INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1941-42

1942

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INTRODUCTION

The Annual Report for the year 1941-42, whilst recording definite progress, does not cover as wide a field as in previous years, due to several unavoidable handicaps as a result of the present war situation. Less attention had to be paid to fundamental researches as the need arose for turning out moulding powders, injection moulded articles, adhesives and varnishes in fairly large quantities, directly or indirectly for military requirements. It may be noted, however, that the impetus of war-production has given the Institute the opportunity to give a commercial shape to some of the work which had so far been investigated only in the laboratory. Particular mention may be made of important industrial uses of modified shellac compositions for the manufacture of water-proof abrasive papers, laminated boards, instantaneous recording discs, insulating tapes, transparent varnishes for the manufacture of glass substitutes, etc. Besides, the large-scale production of thiourea from the "oxide-box" liquors of gas works, as a substitute for urea, has been perfected, opening up thereby an indigenous source for an essential chemical for the manufacture of shellac moulding powders and adhesives in general.

Although the semi-large scale development of new uses for lac has been the distinguishing feature of the work during the year, a much wider development along these lines has been limited by the difficulty in obtaining machinery, special equipment and chemicals. It may, however, be mentioned that industrialists who could improvise the necessary plant have largely drawn upon the results of the investigations at the Institute, which is a matter for satisfaction.

H. K. S.

Namkum,
July, 1942.

INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT FOR THE YEAR 1941-42

ADMINISTRATIVE SECTION

General. — During the year under review, the work of the Institute again showed an all-round progress. The services of Dr. H. K. Sen, M.A., D.I.C., D.Sc., F.N.I., as the Director, were renewed for a further period of five years and Mr. P. S. Negi, M.Sc., continued to officiate as the Entomologist during the year. The Institute was visited by a large number of interested people as usual.

Roads and Buildings. — The construction of the following buildings were sanctioned during the year but due to shortage of labour, etc., only item 2 could be completed during 1941-42.

1. Book godown,
2. A kutcha building at the Experimental Lac Factory,
3. Rest shed at Hesal.

Medical Aid. — Medical aid was rendered to the staff as usual.

Staff. — A number of acting and temporary appointments for short periods were made during the year in the Administrative and Chemical Sections.

In addition, the following new appointments were also made :

(a) Mr. S. P. Roy Chowdhury, B.A., Stenographer,

(b) Mr. S. C. Mukherjee, B.Sc., Junior Chemical Assistant, Class III, in the vacancy caused by the resignation of Mr. P.M. Sivaramakrishnan, M.Sc.,

(c) Mr. C. Tirkey, Laboratory Assistant and Setter, in the vacancy caused by the death of Mr. Bimal Tirkey, the former incumbent.

Mr. Bimal Tirkey, Laboratory Assistant and Setter of the Entomological Section, died after a brief illness. His death is very much regretted.

Staff Club. — The Staff Club continued to maintain its literary and social activities throughout the year.

Water Supply. —During the months of February and March 1942, about one million gallons of water were supplied to the Military.

CHEMICAL SECTION

1. Moulding Powders

(A) Shellac-formaldehyde-urea powder

The numerous enquiries from the Supply Department of the Government of India, as also those of private, bakelite-pressing establishments, made it clear that the moulding powder developed at the Institute had attained practical, commercial possibilities beyond doubt. Whilst work on the improvement of the original powder was carried on vigorously in many of its details, and whilst users of this powder have increasingly expressed their satisfaction as to its quality, compared with the same in previous years, the question of the supply of this powder by the Institute for commercial users became difficult due to the small output of the pilot plant at the Institute. It may be noted, however, that about 2 tons of this shellac moulding powder were supplied to various firms in India at cost price. It is to be noted further that Mr. Gurusharan Lal, Managing Director, Guraru Sugar Mills, Gaya, is putting up a plant close to the Institute for the manufacture of shellac moulding powder with a daily output of about 1 ton. He has also made arrangements for the manufacture of a few chemicals like urea and formaldehyde, small quantities of which are necessary for the production of this powder. It must be admitted, however, that the unavailability of these two chemicals has stood in the way of immediate widespread commercialisation of the modified shellac moulding powder evolved at the Institute. Attempts are being continually made to replace, wholly or partially, these two chemicals in the formulation of a powder which may serve trade requirements.

