarix* feed on the nymphs of this bug. An egg parasite of the bug was found active in April.

(b) *Lampides boeticus* linn, fam. Lycanidae. It is a pest of flower of *palas*. The caterpillar feeds on carpels, stamens and internal petals. The egg is laid on calyx and glued to it by a small stalk. The larva takes 20-30 minutes to cut an irregular hole in the egg-shell and enters the flower through a space between the overlapping petals. In March the larval stage was 8-12 days and pupal stage 6-9 days. An ecto-parasite of the caterpillar was found in April.

(iii) *Pests of* ber (Z. mauritiana) — The Lycamid *Tarucus theopharstus* is a very active leaf pest in December, and the Noctuid *Ophiusa melicerte* Durry in August-September. In October the life-history period of the latter varied from 25 to 34 days.

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

Attempts to collect specimens of lac sticks by correspondence from different regions of the country are continuing and some specimens were also collected by staff members while out on tour for some other work. One difficulty arising in the collection of samples is that in many places lac that is being cultivated is from Ranchi.

12. Influence of Various Environmental Conditions on Lac Insects

The results obtained on potted plants under controlled conditions in the laboratory and under natural conditions in field are summerized below. Details are given in Table XIV (pp. 23 and 24).

TABLE XIV — INFLUENCE OF VARIOUS ENVIRONMENTAL CON

(i) Controlled conditions

	Average mean temperature °C.	Humidity percentage range %	Av... temp...
Kathi 54 (June-July to Oct.-Nov.)	24·5	32-65	
Baisakhi 54-55 (Oct.-Nov. to June-July)	24·6	39-79	
Jethwi 55 (Jan.-Feb. to June-July)	24·3	33-65	
Aghani 54-55 (June-July to Jan.-Feb.)	24·7	33-65	

Sl. No.	Condition	Strain and host used	Crop and date of infection	Sex	Duration in days — I Instar			II Instar			III Inst...	
					No. under observation	Variation	Average	No. under observation	Variation	Average	No. under observation	Variati...
	1	2	3	4	5	6	7	8	9	10	11	12
1 (a)	Controlled	*Rangeeni A. farnesiana*	*Katki* 54 5-7-54	Females	36	17-28	18·8	29	4-19	9·6	22	7-21
				Males	50	17-19	17·9	46	9-20	13·5	46	2-13
(b)	Field	do	do	Females	60	18-30	20·5	55	6-23	10·0	21	3-13
				Males	23	17-25	20·3	21	5-18	12·5	20	3-23
(c)	Controlled	do	*Baisakhi* 54-55 17-10-54	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
(d)	Field	do	do	Females	3	60-77	66·3	3	32-46	40·3	2	17-18
				Males	—	—	—	—	—	—	—	—
2 (a)	Field	do	*Baisakhi* 53-54 2-11-53	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
(b)	Controlled	do	*Katki* 54 7-7-54	Females	9	20-24	21·7	7	5-17	11·0	4	3-11
				Males	11	19-27	22·2	8	6-20	14·2	7	2-9
(c)	Field	do	*Katki* 54 12-7-54	Females	1	21	21·0	1	11	11·0	—	—
				Males	1	21	21·0	1	18	18·0	1	6
3 (a)	Controlled	do	*Baisakhi* 54-55 14-10-54	Females	9	24-39	29·5	4	7-13	9·7	—	—
				Males	1	25	25·0	1	17	17·0	1	4
(b)	Field	do	do	Females	5	61-92	72·4	3	38-49	45·3	3	18-25
				Males	—	—	—	—	—	—	—	—
4	Field	*Rangeeni A. lucida*	*Baisakhi* 53-54 11-11-53	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
5 (a)	Controlled	do	*Katki* 54 26-6-54	Females	—	—	—	—	—	—	—	—
				Males	1	45	45·0	1	15	15·0	1	5
(b)	Field	do	do	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
6 (a)	Controlled	do	*Baisakhi* 54-55 16-10-54	Females	11	18-31	21·4	6	6-22	11·0	1	—
				Males	8	16-24	19·0	8	7-15	12·7	8	2-1...
(b)	Field	do	do	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
7 (a)	Controlled	*Rangeeni ber*	*Katki* 54 28-6-54	Females	9	22-26	23·3	4	4-11	7·7	3	6-1...
				Males	2	20-25	21·5	2	6-8	7·0	2	8-1...
(b)	Field	do	do	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
(c)	Controlled	do	*Baisakhi* 54-55 12-10-54	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
8 (a)	Controlled	do	*Baisakhi* 54-55 15-10-54	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
(b)	Field	do	do	Females	2	61-63	62·0	2	41-47	44·0	1	23
				Males	—	—	—	—	—	—	—	—
9 (a)	Controlled	*Kusmi kusum*	*Aghani* 54-55 6-7-54	Females	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—
(b)	Field	do	do	Females	51	18-22	20·5	51	8-16	10·7	29	12-1...
				Males	6	21-32	22·8	6	9-16	12·8	5	7-1...
10 (a)	Controlled	do	*Aghani* 54-55	Females	32	16-26	18·7	29	6-14	8·3	18	5-1...

ITIONS ON LIFE CYCLE AND GROWTH OF LAC INSECTS

ield conditions		Temperature °C. range
rage an rature C.	Humidity percentage range %	
·7	34-100	36·6-8·8, i.e. (Oct.-Feb. 33·6-2·7°C. and March to June-July 11·1-38)
·7	11-100	2·7-38·8, i.e. (Jan.-Feb. to March 2·7-11·1°C. and March to June-July 11·1-38)
·0	23-100	2·7-38·8 —
·3	54-100	July to Sept. 35-21·1°C.

IV Instar				Variation of total life cycle in days till emergence of larvae or male No. under observation and average life-cycle period in days	Average development per fortnight and No. under observation length × width in mm.	Remarks
Average	No. under observation	Variation	Average			
13	14	15	16	17	18	19
10·9	4	59-68	63·2	(104-109) 108·0 15	0·57 × 0·62(7)	1st generation concluded (5-7-54 to 15-10-54)
6·3	46	1-14	5·2	(39-60) 43·0 56	0·48 × 0·25(6)	Progeny continued as second generation.
11·9	—	—	—	—	0·25 × 0·32(12)	1st generation concluded (5-7-54 to 13-9-54). All insects died.
7·7	20	2-14	7·4	(42-60) 49·0 24	0·31 × 0·15(3)	
—	—	—	—	—	—	2nd generation concluded (17-10-54 to 12-11-54; progeny of 1a)
—	—	—	—	—	—	
17·5	—	—	—	—	0·06 × 0·07(2)	2nd generation concluded (17-10-54 to 2-4-55; progeny of 1a)
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded (2-11-53 to 2-7-54; details included in *Annual Report*, 1953-54)
—	—	—	—	—	—	
5·7	—	—	—	—	0·25 × 0·33(14)	3rd generation concluded (7-7-54 to 10-9-54; progeny of 2a) all insects
5·0	7	2-9	5·5	(44-49) 46·7 10	0·34 × 0·21(12)	died. 1st generation (16-7-53 to 2-11-53), 2nd generation concluded (2-11-53 to 22-2-54; *Baisakhi* 53-54)
—	—	—	—	—	0·47 × 0·51(3)	3rd generation concluded (12-7-54 to 15-11-54; progeny of 2a). All
60·0	1	2	2·0	(47) 47·0 1	0·33 × 0·16(1)	insects died. 1st generation *Kathi* 53 (16-7-53 to 2-11-53). 2nd generation *Baisakhi* 53-54 (2-11-53 to 2-7-54)
—	—	—	—	—	0·11 × 0·17(7)	1st generation concluded (14-10-54 to 14-12-54). All insects died as
4·0	1	9	9·0	(55) 55·0 1	0·30 × 0·16(1)	a result of high temperature due to some defect in the refrigerator
20·6	—	—	—	—	0·05 × 0·07(3)	1st generation continued
—	—	—	—	—	—	
—	—	—	—	—	0·11 × 0·13(9)	1st generation concluded (11-11-53 to 6-7-54; other details included in
—	—	—	—	—	—	*Annual Report*, 1953-54). Progeny continued as 2nd generation and concluded as all insects died
—	—	—	—	—	—	1st generation concluded (28-6-54 to 24-8-54). All insects died
5·0	1	10	10·0	(75) 75·0 1	0·29 × 0·29(1)	
—	—	—	—	—	—	1st generation concluded (28-6-54 to 22-7-54). All insects died
—	—	—	—	—	—	
9·0	—	—	—	—	0·31 × 0·39(12)	1st generation concluded (16-10-54 to 14-12-54). All insects died as
6·8	8	3-13	6·8	(40-47) 45·5 8	0·41 × 0·22(2)	a result of high temperature due to some defect in refrigerator
—	—	—	—	—	—	1st generation concluded (16-10-54 to 1-12-54). All insects died
—	—	—	—	—	—	
8·0	1	70	70·0	(106-110) 108·0 2	0·43 × 0·54(2)	1st generation concluded (28-6-54 to 12-10-54). Progeny continued
13·5	2	3-6	4·5	(42-51) 46·0 2	0·27 × 0·14(1)	as 2nd generation
—	—	—	—	—	—	1st generation concluded (28-6-54 to 22-7-54). All insects died
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded (12-10-54 to 9-11-54; progeny of 6a). All
—	—	—	—	—	—	insects died
—	—	—	—	—	—	1st generation concluded (15-10-54 to 9-11-54). All insects died
—	—	—	—	—	—	
23·0	—	—	—	—	0·04 × 0·05(2)	1st generation concluded (15-10-54 to 28-2-55). All insects died
—	—	—	—	—	—	
—	—	—	—	—	—	1st generation concluded (6-7-54 to 19-7-54). All insects died
—	—	—	—	—	—	
14·7	—	—	—	—	0·25 × 0·33(5)	1st generation concluded (6-7-54 to 13-9-54). All insects died
8·8	5	4-11	6·0	(48) 48·0 7	—	
11·6	8	69-81	73·2	(102-116) 16	0·39 × 0·47(17)	1st generation concluded (14-7-54 to 23-10-54). Progeny continued as 2nd generation

			14-7-54	Males	6	17-28	21·5	5	9-14	12·2	4	7-11
(b)	Field	do	do	Females	7	19-20	10·2	1	12	12·0	—	—
				Males	—	—	—	—	—	—	—	—
(c)	Controlled	do	*Jethwi* 55	Females	12	27-30	27·9	—	—	—	—	—
			9-11-54	Males	—	—	—	—	—	—	—	—
(d)	Field	do	do	Females	6	30-38	34·0	6	45-54	48·4	—	—
				Males	—	—	—	—	—	—	—	—

					(ii) Controlled condition			Fi	
					Average mean temperature °C.	Humidity percentage range %		Aver mea temper °C	
				Katki 54 (June-July to Oct.-Nov.)	17·7	24-100		27	
				Baisakhi 54-55 (Oct.-Nov. to June-July)	17·9	46-94		19	
				Jethwi 55 (Jan.-Feb. to June-July)	18·6	51-66		20	
				Aghani 54-55 (June-July to Jan.-Feb.)	17·8	24-100		27	
1	Field	*Rangeeni A. farnesiana*	*Baisakhi* 53-54	Females	—	—	—	—	—	—	—	—	—
			10-11-53	Males	—	—	—	—	—	—	—	—	—
2 (a)	Controlled	do	*Katki* 54	Females	20	36-61	47·1	20	5-32	19·3	15	6-49	
			13-7-54	Males	4	36-38	37·1	4	20-28	24·5	4	7-18	
(b)	Field	do	*Katki* 54	Females	8	22-45	30·6	5	7-16	13·8	2	14-15	
			28-6-54	Males	1	27	27·0	1	8	8·0	1	9	
(c)	Controlled	do	*Baisakhi* 54-55	Females	—	—	—	—	—	—	—	—	—
			26-1-55	Males	—	—	—	—	—	—	—	—	—
(d)	Field	do	*Baisakhi* 54-55	Females	12	77-81	79·0	4	38-39	38·5	4	20-22	
			16-10-55	Males	4	81-94	88·5	4	30-40	34·0	4	14-29	
13	Controlled	*Rangeeni A. lucida*	*Katki* 53	Females	—	—	—	—	—	—	—	—	—
			21-7-53	Males	—	—	—	—	—	—	—	—	—
14 (a)	Controlled	do	*Katki* 54	Females	15	31-62	46·3	7	8-31	17·5	4	8-38	
			13-7-54	Males	2	36	36·0	2	21-34	27·5	2	9-11	
(b)	Field	do	*Katki* 54	Females	—	—	—	—	—	—	—	—	—
			28-6-54	Males	—	—	—	—	—	—	—	—	—
(c)	Controlled	do	*Baisakhi* 54-55	Females	—	—	—	—	—	—	—	—	—
			18-12-54	Males	—	—	—	—	—	—	—	—	—
(d)	Field	do	do	Females	—	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—	—
15	Field	*Rangeeni ber*	*Baisakhi* 53-54	Females	—	—	—	—	—	—	—	—	—
			11-11-53	Males	—	—	—	—	—	—	—	—	—
16 (a)	Controlled	do	*Katki* 54	Females	17	36-59	40·9	10	11-34	21·1	5	11-27	
			13-7-54	Males	1	46	46·0	1	24	24·0	1	2	
(b)	Field	do	*Katki* 54	Females	—	—	—	—	—	—	—	—	—
			28-6-54	Males	—	—	—	—	—	—	—	—	—
(c)	Controlled	do	*Baisakhi* 54-55	Females	—	—	—	—	—	—	—	—	—
			16-1-55	Males	—	—	—	—	—	—	—	—	—
(d)	Field	do	do	Females	—	—	—	—	—	—	—	—	—
				Males	—	—	—	—	—	—	—	—	—
17 (a)	Controlled	do	*Baisakhi* 54-55	Females	3	46-59	54·6	1	16	16·0	—	—	
			21-10-54	Males	3	62-75	70·0	—	—	—	—	—	
(b)	Field	do	do	Females	—	—	—	—	—	—	—	—	
				Males	—	—	—	—	—	—	—	—	
18 (a)	Controlled	*Kusmi kusum*	*Aghani* 54-55	Females	21	28-37	31·5	15	9-28	23·8	6	17-39	
			14-7-54	Males	4	28-30	29·5	4	28-33	29·7	3	2-21	
(b)	Field	do	*Aghani* 54-55	Females	121	17-30	20·5	3	3-5	4·0	—	—	
			6-7-54	Males	—	—	—	—	—	—	—	—	
(c)	Controlled	do	*Jethwi* 55	Females	—	—	—	—	—	—	—	—	
			15-2-55	Males	—	—	—	—	—	—	—	—	
(d)	Field	do	do	Females	—	—	—	—	—	—	—	—	
				Males	—	—	—	—	—	—	—	—	

8·5	4	3-16	10·5	(40-49) 43·4 5	0·33 × 0·22(6)	
—	—	—	—	—	0·18 × 0·17(7)	1st generation concluded (14-7-54 to 20-8-54)
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded (9-11-54 to 14-12-54; progeny of 10a). All insects died as a result of high temperature due to some defect in refrigerator
—	—	—	—	—	—	
—	—	—	—	—	0·02 × 0·03(6)	2nd generation concluded (9-11-54 to 7-2-55; progeny of 10a)
—	—	—	—	—	—	

ld conditions		Temperature °C. range				
ge ı ture	Humidity percentage range %					
	42-100	36·6-2·7, i.e. (July-Sept. 34·4-21·1°C. and Oct.-Jan. 36·6-2·7°C.)				
	11-100	2·7-38·8, i.e. (Oct.-Feb. 33·6-2·7°C.)				
	11-43	6·1-36·6, i.e. (Jan.-Feb. to March 2·7-11·1°C. and March to June-July 11·1-36·6°C.)				
	67-100	36·6-2·7, i.e. (July-Sept. 36·6-21°C. and Oct.-Feb. 36·6-2·7°C.)				
—	—	—	—	—	0·07 × 0·09(10)	1st generation concluded (10-11-53 to 1-6-54). Other details included in *Annual Report*, 1953-54. All insects died
—	—	—	—	—	—	
19·6	1	112	112·0	(197) 197·0 2	0·14 × 0·17(12)	1st generation (13-7-54 to 26-1-55). Progeny continued as 2nd generation. Six females of 1st generation still living without larval emergence
11·2	4	7-19	11·7	(76-92) 84·5 4	0·24 × 0·15(2)	
14·5	—	—	—	(110) 110·0 2	0·09 × 0·15(3)	1st generation concluded (28-6-54 to 16-10-54). Progeny continued as 2nd generation
9·0	1	1	1·0	(45) 45·0 1	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 12a. All insects died
—	—	—	—	—	—	
20·7	—	—	—	—	0·08 × 0·09(6)	2nd generation continued — Progeny of 12b
24·0	4	7-9	8·0	(154-156) 154·7 4	0·12 × 0·05(4)	
—	—	—	—	—	—	1st generation concluded (21-7-53 to 5-5-54). Details included in *Annual Report*, 1953-54. All insects died
—	—	—	—	—	—	
21·7	1	85	85·0	(153-161) 151·0 2	0·14 × 0·19(7)	1st generation concluded (13-7-54 to 13-12-54). Progeny cotinued as 2nd generation. One female of 1st generation still living without larval emergence
10·0	2	11	11·0	(77-92) 84·5 2	0·30 × 0·13(2)	
—	—	—	—	—	—	1st generation concluded (28-6-54 to 22-7-54)
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 14a. All insects died
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 14a. All insects died
—	—	—	—	—	—	
—	—	—	—	—	0·06 × 0·07(3)	1st generation concluded (11-11-53 to 7-5-54). Other details included in *Annual Report*, 1953-54. All insects died
—	—	—	—	—	—	
21·6	1	111	111·0	(197) 197·0 1	0·12 × 0·17(7)	1st generation concluded (13-7-54 to 16-1-54). Progeny continued as 2nd generation. Two females of 1st generation still living without larval emergence
2·0	—	—	—	—	0·26 × 0·13(1)	1st generation concluded (28-6-54 to 22-7-54)
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 16a
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 16a
—	—	—	—	—	—	
—	—	—	—	—	0·08 × 0·11(2)	1st generation concluded (21-10-54 to 31-3-55)
—	—	—	—	—	0·13 × 0·09(3)	
—	—	—	—	—	—	1st generation concluded
—	—	—	—	—	—	
28·8	3	123-142	135·0	(211-222) 217·3 3	0·17 × 0·26(15)	1st generation concluded (14-7-54 to 10-2-55). Progeny continued as 2nd generation
12·0	3	4-6	5·0	(71-84) 76·6 3	0·17 × 0·11(4)	
—	—	—	—	—	—	1st generation concluded (6-7-54 to 9-8-54)
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 18a
—	—	—	—	—	—	
—	—	—	—	—	—	2nd generation concluded — Progeny of 18a
—	—	—	—	—	—	

(i) *Under Controlled Conditions above* 24°C.

Rangeeni *strain*: (a) Baisakhi 1953-54 *crop* — It was stated in the last *Annual Report* that under controlled conditions of 27°C. and 30-100 per cent humidity range, this crop matured in about 6 months. But under field conditions when the temperature from November to February ranged between 34°-3·4°C. and from March to July between 11°-43·8°C. (average temperature 25·5°C. which has little meaning in such investigations) and humidity range of 14-100 per cent, the *Baisakhi* crop matured in 7 months 27 days to 6 months 2 days, i.e. under controlled conditions, it matured about 2 months earlier than under field conditions.

(b) Katki 1954 *crop* — Under field conditons of average temperature 23·3°C. (range 21°-36°C.) and humidity range of 11-100 per cent, the crop matured in 3 months and 20 days. Under controlled conditions of average temperature 24·6°C. and humidity range 32-74 per cent, the crop matured in 3 months and 18 days, i.e. the crop took practically the same time under controlled as under field conditions.

(c) Baisakhi 1954-55 *crop* — The experiment was being conducted under controlled conditions of average temperature 24·5°C. and humidity range 32-79 per cent, but the refrigerator failed and all the insects died due to sudden rise in temperature.

Kusmi *strain*: Aghani 1954-55 *crop* — Under field conditions as under (b) "*Katki*" above, the lac insects on the control potted plants have died, but the crop on other trees in the field matured in 6 months and 25 days (9-7-54 to 30-1-55). Under controlled conditions as in (ii) "*Katki*", the crop matured in 3 months and 12 days (14-7-54 to 23-10-54). This too early development under controlled conditions is unusual and has never been observed before; it is very likely that it is the progeny of ' spurious ' *kusum* which does mature and has this year, too, matured in about the same period under field conditions also.

(ii) *Under Controlled Conditions below* 20°C.

Rangeeni *strain*: (a) Katki 1953 *crop* — As reported in the last *Annual Report*, under controlled conditions of average temperature 20°C. and 40-100 per cent humidity range, the infection was carried out on 21-7-53, the males under controlled conditions developed and emerged after 86 days against 41-43 days of the insects that developed under field conditions (average temperature 25·9°C. and 36-100 per cent humidity range), and the females under controlled conditions developed and lived for 9 months and 18 days (21-7-53 to 5-5-54), but died without producing the progeny even though they lived nearly for a period 3 times more than the females under field conditions.

(b) Katki 1954 *crop* — Under controlled average temperature 18°C. and humidity range 24-100 per cent, the crop matured on the average in 6 months and 4 days (153-197 days), while under field conditions of average temperature 27·7°C. and 42-100 per cent humidity range, the crop matured in 3 months and 20 days.

Kusmi *strain*: Aghani 1954-55 *crop* — Under controlled conditions of average temperature 17·8°C. and humidity range of 28-100 per cent, the crop matured in 7 months and 7 days as against 8 months 25 days under natural field conditions.

Conclusion — The above data clearly indicate that temperature chiefly governs the development of lac insects. Temperature below 20°C. retards the development of lac insects and temperature 20°-28°C. seems to be the optimum temperature for the development and growth of lac insects.

13. Survey of Lac Enemies and Their Parasites

(i) Fifty-seven small samples of lac from various crops and at various stages, from different localities were caged but no new enemy (predators and parasites) was recorded.

However, two new Chalcids whose role is not known, were recorded.

The predators and parasites that emerged are listed below:

Chalcids:	*Tetrastichus purpureus*	2,398
	Eupelmus tachardiae	54
	Parechthrodrynus clavicornis	36
	Erencyrtus dewitzi	941
	Tachardiaephagus tachardiae	360
	Coccophagus taschirchii	54
	Tachardiaephagus somervilli	8
	Eurytoma palidiscapus	6
	Brachymeria tachardiae	17
	Elasmus claripennis	nil
Braconids:	*Bracon greeni*	53
	Apanteles fakhrulhajiae	18
	Apanteles tachardiae	44
	Chellonus cyclopyra	1
Ichneumonid:	*Pristomerus testaceicollis*	38
Bethylid:	*Perisierola pulveriae*	2
Predators:	*Eublemma amabilis*	215
	Holcocera pulverea	593
	Chrysopa sp.	4
Eublemma scitula found during stick examination.		
Miscellaneous:	Some beetles which are generally scavengers, and tineid, correct role is not known.	

(ii) *Predators*: Chrysopa *sp.* — *Chrysopa* larva is a predator of lac insects. It feeds on lac insects from outside the lac encrustation throughout its life and pupates outside the lac encrustation. So far three species of *Chrysopa* have been met with, viz. (a) *Chrysopa madestes* Banks, (b) *Chrysopa lacciperda kimmins* sp. n., and (c) *Chrysopa* sp. We are grateful to Mr. D. E. Kimmins of British Museum (Nat. His.) for identifying the species. Papers on the biology of the first two species are under compilation.

In August 1954, *Chrysopa* assumed an epidemic form in *Aghani* 1954-55 crop in Hesal. In the absence of any known method of control, mechanical method of control, e.g. collecting by sweeping with brushes and destroying the predator was tried. A summary of the results obtained is given under item 14. Its incidence in lac has also been noted from Laldhang, Lansdowne Forest Division, U.P.

(iii) *Unknown enemies (squirrels, birds, etc.)* — It has been reported several years ago that some enemy damages lac insects in good numbers on trees especially near about crop maturity time and to some extent lac insects in the broodlac tied on to the trees to grow the succeeding crops. The damage was suspected to be unintentional act of squirrels, rats and birds which are believed to break open the lac encrustation at places where larvae of the predators *Eublemma* and *Holcocera* are hiding. The attention to the problem was, however, focussed and its great importance realized when partial defoliation of *palas* to preserve broodlac from heat and drought in the *Baisakhi* (summer crop) was taken up and it had proved to be a success. During the course of these experiments at Kundri, it was observed that in the month of June when all the water sheds in the area were completely dry and there was no wild ripe fruit available, some enemy or enemies systematically broke open the lac test of each individual living lac insect to eat it. The intensity of this damage increased or developed depending on the severity of the summer.

By the nature of damage caused in Kundri and in samples received from other hot areas wheresoever trained lac staff are working, it was suspected that the damage was being caused by birds like wood-peckers and other tree-climbing small animals. Therefore, two

air rifles were purchased and a few birds and squirrels, visiting the lac-bearing *palas* trees and apparently feeding on lac, were shot dead, preserved and brought to the laboratory with a view to an examination of their stomach contents. The entire alimentary canal of each specimen collected is being thoroughly examined bit by bit. Results of examination for 16 squirrels and 21 birds are given below in Tables XV and XVI.

TABLE XV — EXAMINATION OF CONTENTS OF ALIMENTARY CANAL OF SQUIRRELS SHOT AT KUNDRI 10th-27th JUNE 1954

Squirrel No.	Bits of lac resin	Lac larvae	Grown-up female lac insects		Termites	Other insects	Remarks
			Entire or practically entire	Fragments			
1	6	14	17	3	461	—	Ovule of lac insects in good number in stomach and abdomen
2	—	1	7	—	159	1 head resembling that of *Eublemma* larva	—
3	3	7	—	—	221	1 mite	—
4	4	—	—	—	128	1 louse 1 mite 1 beetle	
5	84	8	2	16	321	1 head resembling that of *Holcocera* larva	Ovules of lac insect in good number in along with illum colon rectum
6	38	5	58	1	96	1 head resembling that of *Holcocera* larva	do
7	29	3	33	19	211	—	Plenty of ovules of lac insects throughout alimentary canal
8	—	—	—	—	273	1 faecal pellet of full grown *Eublemma* larva	—
9	37	—	97	37	376	—	Plenty of ovules of lac insects throughout alimentary canal
10	68	6	61	—	71	1 Bletid moth 1 Chalcid group 1 wasp head	Plenty of ovules of the insects in stomach
11	Few not counted	1	28	1	23	—	Number of ovules of lac insects in stomach
12	223	1	75	34	90	2 headless larvae resembling that of *Eublemma*	Plenty of ovules of lac insects in stomach and illum
13	3	—	3	1	146	—	Number of ovules of lac insect in stomach
14	—	—	—	—	80	2 wasps	Few lac embryos in stomach
15	Good number not counted	1	72	—	293	—	Plenty of lac embryos found in stomach
16	—	—	1	—	85	—	—

TABLE XVI — EXAMINATION OF THE CONTENTS OF ALIMENTARY CANAL OF BIRDS SHOT AT KUNDRI 10th-27th JUNE 1954

Specimen No.	Local name	Collection date	Lac resin bits	Lac larvae	Other insects
1	Ramshuga	16·6	1	—	Head of lepidopterious larva resembling *Holcocera* larva
2	Dhaincha	20·6	—	2	—
3	Smaller Katkhudwa	21·6	1	3	2 heads closely resembling heads of *Holcocera* larva
4	Not known	18·6	—	2	—
5	Bulbul	20·6	—	7	—
6	Bigger Katkhudwa	23·6	—	6	4 *Holcocera* eggs
7	Smaller Katkhudwa	16·6	—	—	—
8	Katkhulli	16·6	—	11	—
9	Bara Katkhudwa	17·6	—	—	—
10	Smaller Katkhudwa	18·6	—	3	—
11	Bara Katkhudwa	27·6	—	9	7 nematodes pieces of tapeworms
12	Katkhulli	16·6	—	2	Some segments of tapeworms
13	Not known	18·6	—	4	—
14	Khupsa	18·6	—	1	12 mandibles of some insects
15	Bulbul	20·6	—	—	—
16	Kilkilla	16·6	—	—	Body parts of beetles and ants
17	Seven sisters	18·6	—	—	5 mandibles of some insects, body part of green-grass hoppers
18	Karketta	23·6	—	—	Body parts of grass hoppers and other insects
19	Bulbul	20·6	—	—	—
20	Smaller Katkhudwa	16·6	—	3	—
21	Smaller Katkhudwa	18·6	—	3	Body parts of beetles and red ants

14. Cultural and Preventive Methods of Control of Lac Enemies

(i) *Use of wire-net baskets* — It has already been stated in the previous reports that wire-net baskets are being used to permit lac larvae to filter out to settle on the lac hosts and to trap as many enemy insects as possible inside those baskets. Past experience showed that a number of wire-net baskets besides their natural wear and tear were being damaged by squirrels and rats while on trees; therefore, as a measure of protection to them and to prolong the period of their utility as well as give additional protection to broodlac, bamboo-basket containers were made and inside each bamboo basket one wire-net basket containing broodlac was placed; the bamboo containers were then tied on to the trees.

The maximum price of wire-net basket being used, works out to annas ten, and the cost of bamboo container, in a place like Ranchi where bamboo is not easily available, works out to an anna and a half per container.

Trials conducted showed that taking all causes of wear and tear including damage caused to them by squirrels and rats, all the wire-net baskets become unserviceable after being used for seven seasons. However, the percentage of unserviceable wire-net baskets per succeeding season of use worked out to 5·8, 14·3, 21·7, 44·0, 65·1 and 100. This investigation is complete.

In June 1954, out of 2,569 wire net brood baskets, 111 were damaged by squirrels, rats, etc., but out of 403 wire net brood baskets enclosed in bamboo baskets, not a single wire-net basket was damaged by squirrels, etc. Hence in January 1955, all (1908) wire net brood baskets were enclosed in bamboo baskets and these tied on to trees and it was found that not a single wire-net basket was damaged by squirrels, etc. This is an important contribution to use of wire-net baskets in cultivation of lac. Further, since June 1954, it has also been found that with this modified technique, the damage to wire-net baskets by wear and tear is nil in the first season, 6·0 per cent in the second season, and 9·58 per cent in the third season. In other words, by this technique the normal life of wire net brood basket is considerably increased and wastage in lac is also practically completely prevented.

The number of enemy and friendly insects captured inside the wire-net baskets is given in Table XVII.

TABLE XVII — INSECTS TRAPPED IN WIRE-NET BASKETS CONTAINING BROODLAC

Name and No. of insects	*Jethwi*, 1955 25 baskets containing 4 lb.	*Aghani* 1954-55 25 baskets containing 4 lb. 5 oz.	*Baisakhi* 1953-54 25 baskets containing 2½ lb.	*Katki* 1954 25 baskets containing 3 lb. 2 oz.
Chalcids:				
Marietta javensis	—	1	—	—
Tetrastichus purpureus	7	18	6	144
Eupelmus tachardiae	17	32	9	27
Parechthrodrynus Clavicornis	9	9	1	25
Erencyrtus dewitzi	8	24	3	33
Tachardiaephagus tachardiae	250	76	42	133
Tachardiaephagus somervilli	1	5	1	13
Eurytoma palidiscapus	1	32	—	1
Brachymeria tachardiae	—	—	2	1
Elasmus claripennis	—	—	—	3
Braconids:				
Bracon greeni	1	12	1	7
A. fakhrulhajiae	1	66	1	11
A. tachardiae	19	44	2	13
Chellonus cyclopyra	—	1	2	—
Ichneumonid:				
Pristomerus testaceicollis	—	7	3	9
Bethylid:				
Perisierola pulveriae	3	1	10	1

TABLE XVII — INSECTS TRAPPED IN WIRE-NET BASKETS CONTAINING BROODLAC
(Contd.)

Name and No. of insects	*Jethwi* 1955 25 baskets containing 4 lb.	*Aghani* 1954-55 25 baskets containing 4 lb. 5 oz.	*Baisakhi* 1953-54 25 baskets containing 2½ lb.	*Katki* 1954 25 baskets containing 3 lb. 2 oz.
Predators:				
E. amabilis adult	54	71	109	10
,, ,, eggs	3	18	1	11
,, ,, pupae	40	1	3	5
H. pulverea adult	230	133	216	43
,, ,, eggs	—	—	3	5
,, ,, larvae	—	15	7	251
,, ,, pupae	3	—	16	—
Chrysopa sp. cocoon	—	5	1	5
Other insects:				
Chalcid pupae dead	37	—	1	23
,, larvae	—	—	—	4
Beetle eggs	3	—	—	—
,, larvae	—	—	14	12
Beetles	39	—	114	—

To find out prevalence of the predators (*Eublemma* and *Holcocera*) and Chalcid parasites and other insects including those beneficial in the crop produced by use of wire-net baskets and without it, equal quantities of sticklac were caged at crop maturity. The lac produced by use of wire-net baskets was not immune to outside infection of enemy insects as the trees are in the midst of the areas where lac is produced without the use of wire-net baskets. However, the results given in Table XVIII clearly indicate that the concentration of enemy insects is definitely less in the lac produced by use of wire-net baskets than in the lac produced otherwise. Further, the lac produced without the use of wire-net baskets was purchased from villagers through the Special Officer for Lac Cultivation,

TABLE XVIII

Expt. indicates lac produced by use of wire-net baskets & control without wire net		Prevalence of enemy insects in crop produced by use of wire-net baskets and without it			
		Insects emerged			
Crop and kind of lac	Quantity in lb.	*Eublemma*	*Holcocera*	Chalcid enemies	Other insects
Jethwi, 1954					
Kusmi	20 expt.	13	102	553	79
,,	20 control	98	314	62	134
Katki, 1954					
Rangeeni	20 expt.	133	220	302	164
,,	20 control	121	512	3,782	119
Aghani, 1954-55					
Kusmi	20 expt.	48	443	1,424	364
,,	20 control	100	640	2,320	1,097

hence considerable delay occurred in getting it to laboratory from the time it was cut in the field, whereas the lac produced by use of wire net was produced by the Institute itself and it was caged soon after cutting; hence in the former case many insects escaped before it could be caged, it was not so in the latter case.

(ii) (a) *Mechanical control*: *Sweeping* — As stated under item 13, to meet the epidemic of *Chrysopa* attack, hand picking and sweeping with brushes were adopted in August 1954. To sweep 68 trees, 23½ labourers were required. The cost per tree worked to annas 5½.

The number of insects so collected from 44 trees is shown in Table XIX, but by the nature of control adopted for tall trees like *kusum*, it should be obvious that a good number of the predators may have fallen down on the ground also.

TABLE XIX — COLLECTION OF *CHRYSOPA* BY SWEEPING *KUSUM* TREES

Coupé No.	No. of trees swept for count	Stages and number collected				Average per tree			
		Adult	Pupae	Larvae	Eggs	Adult	Pupae	Larvae	As one unit
II	4	23	19	291	—	5·75	4·75	72·75	83·25
VI	8	7	—	86	—	0·9	—	10·75	11·02
IX	14	15	2	227	—	1·1	1·6	16·2	16·71
XII	10	8	—	86	—	0·8	—	8·6	9·40
XIII	8	2	—	78	—	0·25	—	9·75	10·00
TOTAL	44	55	21	768	—	1·25	1·27	17·5	19·18

Light trap — This was tried for over a fortnight using hurricane lanterns; one night a petromax was also used but no *Chrysopa* was attracted.

(b) *Use of insecticides* — The investigation is being conducted under three heads with D.D.T. and B.H.C., both as dust and spray, at 5 per cent and 0·1 per cent concentration respectively to find their effect on the lac insect, on predators and parasites of lac in the *Rangeeni* as well as in the *Kusmi* crops (*see* Table XX, pp. 32 and 33).

(i) (a) Dust the host plant (*palas* and *kusum*) only once, (1-7 days) before infection.

(b) Spray the host plants (*palas* and *kusum*) only once, (1-7 days) before infection.

(ii) (a) Dust the host plant once a week after the lac larvae have settled on it, i.e. 3 weeks after infection.

(b) Spray the host plant once a week after the lac larvae have settled on it, i.e. 3 weeks after infection.

(iii) (a) Dust lac sticks after cutting crop at maturity.

(b) Dust scraped lac (sticklac) at crop maturity.

(c) Spray lac sticks after cutting crop at maturity.

(d) Spray scraped lac (sticklac) at crop maturity.

The object of (i) and (ii) is to study the effect on lac insect and its enemies during the growth of the crop under natural field conditions and that of (iii) is to study if the carry-over of enemies from the harvested crop to next crop could be prevented.

Treatment [i (a, b)] does not seem to have any adverse or beneficial effect on lac insects or enemies of lac and on the host plants.

TABLE XX — EXAMINATION OF CROP WHILE IN FIELD, UNIT 9 IN. (3 EQUAL PIECES) LENGTHS FOR INCIDENCE OF ENEMY AND BENEFICIAL INSECTS IN THE CROP OBTAINED, UNIT 3 LB.

Treatment	Date of		Initial settlement of lac larvae	Percentage of mortality						Ratio of brood infected to yield obtained	Emergence of insects per 3 lb. of lac		
				Before male emergence			At crop maturity				Enemies		Beneficial
	Applying treatment	Infection of crop		Natural	By enemies	Total	Natural	By enemies	Total		*Eub. & Hol.*	Chalcid	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
For Katki 1954 *crop*													
D.D.T 5% dust	28-6-54 only once	1-7-54	3,630	2·5	4·4	6·9	11·1	34·7	45·8	1 : 3·8	206	593	18
D.D.T. 1% spray	do	1-7-54	2,453	29·0	9·3	38·3	40·3	23·5	64·8	1 : 2·5	222	827	64
B.H.C. 5% dust	do	1-7-54	3,054	17·0	4·0	21·0	35·3	12·6	47·9	1 : 3·2	157	295	6
B.H.C. 1% spray	do	1-7-54	2,268	18·5	5·9	24·4	22·7	20·9	42·9	1 : 5·2	324	429	29
Control	do	1-7-54	1,506	5·0	4·2	9·2	21·6	28·9	50·5	1 : 4·7	182	252	13
For Aghani 1954-55 *crop*													
D.D.T. 5% dust	10-7-54 only once	12-7-54	4,107	15·6	3·3	18·9	27·0	6·8	33·8	1 : 2·0	45	84	36
D.D.T. 1% spray	do	12-7-54	2,886	8·0	—	8·0	27·6	12·1	39·7	1 : 1·7	63	138	48
B.H.C. 5% dust	do	12-7-54	2,759	10·9	0·7	11·6	10·0	2·4	92·4	1 : 1·5	66	90	42
B.H.C. 1% spray	do	12-7-54	4,599	10·9	0·5	11·4	22·3	15·4	37·7	1 : 1·6	45	38	84
Control	do	12-7-54	1,157	23·5	0·7	30·5	55·1	27·4	82·5	1 : 1·7	15	87	33
For Katki 1954 *crop*													
D.D.T. 5% dust	19-7-54 weekly after removing *phunki* brood	1-7-54	904	17·9	2·5	20·4	34·7	9·8	44·5	1 : 4·9	25	48	2

TABLE XX — EXAMINATION OF CROP WHILE IN FIELD, UNIT 9 IN. (3 EQUAL PIECES) LENGTHS FOR INCIDENCE OF ENEMY AND BENEFICIAL INSECTS IN THE CROP OBTAINED, UNIT 3 LB.
(Contd.)

Treatment	Date of		Initial settlement of lac larvae	Percentage of mortality						Ratio of brood infected to yield obtained	Emergence of insects per 3 lb. of lac		
				Before male emergence			At crop maturity				Enemies		Beneficial
	Applying treatment	Infection of crop		Natural	By enemies	Total	Natural	By enemies	Total		*Eub. & Hol.*	Chalcid	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
D.D.T. 1% spray	19-7-54 weekly after removing *phunki* brood	1-7-54	1,402	4·4	5·4	9·8	12·4	37·2	49·6	1 : 5·5	21	120	1
B.H.C. 5% dust	do	1-7-54	578	12·6	12·2	24·8	17·6	42·5	60·1	1 : 4·0	103	570	5
B.H.C. 1% spray	do	1-7-54	915	13·3	10·5	23·8	24·6	45·4	70·0	1 : 6·0	228	33	1
Control	Nil	1-7-54	514	8·7	7·6	16·3	28·7	61·0	89·7	1 : 1·5	119	329	4
For Aghani 1954-55 *crop*													
D.D.T. 5% dust	31-7-54 weekly after removing *phunki* brood	13-7-54	476	11·6	0·2	11·8	23·6	15·7	39·3	1 : 2·0	21	—	—
D.D.T. 1% spray	do	13-7-54	870	12·8	0·8	13·6	24·3	6·5	30·9	1 : 3·0	21	3	1
B.H.C. 5% dust	do	13-7-54	577	24·9	1·4	26·3	36·7	15·7	52·4	1 : 1·3	15	24	12
B.H.C. 1% spray	do	13-7-54	433	12·6	—	—	36·3	9·8	46·1	1 : 3·0	21	9	3
Control	Nil	13-7-54	445	6·3	1·7	8·0	43·2	21·5	64·7	1 : 2·7	24	36	39

Treatment [ii(a,b)] also does not seem to adversely affect the lac insects. It does not also seem to have any effect on the predators (*Eublemma* and *Holcocera*) and the parasites.

Fuller results will be given when the crop has matured.

(iii) *Dusting and spraying the mature crop* — For these experiments, 5 lb. of lac sticks and 2 lb. of scraped lac were used in each case. For spraying, just enough quantity of chemical suspension was employed. For dusting, the ratio of the chemical to lac sticks or scraped lac used was 1: 100. The treated lac was caged immediately after the treatment to note the emergence of predators, parasites, etc. The results of emergence listed in Table XXI do not give any definite indications.

TABLE XXI — COMPARATIVE DATA OF DIFFERENT TREATMENTS OF INSECTICIDES ON MATURE LAC STICKS AND SCRAPED LAC

Lac samples	Treatment	Predators			Parasites of lac insects	Parasites of enemies of lac
		Hol.	*Eub.*	Total		
Baisakhi 1953-54						
Palas lac sticks	5 lb. dusted with 5% D.D.T.	199	128	327	4	4
do	5 lb. dusted with 5% B.H.C.	16	17	33	—	—
do	5 lb. sprayed with 0·1% D.D.T.	6	62	68	50	3
do	5 lb. sprayed with 0·1% B.H.C.	40	69	109	20	2
do	5 lb. control to above	38	18	56	4	—
Palas scraped lac	2 lb. dusted with 5% D.D.T.	8	1	9	—	—
do	2 lb. dusted with 5% B.H.C.	5	15	20	16	—
do	2 lb. sprayed with 0·1% D.D.T.	6	—	6	—	—
do	2 lb. sprayed with 0·1% B.H.C.	9	—	9	1	—
do	2 lb. control to above	26	1	27	29	7
Jethwi 1954						
Kusum lac sticks	5 lb. dusted with 5% D.D.T.	9	41	50	106	2
do	5 lb. dusted with 5% B.H.C.	—	43	43	—	—
do	5 lb. sprayed with 0·1% D.D.T.	22	65	87	17	3
do	5 lb. sprayed with 0·1% B.H.C,	70	86	156	58	6
do	5 lb. control to above	66	66	132	28	3
Kusum scraped lac	2 lb. dusted with 5% D.D.T.	6	—	6	—	—

TABLE XXI — COMPARATIVE DATA OF DIFFERENT TREATMENTS OF INSECTICIDES ON MATURE LAC STICKS AND SCRAPED LAC
(Contd.)

Lac samples	Treatment	Predators			Parasites of lac insects	Parasites of enemies of lac
		Hol.	*Eub.*	Total		
Kusum scraped lac	2 lb. dusted with 5% B.H.C.	2	4	6	—	—
do	2 lb. sprayed with 0·1% D.D.T.	3	12	15	18	1
do	2 lb. sprayed with 0·1% B.H.C.	3	4	7	19	—
do	2 lb. control to above	16	1	17	35	4
Katki 1954						
Palas lac sticks	2 lb. dusted with 5% D.D.T.	12	13	25	90	7
do	2 lb. dusted with 5% B.H.C.	—	—	—	156	7
do	2 lb. sprayed with 0·1% D.D.T.	3	2	5	—	—
do	2 lb. sprayed with 0·1% B.H.C.	—	—	—	—	—
do	2 lb. control to above	69	34	103	297	34
Palas scraped lac	2 lb. dusted with 5% D.D.T.	3	—	3	109	1
do	2 lb. dusted with 5% B.H.C.	5	—	5	58	3
do	2 lb. sprayed with 0·1% D.D.T.	—	—	—	—	—
do	2 lb. sprayed with 0·1% B.H.C.	—	—	—	—	—
do	2 lb. control to above	15	10	25	327	10
Aghani 1955						
Kusum lac sticks	3 lb. dusted with 5% D.D.T.	2	21	23	9	—
do	3 lb. dusted with 5% B.H.C.	—	12	12	—	—
do	3 lb. sprayed with 0·1% D.D.T.	1	17	18	11	—
do	3 lb. sprayed with 0·1% B.H.C.	2	38	40	8	—
do	3 lb. control to above	50	32	82	76	8
D. lanceolaria	4 lb. scraped lac dusted with 5% D.D.T.	—	—	—	26	—
do	4 lb. scraped lac dusted with 5% B.H.C.	—	—	—	24	—
do	4 lb. sprayed with 0·1% D.D.T.	—	—	—	—	—
do	4 lb. control to above	26	3	25	93	21

15. Biological Control

(i) *Parasites of* Eublemma amabilis — Due to insufficient laboratory space, the work on breeding insects as well as control of enemy insects by use of insecticides had to be done side by side, as a result the insecticides have adversely affected breeding work in general.

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

Large-scale liberations in the field and estimation of the effect of liberations would be taken up when air-conditioned room is built and a field area sanctioned.

(a) *Mass breeding of* Bracon greeni *on alternative hosts in the laboratory* — The only alternative (unnatural) host used was *Etiella zinkenella* (pod borer of *Crotolaria saltiana*). The maximum parasitization was 32·4 per cent in April. The maximum number of *B. greeni* bred per *E. zinkenella* larva was 2·25 in July. Though 18,030 host larvae were offered to 23,021 (10,146 males and 12,875 females) of *B. greeni* due to high rate of mortality in the insects for reasons given above, the parasitization of the host was only 7·7 per cent; the number of adult *B. greeni* bred was 1,191 only and the number of adult *B. greeni* bred per host was only 0·8 against 1·8 of previous year. The percentage of females bred was 59·4. Details are given in Table XXIII (p. 37).

(b) Elasmus claripennis, *ecto-parasite of* Eublemma *larva* (*see* Table XXII below).

TABLE XXII — LONGEVITY AND LIFE-HISTORY IN DAYS

Conditions	Month	Longevity				Life-history				Remarks
		Males		Females		Males		Females		
		Variation	Average	Variation	Average	Variation	Average	Variation	Average	
At laboratory temperature	Sept.	1-17	1·88	1-21	3·10	—	—	—	—	Eggs died
	Oct.	1-14	7·91	1-20	10·58	20-22	21·23	—	—	
	Nov.	2-11	5·90	2-29	12·61	21-23	21·50	—	—	
	Dec.	2-19	5·04	4-37	9·92	—	—	—	—	
At 27°C. controlled temperature	Nov.	—	—	—	—	13-14	13·18	—	—	
	Dec.	1-6	3·75	4-11	5·75	13-14	13·80	—	—	
	Jan.	1-10	5·00	3-10	7·78	—	—	—	—	

Number of eggs laid by a female varied from 1 to 37. Egg period was 1 day. At room temperature, the larval period varied from 7 to 11 days and average was 9·19, the pupal period varied from 10 to 12 days and average was 11·31. At 27°C. controlled temperature, larval period was 5-6, average 5·89, the pupal period 6-8 days, average 6·31. In every case the progeny was 100 per cent males, it is just possible that the eggs were laid by females that did not mate.

(ii) *Parasites of* H. pulverea

(a) Apanteles tachardiae, *endo-parasite of* H. pulverea *larva*

		June	*July*	*August*
Average	Male	1·25	1	1
Longevity in days	Female	2·17	2	2

TABLE XXIII — LARGE-SCALE BREEDING OF *B. GREENI* ON UNNATURAL (ALTERNATIVE) HOSTS APRIL 1954 TO MARCH 1955

Month	Host	Condition of larvae offered							*B. greeni* adults bred				
		Introduced	Parasitized	% parasitization	Living	Dead	Pupated	Host and parasite contact in days	Males	Females	Total	Females %	Adults bred per host
1	2	3	4	5	6	7	8	9	10	11	12	13	14
April	*E. zinkenella in* tissue domes	1,200	389	32·40	334	476	1	3	113	131	244	53·6	0·6
May	do	1,240	13	1·04	744	474	9	3	—	—	—	—	—
June	do	1,200	3	0·25	569	627	1	3	1	4	5	80·0	1·6
July	do	1,240	4	0·32	547	650	39	3	5	4	9	44·4	2·25
August	do	1,240	54	4·35	564	586	36	3	28	51	79	64·5	1·4
September	do	2,560	99	3·80	1,664	651	146	1-3	25	48	73	65·7	0·7
October	do	3,310	37	1·10	2,017	1,115	141	1	17	27	44	61·36	1·1
November	do	1,200	100	8·33	741	356	3	3	32	63	94	66·30	0·95
December	do	1,240	136	10·90	822	277	5	3	53	71	124	57·30	0·9
January	do	1,240	173	13·90	735	830	2	3	61	74	135	55·5	0·7
February	do	1,120	195	17·41	669	255	1	3	53	93	146	68·6	0·7
March	do	1,240	194	15·60	665	390	1	3	75	112	187	59·8	0·96
	TOTAL	18,030	1,397	7·7	10,061	6,187	385	1-3	463	678	1,441	59·4	0·8

REMARKS — Insecticides interfered with breeding work.