During the year under review, experiments on the use of other accelerators like aluminium chloride, phosphoric, oxalic and other acids have shown that in many instances, the use of small quantities of these, though not yielding the same high-quality powder as with urea and formaldehyde, gives powders suitable for the production of several types of useful articles. As an example, it may be mentioned that a powder containing only 1 per cent. urea and 1 per cent. aluminium chloride is suitable for the production of insulation boards, rods, hollow wares, etc., although not good enough to be used for the moulding of switches with intricate parts. It has also been found that thiourea can not only replace urea completely but also confers certain advantages both as regards the quality of moulded articles and quantity of the accelerator used. 3 per cent. of thiourea on the moulding powder has contributed to better gloss and water-resistance.

A process for the manufacture of thiourea in fairly large quantities has, therefore, been developed, starting from the cyanide liquor of Messrs. The Oriental Gas Co., Ltd., of Calcutta. An arrangement has been made with this Company for the supply of this liquor for a whole year and it is expected that 36 cwt. of thiourea would be available from this source alone, corresponding to about 60 tons of shellac moulding powder per annum, which may be considered to be adequate for a large portion of the demand for electro-technical goods in this country. This arrangement is specially

important as the manufacture of thiourea does not involve high-pressure technique as is the case in the manufacture of urea. A second method for the production of thiourea from carbon disulphide and ammonia has also been worked out. This latter process depending on charcoal, sulphur and ammonia, has much to recommend.

(B) Shellac-protein moulding powder

The work on shellac-protein moulding powder mentioned in last year's Annual Report was further continued to test the effect of different kinds of vegetable proteins on the quality of moulded articles and especially as to their water-resistance. Groundnut cake, after extraction of its residual oil, gives a material containing as high as 48 per cent. protein, and the residue as fibre. This material was mixed with varying proportions of shellac and additional fillers (*e.g.*, woodflour), and compounded with ammonia, lime and stearates to give, on drying, moulding powders from which articles of good gloss and moderately high heat-resistance were produced, but they are definitely weaker in strength and less resistant to water. Where these two latter properties are not of much consequence, such powders could be used with advantage as they are cheap and are derived from indigenous raw materials. The problem of water-resistance, however, has been solved by the application of a coating of the normal shellac-methylated spirit varnish in which 3 per cent. aluminium chloride on the weight of shellac used has been added. Such a modified shellac varnish coated on compressed jute boards, made from shellac-protein compositions and waste jute, has conferred high water-resistance after short baking at 80-90°C. for half an hour. A test piece immersed in water for 48 hours showed no signs of swelling or blushing. It is now proposed to construct an experimental hut to test the actual weather-resistance of such boards during the ensuing monsoon. A firm managing an important jute mill in Calcutta is taking steps to commercialise the above results and deputed one of their chemists to learn the work in all its details.

(C) Shellac-moulding powders (thermo-plastic)

The use of shellac for moulding articles on the hot and cold technique as practised in the gramophone record industry is as yet its largest outlet. Whilst this specific purpose is satisfactorily met by this technique, the application of this principle to the manufacture of utility articles was investigated with suitably constructed moulds. Plain shellac with appropriate fillers could obviously be worked, but neither the water-resistance nor the heat-resistance was sufficient to justify its use for common utility articles. The incorporation of certain proportions of calcium hydrogen phosphate and/or aluminium chloride improved the heat and water-resistance markedly and various articles of thin sections could be produced in a two-minute cycle, which is practically the cycle in ordinary hot mouldings. The discovery of these two accelerators in shellac moulding is very important in the present conditions, as both these chemicals are readily available in the country. The commercial implication of hot and cold moulding should not, therefore, be brushed aside without sufficient trial. Efficient mould design may remove many of the difficulties encountered in straight shellac mouldings.