TABLE XXIV — BETHYLIDAE (*PERISIEROLA PULVERIAE*)

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

Started from to	No. of adults caged ♂	♀	No. of host (*Hol.*) offered	No. of host (*Hol.*) parasitized	%	No. of eggs laid	Pre-oviposition period Vr. / Av.	Total oviposition period Vr. / Av.	No. of days when eggs laid Vr. / Av.	Average No. of eggs laid per ♀ Vr. / Av.	Longevity in days ♂ Vr. / Av.	♀ Vr. / Av.	Remarks
Oviposition — At Controlled Temperature 27°C. — Breeding on Natural host (*Holcocera pulverea*)													
1st generation adults 11-10-54 to 23-10-54	1	1	45	6	13·3	38	3	8	5	38	escaped	12	1 ♀ laid eggs
2nd generation adults 25-10-54 to 18-11-54	3	7	48	11	22·8	64	1-3 / 1·0	3-9 / 2·7	2-4 / 1·4	3-9 / 9·14	6-11 / 8·0	3·20 / 9·7	All 7 ♀♀ laid eggs
3rd generation adults 9-11-54 to 28-11-54	11	7	66	11	16·6	78	1-12 / 4·16	1-9 / 3·83	1-3 / 1·8	4-22 / 13·0	3-17 / 7·8	5-15 / 10·16	Only 6 ♀♀ laid eggs
4th generation adults 21-11-54 to 20-1-55	8	7	32	11	34·3	78	4-12 / 8·0	1-24 / 12·5	1-10 / 5·5	11-67 / 39·0	3-16 / 7·8	4-48 / 21·4	Only 2 ♀♀ laid eggs
5th generation adults 20-12-54 to 24-1-55	52	6	23	8	34·7	62	4-12 / 7·3	1-7 / 3·3	1-4 / 2·3	9-33 / 20·6	10-48 / 21·5	7-14 / 9·6	Only 3 ♀♀ laid eggs
6th generation adults 13-1-55 to 7-3-55	5	5	67	37	55·2	217	2-4 / 3·2	3-38 / 15·6	2-13 / 6·2	17-96 / 43·4	14-27 / 17·5	14-48 / 26·25	All 5 ♀♀ laid eggs
7th generation adults 27-1-55 to 18-3-55	2	2	33	21	63·6	126	3-5 / 4·0	10-37 / 23·5	5-15 / 10·0	5-97 / 63·0	6-27 / 16·5	26-45 / 35·5	2 ♀♀ laid eggs
8th generation adults 11-2-55 to 26-2-55	3	3	27	9	33·3	46	3-5 / 3·3	1-54 / 3·34	1-4 / 2·3	8-28 / 15·3	7-15 / 11·0	15 / 15·0	All 3 ♀♀ laid eggs
9th generation adults 25-2-55 to 15-3-55	1	2	18	6	33·3	42	3-5 / 4·0	1-10 / 5·5	1-5 / 3·2	9-33 / 21·0	3 / 3·0	7-18 / 12·5	Both 2 ♀♀ laid eggs
TOTAL	86	40	369	120	32·5	751	1-12 / 3·64	1-38 / 7·48	1-15 / 3·5	3-97 / 24·2	3-48 / 7·14	3-48 / 15·4	31 ♀♀ laid eggs

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

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

Started from to	No. of adults caged ♂	♀	No. of host (*Hol.*) offered	No. of host (*Hol.*) parasitization	%	No. of eggs laid	Pre-oviposition period Vr. / Av.	Total oviposition period Vr. / Av.	No. of days when eggs laid Vr. / Av.	Average No. of eggs laid per ♀ Vr. / Av.	Longevity in days ♂ Vr. / Av.	Longevity in days ♀ Vr. / Av.	Remarks
Oviposition — At Laboratory Temperature — Breeding on Natural Host (*Holcocera pulverea*)													
1st generation adults													
19-1-55 to 30-3-55	1	1	23	11	47·8	65	6	32	10	65	19	70	Eggs laid by 1 ♀ only
2nd generation adults													
27-1-55 to 1-2-55	3	4	17	5	29·4	22	7-12 9·5	1-22 11·5	1-4 2·5	11·0	8-11 10·0	11-34 18·0	Eggs laid by 2 ♀♀ only
3rd generation adults													
14-2-55 to 28-2-55	3	3	24	6	23·0	24	5-7 6·3	1-20 7·3	1-4 2·0	8·0	14-0 14·0	14-27 18·3	Eggs laid by 3 ♀♀ only
4th generation adults													
1-3-55 to 14-3-55	3	3	7	1	14·2	3	6-0 6·0	1 day	1 day	3·0	3-13 7·3	3-13 7·3	Eggs laid by 1 ♀ only
Total	10	11	71	23	32·3	114	5-12 6·28	1-32 11.14	1-10 3·14	3-65 16·28	3-19 11·3	3-70 19·9	Total 7 ♀♀ only laid eggs
Oviposition — By Virgin Females — At Controlled Temperature 27°C. on Natural Host (*Holcocera pulverea*)													
9-11-54 to 16-3-55	0	15	68	22	32·35	133	1-6 3·6	1-12 5·5	1-5 2·6	4-36 16·63	0	2-23 10·07	Eggs laid by 8 ♀♀ only
Oviposition — By Virgin Females — At Laboratory Temperature on Natural Host (*Holcocera pulverea*)													
7-2-55 to 12-4-55	0	9	18	6	33·3	32	8-15 11·8	3-12 7·5	2-4 3·0	12-20 16·0	0	3-32 11·25	Eggs laid by 2 ♀♀ only
Oviposition — At Controlled Temperature 27°C. — Breeding on Unnatural Host — *Corcyra* (Pest of Wheat) as Alternative Host													
10-3-55 to 4-4-55	4	4	28	10	35·9	55	3-10 5·6	2-11 7·3	2-5 3·3	11-29 18·3	8-15 11·2	8-25 15·5	Eggs laid by 3 ♀♀ only
1st generation adults													
16-3-55 to 13-4-55	2	2	10	3	30·0	29	14 days	10 days	4 days	29	5-7 6·0	21-28 24·5	Eggs laid by 1 ♀ only
Total	6	6	38	13	34·2	84	3-14 7·75	2-11 8·0	2-5 3·5	11-29 21·0	5-15 9·5	8-28 18·5	Eggs laid by 4 ♀♀ only

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

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

Started from to	No. of adults caged ♂	♀	No. of host (*Hol.*) offered	No. of host (*Hol.*) parasitization	%	No. of eggs laid	Pre-oviposition period Vr. / Av.	Total oviposition period Vr. / Av.	No. of days when eggs laid Vr. / Av.	Average No. of eggs laid per ♀ Vr. / Av.	Longevity in days ♂ Vr. / Av.	Longevity in days ♀ Vr. / Av.	Remarks
Oviposition — Breeding on Unnatural Host — *Corcyra cephalonica* (Pest of Wheat) as Alternative Host at Laboratory Temperature													
Adults bred in laboratory													
5-3-55 to 21-3-55	2	2		No oviposition							4-11 7·5	11-13 12·0	
22-2-55 to 18-4-55	27	14	26	6	23·7	33	Eggs transferred to mass breeding cage				3-20 7·9	4-24 6·5	Mass oviposition cages
5-3-55 to 18-4-55	29	16	26	6	23·7	33	Eggs transferred to mass breeding cage				3-20 7·8	4-24 7·2	Out of 33 eggs, life-history taken for 21 eggs — Rest transferred to mass breeding cage
No eggs laid by two pairs													
1st generation adults													
14-3-55 to 20-4-55	11	11	29	11	37·9	69	6-11 9·0	4-21 11·6	2-5 3·6	17-27 23·0	4-16 7·1	4-35 14·0	Eggs laid by 3 ♀♀ only, 2 cages are in progress
2nd generation adults													
6-4-55 to 18-4-55	3	2		No oviposition							1-12 6·5	3-12 7·5	3 Mass oviposition cages started are in progress
5-3-55 to 20-4-55	43	29	55	17	30·9	102	6-11 9·0	4-21 11·6	2-5 3·6	17-27 23·0	1-20 5·6	3-35 9·9	
Caged Without Food at Controlled Temperature 27°C.													
12-11-54 to 5-2-55	13	6	20	3	15·0	20	2-6 4·0	1-0 1·0	1-0 1·0	5-8 6·6	3-27 7·7	5-14 8·16	Eggs laid by 3 ♀♀ only
Caged Without Food at Laboratory Temperature													
12-11-54 to 18-2-55	5	5	8	2	25·0	10	14-0 14·0	2-0 2·0	2-0 2·0	10-0 10·0	2-16 10·0	9-27 14·4	Eggs laid by 1 ♀ only
Caged Without Host at Laboratory Temperature													
7-3-55 to 21-3-55	3	3	—	—	—	—	—	—	—	—	4-7 5·0	4-14 10·6	

**TABLE XXV — BETHYLIDAE (*PERISIEROLA PU*

Remarks — *1st generation adults emerged from 2 eggs collected from*

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

No. of cages	Started from to	No. of eggs caged	No. shrivelled	No. hatched	Egg period	No. of larvae died	No. spun	No. not spun	Active larval period Vr. / Av.	No. pupated	Total larval period Vr. / Av.
					Life-history — At Controlled Temperature 27°C. — Breeding on Natural						
5	*2nd generation eggs*										
	14-10-54 to 30-10-54	38	11	27	1 day	13	10	4	2-3 / 2·4	4	5 / 5·0
9	*3rd generation eggs*										
	29-10-54 to 11-11-54	64	22	42	1 day	27	13	2	2-3 / 2·15	15	4-5 / 4·4
11	*4th generation eggs*										
	11-11-54 to 3-12-54	78	35	43	1 day	21	20	2	2-4 / 2·95	20	5-6 / 5·3
11	*5th generation eggs*										
	7-12-54 to 10-1-55	78	—	78	1 day	18	58	2	2-3 / 2·89	60	5-7 / 5·2
6	*6th generation eggs*										
	31-12-54 to 24-1-55	62	6	56	1 day	29	27	—	2-4 / 2·7	27	4-5 / 4·4
29	*7th generation eggs*										
	21-1-55 to 12-3-55	217	22	195	1 day	43	146	6	2-3 / 2·6	150	3-6 / 4·79
17	*8th generation eggs*										
	31-1-55 to 19-3-55	126	24	102	1 day	22	73	7	2-4 / 2·8	80	4-7 / 5·1
5	*9th generation eggs*										
	18-2-55 to 4-3-55	46	14	32	1 day	11	21	—	3-0 / 3·0	18	5-7 / 5·7
5	*10th generation eggs*										
	2-3-55 to 16-3-55	42	8	34	1 day	21	13	—	3-0 / 3·0	12	5-0 / 5 0
8	14-10-54 to 19-3-55	751	142	609	1 day	205	381	23	2-4 / 2·8	386	3-7 / 5·7
					Life-history — At Laboratory Temperature (1 batch) — Breeding on Nat						
10	*2nd generation eggs*										
	15-2-55 to 23-3-55	65	13	52	1-2 days	6	25	1	3-5 / 3·96	23	4-8 / 6·08
5	*3rd generation eggs*										
	8-2-55 to 16-3-55	22	5	17	1 day	6	11	—	3-4 / 3·2	11	5-6 / 5·2
6	*4th generation eggs*										
	21-2-55 to 16-3-55	24	—	24	1 day	14	10	—	3-4 / 3·7	10	5-7 / 6·3
1	*5th generation eggs*										
	7-3-55 to 15-3-55	3	1	2	1 day	1	1	—	4 days	1	6 days
22	15-2-55 to 23-3-55	114	19	95	1-2 days	27	47	1	3-5 / 3·7	45	4-8 / 5·9
					Life-history — At Controlled Temperature 27°C. — Breeding on Natura						
18	17-11-55 to 22-3-55	133	10	123	1 day	52	71	2	2-4 / 2·8	71	4-6 / 4·7
					Life-history — At Laboratory Temperature — Breeding on Natural						
6	15-2-55 to 19-3-55	32	1	31	1 day	5	26	—	3-4 / 3·8	26	5-8 / 6·3
					Life-history — At Controlled Temperature 27°C. — Breeding on Unnatural Host — *Co*						
9	*1st generation eggs*										
	15-3-55 to 11-4-55	55	—	55	1 day	21	33	1	2-4 / 3·30	34	4-6 / 4·8
3	*2nd generation eggs*										
	31-3-55 to 16-4-55	29	7	22	1 day	6	16	—	2-3 / 2·4	16	2-3 / 2·4
12	15-3-55 to 16-4-55	84	7	77	1 day	27	49	1	2-4 / 2·8	50	2-6 / 4·0
					Life-history — At Laboratory Temperature — Breeding on Unnatural Host — *Corcy*						
4	*1st generation eggs*										
	1-3-55 to 28-3-55	21	2	19	1 day	—	19	—	3-4 / 3·21	19	5·6 / 5·5
11	*2nd generation eggs*										
	20-3-55 to 18-4-55	69	35	34	1 day	27	4	3	2-3 / 2·5	7	3-6 / 4·7

9	*3rd generation eggs* 29-10-54 to 11-11-54	64	22	42	1 day	27	13	2	2-3 2·15	15	4-5 4·4	8
11	*4th generation eggs* 11-11-54 to 3-12-54	78	35	43	1 day	21	20	2	2-4 2·95	20	5-6 5·3	6
11	*5th generation eggs* 7-12-54 to 10-1-55	78	—	78	1 day	18	58	2	2-3 2·89	60	5-7 5·2	54
6	*6th generation eggs* 31-12-54 to 24-1-55	62	6	56	1 day	29	27	—	2-4 2·7	27	4-5 4·4	6
29	*7th generation eggs* 21-1-55 to 12-3-55	217	22	195	1 day	43	146	6	2-3 2·6	150	3-6 4·79	67
17	*8th generation eggs* 31-1-55 to 19-3-55	126	24	102	1 day	22	73	7	2-4 2·8	80	4-7 5·1	60
5	*9th generation eggs* 18-2-55 to 4-3-55	46	14	32	1 day	11	21	—	3-0 3·0	18	5-7 5·7	9
5	*10th generation eggs* 2-3-55 to 16-3-55	42	8	34	1 day	21	13	—	3-0 3·0	12	5-0 5 0	1
8	14-10-54 to 19-3-55	751	142	609	1 day	205	381	23	2-4 2·8	386	3-7 5·7	22
	Life-history — At Laboratory Temperature (1 batch) — Breeding on Natura											
10	*2nd generation eggs* 15-2-55 to 23-3-55	65	13	52	1-2 days	6	25	1	3-5 3·96	23	4-8 6·08	
5	*3rd generation eggs* 8-2-55 to 16-3-55	22	5	17	1 day	6	11	—	3-4 3·2	11	5-6 5·2	
6	*4th generation eggs* 21-2-55 to 16-3-55	24	—	24	1 day	14	10	—	3-4 3·7	10	5-7 6·3	
1	*5th generation eggs* 7-3-55 to 15-3-55	3	1	2	1 day	1	1	—	4 days	1	6 days	
22	15-2-55 to 23-3-55	114	19	95	1-2 days	27	47	1	3-5 3·7	45	4-8 5·9	1
	Life-history — At Controlled Temperature 27°C. — Breeding on Natural											
18	17-11-55 to 22-3-55	133	10	123	1 day	52	71	2	2-4 2·8	71	4-6 4·7	
	Life-history — At Laboratory Temperature — Breeding on Natural Ho											
6	15-2-55 to 19-3-55	32	1	31	1 day	5	26	—	3-4 3·8	26	5-8 6·3	
	Life-history — At Controlled Temperature 27°C. — Breeding on Unnatural Host — *Cor*											
9	*1st generation eggs* 15-3-55 to 11-4-55	55	—	55	1 day	21	33	1	2-4 3·30	34	4-6 4·8	
3	*2nd generation eggs* 31-3-55 to 16-4-55	29	7	22	1 day	6	16	—	2-3 2·4	16	2-3 2·4	
12	15-3-55 to 16-4-55	84	7	77	1 day	27	49	1	2-4 2·8	50	2-6 4·0	
	Life-history — At Laboratory Temperature — Breeding on Unnatural Host — *Corcyr*											
4	*1st generation eggs* 1-3-55 to 28-3-55	21	2	19	1 day	—	19	—	3-4 3·21	19	5·6 5·5	
11	*2nd generation eggs* 20-3-55 to 18-4-55	69	35	34	1 day	27	4	3	2-3 2·5	7	3-6 4·7	
15	*No eggs in 3rd generation* 1-3-55 to 18-4-55	90	37	53	1 day	27	23	3	2-4 3·06	26	3-6 5·3	
	Eggs Laid by Females Caged without Food at Controlled T											
3	16-1-54 to 7-2-55	20	7	13	1 day	—	10	3	2-4 3·0	13	4-6 5·0	
	Eggs Laid by Females Caged without Food at Laborator											
2	5-2-55 to 25-2-55	10	—	10	1 day	5	5		5-0 5·0	5	9-0 9·0	

LE XXV — BETHYLIDAE (*PERISIEROLA PULVERIAE*)

-1st generation adults emerged from 2 eggs collected from field on 29-9-54

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

No. pun	No. not spun	Active larval period Vr. / Av.	No. pupated	Total larval period Vr. / Av.	Adults emerged ♂	Adults emerged ♀	Adults emerged Total	Pupal period Vr. / Av.	Total life-history ♂ Vr. / Av.	Total life-history ♀ Vr. / Av.	% of survival	% of ♀♀
lled Temperature 27°C. — Breeding on Natural Host (*Holcocera pulverea*)												
10	4	2-3 2·4	4	5 5·0	2	12	14	4 4·0	10-11 10·5	10-11 9·5	37·8	85·7
13	2	2-3 2·15	15	4-5 4·4	8	7	15	4-8 5·4	10-11 10·25	10-14 12·88	23·4	46 6
20	2	2-4 2·95	20	5-6 5·3	6	12	18	4-5 4·9	11-12 11·16	10-12 11·41	23·07	66·6
58	2	2-3 2·89	60	5-7 5·2	54	6	60	4-10 6·29	11-14 12·09	12-16 15·3	76·9	10·0
27	—	2-4 2·7	27	4-5 4·4	6	20	26	5-7 6·6	11-13 12·16	11-13 12·08	41·9	76·9
46	6	2-3 2·6	150	3-6 4·79	67	79	146	5-11 7·7	10-14 11·4	10-14 11·5	67·2	54·1
73	7	2-4 2·8	80	4-7 5·1	60	9	69	3-8 5·2	7-14 11·06	12-14 12·2	54·7	13·04
21	—	3-0 3·0	18	5-7 5·7	9	9	18	4-7 5·16	10-15 12·5	10-13 11·2	39·13	50·0
13	—	3-0 3·0	12	5-0 5 0	12	0	12	5-6 5·6	12-0 12·0	0	28·5	0
81	23	2-4 2·8	386	3-7 5·7	224	154	378	3-10 5·31	10-15 11·45	10-16 11·7	50·3	40·7
ry Temperature (1 batch) — Breeding on Natural Host (*Holcocera pulverea*)												
25	1	3-5 3·96	23	4-8 6·08	5	18	23	5-10 7·4	10-19 14·0	10-20 15·3	35·3	78·2
11	—	3-4 3·2	11	5-6 5·2	1	1	2	7-0 7·0	14-0 14·0	14-0 14·0	9·0	50·0
10	—	3-4 3·7	10	5-7 6·3	4	6	10	6-10 7·4	13-14 13·5	14-17 15·5	41·7	60·0
1	—	4 days	1	6 days	Pupa attacked with mites and died							
47	1	3-5 3·7	45	4-8 5·9	10	25	35	5-10 5·7	10-19 13·8	10-20 15·3	30·7	71·4
olled Temperature 27°C. — Breeding on Natural Host (*Holcocera pulverea*)												
71	2	2-4 2·8	71	4-6 4·7	70	0	70	3-8 6·4	10-14 12·04	—	52·6	—
oratory Temperature — Breeding on Natural Host (*Holcocera pulverea*)												
26	—	3-4 3·8	26	5-8 6·3	24	0	24	4-9 6·0	12-17 13·3	0	75·0	—
ture 27°C. — Breeding on Unnatural Host — *Corcyra* (Pest of Wheat) as Alternative host												
33	1	2-4 3·30	34	4-6 4·8	3	25	28	5-6 5·6	11-12 11·6	3-12 10·3	50·9	89·1
16	—	2-3 2·4	16	2-3 2·4	3	13	16	4-5 3·0	9-10 9·3	9-10 9·46	55·5	81·2
49	1	2-4 2·8	50	2-6 4·0	6	38	44	4-6 4·58	9-12 9·0	3-12 7·2	52·3	86·3
erature — Breeding on Unnatural Host — *Corcyra* (Pest of Wheat) as Alternative Host												
19	—	3-4 3·21	19	5·6 5·5	6	13	19	5-7 4·63	12-13 12·8	12-13 12·7	90·4	6·84
4	3	2-3	7	3-6	4	2	6	3-6	9-11	11	8·6	33·3

46	6	2-3 2·6	150	3-6 4·79	67	79	146	5-11 7·7	10-14 11·4	10-14 11·5	67·2	54·1
73	7	2-4 2·8	80	4-7 5·1	60	9	69	3-8 5·2	7-14 11·06	12-14 12·2	54·7	13·04
21	—	3-0 3·0	18	5-7 5·7	9	9	18	4-7 5·16	10-15 12·5	10-13 11·2	39·13	50·0
13	—	3-0 3·0	12	5-0 5 0	12	0	12	5-6 5·6	12-0 12·0	0	28·5	0
81	23	2-4 2·8	386	3-7 5·7	224	154	378	3-10 5·31	10-15 11·45	10-16 11·7	50·3	40·7
ry Temperature (1 batch) — Breeding on Natural Host (*Holcocera pulverea*)												
25	1	3-5 3·96	23	4-8 6·08	5	18	23	5-10 7·4	10-19 14·0	10-20 15·3	35·3	78·2
11	—	3-4 3·2	11	5-6 5·2	1	1	2	7-0 7·0	14-0 14·0	14-0 14·0	9·0	50·0
10	—	3-4 3·7	10	5-7 6·3	4	6	10	6-10 7·4	13-14 13·5	14-17 15·5	41·7	60·0
1	—	4 days	1	6 days	Pupa attacked with mites and died							
47	1	3-5 3·7	45	4-8 5·9	10	25	35	5-10 5·7	10-19 13·8	10-20 15·3	30·7	71·4
)lled Temperature 27°C. — Breeding on Natural Host (*Holcocera pulverea*)												
71	2	2-4 2·8	71	4-6 4·7	70	0	70	3-8 6·4	10-14 12·04	—	52·6	—
)oratory Temperature — Breeding on Natural Host (*Holcocera pulverea*)												
26	—	3-4 3·8	26	5-8 6·3	24	0	24	4-9 6·0	12-17 13·3	0	75·0	—
ture 27°C. — Breeding on Unnatural Host — *Corcyra* (Pest of Wheat) as Alternative host												
33	1	2-4 3·30	34	4-6 4·8	3	25	28	5-6 5·6	11-12 11·6	3-12 10·3	50·9	89·1
16	—	2-3 2·4	16	2-3 2·4	3	13	16	4-5 3·0	9-10 9·3	9-10 9·46	55·5	81·2
49	1	2-4 2·8	50	2-6 4·0	6	38	44	4-6 4·58	9-12 9·0	3-12 7·2	52·3	86·3
erature — Breeding on Unnatural Host — *Corcyra* (Pest of Wheat) as Alternative Host												
19	—	3-4 3·21	19	5·6 5·5	6	13	19	5-7 4·63	12-13 12·8	12-13 12.7	90·4	6·84
4	3	2-3 2·5	7	3-6 4·7	4	2	6	3-6 5·5	9-11 10·0	11 11·0	8·6	33·3
23	3	2-4 3·06	26	3-6 5·3	10	15	25	3-7 5·8	9-13 11·7	11-13 14·4	27·7	60·0
Females Caged without Food at Controlled Temperature 27°C.												
10	3	2-4 3·0	13	4-6 5·0	0	11	11	6-7 6·8	0	13-14	55·0	100
by Females Caged without Food at Laboratory Temperature												
5		5-0 5·0	5	9-0 9·0	1	4	5	10-0 10·0	20-0 20·0	20-0 20·0	50·0	80·0

Actual oviposition could not be observed and egg also was not found. The life-history period in days is given below:

Month	Sex	Minimum endo-parasite (egg and larva)		Cocoon		Minimum life-cycle period	
		Variation	Average	Variation	Average	Variation	Average
June-Oct.	Male	11-20	16·5	6-10	7·5	18-25	23·1
,,	Female	—	—	5-6	5·6	—	—
Feb.-March	Male	—	—	7-11	10·5	—	—
,,	Female	—	—	6-8	6·7	—	—
(b) *Apanteles fakhrulhajiae*						—	—
Feb.-March	Male	—	—	7-11	10·5	—	—
,,	Female	—	—	6-8	6·7	—	—
(c) *Pristomerus testaceicollis*						—	—
Feb.-March	Male	—	—	11-13	11·6	—	—
,,	Female	—	—	—	10·0	—	—

(d) *Perisierola pulveriae* (Bethylid)— It is an ecto-parasite of *Holcocera pulverea* larva. Work was started in September 1954 with one pair of unhatched eggs found in the field on a *Holcocera* larva. From end of September 1954 to March 1955, ten direct generations have been bred in the laboratory at laboratory temperature as well as at controlled temperature of 27°C. An alternative (unnatural) host *Corcyra cephalonica* (pest of cereals, wheat, etc.) has been found convenient to breed the parasite for large-scale breeding. In winter, egg laying by the parasite was more under 27°C. controlled temperature than under ordinary conditions while reverse was the case with regard to longevity of the adult. The female parasite can reproduce parthenogenitically and the progeny is 100 per cent males. The parasite was available in the field throughout the period, but percentage of parasitization of the host was low, probably due to the fact that the broodlac in the plantation, which is the main source of our supplies of material, is in large number of cases put on the trees in wire-net baskets.

The details of breeding, etc., on natural and unnatural hosts are given in Tables XXIV and XXV (*see* pp. 38-42).

16. *Ad Hoc* Research

Kusmi lac being in great demand, a few other hosts were tried to grow it, and the results of analysis in Table XXVI show that the two *Dalbergia* species are good *Kusmi* hosts practically in all respects. Grape-vine (*Vitrus vinifera*) was found to be a casual lac host of lac insects.

TABLE XXVI — COMPARATIVE ANALYSIS OF SOME STICKLACS PRODUCED IN RANCHI AREA ON POSSIBLE *KUSMI* HOSTS

Crop	Host and condition of lac	Percentage yield of seed lac	Bleach index in cc.	Grade	Hot alcohol-insolubles	Colour index
Aghani 1954-55	*Schleichera oleosa* (*Kusmi*)	75·0	81	I B	2·692	9
,,	*Dalbergia latifolia* (rose wood)	72·5	64	I A	1·824	9
,,	*Dalbergia lanceolaria*	62·8	80	I A	2·644	11
,,	*Acacia catechu* (*khair*)	71·8	75	I A	1·608	8
,,	*Ficus infectoria* (*pakur*)	73·9	63	I A	3·256	12

II. INSTITUTE PLANTATION, NAMKUM

The general upkeep of the plantation was maintained as per policy laid down and funds available. Whenever possible, young trees were manured with farm-yard and chemical manure. Green manuring with Boga medlor (*Tephrosia candida*) was carried on throughout the plantation to suppress the growth of grass. *Crotolaria saltiana* was cultivated in order to use its pod-borer larvae as alternative host to breed *Bracon greeni* in the laboratory. Young plants for use in pots and in other places were raised in the nursery. For experimental work, a limited number of trees (440) were infected to grow various crops. *Kusum* and *khair* seeds were directly sown in their respective plots to fill up the gaps. Rose cuttings were planted to try it as a bush plant for cultivation of lac.

III. TRAINING AND ADVISORY SERVICE

(i) *Training* — In all there were 16 trainees; out of these, 6 were from Bihar, 1 from Bombay, 1 from West Bengal, 2 from Bhopal, 3 from U.P., 1 from Vindhya Pradesh, 1 from Andhra and 1 from Special Officer for Lac Cultivation, I.L.C.C. The 6 Bihar, 1 U.P. and 1 West Bengal trainees successfully completed the full course of training during the period. The Bombay and Bhopal trainees left the Institute after about 6 months' incomplete training. Five trainees are continuing.

(ii) *Advisory Service*:

(a) *To outsiders* — Various institutions from different parts of the country and persons interested in lac cultivation were given necessary advice.

At the request of the West Bengal Government to depute an officer to take part in an enquiry into cultivation and marketing of lac in West Bengal, Shri S. N. Gupta, Scientific Officer, was sent for the purpose. The team consisting of two West Bengal Officers and Shri Gupta, after touring in the State, have submitted a report to the West Bengal Government.

The *Kusum* Brood Farm of the M.P. Government at Bagra Tawa was continuously failing for the last three years to produce broodlac, hence certain experimental lines of work were laid down in June 1954 to meet the difficulty. The *Jethwi* 1955 crop was propagated in the brood farm on these lines and the crop is progressing satisfactorily.

In the Lansdown Forest Division, U.P. at Kotdwara, there was spurious swarming of lac larvae in November instead of the normal time in January. The following crop (*Jethwi*) 1955 from the previous spurious broodlac was used for infection as advised and the crop is progressing satisfactorily. But this is an important problem which affects *Kusmi* crops and requires closer investigations.

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

(b) *To Special Officer for Lac Cultivation* — At the request of the Special Officer for Lac Cultivation, inspite of the shortage of staff in the department, tours had to be undertaken in several parts of Bihar, Madhya Pradesh, Punjab and Uttar Pradesh. For some of the areas already visited by the S.O.L.C. and his department, exploratory work plans were prepared and in some cases reports sent to the Government and officers of the State concerned in order to facilitate the extension work of the S.O.L.C. Work plan was also prepared for the Upper Godavari Forest Division of Andhra and sent to S.O.L.C. as desired by him.

In addition to the above, a large number of samples of lac and broodlac, received by S.O.L.C. and sent to the Institute by him from various areas in Assam, Bihar, Bombay, Madras, Madhya Pradesh, Uttar Pradesh, etc., were examined, and necessary information and advice were given to him to be conveyed to the

parties concerned. Every possible assistance was also given to S.O.L.C. in selection and despatch of broodlac.

Advice and casual demostrations were also given to Forest Staff from M.P. and U.P. that came to Namkum to receive broodlac. A short revision course was held for staff under demonstration in Bihar.

In addition, the following specimens were bred and supplied to various parties:

1. *M. Hebetor* cocoons	(85)	Head of the Division of Entomology, Indian Agricultural Research Institute, New Delhi.
2. *B. Greeni* larvae	(25)	Head of the Division of Entomology, Indian Agricultural Research Institute, New Delhi.
3. *B. greeni* cocoons	(110)	Mr. G. W. Anglet, Entomologist, U.S. Dept. Agriculture, New Delhi.

TABLE XXVII — A STATEMENT OF LAC PRODUCED AND ITS DISPOSAL DURING THE YEAR 1954-55 (from 1st April 1954 to 31st March 1955)

Crop and locality	Scraped or broodlac produced and its disposal											
	Produced			Under use in department			Driage			Supplied to Chemical Section		
	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.	Md.	sr.	ch.
Baisakhi 1953-54	0	5	0*	0	5	0*		—			—	
Namkum	0	22	1†	0	1	2†	0	3	5½†	0	17	9½†
Jethwi 1954 Hesal	19	33	½†	13	24	2½†	4	16	5†	1	32	9†
Namkum	2	20	0†	0	4	8†	0	17	9†	1	37	15†
Katki 1954	0	10	0*	0	10	0*		—			—	
Namkum plantation	4	4	13†	3	0	13†	0	22	0†	0	22	0†
Aghani 1954-55	0	10	0*	0	10	0*		—			—	
Hesal	6	22	10†	4	35	14†	0	32	12†	0	34	0†
Namkum plantation	5	22	2½†	3	34	3†	0	25	10½†	1	2	6†

* Brood lac. † Scraped lac.

RECEIPTS

	Quantity Md.	sr.	ch.	Value Rs.	as.	ps.
1. By supply of broodlac for use in the department from Namkum plantation (*Baisakhi* 1953-54 crop) ...	0	5	0*	12	8	0
* i.e. 10 lb.						
2. (a) By supply of scraped lac for use in the department from Namkum plantation (*Baisakhi* 1953-54 crop)	0	1	2	2	13	0
(b) By supply of scraped lac to Chemical Section from Namkum plantation (*Baisakhi* 1953-54 crop) ...	0	17	9½	43	15	9
(c) By supply of scraped lac for use in the department from Hesal plantation (*Jethwi* 1954 crop) ...	13	24	2½	1,224	5	6
(d) By supply of scraped lac to Chemical Section from Hesal plantation (*Jethwi* 1954 crop)	1	32	9	163	4	3
(e) By supply of scraped lac for use in the department from Namkum plantation (*Jethwi* 1954 crop) ...	0	4	8	10	2	0
(f) By supply of scraped lac to Chemical Section from Namkum plantation (*Jethwi* 1954 crop) ...	1	37	15	175	5	9
* i.e. 1,470 lb.	17	37	14*	1,619	14	3

RECEIPTS (*Contd.*)

	Quantity			Value		
	Md.	sr.	ch.	Rs.	as.	ps.
3. By supply of broodlac for use in the department from Namkum plantation (*Katki* 1954 crop)	0	10	0	18	12	0
4. (a) By supply of scraped lac for use in the department from Namkum plantation (*Katki* 1954 crop) ...	3	0	13	271	13	3
(b) By supply of scraped lac to Chemical Section from Namkum plantation (*Katki* 1954 crop)	0	22	0	49	8	0
(c) By supply of scraped lac to Chemical Section from Hesal plantation (*Aghani* 1954-55 crop) ...	0	34	0	119	0	0
(d) By supply of scraped lac for use in the department from Hesal plantation (*Aghani* 1954-55 crop) ...	4	35	14	685	9	0
(e) By supply of scraped lac for use in the department from Namkum plantation (*Aghani* 1954-55 crop) ...	3	34	3	539	10	6
(f) By supply of scraped lac to Chemical Section from Namkum plantation (*Aghani* 1954-55 crop) ...	1	2	6	148	5	0
* i.e. 1,176½ lb.	14	9	4*	1,813	13	9
5. By supply of broodlac for use in the department from Hesal plantation (*Aghani* 1954-55 crop)	0	10	0*	50	0	0
*i.e. 20 lb.						
6. (a) By supply of scraped lac to Chemical Section from purchased lac (*Baisakhi* 1953-54 crop) ...	0	16	8½	41	6	6
(b) By supply of scraped lac from miscellaneous lac (*Baisakhi* 1953-54 crop) to Chemical Section ...	0	0	6	0	15	0
(c) By supply of scraped lac from purchased lac from Kundri (*Baisakhi* 1953-54 crop) to Chem. Section ...	4	0	0	292	0	0
*i.e. 362 lb.	4	16	14½*	334	5	6
7. (a) By supply of scraped lac to Chemical Section from purchased lac (which was under use in the department) (*Katki* 1953 crop)	0	9	11¾	19	15	9
(b) By supply of scraped lac to Chemical Section from Namkum plantation (*Katki* 1953 crop) ...	0	16	8	33	13	3
(c) By supply of scraped lac from purchased lac (which was under use in the department) (*Aghani* 1953-54 crop) to Chemical Section	0	6	15	17	8	9
(d) By supply of scraped lac from Hesal and Namkum plantation (*Aghani* 1953-54 crop) to Chem. Section ...	6	39	11½	712	11	3
(e) By supply of scraped lac for use in the department from purchased lac (*Aghani* 1953-54 crop) ...	0	3	0	6	0	0
(f) By supply of scraped lac from Hesal plantation (*Aghani* 1953-54 crop) for use in the department ...	1	30	0	178	8	0
*i.e. 790 lb.	9	25	14¼*	968	9	0

CHEMICAL SECTION

I. FUNDAMENTAL

1. CHEMICAL CONSTITUTION OF SHELLAC

The work on the chemical constitution of shellac was continued (*vide Annual Report*, 1953-54, p. 25).

(i) *Position of the hydroxyl group in butolic acid* — The dicarboxylic acid, obtained from the hydrolysed products of the mixed amides of butolic acid, on purification melted at 149°-150°C. and the mixed m.p. with pure adipic acid (m.p. 152°-153°C.) and suberic acid (m.p. 141°-142°C.) was 149°-150°C. and 135°-136°C. respectively. The analytical data for the unknown as well as adipic and suberic acids are given below:

Acid	M.P. in °C.	Acid value	Mol. wt.	*R_f value in *n*-butyl alcohol: 90% formic acid: water (6:5:5)
Unknown	149-150	768·2	145·7 from A.V.	0·80
Adipic	152-153	767·1	146·0	0·80
Suberic	141-142	643·7	174·0	0·90

From the above data the unknown acid appears to be identical with adipic acid and hence the hydroxyl group in butolic acid is attached to the sixth carbon atom. It may be noted that the unknown acid has been identified as adipic acid by means of paper partition chromatography using the solvent *n*-butyl alcohol : 90 per cent formic acid : water (6 : 5 : 5).

A second hydrolysed product from mixed amides of butolic acid, an amine, having ammonia-like odour, was alkaline to red litmus. Attempts were made to identify it by means of the following derivatives:

Picrate — The picrate was prepared by mixing hot solutions of the amine and picric acid in water. The picrate, on recrystallization from ether, gave beautiful needle-shaped crystals, m.p. 92°-95°C. Some low melting impurity was observed which was difficult to remove.

Benzoyl derivative — The benzoyl derivative was prepared according to the Schotten and Baumann method. A liquid substance was obtained which on extraction with ether gave ultimately a sweet smelling crystalline compound, m.p. 31°-32°C. Here also some low melting impurities were observed which were difficult to remove.

Platinic chloride salt — The amine was dissolved in concentrated hydrochloric acid and to the hot solution excess of platinic chloride solution was added. The yellow chloroplatinate of the amine immediately separated. It crystallized from hot alcohol in the form of leaflets. The molecular weight of the amine was determined by ignition of the salt and estimation of platinum.

Analysis: Substance taken, 0·0198 gm.; residue after ignition, 0·0056 gm.; mol. wt. of the amine found, 139·8. Calculated for nonylamine: 143·0.

The other two products of hydrolysis, the steam-volatile acid and the amino acid, are being identified through some of their derivatives.

(ii) *Synthesis of butolic acid* — As the hydroxyl group in butolic acid has been found to be attached to its sixth carbon atom, butolic acid may be presumed to be 6-hydroxypentadecanoic acid. Attempts are being made to synthesize the acid; some of the intermediates have been prepared already, and are reported below:

Ethyl hydrogen adipate — (a) Adipic acid (50 gm.), ethyl alcohol (100 cc.) and concentrated sulphuric acid (2-5 cc.) were heated under reflux on the water bath for 12 hr. The mixture was poured into water and extracted with ether. The ether

* For definition, *see* p. 51

layer was washed successively with saturated sodium sulphate solution and water. After drying over anhydrous sodium sulphate, ether was distilled off and the ester mixture subjected to high vacuum distillation. The diethyl adipate (30 gm.) distilled at 120°-125°C./6 mm. and ethyl hydrogen adipate (20 gm.) at 156°-158°C./ 5 mm. There was some residual adipic acid left.

(b) A mixture of diethyl adipate (202 gm.; 1 mole) and adipic acid (146 gm.; 1 mole) was refluxed for about 8 hr. under 85 mm. pressure. The mixture, on vacuum distillation, yielded diethyl adipate (135 gm.), ethyl hydrogen adipate (86·5 gm.) and residual adipic acid.

n-Octyl bromide — The bromide, b.p. 93°-94°C./21 mm., was prepared from a mixture of *n*-octyl alcohol (71 gm.), hydrobromic acid (40 per cent) (280 gm.) and concentrated sulphuric acid (34 cc.) according to the procedure given in Gilman's *Organic Synthesis*, Collective Vol. I, p. 28. The yield of pure bromide was 90 gm.

n-Nonyl bromide — An attempt was made to prepare *n*-nonyl bromide according to the method described by Max Rottenberg (*Helv. Chim. Acta*, **36**, p. 1119, 1953) for the preparation of *n*-pentadecyl bromide. A mixture of dry silver capricate (13·95 gm.) and dry capric acid (8·6 gm.) was suspended in 400 cc. of dry boiling carbon tetrachloride taken in a 1 l. ground-joint three-necked flask provided with an efficient condenser, a mercury-sealed stirrer and a dropping funnel. The mixture was treated with 4·7 cc. of bromine dissolved in a little carbon tetrachloride, the solution being added gradually in 10 min. The resulting brown mixture was further boiled for 10 min., cooled, filtered and the residue washed with enough carbon tetrachloride. The combined carbon tetrachloride solution was washed successively with water, potassium iodide solution, thiosulphate solution and water, and for removal of free acid, with 5 per cent caustic potash in 50 per cent aqueous alcohol and water. The liquor was dried over anhydrous calcium chloride, solvent removed and the bromide vacuum-distilled, b.p. 88°C./4 mm.; yield 6 gm.

(iii) *Examination of Salt Fractions of Shellac*

(a) *Dark-coloured zinc salt* — The soluble calcium salt (*I.L.R.I. Annual Report*, 1953-54, p. 26) obtained from the dark-coloured zinc salt by method (ii) on decomposition, gave a thick liquid product. This liquid on standing in presence of 20 per cent caustic soda solution gave some insoluble sodium salt which, on decomposition, yielded an acid, m.p. 95·5°-96·5°C. On recrystallization from aqueous alcohol the acid melted at 96°-97°C.

The filtrate containing the water-soluble sodium salt was decomposed and a liquid mass obtained which, on standing in the cold, became semi-solid. On digestion with ether, a soluble thick liquid and an insoluble semi-hard mass could be obtained. The insoluble mass was dissolved in alcohol, water added till turbid, and kept in the cold for a long time, but nothing crystallized out. The thick liquid product had a peculiar smell and a somewhat greenish colour. The product decolourized permanganate but not bromine. It responded to the aldehyde test but not to Liebermann test. A.V. found, 249·2.

(b) *Hot water-insoluble zinc salt* — After separation of dimethyl shellolate from the mixture of esters from hot water-insoluble zinc salt, there remained a liquid ester. Further attempts to get more crystalline esters were unsuccessful. The liquid ester showed positive test for aldehyde.

(c) *Alcohol-insoluble lead salt* — The liquid ester, left after separation of dimethyl shellolate, was saponified. The salt was decomposed in alcohol medium and after addition of water, extracted with chloroform and ether. A hexagonal-shaped crystalline acid, m.p. 161°-162°C. with decomposition, A.V. 385·9, was obtained from the chloroform extract. The ether extract also gave a mixture of crystalline acids, hexagonal and rod-like, m.p. 160°-161°C., A.V. 374·4.

(d) *Ether-soluble liquid acid from barium salt* — The liquid acid was esterified and the methyl esters fractionated into six fractions by high vacuum distillation (*I.L.R.I. Annual Report*, 1953-54, p. 27). The two fractions (c) and (d) were solid and these on recrystallization melted at 72°-73°C. Decomposition of the ester gave an acid melting at 96°-97°C.

(iv) *Separation and Identification of Acidic Fractions from Hydrolysed Shellac*

(a) *Barium salt from water-insoluble liquid acid* — The precipitated barium salt obtained from water-insoluble liquid acid (*I.L.R.I. Annual Report*, 1953-54, p. 29) was fractionated into four fractions by successive extractions with boiling absolute methyl alcohol, hot water and hot 50 per cent aqueous ethyl alcohol.

The methyl alcohol-soluble fraction on treatment with water gave water-insoluble and -soluble fractions. The former on decomposition gave butolic acid, while the latter, a soft mass.

A solid acid, m.p. 96°-97°C., and a liquid acid were obtained from each of the hot water and hot 50 per cent aqueous alcohol extracts.

(b) *Water-soluble acid as sodium salt* — The acid was purified through its mercury salt. The acid and saponification values of the acid were 200·3 and 330·0 respectively, indicating a lactonic structure. It reduced Tollen's silver nitrate solution with the separation of black metallic silver suggesting the presence of some reducing group. A part of the acid was dissolved in hot water, a solution of semicarbazide hydrochloride and sodium acetate added and then heated on the water bath. On cooling at room temperature there separated beautiful clusters of crystals which melted with decomposition at 234°-235°C. The formation of semicarbazone indicates the presence of an aldehyde group in addition to the lactonic group in the acid molecule.

(v) *Separation and identification of acidic fractions from hydrolysed soft resin* — It has been shown that a part of hydrolysed shellac acids is water-soluble, which mostly consists of dicarboxylic acids of the shellolic acid type including one having lactonic and aldehydic groups. With a view to finding out whether any part of hydrolysed soft resin acids is soluble in water, and the nature of the soluble acid, if any, soft resin was hydrolysed and the hydrolysed product was treated in a similar manner to shellac (*I.L.R.I. Annual Reports*, 1952-53, p. 35 and 1953-54, p. 29). It has been found that a portion of the acids obtained by hydrolysis of soft resin is soluble in water and is partially made up of the aldehydo-lactonic acid. The amounts of different fractions obtained from 50 gm. of soft resin (prepared by the urea-polymerization method in acetone) and their properties are given in Table I(a).

TABLE I(a) — ACIDIC FRACTIONS OBTAINED FROM 50 gm. OF SOFT RESIN ON SAPONIFICATION

Acid fractions	Weight obtained gm.	Acid value	Sap. value	Aldehyde test	Permanganate test	Bromine test
1. Ether-soluble	2·87	257·5	338·3	+Ve	+Ve	—Ve
2. Chloroform-soluble	0·20	194·3	290·3	+Ve	+Ve	—Ve
3. Ethyl acetate-soluble	2·79	269·8	324·3	+Ve	+Ve	—Ve
4. Water-soluble as sodium salt	4·30	—	—	+Ve	+Ve	—Ve
5. Aleuritic acid (isomer, m.p. 96°-97°C.)	6·18	—	—	—Ve	+Ve	—
6. Insoluble liquid acid	33·10	—	—	—Ve	+Ve	—
Total	49·44					

Treatment of insoluble liquid acid, vide (6) *in Table I*(a) — Barium-, zinc- and hot water-insoluble zinc salts were prepared from the insoluble liquid acid adopting the usual procedure. The filtrate left was allowed to concentrate at room temperature when a further crop of zinc salt was obtained. The remaining filtrate was then treated to get alcohol-insoluble and -soluble lead salts.

The barium salt was the most coloured of all and was extracted with ether when a thick brown liquid smelling like heated shellac, presumably the odoriferous principle of shellac, was removed. The barium salt was then extracted with absolute methyl alcohol. The alcohol-soluble salt was treated with water and most of it was insoluble in water which, on decomposition, gave butolic acid. The water-soluble salt gave a very little amount of acid, m.p. 91°-92°C.

(vi) *Separation of the aldehydo-lactonic acid from* Kusmi *shellac* — Angelo's dewaxed and decolourized shellac gives positive test for aldehyde with Tollen's ammoniacal silver nitrate solution on long standing, but a fresh sample of *Kusmi* shellac (made in I.L.R.I. factory) gave the positive test very readily. An attempt has been made to separate the aldehydo-lactonic acid from freshly made samples of *Kusmi* shellac. It is known that aldehydes may undergo certain changes in presence of relatively strong alkali; so to avoid the possibility of a change in this case, shellac was hydrolysed with dilute alkali at room temperature for a comparatively short period (about 24 hr.).

100 gm. of *Kusmi* shellac were hydrolysed with 1 l. of 0·5*N* caustic soda solution at room temperature (the amount of alkali was just sufficient to saponify the amount of shellac taken) for about 24 hr. with occasional stirring. The solution was then treated with an equivalent amount of dilute hydrochloric acid and the clear supernatant liquor was successively extracted with ether, chloroform and ethyl acetate. The mother liquor was then treated with solid sodium carbonate, evaporated to dryness and kept for the separation of the aldehydo-lactonic acid. The results so far obtained are given in Table I(b).

TABLE I(b) — SEPARATION OF WATER-SOLUBLE ACIDIC FRACTIONS FROM HYDROLYSED *KUSMI* SHELLAC (100 gm.)

Acidic fractions	Weight obtained gm.	Acid value	Sap. value	Aldehyde test	Permanganate test	Bromine test
1. Ether-soluble	10·8	211·7	—	+Ve	+Ve	—Ve
2. Chloroform-soluble	1·6	223·8	339·8	+Ve	+Ve	—Ve
3. Ethyl acetate-soluble	8·0	261·0	385·0	+Ve	+Ve	—Ve

The three extracts contained a fair proportion of the aldehydic acid, as was evident from the immediate separation of metallic silver and formation of beautiful silver mirror on treatment with Tollen's reagent.

(vii) *Paper partition chromatography* — Nowadays paper chromatography is finding universal application as a powerful analytical method for the rapid separation, identification and estimation of organic acids and various other substances.

Since shellac is known to comprise several poly-hydroxy poly-basic fatty acid units, the choice of this new technique for their separation and identification follows as a natural corollary to its immense success in other fields. Investigations employing this method are described below.

(a) *Paper chromatographic separation of dicarboxylic acids* — It has been mentioned earlier that one of the products of hydrolysis of amides from butolic acid is adipic

acid. In order to identify this (adipic) acid by means of paper partition chromatography, preliminary work was started with some dicarboxylic acids, e.g. malonic, succinic, glutaric, adipic, suberic, azeleic and sebacic acids. The procedure adopted for the ascending technique in which the solvent was allowed to run up the paper by capillary action was briefly as follows:

One per cent solutions of the acids were made either in water or in aqueous alcohol or alcohol as the case may be and the spots were placed on a straight line, 2·5 cm. above the bottom edge of No. I Whatman filter paper, by means of capillary pipettes; the spots were spaced 2·5 cm. apart from each other and from the side edges of the paper. These spots were dried on standing at room temperature, or by means of infra-red lamp where necessary. The paper was then formed into a cylinder by stapling and kept standing on a tray in a closed chamber. Usually solvents were first saturated with water. The water-rich phase so formed was placed inside the development chamber for saturation of the chamber as well as of the paper. After allowing sufficient time for saturation, the solvent-rich phase was poured into the tray holding the paper and allowed to develop for specific periods. The paper was taken out and dried first at room temperature and then in the steam oven. The dried paper was sprayed with a 0·04 per cent alcoholic bromophenol blue indicator solution, made just blue with caustic soda solution, when as a result beautiful yellow spots developed against the blue background. The R_f value of each acid was then calculated. (The R_f value is the ratio of the distance the substance has travelled from its original starting point to the distance moved by the solvent front in the same time.) The R_f values obtained for the dicarboxylic acids in different solvents are given in Table II.

TABLE II — R_f VALUES OF DICARBOXYLIC ACIDS IN DIFFERENT SOLVENTS

Acid	*Solvent					
	A	B	C	D	E	F
Malonic	0·52-0·54	0·73	0·15	0·06	—	—
Succinic	0·60-0·62	0·84	0·24	0·12	—	—
Glutaric	0·71-0·72	0·91	0·29	0·15	—	—
Adipic	0·80	0·93	0·33	0·20	—	—
Dicarboxylic acid from hydrolysed butolic acid	0·80	—	—	—	—	—
Suberic	0·90-0·92	0·96	0·44	0·30	—	—
Azeleic	0·93-0·94	0·97	0·48	0·35	—	—
Sebacic	0·95-0·97	0·97	0·53	0·40	—	—

* Solvent A — *n*-Butyl alcohol: 90 per cent formic acid: water (6:5:5)
B — *n*-Butyl alcohol: acetic acid: water (5:1:4)
C — 90 per cent ethyl alcohol: liq. ammonia: water (90:4:6)
D — 95 per cent ethyl alcohol: liq. ammonia (100:4)
E — *n*-Butyl alcohol saturated with 2*N* ammonia solution
F — Iso-butyl alcohol saturated with 2*N* ammonia solution

The acid spots did not move at all in the solvents E and F. Good separation of the acids was obtained in the solvents A, B, C and D. Only in solvent B, azeleic and sebacic acids come to the same point. It will be further noticed that R_f values were higher when the solvent was enriched with water (cf. C and D).

(b) *Paper chromatographic separation of hydroxy acids* —In a similar manner the R_f values of butolic acid, dihydroxy stearic acids, aleuritic acid, aleuritic acid isomer

(m.p. 96°-97°C.) and shellolic acid in different solvents were determined by the ascending method and the results are given in Table III.