(D) Cold moulding

Cold moulding is a very promising line of work that has been initiated during the year under review. Cold moulding with subsequent progressive baking has given rise to products

of excellent gloss and resistance to heat and water. The stoving enamel developed at the Institute (*vide Jour. Ind. Chem. Soc.* Vol. III, No 1, 1940) is mixed with fillers, especially asbestos, between hot rollers, and dried at 140°C. for 1 hour. The composition is then moulded at ordinary temperatures, 25-35°C. The article is taken out and allowed to bake at 80°C. for 24 hours, 110°C. for 24 hours and 130-140°C. for another 24 hours. The article is hard and resistant to water and mild acids and alkalis but slightly dull in appearance; on buffing, however, it acquires a high polish.

Similar products could be obtained by the use of shellac-drying oil compositions and shellac modified with fatty acids in presence of accelerators like aluminium chloride, maleic or phosphoric acid or its anhydride, urea or thiourea, etc., with asbestos or other mineral fillers. These compositions have been found suitable for the preparation of large battery-boxes, panels, boards, tiles, etc.

(E) Injection moulding

The main progress in this section during the year under review is the use of ammonia as the accelerator. It has been found that compositions made with ammonia as accelerator have different flow characteristics at different temperatures, depending on the amount of catalyst and independent of the time of curing. Thus, with the usual composition containing

Shellac	300	parts
Jute-waste	200	,,
Kaolin	100	,, (or barytes : 300)
Pigment	15	,,
Calcium stearate ..	9	,,

and using 1 per cent. of ammonia (0·88 sp. gr.) on the weight of lac, the flow temperature is about 110°C.; with 2 per cent., 125-130°C. and with 3 per cent., 150°C. With more than this amount of ammonia, the injection is impossible as it results in charring due to decomposition.

About 7,000 injection-moulded switches have already been sold by the India Moulding Company of Calcutta and it is reported that no complaint has so far been received regarding their performance. The extent of the sale of this type of switches seems to be limited only by the unavailability of metal parts for fitting up the article.

(F) Fibrous fillers

As was reported last year, the difficulty of importing wood flour from abroad, as also the fundamental need for manufacturing a standard wood flour in India for a sound plastic moulding industry, led the Institute to the investigation of suitable methods for the large-scale production of fibrous fillers in general. Two distinct methods, 'wet' and 'dry', were investigated and it was found that for all ordinary purposes, no appreciable difficulty need be envisaged in the supply of this material, given proper grinders, sifters and air-flotation equipment. Even the ordinarily ground saw-dust when repeatedly sifted gives a flour good enough for incorporation with resins. During the year under review, waste pulp from paper mills was also tried as a filler and was found to yield mouldings of considerable strength. Such pulp, without further disintegration, yielded a filler suitable

for high shock-resistant mouldings, the use of which for special purposes could be visualised. The Committee proposes to co-operate with a firm of paper manufacturers in Calcutta to investigate thoroughly the use of the by-products of that industry in conjunction with lac for various possible applications.

Bagasse, a by-product of the sugar industry, can also be ground and used as a filler, although the moulded product is not as strong as when wood-flour is used.

Jute waste, which is being used successfully as a filler in injection-moulded articles for the last two years, was examined further for various other articles, and boards of different types have been moulded which have a great commercial future in this country (*supra* under Moulding Powders).