TABLE III — R_f VALUES OF HYDROXY ACIDS IN DIFFERENT SOLVENTS

Acid	*Solvent						
	A	B	C	D	E	F	G
Butolic, m.p. 54°-55°C.	1·0	1·0	0·86	0·81-0·82	0·91	0·68-0·70	—
Dihydroxy stearic, m.p. 90°C.	1·0	1·0	0·83	0·79-0·80	—	—	—
Dihydroxy stearic, m.p. 129°C.	1·0	1·0	0·83	0·79-0·80	—	—	—
Aleuritic, m.p. 100°-101°C.	0·93	0·92	0·81	0·71-0·72	0·88	0·49-0·51	0·34
Aleuritic isomer, m.p. 96°-97°C.	0·94	0·92	0·81	0·71-0·72	0·88	0·49-0·51	0·34
Shellolic, m.p. 206°C.	0·84	0·87	0·50	0·31-0·33	0·71	0·05-0·07	0·02

* Solvent A — *n*-Butyl alcohol: 90 per cent formic acid: water (4: 2·5: 3·5)
B — *n*-Butyl alcohol: acetic acid: water (5: 1 : 4)
C — 90 per cent ethyl alcohol: liq. ammonia: water (90: 4: 6)
D — 95 per cent ethyl alcohol: liq. ammonia (100: 4)
E — Methyl alcohol: liq. ammonia (100: 10)
F — *n*-Butyl alcohol saturated with 2*N* ammonia solution
G — *n*-Butyl alcohol: liq. ammonia (100: 10)

Butolic acid and dihydroxy stearic acids moved with the solvent front in solvents A and B; no spots could be identified for dihydroxy stearic acids in solvents E, F and G. It is interesting to note that the isomeric acids travel with the same speed giving the same R_f values. Good separation of the hydroxy acids of shellac was obtained in solvents C, D, E, F and G. Here also it will be seen that solvent enriched with water (solvent C) gave higher R_f values.

(c) *Separation by reversed phase method* — Attempts were made to separate and determine the R_f values of the dihydroxy acids using the reversed phase method as follows: The paper was first impregnated with a 25 per cent solution of white spirit in ether. Ether was removed and white spirit acted as the stationary phase. The substances were then immediately placed on the starting line of the impregnated paper which was at once developed by the ascending technique; the mobile phase being isopropyl alcohol: water: white spirit (6·5: 3·5: 1). The results show promise, but so far reproducible results could not be obtained.

(d) *Paper chromatographic separation of shellac and rosin* — Some preliminary work for the separation of shellac and rosin was undertaken, following the same procedures as described earlier. It was found that shellac and rosin did not travel in solvent 1 (*vide* Table IV), but travelled with different speeds in the other solvents tried. The results so far obtained are quite promising and are as follows:

TABLE IV — R_f VALUES OF SHELLAC AND ROSIN

	Solvent	Ascending method		Reversed phase method	
		Shellac	Rosin	Shellac	Rosin
1.	*n*-Butyl alc.: 90% formic acid: water (4: 2·5: 3·5)	No movement	No movement	—	—
2.	95% Ethyl alc.: liq. ammonia (50 : 4)	0·95	0·92	—	—
3.	Phenol saturated with water+ammonia vapour	Streak	0·81	—	—
4.	Isopropyl alc.: water: white spirit (6·5: 3·5: 1)	—	—	0·89	0·79

2. Physico-chemical Studies on Lac

(i) *Osmotic pressure and molecular weight* — It is known that molecular weight determination of partially polymerized samples of shellac by Rast's (cryoscopic) method does not give any insight into the molecular growth resulting from progressive thermal polymerization. The use of osmotic cells, however, appears to be better suited to the purpose, because of their successful use already in the determination of molecular weight of normal shellac (Basu, S., *J. Ind. Chem. Soc.*, **25**, 1948).

An osmotic cell, fabricated according to the design of Herzog [*Z. Physik. Chem.*, Bodensteim Festband, 239 (1931)] was accordingly tried. Preliminary work with available membranes, however, did not give satisfactory results. The investigation will be continued with suitable cellophane membranes as soon as available.

(ii) *Action of accelerators on shellac solutions* — It is well known that chemicals such as oxalic acid, urea, tartaric acid, etc., behave as accelerators in the polymerization of lac and that some of these are used along with shellac in the preparation of lac moulding powders. It is also known that shellac spirit varnishes when treated with these accelerators produce films with improved heat and water resistance as compared with plain shellac varnishes. However, shellac varnishes containing some of these accelerators such as urea possess very high viscosities which limit their applicability. If, therefore, an accelerator could be found which would not raise the viscosity of the varnish appreciably but enhance the desirable properties of the resulting film, such as heat and water resistance, it would obviously be a great advantage. The change in viscosity of shellac varnishes on treatment with accelerators, other than urea, does not appear to have received much attention and was considered worth investigating. The following experiments were tried:

Twenty per cent as well as 10 per cent varnishes of shellac in alcohol were prepared. Phthalic acid, urea, oxalic acid and tartaric acid were dissolved in both absolute and 95 per cent ethyl alcohol (by volume) in percentages varying from 1 to 5 on the dry weight of shellac. The concentration of shellac solution was determined by evaporating a known volume of solution. The viscosities of the solution were measured at 25°±1°C. at intervals of one week using an Ostwald U tube viscometer. Angelo's dewaxed shellac was used throughout the experiment. The results are given in Tables V and VI.

TABLE V — RELATIVE VISCOSITY OF 10 PER CENT SHELLAC VARNISH AT 25°±1°C.

Accelerator used	Percentage of accelerator	Relative viscosity		
		Freshly prepared varnish	After a week	After two weeks
(Control) Nil	Nil (10% varnish)	2·9130	2·9616	2·9858
Phthalic acid	1	2·9036	2·9198	2·9198
	3	2·9495	2·9495	2·9494
	5	2·9509	2·9752	2·9833
Urea	1	2·9565	3·0295	3·1992
	3	2·9688	3·2601	3·8559
	5	3·0178	3·5451	4·5754

TABLE VI — RELATIVE VISCOSITY OF 20 PER CENT SHELLAC VARNISH AT 25°±1°C.

Accelerator used	Percentage of accelerator	Relative viscosity					
		Freshly prepared varnish	After a week	After two weeks	After three weeks	After four weeks	After five weeks
(Control) Nil	Nil	7·7916	7·7070	7·7916	7·8503	7·9173	7·8754
Phthalic acid	1	7·8054	7·6922	7·7257	7·7425	7·7425	7·7173
	3	7·9445	7·7928	7·7507	7·8013	7·7844	7·7507
	5	8·002	7·9526	7·9314	7·9736	7·8808	7·9062
Urea	1	7·7638	10·3187	11·6896	11·8991	11·8698	11·7902
	3	8·0278	43·9934	gelled	—	—	—
	5	8·2373	gelled	—	—	—	—
Oxalic acid	1	8·2041	9·4866	9·2752	—	9·2076	—
	3	8·8925	9·5609	9·2986	—	9·2648	—
	5	9·1627	9·7546	9·3878	—	9·6172	—
Tartaric acid	1	8·9812	9·6299	9·3519	—	9·8405	—
	3	9·1066	10·0244	10·2650	—	9·9914	—
	5	9·5434	10·2226	10·5789	—	10·7571	—

It will be observed from the tables that as the amount of accelerators is increased from 1 to 5 per cent, the viscosities of the solutions also increase. The rise in the case of urea solution is very high. As observed by previous workers, 20 per cent shellac solution gells within 15 days even though the urea content is 3 per cent only. This solution gells within a week if it contains 5 per cent of urea. It is seen that when only 1 per cent of urea is present, the viscosities of the solutions rise to one and half times the original value after a week, attaining a maximum value in the fourth week, after which there is a gradual fall. The maximum value is not very different from the value for a one-week-old solution.

It is further noticed that with a 10 per cent varnish, the rise in viscosity of the solution is gradual if the amount of urea incorporated is only 1 per cent while the rise in the viscosity gets very much faster if the amount of accelerator is increased to 5 per cent.

In the case of phthalic acid, tartaric acid and oxalic acid, the viscosity increases with an increasing amount of the acid but the actual increase is quite small. It was noted further that the addition of oxalic or tartaric acid to the shellac solution always resulted in a little precipitate which settled to the bottom on keeping. The study of film properties of these varnishes as well as the study of the viscosities of more concentrated solutions is in progress.

(iii) *Specific heat measurements on shellac* — A thorough investigation of specific heat of shellac and its constituents could possibly reveal the degree of polymerization of shellac, percentage of various constituents present, and its melting point. Specific heat of lac and its constituents has been measured by Bhattacharya (*Indian J. phys.*, 1940, **14**, 415; also *I.L.R.I. Annual Report*, 1938-39), up to 50°C. This upper limit of temperature seems to be too small for any fruitful conclusions to be drawn, and hence investigations were carried out to extend this range above the melting point of lac. The apparatus used by previous workers was modified to ensure better uniformity of temperature, by embedding copper sheets in spiral forms. The measurements made on *kusum* shellac gave the following results: Specific heat increased uniformly from 0·34 to 0·38 within the range 15°-35°C.; beyond 35°C. the increase was very abrupt and a maximum value of 0·72 was registered near the temperature range of 70°-80°C.; the value decreased to 0·54 after 90°C., remaining constant at this value up to 110°C. These values for specific heat of shellac have been used to compute its latent heat of fusion which was found to be 14 cal./gm. The plotting of specific heat against temperature gave the melting point of shellac to be nearly 75°C.

(iv) *Polymolecularity of polyesters of* 9: 10-*dihydroxy hexadecane* 1: 16-*dicarboxylic acid* — The study was undertaken in order to investigate the molecular weight distributions of different species of polyester molecules of different degrees of polymerization in a particular polyester.

Polyesters were prepared by thermal heating of the diacid, 9: 10-dihydroxy hexadecane 1: 16-dicarboxylic acid in the usual way. Three polyesters of low, medium and high degree of polymerization (D.P.) were obtained by heating the diacid for different periods and their D.P.s were determined by the usual end-group titration. The fractionation of low D.P. polyester was studied first. The polyester was weighed and dissolved in acetone and titrated with water as precipitant. The precipitate was separated, dried and weighed accurately and finally the D.P. determined. Successive fractionations were

TABLE VII

G=percentage remaining in solution	Degree of polymerization	Degree of polymerization	dG/dD.P.	D.P.	dG/dD.P.
93·49	1·93	1·5	75·0	1·6	75·0
89·33	1·85	1·4	75·0	1·65	83·27
83·16	1·725	1·35	75·0	1·70	225·0
70·27	1·64	1·30	70·0	1·725	100·0
60·67	1·49	1·25	100·0	1·75	66·66
50·96	1·37	1·225	125·0	1·8	50·0
44·61	1·30	1·2	332·34	1·85	50·0
40·90	1·235	1·19	400·0	1·90	50·0
36·77	1·205	1·175	266·66	—	—
27·79	1·18	1·15	250·00	—	—
21·30	1·175	1·125	171·42	—	—
13·95	1·135	1·10	150·00	—	—
10·04	1·125	1·075	100·00	—	—
6·61	1·10	—	—	—	—
0·00	1·05	—	—	—	—

continued till qualitatively no fraction remained in the solution to be precipitated. A curve was drawn indicating the integral weight distribution of the various fractions thus obtained by plotting the percentage of polyester remaining in solution after a fraction had been separated (G), (G being the polyester per cent remaining in solution after a particular fractionation) against its D.P. From this curve, the differential weight distribution curve was drawn again by plotting $\frac{dG}{dD.P.}$ against D.P. Data are given in Table VII (p. 55).

Experiments are in progress to investigate similar behaviour of fractions obtained from the polyester of medium and high degree of polymerization.

3. STANDARDIZATION, GRADING AND ANALYSIS

(i) *Determination of cold alcohol-insoluble non-volatile matter in seedlac, shellac and bleached lac* — A comparative study of the two principal methods proposed for this determination, viz. the method adopted by the U.S. Association and that recommended by the British Standards Institution (B.S.I.) was carried out during the past year and the results were reported in the *Annual Report* for the year 1953-54. This investigation showed that the American method is comparatively easy and gives more reliable results. This method involves the filtration of the cold alcoholic solution of the lac through a tared filter paper, previously freed from alcohol-soluble matter by washing with alcohol and then dried to constant weight. It would be an advantage to eliminate this which naturally involves manipulation and, therefore, time. A simple means towards this end is the use of two filter papers instead of one, a technique that has been successfully employed in the packet method for the determination of hot alcohol-insoluble matter in lac proposed by the B.S.I. In such a case no previous washing of the filter papers with alcohol is necessary. The method as developed in the present case is as follows:

Two filter papers of the same grade and size are taken, dried in an oven at 105° ± 2°C. and then transferred to two separate weighing bottles with lids. After cooling, one weighing bottle with filter paper is placed in one of the pans of the balance and the other weighing bottle in the other. The two pans are then balanced by the addition of weights to the lighter side. This weight is noted. The two filter papers are then placed one over the other concentrically and then folded in the usual manner to form one filter. After filtering the lac solution and washing free from resin, the two filter papers are separated, placed in their original weighing bottle containers and then dried to constant weight and the difference in weight between the two is determined as before. The difference between these two weighings gives the weight of the undissolved residue on the filter, the weight of the matter soluble in alcohol, if any, in one filter paper compensating for that in the other. The results of a few typical experiments are given in Table VIII. (The results of this determination in the case of a few samples were recorded in the *Annual Report* for 1953-54 also.)

TABLE VIII — NON-VOLATILE MATTER INSOLUBLE IN COLD ALCOHOL IN SEEDLAC

Expt.	Seedlac	Determination using single filter paper previously washed with alcohol	Carried out using two filter papers
1.	A	(i) 4·8065%	4·9106%
		(ii) 4·9036%	4·9358%
2.	B	(i) 9·0651%	9·0900%
		(ii) 9·0732%	9·5900%
3.	C	(i) 8·7360%	8·7560%
		(ii) 8·5900%	8·7613%
4.	D	(i) 10·9601%	10·9600%
		(ii) 10·9541%	10·7280%

The filtration and washing through the two-paper filter generally took about half an hour more than when a single-paper filter was used, but the previous washing of the filter paper and drying to constant weight had been avoided. Table VIII clearly indicates that the two-paper filter can be successfully employed in place of the single-paper filter which requires to be previously washed free from alcohol-soluble matter.

(ii) *Estimation of lead in shellac* — Experiments were undertaken to examine the two methods for the estimation of lead in shellac, namely, the one given in the Appendix Q of the Third Draft Proposal for shellac, and the other proposed by the U.K. The latter method only involves certain modifications of the former and these modifications were considered by the Lac and Lac Products Sectional Committee (CDC 9) in its last meeting held at Calcutta on 9 June 1954. It was suggested by the CDC 9 that the Indian Lac Research Institute might check up the procedure recommended by the U.K. Details of the experiments are given below:

Pure samples of shellac were melted with lead chromate (chrome yellow) in the proportions 0·04, 0·08 and 0·1 per cent, and Pb was estimated by both methods. Results are given in Table IX.

TABLE IX — ESTIMATION OF LEAD IN SHELLAC

Sample	Method 1 (according to App. Q)	Method 2 (proposed by the U.K.)
1.	0·04%	0·04%
2.	0·08%	0·1%
3.	0·11%	0·1%

Also some pure samples of shellac were melted with PbO and $Pb(NO_3)_2$ to form several compositions containing lead of the order of 0·1, 0·06 and 0·03 per cent and the British method was tried.

The results are tabulated below (Table X).

TABLE X — ESTIMATION OF LEAD IN SHELLAC

Sample with %Pb	% Pb found by method proposed by U.K.	Average %Pb
0·1213%	A { 0·1161, 0·1282 }	0·1221
0·128%	B { 0·1389, 0·1334 }	0·1361
0·037%	A { 0·0370, 0·0382 }	0·0376
0·037%	B { 0·0400, 0·0350 }	0·0375
0·0647%	A { 0·0650, 0·0650 }	0·0650
0·065%	B { 0·0648, 0·0648 }	0·0648

The set of results A was obtained with samples prepared by using PbO, and the set of results B with samples prepared by using $Pb(NO_3)_2$. Experiments are in progress to examine the Pb content of these samples by the App. Q method also.

(iii) (a) *Determination of the bleach index and bleachability characteristics of lac* — A new simple method for the determination of the bleach index and bleachability characteristics of lac without the use of " Standard seedlacs " has already been reported from this Institute (*I.L.R.I. Annual Reports*, 1952-53, 1953-54; *J. sci. & industr. Res.*, **13B**, 1954). This method involves *inter alia* that the bleaching should proceed overnight before the colour of the filtered bleached solutions in terms of $N/1000$ iodine is determined. This would mean that the results of the determination will be available only about 20 hr. after the commencement of the experiment. Shortening this period will obviously be of advantage and particularly so, if the determination could be completed on the same day. With this end in view, the following investigation was undertaken.

It is well known that the rate of bleaching is considerably influenced by temperature, being greatly accelerated if the temperature is increased. One obvious method to reduce the time required for the determination would, therefore, be to carry out the bleaching operation at higher temperature. The details of the experiments are as follows: A sample of seedlac ($37{\cdot}5 \pm 0{\cdot}1$ gm.) was extracted with sodium carbonate solution under the usual condition and the extract made up to 280 cc. It was then treated with 95 cc. of bleach liquor and placed in a thermostat maintained at a definite temperature. The colour ratio of the bleaching solution, after filtering off the wax from an aliquot portion as quickly as possible, was determined every half an hour and the corresponding bleach index read from the curve. After a few hours, the remaining solution was maintained in the thermostat at the same temperature overnight. The next morning 4 cc. more of bleach liquor was added and the colour ratio determined as usual after a lapse of half an hour. The results obtained are reproduced in Table XI.

TABLE XI

Palas seedlac									*Ber* seedlac
Expt.	Time of bleaching	Colour ratio at			Corresponding bleach index at			Colour ratio	Bleach index
		35°C.	37·5°C.	40°C.	35°C.	37·5°C.	40°C.		
1.	1 hr.	2·11	1·75	3·24	96	102	81	1·72	102
2.	1½ hr.	—	1·71	3·51	—	103	78	1·55	106
3.	2 hr.	2·41	1·83	2·25	91	100	93	1·64	104
4.	2½ hr.	2·83	1·38	1·95	85	108	99	—	—
5.	3 hr.	—	1·21	1·62	—	113	104	1·19*	113*
6.	3½ hr.	2·11	1·05	1·34	96	117	109	0·974†	120
7.	4 hr.	—	1·00	—	—	118	—	—	—
8.	5½ hr.	1·47	—	—	108	—	—	—	—
9.	7 hr.	1·10	—	—	116	—	—	—	—
10.	24 hr.	2·83	1·71	2·44	85	102	90	2·20	98

*Time of bleaching in this case was 2 hr. 50 min. and not 3 hr.
†Time of bleaching in this case was 3 hr. 20 min. and not 3½ hr.

From the above table, it is clear that the colour of the bleaching solution becomes lightest in the course of 2-2½ hr. and that thereafter it slowly progressively darkens. Therefore, a number of further samples were tested up to two and a half hours at half hourly intervals. In these experiments, the lac extract was kept in the thermostat for 10 min., by which time it had attained the temperature of the bath, before addition of the bleach liquor. The results obtained are shown in Table XII (p. 59).

It will be observed from the table that between the temperature limits of 35°-40°C., the values obtained do not vary much. It was, therefore, decided to carry out all future determinations only at one temperature, viz. $37{\cdot}5° \pm 1$°C. The bleach indices of

TABLE XII

Expt. No.	Sample reference	Overnight keeping and adding 4 cc. bleach liquor			Temperature °C.	After ½ hr.		After 1 hr.		After 1½ hr.		After 2 hr.		After 2½ hr.	
		Colour ratio	Average	Bleach index from curve		Colour ratio	Bleach index from curve	Colour ratio	Bleach index from curve	Colour ratio	Bleach index from curve	Colour ratio	Bleach index from curve	Colour ratio	Bleach index from curve
1	A	5·90	6·20	58	35·0	4·60	69	4·80	67	5·00	66	5·40	63	5·0	66
					37·5	4·60	69	5·20	65	5·40	63	6·00	60	5·4	63
		6·40			40·0	4·80	67	6·60	60	6·20	58	6·00	60	5·5	63
2	B	4·70	4·90	67	35·0	4·00	74	4·50	70	4·80	67	5·00	66	4·4	70
					37·5	4·30	71	4·60	69	4·70	68	5·30	64	4·7	68
		5·00			40·0	4·30	71	4·60	69	4·70	68	4·20	72	3·8	76
3	C	3·30	3·25	82	35·0	2·50	90	2·80	86	2·90	84	2·90	84	—	—
					37·5	2·50	90	3·20	82	2·80	86	2·60	88	—	—
		3·20			40·0	2·60	88	3·20	82	2·80	86	2·50	90	—	—
4	D	2·10	2·20	94	35·0	1·80	101	2·10	96	2·20	94	2·10	96	—	—
					37·5	1·80	101	2·20	94	2·10	96	1·80	101	—	—
		2·30			40·0	1·90	99	2·20	94	2·20	94	2·00	98	—	—
5	E	1·45	1·55	105	35·0	1·50	107	1·60	105	1·40	108	1·30	111	—	—
					37·5	1·40	108	1·50	107	1·40	108	1·30	111	—	—
		1·65			40·0	1·60	105	1·70	109	1·60	105	1·40	108	—	—
6	F	1·00	1·00	119	35·0	0·80	124	0·90	121	0·80	124	0·70	128	—	—
					37·5	0·90	121	1·00	119	0·80	124	0·60	130	—	—
		1·00			40·0	0·90	121	0·80	124	0·60	130	—	—	—	—
7	G	0·36	0·38	142	35·0	0·36	144	0·33	146	0·31	148	0·28	150	—	—
					37·5	0·38	142	0·32	146	0·30	148	0·25	152	—	—
		0·39			40·0	0·32	145	0·34	146	0·30	148	0·25	152	—	—

TABLE XIII

Temperature 37·5° ± 1°C.

Expt. No.	Sample reference	Overnight keeping and adding 4 cc. bleach liquor			After 1 hr.			After 1½ hr.			After 2 hr.		
		Colour ratio	Average	Bleach index from curve	Colour ratio	Average	Bleach index from curve	Colour ratio	Average	Bleach index from curve	Colour ratio	Average	Bleach index from curve
1	H	4·40 4·60	4·50	69	4·10 3·90	4·00	74	4·20 4·20	4·20	72	4·30 4·20	4·25	71
2	I	3·70 3·70	3·70	76	3·45 3·50	3·48	78	3·90 3·85	3·88	75	3·75 3·65	3·70	76
3	J	3·40 3·60	3·50	78	3·40 3·65	3·53	77	3·20 3·55	3·38	80	3·10 3·25	3·18	82
4	K	3·40 3·40	3·40	79	2·82 3·20	3·01	84	3·50 3·65	3·58	77	3·30 3·40	3·35	80
5	L	2·30 2·50	2·40	91	2·35 2·40	2·38	92	2·15 2·15	2·15	95	2·10 2·10	2·10	96
6	M	1·65 1·55	1·60	105	1·40 1·60	1·05	107	1·25 1·35	1·30	111	1·20 1·20	1·20	114
7	N	1·51 1·43	1·47	107	1·52 1·43	1·48	107	1·35 1·30	1·33	111	1·20 1·20	1·20	114
8	O	0·60 0·60	0·60	132	0·54 0·45	0·50	136	0·48 0·42	0·45	138	0·42 0·40	0·41	140
9	P	0·43 0·42	0·43	138	0·39 0·40	0·40	141	0·37 0·39	0·38	142	0·35 0·37	0·36	143

a number of further seedlac samples were then determined maintaining the thermostat at this temperature. The results obtained are given in Table XIII (p. 60).

From the tables it will be seen that in most of the cases the values obtained by allowing bleaching to proceed for one hour come closest to the actual bleach index of the sample as will also be evident from Table XIV.

TABLE XIV — DIFFERENCE BETWEEN THE ACTUAL BLEACH INDEX AND THE BLEACH INDEX AS DETERMINED BY ALLOWING THE BLEACHING TO PROCEED FOR DIFFERENT PERIODS

Sample	Actual bleach index	Difference in values obtained by allowing the bleaching to proceed for		
		1 hr.	1½ hr.	2 hr.
A	58	7	5	2
B	67	2	1	−3
C	82	0	4	6
D	94	0	2	7
E	105	2	3	6
F	119	0	5	11
G	142	4	6	10
H	69	5	3	2
I	76	2	−1	0
J	78	−1	2	4
K	79	5	−2	1
L	91	1	4	5
M	105	2	6	9
N	107	0	4	7
O	132	4	6	8
P	138	3	4	5

The above table shows that out of the 16 samples examined, the values for 11 samples differ by ± 3 cc. and those for 5 samples by ± 5 cc. from the actual value, while only in one case the difference exceeds 5 cc. As 5 cc. is the more or less accepted variation in the values of bleach index determinations, one hour at 37·5° ± 1°C. appears to be adoptable conditions. The work is being continued.

(b) *Alternative source of bleach liquor* — For the determination of the bleach index/bleachability of lac, the preparation of bleach liquor has been recommended in two ways, viz. (i) from caustic soda solution by direct chlorination, and (ii) from H.T.H. bleaching powder by treatment with aqueous sodium carbonate. All our experiments so far had been carried out using bleach liquor prepared by the former method as no H.T.H. bleaching powder was available. A sample of H.T.H. bleaching powder, however, has been received recently, and experiments have been carried out using this; the results obtained using H.T.H. bleaching powder are given in Table XV (p. 62) side by side with those obtained by using bleach liquor prepared as before, for comparison.

It is evident that practically the same values are obtained by using bleach liquors made either way.

TABLE XV

Sample	Using bleach liquor obtained by chlorination of NaOH solution			Using bleach liquor prepared from H.T.H. bleaching powder		
	Colour ratios		Bleach index	Colour ratios		Bleach index
1.	(a) 4·0 (b) 4·30	4·15	72	(a) 4·60 (b) 4·40	4·50	70
2.	(a) 2·04 (b) 2·33	2·18	94	(a) 2·20 (b) 2·32	2·26	93
3.	(a) 1·17 (b) 1·15	1·16	114	(a) 1·36 (b) 1·30	1·33	110

II. APPLIED

1. Varnishes, Lacquers and Paints (*see also* 2 below)

(i) *Ageing properties of shellac-linseed oil paints* — It is now over seven years since the wood and iron works of the Institute laboratories and staff quarters were painted with shellac-linseed oil paints. The painted surfaces indoors do not yet show any blemishes or other signs of deterioration.

(ii) *Shellac-based anti-corrosive and anti-fouling paints*—A preliminary report has been received from Bombay about the performance, on actual sea water immersion tests, of our shellac-based anti-corrosive and anti-fouling paints. Modified samples have again been submitted.

2. Modification of Lac and its Derivatives

(i) *Shellac-rosin combinations* — The preparation of an oil-soluble shellac-rosin-glycerine combination has been described already (*I.L.R.I. Annual Report*, 1953-54). One of the applications envisaged for oil varnishes prepared from this modified shellac was as a clear baking insulating varnish for the impregnation of electrical coils, etc., and also for the preparation of yellow-varnished insulating cloth popularly known as "Empire Cloth". Such a varnish with the requisite volatile content, drying time and ageing properties was formulated and sent to the Government Test House, Alipore, Calcutta, for testing and report. Their report on the first sample indicated that the varnish was satisfactory and conformed to the British Standard Specification (No. 119-1930) and the corresponding Indian Standards in all respects except two, viz. (a) the pH of the film was a bit too high, and (b) the films produced on the testing paper were not perfectly smooth.

The compositions were, therefore, modified and samples again sent for test. The report received indicates that the two defects mentioned earlier have been overcome. The relevant portion of the Government Test House report on the latest sample is reproduced below:

"Appearance	Practically clear, dark-coloured fluid
Miscibility with white spirit.	Satisfactory.
Time of drying on tissue paper as determined in accordance with the specified method	Less than 8 hr.
Nature of the dried film obtained as above	Brownish, glossy, practically transparent and fairly smooth.
Electric strength at 90°C., as determined in accordance with the specified method, expressed as average break-down voltage with an average film thickness of 6·3 mils	1,175 volts
Ageing, as determined in accordance with the specified method	Satisfactory: the film did not show any sign of cracking or decomposition

Effect of oil as determined in accordance with the specified method	Satisfactory: the varnish film was found to resist the action of oil
Acidity or alkalinity of varnish film as determined in accordance with the specified method, expressed as pH value	4·3
Volatile matter (100°-110°C.)	39·8%
Specific gravity at 25°C.	0·921
Absolute viscosity at 25°C.	1·97 poises
Closed flash point (Abel)	111°F.

"*Remarks* — The sample could not be tested for its resistance to moisture for lack of facilities at the moment.

"In other respects, however, it satisfies the requirements of British Standard Specification No. 119-1930 for clear baking oil insulating varnish for electrical purposes."

Steps are now being taken to interest the varnish-makers in this varnish.

(ii) *Film properties of oil varnishes made from shellac-rosin-glycerine modified resin, ester-gum and synthetic resins* — Oil varnishes were made with these resins using 1 part resin to 2 parts of medium-bodied linseed stand oil, by heating up to the required temperature and thinning to about 40 per cent volatiles so as to obtain varnishes of brushable consistency. Ester-gum varnish and varnish from Bedesol (99) were prepared by incorporating the resin in oil at a temperature of 200°C. Shellac-rosin-glycerine composition was incorporated at a temperature of 260°C., and the melt then raised to 270°C. and maintained for 15-20 min. All the compositions including the ester-gum and Bedesol varnishes were thinned after cooling down to 150°C., and driers added in the form of terebines in proportions corresponding to 0·6 per cent Pb; 0·06 per cent Mn and 0·06 per cent Co on oil content.

The films, made by brushing and flowing on glass and tin panels, were dried in air for 15 days. These were then tested for hardness, flexibility and water resistance. The set-dry time was determined both by finger touching and in the siccatometer.

It was noticed that the set-dry time obtained from the siccatometer was always higher than that obtained by the finger-touch method. The results obtained are given in Table XVI.

TABLE XVI — FILM PROPERTIES OF OIL VARNISHES BASED ON (MODIFIED) SHELLAC-ROSIN-GLYCERINE, ESTER-GUM AND BEDESOL

No.	Varnish	Set-dry time in hr.		Hand-dry time (in hr.)	Scratch hardness load on 1 mm. steel ball (in gm.)	Rocker hardness (glass 100)	Flexibility and adhesion	Water-immersion test at 25°C.	
		Finger touch	Siccatometer					Whitening	Lift
1	Modified shellac composition varnish (oil length 15 gallons)	5	6	<24	300	28	All of them stand the minimum diameter mandrel	5 hr.	>24 hr.
2	Modified shellac composition varnish (oil length 20 gallons)	4½	6½	<24	300	16		4 hr.	>24 hr.
3	Ester-gum varnish (oil length 20 gallons)	8	10	>24	600	26		3 hr.	>24 hr.
4	Bedesol (99) varnish (oil length 20 gallons)	4½	4	<24	350	24		>24 hr.	>24 hr.

From the results in Table XVI it is clear that in regard to drying properties and water resistance, shellac-rosin-glycerine composition is better than ester-gum, but inferior to the Bedesol varnish.

These varnishes were made into enamels and the film properties of these air-dried enamels examined. The pigmentation in the enamel was observed to increase the hardness and to some extent improve the water resistance also.

The results are shown in Table XVII.

TABLE XVII

No.	Enamel	Scratch hardness load in gm. on		Rocker hardness	Flexibility and adhesion	Water-immersion test at 25°C.	
		Gramophone needle	1 mm. steel ball			Whitening	Lift
1	Modified shellac comp. enamel based on 15 oil length varnish	100-150	320-450	28-40	Good even at minimum dia. mandrel.	>6 hr.	>6 hr.
2	Modified shellac comp. enamel based on 20 oil length varnish	150	400	12		>6 hr.	>6 hr.
3	Bedesol enamel based on 20 oil length varnish	—	—	—		—	—
4	Ester-gum enamel based on 20 oil length varnish	200	600	18		>6 hr.	>6 hr.

No Bedesol enamel could be prepared, as the Bedesol varnish, when ground with the pigments, jelled.

The study is being continued particularly in regard to weathering properties.

(iii) (a) *Addition of water-insoluble silicones to shellac spirit varnishes* — Attempts have already been made (*I.L.R.I. Annual Report*, 1952-53) to improve the water resistance of shellac spirit varnishes by the addition of limited amounts of a water repellent silicone fluid (D.C. 200). It was found that while the addition of silicone did not enhance the water resistance, the desirable properties of the shellac film such as smoothness and homogeneity were adversely affected by such addition.

Another Dow Corning silicone (X.R. 540) of "improved" compatibility was recived during the year under report through the kind courtesy of the Metropolitan Architects and Engineers Ltd., Calcutta.

This also was examined as before. Thus, dewaxed lac was dissolved in 3 times its weight of a solvent mixture containing 70 parts ethyl alcohol and 30 parts toluene. One set of films was made with this varnish, used as control. Appropriate quantities of the silicone were then added to different portions of this varnish to produce varnishes containing 0·5, 1 and 2 per cent of the silicone respectively on the weight of lac. Clear solutions were obtained. Films on glass and tin panels were made with these compositions as well as with a dewaxed lac-alcohol varnish for purposes of comparison.

These films were tested after air drying for 15 days: results obtained are given in Table XVIII.

TABLE XVIII

No.	Varnish	Scratch hardness load in gm. on		Rocker hardness (glass 100)	Flexibility and adhesion mm.	Water immersion test time in hours at					
						17·5°C.		25°C.		30°C.	
		Gramophone needle	1 mm. steel ball			Whitening	Lift	Whitening	Lift	Whitening	Lift
1	Dewaxed lac varnish in alcohol	150	1,300 to 1,500	88	10·5	—	—	>24	5-24	5-8	1
2	Dewaxed lac varnish in alc.-toluene mixt (7:3)	150-200	1,500	56	—	—	—	>24	>24	5-8	>20
3	Varnish No. 2 containing 5% silicone on the basis of lac	30	100	56	18	>24	>24	—	—	—	—
4	Varnish No. 2 containing 1% silicone	30	60	48	21	>24	4	—	—	—	—
5	Varnish No. 2 containing 2% silicone	40	120	44	22	4	>24	5-20	>24	8	>20

It is clear from the table that the addition of this silicone also does not in any way improve the blush resistance of shellac spirit varnishes.

(b) *Addition of water-soluble silicones to shellac (aqueous) varnishes* — Shellac dissolves in aqueous medium in the presence of mild alkalies such as borax, sodium carbonate, ammonia or triethanolamine to form aqueous varnishes which are widely used for floor polishing, stiffening of hats and for a variety of other purposes. Air-dried films of aqueous varnishes are not very water-resistant, being easily washed away by warm water on immersion for a few hours.

Sodium methyl siliconate is a water-soluble silicone and like most other silicones is also water repellent (KATHER, W. S. and TORKELSON, A., *Ind. & Eng. Chem.*, Vol. 46, No. 2, Feb. 1954, pp. 381-384). This water-soluble silicone is already being used widely in cement and wall plaster compositions, and also in brick manufacture. Therefore, it was considered desirable to study its use with aqueous shellac varnishes to see whether it will improve the water resistance of the resulting films.

Twenty-five per cent aqueous shellac varnishes were prepared using borax (20 per cent), ammonia (10 per cent), sodium carbonate (10 per cent) and triethanolamine (60 per cent on the weight of shellac) respectively. These varnishes were filtered separately to remove the wax. Each of the wax-free varnishes was divided into 4 parts and sufficient silicone added to each to produce varnishes containing 0·5, 1·0 and 2·0 per cent silicone respectively, on the weight of lac. Films were made from these, as well as from the silicone-free varnishes by flowing on glass and tin panels and allowing to drain in an almost vertical position to air-dry. One set of air-dried panels was also baked at 100°-110°C. for 4 hr. Films were tested after two months' ageing. Shellac spirit varnish films obtained under identical conditions were also tested side by side. Table XIX (p. 66) indicates the results obtained.

It will be noted that almost all the films with or without the water-soluble silicone were washed away by water within a period of an hour, except those obtained with ammonia varnish. Therefore, the presence of sodium methyl siliconate does not result in any improvement in the water resistance of aqueous shellac varnish films.

TABLE XIX

No.	Varnish	Water-immersion test at 30°C.		Remarks
		Air-dried films	Oven baking at 100°-110°C. for 4 hr.	
1	Aq. varnish of shellac using Na_2C0_3	Washed away within 15 min.	Washed away within 15 min.	—
2	Varnish No. 1 with 0·5% silicone	do	do	—
3	Varnish No. 1 with 1% silicone	do	do	—
4	Varnish No. 1 with 2% silicone	do	do	—
5	Aq. varnish of shellac using ammonia	Film not washed away nor blushed but considerably weakened within 24 hr.	Film not washed away nor blushed up to 24 hr. but considerably weakened within 20 hr.	—
6	Varnish No. 5 with 0·5% silicone	do	do	—
7	Varnish No. 5 with 1% silicone	do	do	—
8	Varnish No. 5 with 2% silicone	do	do	—
9	Aq. varnish of shellac in borax	Washed away within 15 min.	Washed away within 15 min.	Water solution of silicone gets mixed with borax solution of shellac very easily
10	Varnish No. 9 with 0·5% silicone	do	do	—
11	Varnish No. 9 with 1% silicone	do	do	—
12	Varnish No. 9 with 2% silicone	do	do	—
13	Aq. varnish of shellac in triethanolamine	Washed away within 2 hr.	Film considerably weakened; lifted within 2 hr. and washed away within 4 hr.	Some of these films with silicone are tacky even after baking
14	Varnish No. 13 with 0·5% silicone	Washed away within 2 hr.	do	—
15	Varnish No. 13 with 1% silicone	do	do	—
16	Varnish No. 13 with 2% silicone	do	do	—
17	25% varnish of the silicone in water as control	Not blushed nor washed away but considerably weakened within 24 hr.	Not washed away nor blushed but weakened within 24 hr.	While applying, the varnish film does not stick to glass
18	25% varnish of shellac in alcohol as control	Not washed away but blushed	Not washed away but blushed	—

3. Moulding Compositions

Lac dimethylol urea (D.U.) moulding compositions — As reported already (*I.L.R.I. Annual Report*, 1953-54), compositions made with old samples of D.U. stuck to the moulds and this could not be avoided by any physical manipulation in moulding operations. Series of experiments were tried to find out the reason and, if possible, the remedy for this. It was considered possible that the D.U. being old might have lost a portion of its formaldehyde, and hence first, experiments were made on the following lines: (1) Use of higher percentage of D.U., (2) use of less amount of D.U. with a little paraform, (3) longer hours of B.P. mixing, (4) running the composition for longer hours on the hot rollers, and (5) manipulation in the order of adding the different ingredients on the hot rollers. In all cases, unless otherwise stated, the ingredients were used in the following proportions:

Shellac	100 parts	A
D.U.	15 parts	
CaO	1 part	
Maleic acid	2 parts	B
Wood flour	100 parts	
Pigment	3·5 parts	
Al.-stearate	3 parts	

The detailed procedure and results of moulding are given in Table XX (pp. 68-70).

It will be evident from Table XX that incorporation of paraform or any change in the percentage of D.U. does not reduce the moulding troubles. On the contrary blisters (which could not be cured by longer baking of the moulding powders) were found due to breaking up of paraform under high temperature and pressure. Any manipulation in the order of adding the different ingredients also did not improve the moulding. It was also noticed that hot rolling with maleic acid and fillers helped in the partial breaking up of paraform, as was evident from the smell, probably due to the increase of pressure between the rollers after the addition of bulky fillers.

The only way of partially overcoming moulding troubles appeared to be longer heat treatment in the course of hot mixing of the different ingredients in B.P. mixer before hot rolling (*vide* Table XX, composition Nos. 34, 37, 41 and 42).

Aniline hydrochloride 2 per cent on the weight of lac was also tried as hardener in place of CaO and maleic acid: the resulting composition obtained by hot rolling the different ingredient was, however, too soft for moulding even after baking for 4 hr.; one per cent CaO and 2 per cent aniline hydrochloride worked better as hardeners. Satisfactory moulding could be done with this composition after baking for only 2½ hr., but the impact strength of the composition was very poor (1·70 cm.kg./cm.^{2}). Incidentally to round up the work on the action of various hardeners on lac, life under heat of shellac mixed with 1, 2 and 5 per cent of these hardeners (maleic acid and aniline hydrochloride) was examined with the following results:

Maleic acid		*Aniline hydrochloride*	
1 %	14 min.	1 %	10 min.
2 %	10 min.	2 %	9 min.
5 %	7 min.	5 %	5 min.

4. Miscellaneous Uses of Lac

(i) *Cement for electric-bulb caps* — Attempts were made to modify the composition of cement, reported earlier, by using very cheap types of fillers, such as brick dust, fine sand, etc., in place of chalk, mica, etc. Though the pastes made by mixing these ingredients

TABLE XX

Composition No.	Any change in standard composition	Whether B.P. mixed or hot rolled	Order in which the ingredients were mixed and other details	Total time of hot mixing and other remarks	Baking time	Moulding results
31	D.U. 7½ parts, paraform 0·25 parts	Hot rolled only	Ingredients (A) with paraform hot rolled for 10 min. after which CaO and (B) were added; composition left rollers within 1 min. Maleic acid was added and further hot rolled for 15 min. when it came out in a sheet form	26 min. Very slight smell of formalin in the beginning; strong smell in the last 15 min.	5 hr.	Slight blisters were found on moulding at 140°C. even after drying for 5 hr. This could not be improved even by baking up to 8 hr. gloss and flow good; does not stick to moulds Impact strength 4·0 cm.kg./cm.² Water resistance — poor
32	do	do	Ingredients (A) with paraform hot rolled for 10 min. Maleic acid added and hot rolled for 5 min.; all other ingredients added, and hot rolled for 20 min.	35 min. Smell of formalin as in 31	5 hr.	do Impact strength 4·0 cm.kg./cm.² Water resistance — poor
33	do	do	Ingredients (A) with paraform hot rolled for 10 min.; CaO added, hot rolled for 5 min. Maleic acid added and hot rolled for 5 min.; finally (B) added and hot rolled for 30 min.	50 min. Smell of formalin as in 31	5 hr.	do Impact strength 4·2 cm.kg./cm.² Water resistance — poor
34	do	B.P. mixed and hot rolled	All ingredients except CaO and maleic acid hot mixed in B.P. mixer for 10 min.— CaO added and further hot mixed for 1 hr. — shifted to hot rollers and rolled for 5 min. Maleic acid added and further hot rolled for 15 min.	1 hr. 25 min. More smell of formalin than any of the above compositions	3 hr.	Blister-free moulding— good gloss and flow Impact strength 3·5 cm.kg./cm.² Water resistance — poor

TABLE XX (*Contd.*)

Composition No.	Any change in standard composition	Whether B.P. mixed or hot rolled	Order in which the ingredients were mixed and other details	Total time of hot mixing and other remarks	Baking time	Moulding results
35	D.U. 7½ parts, no paraform	B.P. mixed and hot rolled	do — Hot rolled for 23 min. after adding maleic acid	1 hr. 33 min. Smell of formalin less than (34)	3 hr.	do — Does not show white marks after immersion in water for 24 hr. Impact strength 4·0 cm.kg./cm.^{2} Water resistance — good
36	Standard composition	Hot rolled only	Ingredients (A) hot rolled for 10 min. CaO added, hot rolled for 5 min. Maleic acid added. Hot rolled for 5 min. Ingredients (B) added and hot rolled for 27 min.	47 min. No smell of formalin — slight smell after adding (B)	3 hr.	Soft composition which sticks to the mould. Difficult to work in complex moulds Impact strength 4·2 cm.kg./cm.^{2} Water resistance — fair
37	do	B.P. mixed and then hot rolled	All ingredients except CaO and maleic acid were mixed in the B.P. mixer for 10 min. CaO added and further mixed for 1 hr. Removed to the hot rollers. Maleic acid added and further hot rolled for 18 min.	1 hr. 28 min. Smell of formalin coming	2½ hr.	do — But slightly better could be removed from complex moulds with little trouble. Impact strength 4·2 cm.kg./cm.^{2} Water resistance — good, does not blister or fade after immersion in water for 24 hr.
38	do — But without maleic acid	Hot rolled only	Ingredients (A) hot rolled for 10 min. CaO added, hot rolled for 5 min., rest of the ingredients added, hot rolled for 3 min.	18 min. No smell of formalin	4 hr.	Blisters found on moulding which could not be cured by longer drying.

TABLE XX (*Contd.*)

Composition No.	Any change in standard composition	Whether B.P. mixed or hot rolled	Order in which the ingredients were mixed and other details	Total time of hot mixing and other remarks	Baking time	Moulding results
39	Standard composition but without lime	Hot rolled only	Ingredients (A) hot rolled for 10 min. Maleic acid added, hot rolled for 5 min, other ingredients added, hot rolled for 15 min.	30 min. Good smell of formalin in the last part of hot rolling	2½ hr.	Blister-free moulding, can harden compositions, sticks to moulds Impact strength 3·6 cm.kg./cm.² Water resistance — fair
40	Standard composition but without lime and maleic acid	do	Ingredients (A) hot rolled for 10 min., (B) added and hot rolled for 5 min.	15 min. No smell of formalin	5 hr.	Very soft composition, cannot be cured by longer baking, rejected further tests.
41	Standard composition with 0·5 part paraform	Hot rolled	Ingredients (A) hot rolled for 10 min., lime added, hot rolled for 5 min. Maleic acid added and hot rolled for 5 min. Ingredients (B) added and hot rolled for 20 min.	40 min. — Smell of formalin after (B) was added.	3 hr.	Gloss and flow good but sticks to moulds.
42	Standard composition with 0·5 part paraform	B.P. mixed and then hot rolled	All ingredients except CaO and maleic acid, B.P. mixed for 10 min. CaO added and hot mixed for 2 hr., removed to rollers, hot rolled with maleic acid for ½ hr.	2 hr. 40 min. Smell of formalin while mixed in B.P. More smell of formalin while hot rolling	3 hr.	Gloss and flow good but does not stick to moulds, worked satisfactorily with complex moulds Impact strength 4·2 cm.kg./cm.² Water resistance — good

with alcohol were quite sticky, they were not fully cured in the capping machine even after 4 minutes' baking. A standard bakelite cement on analysis showed the proportion of resin: filler to be 20: 80 and the filler to be chalk only. Cements made with the previously formulated lac resin and chalk used in the same proportions as in the bakelite cement, worked well in the capping machine.

Meanwhile Pradip Lamp Works, Patna, wanted compositions which could be cured by heating only $1\frac{3}{4}$ min. in the capping machine and at the same time would stand 25 lb. torque test as well as boiling water test for 2 hr. The bakelite cement, now in use by the firm, though otherwise good, stands boiling water test for $\frac{1}{2}$ hr. only. Since our standard compositions reported earlier are not properly cured by working in the capping machine for only $1\frac{3}{4}$ min., compositions were made using hard lac resin (prepared from shellac by the alkali-washing method) and chalk in the ratio 20 : 80 along with 2·5 to 5 per cent lime on the weight of resin; these fared better in the capping machine but did not stand the torque test. They also became loose by boiling in water for only 5-6 min. The following modification was, therefore, made and tried in their factory at Patna:

Hard lac resin	100 parts	Refluxed for 2 hr.
Methylated spirit	200 parts	
Urea	9 parts	
Formalin	25 parts	
Maleic acid	1 part	Further refluxed for $\frac{1}{2}$ hr. and then bottled.

A paste was prepared by mixing the above varnish with chalk in the proportion of total resin: chalk = 20: 80. This composition was nearly thermo-setting and worked much better: It stood the torque test perfectly and the boiling water test for $\frac{1}{2}$ hr. and is, therefore, similar to the bakelite cement in current use. Further modification of the above varnish with $AlCl_3$, etc., is being tried.

5. Improvements in the Manufacture of Seedlac, Shellac, Bleached Lac, etc.

(i) *Making of shellac by autoclave* — It was observed that as compared with the country process, the yield of shellac of T.N. grade from the autoclave is somewhat less. The problem of increasing the yield is being worked out on a laboratory scale. Although promising results have been obtained so far, the experiments have to be repeated before being tried on a pilot plant scale.

(ii) *Shellac-making machine* — The design of the sheet-making machine has been further improved and the optimum conditions to produce continuous sheets of equal thickness have been found out. Now continuous sheets of shellac can be obtained at the rate of 1 sr. (= 2 lb.) per 5 min.

(iii) *Shellac from ammonia-lac* — The excellent performance of baked ammonia-lac coatings on earthenware suggested the possibility of making shellac from ammonia-lac. Following experiments were, therefore, made to remove ammonia from thin coatings of ammonia-lac by baking at moderate temperatures.

A thin layer of ammonia-lac (made by dissolving 15 gm. of lac in 120 cc. of water containing 4·5 cc. of liq. ammonia) was applied on several glass plates (6 in. × 6 in. size) and the plates were separately baked at 60°, 70° and 80°C. in an oven. Films from the plates were scraped at intervals of 1 hr. and their solubilities in alcohol and water tested with the following results:

	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	6 hr.
60°C.	W.S.	W.S.	Sl.W.S. Al.S.	Sl.W.S. Al.S.	Sl.W.S. Al.S.	Sl.W.S. Al.S.
70°C.	,,	,,	,,	,,	,,	,,
80°C.	Sl.W.S. Al.S.	Sl.W.S. Al.S.	,,	,,	,,	,,

W.S. = Water-soluble
Al.S. = Alcohol-soluble
Sl. = Slightly

It was found that even thin ammonia-lac coatings could not be made ammonia-free by baking at 80°C. for as long as 6 hr.

Attempts were next made to expel ammonia by autoclaving ammonia-lac in such a way that steam always comes out from the valves of the autoclave carrying along the expelled ammonia, if any. Ammonia-lac solution was taken in an autoclave and steam was allowed to pass through the valves at 1½ atm. pressure (≡ 110°C.) for 1 hr. The lac solution on opening the autoclave was found to be unaltered and no water-insoluble lac could be obtained.

The experiment was repeated as follows:

Ammonia-lac was dried on water bath. This lac was found to have a melting point of 100°C. and was water-soluble. This was taken in the autoclave and steam was allowed to pass through the valves so that pressure was constant at 2 atm. pressure (≡ 120°C.) for 2 hr. The lac thus prepared was only slightly water-soluble and when dissolved in alcohol gave a turbid solution. Autoclaving alone thus failed to expel ammonia completely from ammonia-lac.

In continuing the experiment it was noticed that if ammonia-lac were boiled in an open vat till all the water were evaporated, the resinous mass left behind was almost ammonia-free. In order to draw out sheets of such resin, using the sheet-making machine, a bigger charge was prepared as follows:

10 lb. of seedlac were soaked in 15 l. of water and 450 cc. liq. ammonia and left overnight. Next day the solution was heated and mixed well at 60°C. for ½ hr. and filtered through cloth. The residue was washed with 3 l. of hot water. The total filtrate was allowed to evaporate in an open vat (enamelled, steam jacketed) by passing steam at 50 lb. pressure. After three hours, a resinous mass was left behind which was free from moisture and ammonia. Sheets could be drawn out from this only for a short while as the resin polymerized in the vat if left for 3-5 min. only, so that the entire lot could not be converted into sheets. As may be expected, resin thus obtained had very poor life and flow. On repeating the experiment on a laboratory scale by steam distilling ammonia-lac in a flask, the distillate was found to be alkaline even after boiling for 3 hr. About 80 per cent of lac was found to precipitate out in the water on being left overnight. This lac was taken in a basin and treated over sand bath till moisture-free.

The moisture-free shellac thus prepared had better flow than the one prepared in autoclave, and could be drawn out into thin sheets by passing between rollers. Analytical data of this, and of shellac made by the usual process from the same seedlac are given below:

	Shellac from ammonia-lac	*Shellac by ordinary method*
Life	42 min.	57 min.
Flow	462 sec.	75 sec.
Acid value	72·9	71·5
Hot alc.-insolubles	2·18 %	1·14 %

The properties of shellac from ammonia-lac obviously are not satisfactory. Recovery of lac from ammonia-lac solution by acid precipitation using some organic acid was next attempted. This was done in order to avoid the long hours of heat treatment which is responsible for the partial polymerization of shellac.

225 gm. of seedlac were dissolved in 500 cc. of water containing 20 cc. of liq. ammonia and the solution was filtered through cloth. The residue left on cloth amounted to 4·5 gm. when dry. Dilute acetic acid solution (1:6) was added gradually and the lac precipitated from the ammonia-lac solution. The lac was washed under a tap, ball-milled with water and finally filtered and washed over filter paper. A fine sandy cream-coloured powder was obtained which on melting developed the natural colour of shellac. Shellac thus prepared had the following properties:

Life	40 min.
flow	410 sec.
Hot alcohol-insolubles	2·3 %

Evidently shellac thus prepared is in no way better than that made by the heat treatment method. Further work is in progress.

(iv) *Making seedlac and shellac of low bleach number* — To start with, a few experiments were done to prepare seedlac of low bleach number from sticklac of ordinary quality, subject to the condition that the yield should not be affected appreciably. For this purpose, a small washing barrel was made with some stirrers of m.s. flat bars in it, this type of barrel being in actual use in some commercial factories. At the outset, washing soda was used in increasing quantities for washing the same quantity of lac. But this did not bring down the bleach number appreciably. However, if washing was carried out in mortar and pestle, which simulates the rubbing with feet, the bleach number of the prepared seedlac was found to gradually come down as the quantity of soda was increased. Keeping in view the results obtained so far, the stirring arrangement inside the washing barrel has been modified and the resulting products appear to be similar to the products obtained with mortar and pestle. Some of the results obtained are as follows:

Quantity of soda used per md.* of lac: in chataks†	0	2	4	6	8	16
Bleach number of seedlac washed in barrels with stirring rod	122	120	120	114	114	115
Bleach number of seedlac washed using mortar and pestle	120	100	—	—	92	87
Bleach number of seedlac washed in barrel with modified stirrer	94	—	84	—	—	78

*82 lb. nearly. †1 chatak = 2 oz. nearly.

The product of the modified barrel having been found similar in properties to those of the mortar and pestle, all subsequent experiments were done in the modified barrel.

Experiments were next performed to find out the comparative efficiency of different chemicals in washing seedlac. The results are shown in Table XXI.

TABLE XXI

Baisakhi *lac was used. Washing time*: 1 *hr.*

Chemicals used in chataks per md. of lac	With water only	Ammonia 2½ ch.	Soda 4 ch., bleaching powder 8 ch.	Sodium sulphite 4 ch.	Sodium hydroxide 8 ch. (NaOH 86%)
Yield %	64	53·3	56·8	57·0	57·7
Bleach index	114	90	96	94	87
Remark	—	Regain the colour after keeping for a few days	The seedlac developed white spots and looked dull	The seedlac was glossy	Surface gloss was less but grains were clean

The table shows sodium hydroxide to be the most efficient washing reagent. Subsequent experiments were done to find out the minimum quantity of the reagent needed to ensure best results particularly in regard to yield and bleach index of seedlac. Results are given in Table XXII.

TABLE XXII

Baisakhi (ber) *lac was used. Washing time*: 1 *hr.*

Sodium hydroxide used in gm. for 1 lb. (½ sr.) of lac.	0	1	2	3	4	5	6	7	8	9	10
Yield %	64	61	57·2	57	57	57	57	55	53	52	51
Bleach index	114	98	94	93	91	87	85	78	75	73	70
Colour index	11	9·5	7·5	7	6·7	5·8	4·4	4·4	4	3·8	3·7
Hot alcohol-insolubles %	4·19	3·51	3·65	2·63	2·91	2·91	3·02	2·21	2·32	1·35	1·17

The above table shows that by increasing the quantity of sodium hydroxide above 7 gm. per pound of sticklac, while the yield comes down markedly, the properties of the product do not show corresponding improvement. Moreover, bleach index 78 corresponding to this value of NaOH is near about that of *kusum* seedlac whose bleach index is taken as 80; hot alcohol-insolubles content is also near about 3 per cent.

These experiments were continued with *palas* lac of Ranchi region, and a sample of lac received from Poona, the quantities of sodium hydroxide used being 6, 7 and 8 gm. per lb. (½ sr.) of lac. Results are given in Table XXIII.

TABLE XXIII

Quality of lac washed	*Palas* lac of Ranchi				Poona lac			
Quantity of sodium hydroxide used in gm. per lb. (½ sr.) of lac	0	6	7	8	0	6	7	8
Yield %	69·1	61·3	61	60	78	72·6	68·6	61·0
Bleach index	121	80	78	78	120	80	75	76
Colour index	12	4	4	3·5	16·5	8·8	7	7
Hot alcohol-insolubles %	5·28	2·24	2·66	1·89	8·81	7·82	7·76	7·84

Evidently, washing with 7 gm. of sodium hydroxide per pound of lac gives the desired product. Experiments were repeated, in which washing was done by rubbing with feet as in the country process as well as in the modified barrel. *Rangeeni* lac was used in the experiments with the following results:

TABLE XXIV

	Washed in drum (modified barrel)		Washed by feet	
Sodium hydroxide used in gm. per lb. of lac	0	7	0	7
Yield %	71	58·3	75	64·2
Colour index	7·1	3·5	7	3
Bleach index	98	70	95	68
Hot alcohol-insolubles %	3·57	2·71	3·52	1·95

From the above data, washing by feet is observed to give the same result as washing in improvised drum. It may be noted, however, that though bleach indices of the seedlac were reduced to 68-70, the yields were affected very adversely. As, however, so much lowering of bleach index is not required, an experiment was done with 3·5 gm. of caustic soda per pound of lac. This increased the yield of seedlac to 70 per cent, the bleach index, the colour and the percentage of hot alcohol-insolubles for the resulting seedlac being respectively 78, 4·3 and 3·19 per cent.

Next, to find the effect of washing with caustic soda on the shellac subsequently to be made from the seedlac, shellac was made from the samples of seedlac washed with 3·5 and 7 gm. of caustic soda per pound of lac as well as from seedlac prepared without using any washing agent. The results were as follows:

TABLE XXV

Quality of seedlac, washed with NaOH gm./lb.	0·0	3·5	7
Yield of shellac %	80·0	83·0	85
Colour	9·5	6·0	5
Life (minutes)	43·0	43·0	43
Flow (seconds)	116·0	117·0	119

Washing of lac with caustic soda might be expected to remove some portion of the lac complex of high acid value, and hence to reduce the acid value of the product, as compared with seedlac not treated with caustic soda during washing. So, the acid values of seedlac were determined with results as follows:

Washed with caustic soda: gm./lb.	*Acid value*
0·0	71·91
3·5	71·18
7·0	70·58

Evidently the use of caustic soda does not change the acid value appreciably.

It may be concluded on the basis of the work conducted till now, that washing of lac with caustic soda is beneficial, giving seedlac of improved characteristics. Further work is in progress to find the specific quantity of caustic soda that will be required for different qualities of lac.

(v) *Lac washing with enzymes* — Preliminary work has been done to wash lac with some proteolytic enzyme, as a substantial part of the insolubles in seedlac consists of insect bodies. Results so far obtained are promising.

(vi) *Studies on bleached lac*: (a) *Keeping quality* — The bleached lac industry is one of the major consumers of lac at present and is gaining in importance every day. The industry is established mostly in the United States, which country incidentally is also the largest consumer of lac. The raw material used is chiefly seedlac exported from this country and Thailand.

Bleached lac, which is highly valued for its many outstanding properties, suffers from one important defect, namely, its poor keeping quality in the dry state. Earlier investigators who had worked on the problem recommended remedial measures to overcome this difficulty and the following studies were undertaken in order to evaluate the comparative effectiveness of these remedies.

The actual process of bleaching itself is rather simple, involving in successive steps the dissolution of lac in soda, treatment of the solution with bleach liquor and reclaiming the lac from the bleached solution by acidification with mineral acid. Strict control of conditions at every stage is, however, necessary to ensure satisfactory and consistent quality. Several (nearly fifty) samples of bleached lac were prepared under variety of conditions, the conditions being altered one by one. The resulting samples were stored in the dry state in the form of fine powder, as well as small and large granules. A few samples were also converted into flakes by melting under boiling water and squeezing between cold steel rollers. Colour index, acid value and matter insoluble in cold alcohol were determined in each case and the samples stored in paper bags in an isolated room under atmospheric conditions. The cold alcohol-insolubles are being determined from time to time at frequent intervals.

Acid value — One surprising observation in the course of these investigations was that the acid values of most of the well-washed bleached lacs lie between 60 and 70, whereas earlier workers had invariably recorded values of 80 and upwards. Incidentally, the few samples which had acid values exceeding 70-72 were found to have poor keeping qualities and to deteriorate rapidly, whereas those with acid values below this range were stable. 8-10 months have elapsed since the preparation of these samples and in some cases fifteen months, but all of them, with acid values below 70-72, have retained their solubility unimpaired so far.

(b) *Changes taking place on conversion of bleached lac into flakes* — Conversion of bleached lac into flakes requires heat treatment although in presence of water. As bleached lac is known to be very sensitive to heat, the changes in colour and keeping qualities due to this treatment were investigated. One-half of a batch was merely washed as usual with cold water and air-dried in powder form to serve as control, while the remaining half was converted into flakes. The constants of the two forms are recorded in Table XXVI.

TABLE XXVI — PROPERTIES OF BLEACHED LAC IN THE FORM OF POWDER AND FLAKES

Sample No.	Powder					Flakes				
	Acid value	Colour index		Cold alcohol-insolubles		Acid value	Colour index		Cold alcohol-insobles	
		Fresh	After 6 months	Fresh %	After 6 months %		Fresh	After 6 months	Fresh %	After 6 months %
1	65·61	0·41	0·55	2·46	3·796	66·12	0·625	0·77	2·44	3·408
2	65·61	0·40	0·55	3·286	5·76	65·21	0·625	0·83	3·242	3·368
3	—	—	—	—	—	66·56	0·770	1·10	3·248	3·252

Obviously there has been some darkening of the colour during this treatment but the keeping quality is hardly affected.

(c) *Accelerated ageing* — It is well known that the keeping quality of bleached lac (or, for that matter of any lac) is rapidly imperilled by a rise in temperature. One way of carrying out the accelerated ageing of these lacs would, therefore, be to subject them continuously to high temperatures. A few samples of bleached lac were, therefore, stored in an incubator maintained at 36°-39°C. and their solubilities determined at frequent intervals. The results are given in Table XXVII.

TABLE XXVII — KEEPING QUALITY OF BLEACHED LAC ON ACCELERATED AGEING

Sample No.	Acid value	Sample kept at laboratory temperature (control): Cold alcohol-insolubles %			Sample subjected to accelerated ageing (kept at 36°-39°C.): Cold alcohol-insolubles %		
		When fresh	After 3 months	After 10 months	When fresh	After 3 months	After 10 months
1	70·25	2·436	2·408	2·128	2·436	2·420	2·374
2	67·84	2·592	2·900	3·256	2·592	2·620	2·796
3	69·69	2·576	2·740	3·088	2·576	2·680	2·792
4	55·35	3·112	—	3·332	3·112	—	3·560

Apparently, these samples have quite satisfactory keeping qualities.

(vii) *Yield of bleached lac from seedlac* — The yield of bleached lac from seedlac was found to vary between 80 and 85 per cent and never to exceed 85 per cent. The undissolved material during the initial extraction of seedlac with soda generally constituted about 3 per cent, thus accounting for a total of only about 88 per cent at the maximum. This yield is rather surprisingly low and requires investigation. This is being looked into.

(viii) *Bleaching of lac with alternative bleaching agents*: *Sodium chlorite* — It was found that although the keeping qualities of the hypochlorite bleached lacs were quite satisfactory, their "life" and flow were still rather poor. As improvements in these properties also are highly desirable, bleaching of lac by materials other than hypochlorite were investigated.

The material tried was sodium chlorite, a product which is finding increasing use in the paper and textile industries.

Samples of seedlac were bleached with this chemical as follows: 118 parts of seedlac were dissolved in a solution of 11·8 parts of sodium carbonate in 1,000 parts of water by boiling for half an hour. The solution was strained and brought to 40°C. and to it were added 200 parts of sodium chlorite solution containing 10 parts of chlorine, and 7·8 parts of formaldehyde solution containing 2·2 parts of formaldehyde. The reaction was found to be strongly exothermic and a rise in temperature up to 8°C. was noticed. The reaction was allowed to proceed for about 2 hours. A small portion of the solution was pipetted out, filtered, and its colour ratio determined using a Dubosque Colorimeter. The colour ratios were found to be about 3.

The bleached solution was diluted to thrice its volume with cold water and precipitated with dilute sulphuric acid. The precipitated lac was filtered and washed free from acid. It was then air-dried. The yield and analytical data of the resulting bleached lac are given in Table XXVIII.

TABLE XXVIII

	Expt. I	Expt. II
Yield	78·6 %	82·5 %
Moisture	0·85 %	0·7 %
Acid value	102·6	109·2
Colour index	0·44	0·38
Cold alcohol-insolubles	4·48 %	5·06 %
Fluidity:		
Time to pass 1st in.	152 sec.	140 sec.
,, 2nd in.	460 sec.	450 sec.
,, 3rd in.	1,210 sec.	1,200 sec.
,, 4th in.	No flow	No flow

It will be observed from the above table that the acid values of these bleached lacs are very high. It was thought that wet grinding in a pebble mill might perhaps be effective in reducing the acid values, and so another batch was prepared in which after precipitation, the lac was ball-milled with water for about 1 hour. Side by side, a similar sample was also bleached with sodium hypochlorite to compare the properties of the two bleached lacs. The yield and analytical data of the two bleached lacs are tabulated below (Table XXIX).

TABLE XXIX

	Bleached lac obtained by bleaching with sodium hypochlorite	Bleached lac obtained by bleaching with sodium chlorite
Yield	83·30 %	78·70 %
Moisture	0·70 %	0·61 %
Acid value	69·10	110·60
Colour index	0·36	0·29
Cold alcohol-insolubles	3·62 %	3·57 %
Life under heat	12 min.	32 min,
Fluidity:		
Time to pass 1st in.	85 sec.	80 sec.
,, 2nd in.	340 sec.	180 sec.
,, 3rd in.	No flow	325 sec.
		No flow after crossing $3\frac{1}{2}$ in.

The acid value of bleached lac obtained by bleaching with sodium chlorite, even after ball-milling is still very high. Life under heat is better as compared to that of lac obtained by bleaching with sodium hypochlorite. It is proposed to continue bleaching with sodium chlorite using activating agents other than formaldehyde, and also other bleaching materials.

(ix) *Colour retention of bleached lac varnishes* — Following the preparation of bleached lacs of satisfactory keeping qualities while in the dry state, colour stability of these lacs while in varnish form was investigated. Ten per cent solutions of a few samples in re-distilled spirit were prepared and the colour index determined after filtering off the

wax under the usual conditions. The varnishes were stocked in glass vessels with wooden stoppers in a cupboard. The colour indices and acid values of these varnishes after storage for six months are shown in Table XXX.

TABLE XXX

Sample No.	Colour index		Acid value (mg. of KOH per cc. of varnish)	
	When freshly made	After 6 months' storage	When freshly made	After 6 months' storage
1	0·43	0·38	6·531	6·186
2	0·43	0·42	6·528	6·416
3	0·33	0·30	6·552	6·413
4	0·50	0·43	6·723	6·413

There has thus been no deterioration in colour. The acid value, however, has been slightly lowered. The study is being extended to aqueous varnishes.

(x) *Decolourization of shellac* — Different decolourizing agents manufactured in India were compared with one of foreign make as regards their efficiency in decolourizing lac in spirit solution. One sample prepared by Ashok Traders, Bombay, named as "Accarb" and another prepared from bagasse by Jiwaji Industrial Research Laboratory, Gwalior, were found to be somewhat comparable to that of E. Merck & Co.

6. *Ad Hoc* Work

(i) *Dewaxed decolourized lac* — A sample of dewaxed decolourized lac claiming to have exceptionally good "life" and flow was received during the year under report and examined for its various physical and chemical properties. These properties were also determined for normal shellac, dewaxed lac and two samples of hypochlorite-bleached lac for purposes of comparison. The results obtained are given in Table XXXI.

TABLE XXXI

	Regular shellac	*Dewaxed lac	Dewaxed decolourized lac	Hypochlorite-bleached lac	
				Sample I	Sample II
Acid value	73·13	69·05	117·2	57·03	75·58
Saponification value	233·5	222·2	291·4	251·6	258·8
Colour index	11	3	0·45	0·22	0·5
Flow (seconds)	126	No flow	180	No flow	No flow
Life under heat (minutes)	51	14	118	51	12
Hot alcohol-insolubles	1·56%	3·93%	0·18%	0·46%	—
Cold alcohol-insolubles	7·30%	13·4%	0·96%	4·74%	—
Iodine value	16·6	12·56	6·636	4·405	10·32

*This sample of dewaxed lac was rather old.

Film properties of the sample were next examined and compared with those of shellac and bleached lac varnishes as well as varnishes obtained by filtering off the wax from the latter two. The results are presented in Table XXXII.

TABLE XXXII — FILM PROPERTIES OF DEWAXED, BLEACHED AND OTHER LACS (FILM OBTAINED ON GLASS AND TIN PANELS FROM 25 PER CENT SOLUTIONS OF LAC IN RECTIFIED SPIRIT BY FLOWING)

No.	Varnish used	Scratch hardness (load on 1 mm. steel ball in gm.)	*Flexibility mm.	Rocker hardness (glass as 100)	Water immersion test time in hr. at							
					17·5°C.		25°C.		30°C.		40°C.	
					Whitening	Lift	Whitening	Lift	Whitening	Lift	Whitening	Lift
1	Ordinary shellac varnish	600	8	30	24	4	3	1	2½	>24	1	>24
2	Dewaxed shellac varnish by filtering varnish No. 1	110	10·5	90	24	½	>6	<½	3	5	1½	>6
3	Regular bleached lac varnish	700	6	10	24	1	>6	<1	16	>24	1½	>6
4	Dewaxed bleached lac by filtering varnish No. 3	50	8	100	24	4	>6	<1	>24	5	2½	>6
5	Commercial dewaxed lac varnish	—	—	96	—	—	>6	½	3	1	1½	>6
6	Dewaxed bleached lac varnish (sample under test)	70	4	72	1	>24	<½	<6	<1	>24	<½	>24

*These figures refer to the minimum diameter of the mandrel over which the film withstands bending without cracking and lifting.

The above two tables show the received sample of dewaxed decolourized lac under test to be definitely superior to ordinary hypochlorite-bleached lac and dewaxed lac in regard to life, flow, flexibility and adhesion. It is even better than ordinary shellac in these respects except for flow. Its acid value, however, is abnormally high and its water resistance extremely poor. Moreover, the material is very soft and low-softening and coalesces together into a block when the powdered product is kept for a short time even at the laboratory temperature. In fact its softening point is so low and water resistance so poor that even at about 40°C. the film disintegrates almost completely. Incidentally it may be noted that hypochlorite-bleached lac, either as such or wax-free, is superior to ordinary shellac in regard to flexibility, hardness and water resistance.

(ii) *Yield of seedlac and shellac* — As in the last year samples of *Baisakhi* and *Katki* sticklac were collected from Daltonganj and yields of seedlac and shellac per maund of sticklac were determined. Results are given in Table XXXIII.

TABLE XXXIII

Sample No.	Seedlac ordinary (1)		Seedlac fine (2)		Shellac from (1)		Shellac from (2)	
	Sr.	ch.	Sr.	ch.	Sr.	ch.	Sr.	ch.
Baisakhi								
No. 1 (*palas*)	15	8	15	0	14	8½	14	1
No. 2 (*palas*)	14	8	14	0	13	9½	13	7
No. 3 (*ber*)	25	0	23	8	24	2½	21	3
Katki								
No. 1	20	8	20	0	18	10	18	3
No. 2	20	14	20	8	19	0	10	10
No. 3	19	0	18	0	17	4½	16	8½

A sample of lac was also received from the Forest Utilization Officer, Bombay State, and processed; yield of seedlac was found to be 23 sr. 10 ch. from 1 md. of lac.

III. PROPAGANDA AND PUBLICITY (UTILIZATION OF LAC)

Work under this head proceeded more or less on the same lines as before (*I.L.R.I. Annual Report*, 1953-54). A brief account of the activities during the period under review is given below:

General — Contact was maintained with actual and potential consumers of lac in India and also with a few abroad, through correspondence, personal visits and interviews at the Institute. Several important visitors were shown round the Institute and various aspects of the lac industry explained. Requests for literature on the cultivation and industrial uses of lac were attended to, and information regarding the sources of supply of seedlac and shellac, important manufacturers and dealers, availability of equipment with approximate cost, etc., was given to interested parties. Suggestions were given to the Chief Conservator of Forests, Vindhya Pradesh, and the Director of Industries, Madhya Bharat on the starting of some industries in their respective places, such as the manufacture of sealing waxes, improved shellac polishes, coating of earthenware, etc.; necessary details of the processes of manufacture of these products were also supplied.

Consumption of lac in India — With a view to estimating the present consumption of lac in the country, a comprehensive questionnaire was issued to practically all the important industrial and semi-industrial concerns in India using lac, namely, (1) manufacturers of paints, varnishes, polishes, lacquers, etc.; (2) gramophone-record manufacturers; (3) sealing wax industries; (4) manufacturers of other miscellaneous items, such as adhesives or cements, water-proof abrasive papers and grinding wheels, micanite products, etc., and also to Directors of Industries of different States, and Railways and Defence establishments of the Government of India. Wherever possible, data were also collected by personal visits. A number of parties intimated their consumption of shellac, and replies from others are still awaited. The figures pertaining to some of the important uses of shellac so far collected are given below:

1. Paints, varnishes, polishes and lacquers	25,500	md. per year
2. Gramophone records	6,500	,, ,, ,,
3. Sealing wax	500	,, ,, ,,
4. Adhesives and cements	300	,, ,, ,,
5. Rubber mixings	50	,, ,, ,,
6. Art inks	50	,, ,, ,,
7. Lacquering on brassware and other materials	1,000	md. approximate
8. Wooden turnery	1,000	,, ,, ,,
9. Miscellaneous which include pyrotechnics bangles, jewellery fillings, etc.	1,000	,, ,, ,,
	35,900	md. per year
	or 36,000	md., say

This, in terms of sticklac, corresponds to nearly 65,500 md. or 6·0 per cent of the country's total average annual production of 1,100,000 md. Out of this, consumption in the forms of sticklac and seedlac is quite small, being about 700 md. and 1,000 md. respectively. As mentioned above, replies to a large number of enquiries are yet to come; also in some instances, particularly those based on cottage industries, e.g. lacquering on wooden articles, brass and other wares, miscellaneous items like pyrotechnics, bangles, jewellery, sealing wax, pottery coatings, etc., figures are approximate and incomplete as the use of lac in such industries is widely distributed, sometimes in remote places, throughout the country. Attempts are being made to collect these figures from various sources. When these figures are available, it is expected that the total figure may go up by another 2-3 per cent, thus bringing India's present internal consumption to nearly 8-9 per cent.

Varnishes and paints — Circular letters containing brief description of the preparation, properties, performances and various uses of shellac linseed oil compositions as also of varnishes based on shellac ester gum combinations were issued to practically all the paint and varnish manufacturers of India and the Defence and Railway establishments of the Government of India. These concerns were requested to give trials to these various compositions and take up their manufacture in the event of any of these proving suited to their requirements. Actual demonstrations of the methods of making these at the factories of interested parties, if necessary, were also promised.

As a result, requests for trial samples together with details of manufacturing them, sources and availability of raw materials, etc., were received from paint and varnish manufacturing firms, Technical Development Establishments of the Armed Services Wing at Kirkee, Kanpur, Dehra Dun; Integral Coach Factory of the Indian Railways at Perambur; Chief Mechanical Engineer, Southern Railway; the Chief Conservator of Forests, Madhya Pradesh; Bhor Industries, Poona, etc.; and their requests were complied with. Results of examination made by some of the parties have been received and those from others are awaited.

Messrs India Electric Works, Calcutta, have reported that some of the compositions are suitable as clear baking insulating varnishes for impregnating armature coils and making insulating cloth (" Empire Cloth "). The methods of making these varnishes and the coating technique for manufacturing insulating cloth were also demonstrated at their factory. The Chemist-in-charge of the factory is now able to make large quantities of these varnishes and a moderate-sized plant for making both the varnish and insulating cloth is about to be put up by the firm. For their immediate requirements, however, bulk samples of shellac ester gum combination sufficient to make 50 gallons of the varnish have been supplied.

Messrs Murarka Paint & Varnish Works, and India Paint & Varnish Co. Ltd., have reported that actual trials are in progress, and results obtained so far are encouraging. The Technical Development Establishment, M.E. Kirkee, has reported that one of the compositions satisfies all its requirements, but fails in one respect, namely, in corrosion tests. Arrangements are being made to send an alternative sample overcoming this defect. The other parties have replied that the actual service trials of the samples are under way and that the results would be reported shortly.

Samples of these varnishes and paints as well as special " lead-free " compositions with or without cashew nut shell liquid-formaldehyde varnish which were sent previously to the Central Standards Office, Chittaranjan, Ministry of Railways, did not prove satisfactory as exterior carriage paints, and fresh modified samples for further tests are about to be supplied.

Oil cloth — Contact is being maintained with Messrs Bhor Industries, Poona, and Strawboard Manufacturing Co., Saharanpur, regarding the manufacture of oil cloth. Both the firms were supplied at their request with 1 cwt. of the oil-cloth composition for large-scale trials; while the report from the latter firm is yet to come, the former has expressed

satisfaction with the results of preliminary trials and is planning to carry out large-scale trials. The Technical Director of the firm was also quite satisfied with the finish and quality of the cloth, and expressed his keen desire to take up the manufacture of lac-based oil cloth, provided the cost of the unpigmented composition did not exceed 12 annas per pound.

As a further measure to popularize the lac-oil compositions, active co-operation and help of the National Research Development Corporation of the Government of India was also sought during the period. The corporation was supplied with complete information as to the sources and availability of raw materials, type of equipment required, approximate cost of production, etc.

Adhesives and cements — As reported by Messrs B. M. Singh & Son, Calcutta, a prominent dealer and manufacturer of electrical accessories, a new Institute formulation based on bleached lac has been found to give satisfactory adhesive for making flexible micanite. The firm is about to manufacture the adhesive for its own use, and details of its preparation as also sources of supply of bleached lac have been intimated to it. A few pounds of bleached lac prepared at the Institute have also been sent to the firm to enable it to start the work. Contact is being maintained with the firm to watch its progress.

Contact has been established with another firm, namely, Messrs Premier Mica Mining & Manufacturing Co., Calcutta, who are at present manufacturing mostly micanite and moulded micanite articles using shellac and modified shellac as the main adhesive. All their products have been tested and found to comply with B.S.S. Specifications. Most of the manufactured products of the firm are used for repair purposes. The chief consumers are the Railways, General Electric Company, Tata Iron & Steel Co. Ltd., Balmer Lawrie, etc.

Methods of making gasket shellac compound and black adhesive tape from lac have been given to interested parties. A firm in Saharanpur to which about 10 gallons of black adhesive tape composition were sent for large-scale trials, has reported that the firm is satisfied with the performance of the composition and will take up its manufacture shortly.

Details of the manufacture of water-proof abrasive papers and cloth were supplied to Messrs Bhor Industries, Poona, as they expressed a keen desire to take up their manufacture.

Moulding compositions — Technical Development Establishment of the Armed Services Wing, Dehra Dun, is very much interested in the use of shellac composition for making binocular eye cups. Tests made by them so far have proved the eye cups to be satisfactory in respect of indoor tests. The samples are at present undergoing field tests and a report on these is expected shortly.

Samples of lac-moulding compositions have also been sent on request to Messrs India Capacitor Manufacturing Co., Jullunder, for making tubular condensers used in some of the electrical equipment. These compositions on testing were found to have very good electrical properties. The firm is reported to be using large number of such condensers and if the lac composition is found suitable for the purpose, a fair amount of lac may be expected to be consumed in this line. Another firm in Calcutta is being advised to use shellac compositions for making paper insulation tubes largely required by telephone factories.

Lac coating on earthenware — The use of shellac coating on earthenware has continued to receive wide interest from both the public and various cottage industries, Directorates of State Governments, etc. In this connection numerous requests were received for the supply of literature and other information regarding the availability of raw materials, costing data, etc. These have been attended to. It may be of interest to mention that training in methods of coating earthenware with lac is actually being given to many students in the Village Pottery Training Centre of the All-India Village and Khadi Industries Board at Khanapur near Belgaum. In this connection a complete demonstration of

the process in all its details beginning from the preparation of the coating composition to the finished article was also arranged for about a fortnight at the Emporium of the Khadi Industries Board in Bombay.

As a part of further publicity and propaganda, large-scale demonstration of the process was also conducted in March 1955, at All-India Sarvodaya Sammelan, Puri, where 14,000-16,000 various earthenware articles, e.g. tumblers, bowls, dishes, etc., were coated with lac and supplied to all the delegates present on the occasion. The lac-coated atricles were very much appreciated by one and all.

Bleached lac — Parties interested in bleached lac were supplied with details of manufacture and sources of its supply. Messrs Bengal Chemical & Pharmaceutical Works, Calcutta, and Lalpur Shellac Factory, Ranchi, are engaged in the manufacture of small quantities of bleached lac, and the parties requiring the material are referred to these firms. Whenever possible, samples of bleached lac were supplied from the Institute also.

Miscellaneous enquiries — Details of manufacture of superior quality sealing waxes, the type of moulds used, sources of supply of raw materials required, etc., were supplied to the parties concerned.

Method of overcoming certain difficulties in connection with the use of shellac polishes and spraying lacquers in humid atmospheres were suggested to a firm in Bombay.

Particulars regarding the manufacture of shoe-polishes, using lac wax and sources of availability of the necessary raw materials were given to interested parties. A firm in Dehra Dun is making use of large quantities of shellac wax for preparing shoe-polishes. These polishes are marketed under the trade name of " Chamak " and their quality is reported to compare favourably with that of foreign made ones.

Suggestions for preventing tarnishing of art metalware and gold, and silver embroideries by application of thin coats of modified varnish made from bleached (white) lac were given to a firm in Banaras and to T.D.E. (Textile & Clothing), Kanpur. Parties were also advised on the methods of preventing discolouration of shellac varnishes during storage.

Requests for literature on the cultivation and utilization of lac as also for samples of manufactured products were attended to.

Messrs India Linoleums Ltd., are interested in the use of shellac varnishes for finishing various linoleum cloth they are manufacturing at present. They are currently using shellac spirit varnish which gives a dull mat finish and they asked for suggestions to improve the quality of the shellac varnish so that it might give glossy or semi-glossy finishes. Suitable suggestions have been given and also samples of bleached lac supplied for their tests. Details of making " Holland Cloth " as per sample supplied by the firm also were given.

Samples of bleached lac and bleached lac varnishes have been sent to the Archaeological Chemist in India, Hyderabad, for use as protective coatings in archaeological specimens.

Details of making paper-laminated tubes and bobbin flange from lac compositions were furnished to interested parties, and wherever possible, samples of paper laminates were also sent for their examination.

Publicity — A note on the improvement in technique resulting in the production of bleached (white) lac of exceptional purity, good texture and keeping quality has been sent to the Director of Publicity, Ministry of Food & Agriculture, Government of India, for publicity purposes.

Sets of samples of lac and lac products representing the various uses of lac were sent during the period to the following educational institutions and exhibitions held in this country and abroad. In some of the important exhibitions, the Institute actively participated by deputing its staff to give practical demonstrations of some of the new developments and to explain to the public the various uses of lac. Printed pamphlets containing brief descriptions of the various processes and other informations were distributed to the interested visitors.

1. All-India Khadi Village Industries Exhibition, New Delhi
2. Canadian International Trade Fair, Toronto, Canada
3. All-India Sarvodaya Sammelan, Budh Gaya
4. Balvikas Mandir, Sholapur, Bombay
5. Rural Exhibitions, Purulia, Bihar
6. Lusanne Trade Fair, Lusanne (Switzerland)
7. Directorate of Marketing & Inspection, Government of India, New Delhi
8. Frankfurt Autumn Fair, Frankfurt, Germany
9. The President, Trithala High School, Trithala, South Malabar, South India
10. World Forestry Congress, Dehra Dun
11. Gwalior Fair & Exhibition, Gwalior, Madhya Bharat
12. Annamalai University Silver Jubilee Exhibition, Annamalai, South India
13. Indian National Congress Exhibition, Madras
14. Mysore Lac & Paint Works, Exhibition, Mysore
15. Milan Samples Fair, Milan, Italy
16. City College Biological (College) Exhibition, Calcutta
17. Extension Training Centre, Bihar

Training in the industrial uses of lac — During the period under review, practical training was given to four candidates, deputed by various State Governments, on the analysis of lac, manufacture of improved varnishes, sealing waxes, etc.

IV. METEOROLOGICAL REPORT

The average meteorological data for each month during 1954-55 are given in the following table:

Month and year		Mean wind (miles/ hr.)	Mean max. temperature (°F.)	Mean min. temperature (°F.)	Mean dry bulb temperature (°F.)	Mean humidity (%)	Mean sunshine (hr./day)	Total rainfall (in.)	Highest max. (°F.)	Lowest min. (°F.)
April	1954	2·96	104·1	73·7	90·7	21·6	9·48	0·15	109	64
May	1954	3·05	107·2	78·5	92·0	44·3	10·00	0·25	111	74
June	1954	2·05	95·3	75·0	83·6	76·3	5·70	7·74	104	70
July	1954	1·29	90·0	74·2	80·4	83·9	4·32	14·46	98	72
August	1954	1·50	88·7	73·6	80·0	80·7	5·14	6·72	95	70
September	1954	1·11	90·1	72·8	78·8	85·1	5·33	10·99	98	70
October	1954	0·70	86·7	62·4	75·9	62·0	8·48	0·65	98	52
November	1954	0·44	81·3	49·5	70·5	42·6	10·68	0·00	86	46
December	1954	0·38	78·9	48·4	67·5	48·6	9·47	0·20	84	40
January	1955	0·37	76·0	48·9	65·0	53·2	7·81	3·13	85	37
February	1955	0·76	82·3	52·0	69·5	40·3	10·20	0·30	88	46
March	1955	2·20	93·7	62·7	82·2	25·6	9·94	0·23	102	52

The highest maximum temperature recorded was 111°F. and was recorded only on one day, viz. the 27th of May 1954. Similarly the lowest was also recorded only on one day, viz. the 7th of January 1955 when the minimum had dropped down to 37°F. The total rainfall during the year ammounted to 44·82 in. and the monsoon rainfall to 39·91 in. as against 65·71 and 59·5 in. respectively during the previous year.

S. V. PUNTAMBEKAR
Director
Indian Lac Research Institute
Namkum

APPENDIX I

Tabulated Statement of Progress of Investigations

(ENTOMOLOGICAL)

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
I. RESEARCH & INVESTIGATIONS			
1. Improving crop production on *palas* by partial defoliation			
(i) Preservation of *Baisakhi* broodlac on *palas*	1948-49	As a result of partial defoliation, crop (*Baisakhi* 1953-54) survived on 79 per cent partially defoliated trees, while that outside the experimental area perished wholesale owing to heat and drought. The good effect, however, was partially offset by unknown enemy (probably birds or squirrels) that ate up both lac and lac insects.	To be continued.
(ii) Residual effect of repeated partial defoliation of *palas* on lac production	1952-53	Experiments being re-designed. Data obtained so far indicate that partial defoliation effects better preservation of broodlac by reducing mortality of lac insects.	To be continued.
2. (i) Economics of utilizing *palas* for *Baisakhi*, and *ber* for *Katki* crop only	...	Experiments laid down and operations to start next year.	
(ii) Comparative preservation of broodlac on *ber*, by partial pruning before and after infection	...	Partial pruning in December-January, i.e. after infection, effects better preservation of broodlac.	
3. Finding of, and trials on, lac hosts for *Baisakhi* crop including certain *Ficus* species	1945-46	Hosts tried were: *A. lucida*, *F. cunia* and *O. dalbergioides*. Best results obtained with *A. lucida*, ratio of brood used to brood obtained for this being 1: 9·86.	
4. Determination of brood-carrying capacity of the major lac hosts	1952-53	Experiments conducted with 30 *kusum*, 10 *palas* and 5 *ber* trees for the summer crop. Ratios of brood used to brood obtained were respectively 1: 3·42 (average), 1: 1·94 and 1: 0·23 for these hosts, and for *Aghani* for *khair* 1: 0·54, for *Katki* for *palas* 1: 2·2 and for *ber* 1: 2·3.	Regional sub-stations necessary for this experiment.
5. Proper time of harvesting for maximizing yield	...	Experiments laid at Namkum since this year.	Regional sub-stations necessary for this experiment.

APPENDIX I (*Contd.*)

Item	Commenced	Progress	Future work proposed
6. Determination of optimum density of larval settlement on various hosts	1953	In *Katki* highest yields were obtained from *palas* and *khair* by using ½ of quantity normally required, and on *ber* by using full quantity; for *Kusmi* crop on *kusum*, in *Jethwi* by using ½ of quantity generally required, in *Aghani* by using ⅓ of quantity generally required, and on *khair* by using ½ of quantity generally required. Statistically examined treatments are significant only on *kusum*.	To be continued.
7. Effect of change of host plant on crop production	1952-53	Progeny resulting from the propagation of *kusum* brood on *ber*, *khair* and *pakur* were tried on *kusum* again. Best results were obtained by putting back progeny from *khair* on *kusum* again. In the case of *Rangeeni* crops, alternation of *A. lucida* and *ber* yield the best results.	Sufficient number of hosts for the experiment not available yet.
8. Determination of the most suitable pruning method and seasons for *kusum*	1951	Trees subjected as before to 4 treatments (*vide* text). Growth of shoots and yield of both brood and total lac measured. As regards lac yield, treatment results in *Jethwi* could be graded in the order I, II, III and IV. No significant difference at 5 per cent level observed between one treatment and another as regards yield of broodlac. In *Aghani*, Treatment III is significantly better than others.	To be continued.
9. Growing of lac hosts under bush and crop conditions	1952-53	*Arhar* seeds sown for study of this host under crop condition. For *A. lucida* already converted into bush, the ratio of brood used to brood yield was 1 : 3·12 (in terms of scraped lac).	To be continued.
10. Collecting pests of host trees, noting their parasites and control operations against various pests	1950	A paper on *T. javanica* communicated to the Press. *Serinatha augur*, a pest on dry *kusum* fruits studied: Results presented in a paper before the Science Congress (1955). A comprehensive list of pests being compiled. Several pests of *ber* and *palas* collected for study.	To be continued.
11. Determination of the various races, strains, species, etc., of lac insects, their performances, cross-infestations, etc.	...	Collection of specimens continued.	To be continued.

APPENDIX I (*Contd.*)

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
12. Influence of various environmental conditions on lac insects	1952-53	Both *Rangeeni* and *Kusmi* crops (including insects) at controlled temperatures investigated. Temperature seems to be the governing factor for growth of insects, temperature above 20°-28°C. being optimum for best development.	To be continued.
13. Survey of lac enemies and their parasites	1950	Fifty-seven samples of lac examined: no new enemies found. Two new Chalcids recorded. Various control measures were tried against a mass invasion (unusual) by *Chrysopa* sps. two of which have been identified. Unknown enemy of lac insects were found to be squirrels and some birds. They are yet to be identified.	
14. Cultural and preventive methods of control of lac enemies	1945	(i) Use of wire-net baskets as brood containers — Economics were studied. Percentage of survival after successive seasons of use determined. Insects captured in the baskets counted. To prolong the life of wire-net baskets and to make them more efficient and economical, bamboo-containers have been devised.	To be continued
		(ii) (a) Mechanical control — Mass invasion by *Chrysopa* sought to be stemmed by brushing, sweeping and light trapping. The last did not attract *Chrysopa*. (b) Insecticides— D.D.T. and B.H.C. tried (dusting and spraying).	To be continued.
		(iii) Lac sticks and scraped lac dusted and sprayed with D.D.T. and B.H.C. Conclusive results not yet obtained.	To be continued.
15. Biological control	1942	(i) Mass breeding of *B. greeni* on alternative hosts continued. *E. zinkenella* was the alternative host. Maximum parasitization was 32·4 per cent in April. Max. No. of *B. greeni* bred on the host (per host) =2·25 in July 1954. Breeding work suffered by reason of insecticides being used in the vicinity for want of adequate laboratory space.	To be continued.
		(ii) Longevity was studied of *A. tachardiae* and *P. testaceicollis* endo-parasites of *H. pulverea* larvae and of *E. claripennis*, ecto-parasite of *E. amabilis*. The Bethylid *Perisierola pulveriae*, parasite of *Holcocera* has been successfully bred on its natural and laboratory host *Corcyra cephalonica*.	To be continued.

APPENDIX I (*Contd.*)

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
16. *Ad Hoc* Research	...	*Dalbergia latifolia* and *D. lanceolaria* produced high class *Kusmi* lac.	
II. INSTITUTE PLANTATION (NAMKUM)	...	Plantation maintained as usual. Green manuring carried out. *C. saltiana* cultivated to provide alternative hosts for *B. greeni*. *Kusum* & *khair* seeds sown.	To be continued.
III. TRAINING AND ADVISORY SERVICE	...	Sixteen persons were under training in lac cultivation. 8 completed full training, 3 part training. Technical advice was given to various States, as well as to S.O.L.C. Practical help rendered on behalf of S.O.L.C. to States, produced good results in M.P. to produce broodlac on *kusum* and profitable use of spurious *kusum* in U.P. Specimens were supplied to various parties.	
CHEMICAL			
I. FUNDAMENTAL			
1. Chemical constitution of lac			
(i) Butolic acid	1947	Four hydrolysed products from mixed amides of butolic acid separated so far. Using paper partition chromatography, the position of -(OH) in butolic acid could be determined.	Work on identification of the hydrolysed products will be continued.
(ii) Synthesis of butolic acid	1954	Several intermediaries, e.g. ethyl hydrogen adipate, *n*-octyl and *n*-nonyl bromides, etc., have been prepared as a preliminary step to synthesis.	To be continued.
(iii) Salt fractions of shellac	1947	Constituent acids separated as zinc, lead and barium salts, were further studied. Further fractionation of these gave several crystalline products.	To be continued.
(iv) Acidic fractions from hydrolysed shellac.	1953	Water-soluble and -insoluble liquid acids already separated were converted into barium and sodium salts and further fractionation carried out. The end-product in one case was found to be butolic acid. The water-soluble acid indicated the presence of aldehydo-lactonic acid in it.	To be continued.
(v) Acid fractions from hydrolysed soft lac resin	1954	Six acid fractions were obtained. A portion of the acid fractions was found to contain aldehydo-lactonic group.	To be continued.
(vi) Aldehydo-lactonic acid from *Kusmi* shellac	1955	Hydrolysis with mild alkali for 24 hr. gave finally 3 acid fractions, giving +ve reaction for aldehyde.	To be continued.

APPENDIX I (*Contd.*)

Item	Commenced	Progress	Future work proposed
(vii) Paper partition chromatography	1954	(a)+(b) Paper partition chromatography of dihydroxy acids was carried out with a view to application of the results to separation of constituents of shellac. (c) Chromatographic separation of shellac and rosin was attempted with promising results.	To be continued.
2. Physico-chemical properties of lac			
(i) Osmotic pressure and molecular weight	1954	An osmotic cell has been fabricated to be used for the determination of the molecular weights of the heat-treated, partially polymerized samples of shellac.	To be continued.
(ii) Action of accelerators on shellac solutions	1954	Urea, phthalic acid, oxalic acid and tartaric acid were used as accelerators. Change in viscosity very pronounced in the case of urea, not so in other cases.	Film properties of varnishes from these solutions are to be investigated.
(iii) Specific heat of shellac	1938-40 again 1954	A newly designed apparatus was used to extend the measurement of sp. heat up to 110°C. The data were utilized to determine the latent heat and the melting point of shellac.	To be continued.
(iv) Poly-molecularity of poly-ester of 9:10 dihydroxy hexadecane 1:16 dicarboxylic acid	1954	Corresponding to a certain polymeric level reached by thermal heating, molecular weight distributions of different species of poly-ester molecules were determined.	To be continued.
3. Standardization, grading and analysis			
(i) Non-volatile cold alcohol-insolubles in seedlac, shellac and bleached lac	1954	The U.S. Association method was improved by a modified procedure of filtration, which in essence consists in using 2 filter papers placed one on top of another instead of one, to filter the solution; the difference in weight between the two filter papers gives the measure of insolubles.	
(ii) Estimation of lead in shellac	1954	The proposed U.K. method was tested for its accuracy by melting known proportions of lead (0·04-0·1 per cent) with shellac and determining the Pb content.	To be continued.
(iii) (a) Bleach index and bleachability of lac	1952	The recently developed method was improved in that the time of determination could be reduced from 20 hr. to a little over 1 hr.: this could be accomplished by carrying out bleaching at 37·5°±1°C.	To be continued.

APPENDIX I (*Contd.*)

Item	Commenced	Progress	Future work proposed
(b) Alternative bleaching agent	1955	Bleach liquor was prepared by treating H.T.H. bleaching powder with aqueous sodium carbonate, which proved as good as that obtained by chlorination of caustic soda solution.	To be continued.
II. Applied			
1. Varnishes, lacquers & paints			
(i) Ageing properties of shellac-linseed oil paints	1946	Surfaces indoors (wooden or iron) painted 7 years back are keeping quite well.	To be continued.
(ii) Shellac-based anti-corrosive and anti-fouling paints	1953	Samples made according to modified formulation are awaiting sea-immersion tests.	To be continued.
2. Modification of lac and its derivatives			
(i) Shellac-rosin-glycerine combination	1954	This oil-soluble resin, as originally formulated had a slightly high pH, and its films were slightly rough: Modified formulation is reported by Alipore Test House to be highly suitable as a "clear-baking oil-insulating varnish for electrical purposes".	Attempts are to be made to induce industrialists to adopt this.
(ii) Film properties of oil varnishes from shellac-rosin-glycerine combination, ester-gum and Bedesol	1953-54	Shellac-rosin-glycerine combination was superior to ester-gum, but somewhat inferior to Bedesol, as regards water resistance and drying properties.	To be continued.
(iii) Incorporation of silicone resins in shellac-spirit and shellac (aqueous) varnishes	1954	Incorporation of both water-soluble and -insoluble types of silicone resin in the varnishes did not show any improvement in water resistance.	
3. Moulding compositions: Lac-dimethylol (D.U.) urea moulding compositions	1946	Various investigations were carried out to improve the moulding properties of compositions prepared using old D.U., but without success.	
4. Miscellaneous uses of lac cement for electric-bulb caps	1951	A nearly thermo-setting resin, as good in performance as "bakelite" could be formulated. Awaiting tests in a factory.	May be continued.
5. Improvement in the manufacture of seedlac, shellac, bleached lac, etc.			
(i) Making of shellac by autoclave	1950	Yield from the autoclave was sought to be raised: promising results have been obtained.	To be continued.

APPENDIX I (*Contd.*)

Item	Commenced	Progress	Future work proposed
(ii) Shellac (sheet) making machine	1950	With an improved design of the machine, trouble-free continuous production at the rate of 1 sr. (2 lb.) per 5 min. was possible.	To be continued.
(iii) Shellac from ammonia-lac	1953	Lac recovered from an ammoniacal solution did not have satisfactory properties.	To be continued.
(iv) Making shellac and seedlac of low bleach number	1954	A washing barrel was designed. Various chemicals, e.g. ammonia, soda, bleaching powder, sodium sulphite, sodium hydroxide were added to water. Addition of NaOH brought down the bleach number *remarkably*.	To be continued.
(v) Lac washing with proteolytic enzymes	1954	Experiments were started.	To be continued.
(vi) Bleached lac; keeping quality	1953	(a) Well-washed samples of hypochlorite bleached lac with A.V. less than 70-72, and stored in bags, kept perfectly well for over 15 months. Previous workers obtained bleached lac with A.V. equal to 80 and upwards, which deteriorates rapidly.	To be continued.
		(b) Bleached lac converted into flakes also kept quite well, although slight darkening appeared after some period.	To be continued.
		(c) Accelerated ageing (by keeping at 36°-39°C.) tests, carried on over 10 months, showed the samples to be keeping well all the time.	To be continued.
(vii) Yield of bleached lac from seedlac	1953	The total yield *plus* the approximately known insoluble portion makes up nearly 88 per cent; what happens to the rest (12 per cent) is being investigated.	To be continued.
(viii) Alternative bleaching agent (sodium chlorite)	1955	With a view to obtaining, if possible, bleached lac of improved flow and life, sodium chlorite was used instead of sodium hypochlorite as a bleaching agent. A.V. of the product is high.	To be continued.
(ix) Colour retention of bleached lac varnishes	1954	Ten per cent (dry) spirit solutions kept for 6 months reveal no significant deterioration in colour or otherwise except slight rise in A.V.	Investigation will be extended to aqueous varnishes.
(x) Decolourization of shellac	1954	Decolourizing agents of indigenous manufacture were compared with a foreign one: only one product was somewhat comparable to a reputed German brand.	

APPENDIX I (*Contd.*)

ITEM	COM-MENCED	PROGRESS	FUTURE WORK PROPOSED
6. *Ad hoc* work			
(i) Dewaxed decolourized lac	1954	A sample received from outside and claimed to have good properties was examined and found to be inferior to ordinary shellac in several respects.	
(ii) Yield of seedlac and shellac from bazar lac	...	Sticklac was purchased from Daltongunj and examined for percentage yields of seedlac and shellac.	
III. PROPAGANDA AND PUBLICITY	...	Enquiries were replied to, statistics of consumption collected. Participation in exhibitions helped popularization of lac.	

APPENDIX II

List of Papers and Pamphlets Published or Communicated for Publication during 1954-55

1. Indian Lac Research Institute. Bull. No. 83. A new method for the determination of the bleach index of lac, by Y. SANKARANARAYANAN and P. K. BOSE (*J. sci. industr. Res.*, Vol. 13B, No. 7, 1954)
2. Ditto. Bull. No. 84. Dimorphism in lac insects, by P. S. NEGI (*Indian Forester*, August 1954)
3. Ditto Tech. Note No. 10. Moulding Powder from Jute stick dust, by P. K. GHOSH, T. BHOWMIK & P. K. BOSE (Communicated to the Press)
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APPENDIX III

Statistics of Sticklac Production in India during 1954-55 (in maunds)

Year	*Baisakhi*	*Jethwi*	*Katki*	*Aghani*	Total
1954-55	6,00,000	45,500	2,29,000	1,58,000	10,33,000
1953-54	4,26,500	15,500	1,61,000	51,000	6,54,000
1952-53	9,29,000	29,000	1,56,000	38,500	11,52,500

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