2. Varnishes and Lacquers

During the year under review, several enquiries for elastic, baking varnishes for the manufacture of water-proof emery paper, protective paper for gauze during sterilisation and water-proof packing paper were received. Suitable compositions, depending upon the condensation of the shellac-urea-formaldehyde resin with varying quantities of fatty acids, *e.g.*, linseed oil fatty acids, stearic acid, oleic acid, etc., and maleic anhydride or aluminium chloride were evolved. These were tested in commercial establishments and were reported to be satisfactory. A typical method of preparing such a varnish is as follows :

> 700 gms. of lac are treated with 180 gms. linseed oil fatty acids or oleic acid, at 140°C. for 1-2 hours. The resin is then dissolved in 1000 cc. of butyl alcohol to which are added 105 gms. paraformaldehyde and 35 gms. urea. The whole is refluxed for 2 hours at 120°C. To this solution are added 14 gms. maleic anhydride and the mixture is distilled under vacuum until as much butyl alcohol as possible (about 700 cc.) is recovered. The solution is thinned with solvent naphtha to make up 2500 cc. The varnish is used for coating paper or cloth on which emery powder is laid. On subsequent baking for 2 hours at 110-120°C., an excellent material is produced which is approved by the Railways.

Mention was made in the previous Annual Report of the preparation of a black baking varnish from *kiri* and refuse lac. Occasional gelling of this varnish used to occur on keeping, but it has now been found that the varnish may be preserved without deterioration for any length of time, if the thinner used is a mixture of kerosene and turpentine.

3. Adhesives

Interaction of unsaturated dibasic acids like maleic acid, fumaric acid, etc., or their anhydrides, with shellac, shellac acids or esters in the presence of solvents followed by the action of benzoyl peroxide has given rise to resins of extraordinary adhesive properties which could be made use of for joining glass to glass, glass to metal or metal to metal.

4. Shellac-Rubber Combinations

The work on the combination of shellac with rubber was continued during the year with conspicuous success in certain directions. Whilst a detailed and systematic

study of the properties of vulcanised rubber and vulcanised shellac-rubber combinations is being made, particularly as regards abrasion, action of solvents, effect of water, etc., several useful and practical results have been already obtained.

(1) The mastication of crêpe-rubber with fillers and vulcanising materials takes considerably less power and time in the presence of shellac, the shellac acting mainly as a plasticiser.

(2) The introduction of a certain amount of cement as a filler along with the normal vulcanising agents and active fillers increases the water-resistance markedly and, to some extent, resistance to hydrocarbon solvents.

(3) There is no special difficulty experienced in vulcanising shellac-rubber combinations and moulded goods can be produced with 5 minutes' cure at 145°C. Shoe-heels of satisfactory toughness and flexibility have been prepared in this way.

(4) Apart from other valuable properties expected from the combination of rubber with shellac, there are definite reasons to believe that shellac defers ageing of rubber.

(5) The vulcanised stock of rubber in conjunction with 10 per cent. shellac renders the flow of the material 20 per cent. more than that of vulcanised rubber without shellac.

(6) Low-temperature carbonisation tar, when aerated at 120°C. in the presence of small percentages of sulphur until all the moisture has been removed, serves as a medium-quality vulcanising agent for rubber-shellac compositions. This is important in view of the difficulty of importing synthetic vulcanising agents at the present time.

A firm in Bombay is at present investigating the possibilities of the manufacture of renovated tyres out of a rubber-shellac composition prepared at this Institute.

5. Fundamental Researches

(A) Solutions of shellac and related materials in mixed solvents

The study of the extreme case of the dissolution of a substance in a mixture of non-solvents, which is so common among varnish components, was continued. This research was limited to a study of viscosity, solubility and gelation capacity of such systems.

The viscometric studies have been completed and a fairly complete understanding of the viscosity behaviour has been arrived at, based on experimental studies of the following systems: shellac in acetone-water, acetone-glycol, methyl acetate-glycol and acetone-alcohol; ethyl cellulose in cyclohexanol-cyclohexane and alcohol-toluene; ½″ R.S. nitrocellulose in alcohol-dioxane; and glyptal in n-butyl acetate-ethyl alcohol. The results are too elaborate to be reported here, and have been compiled and published in the Journal of the Indian Chemical Society (*vide*, *Jour. of the Ind. Chem. Soc.* Vol. XIX, 1942).

Quite a comprehensive study has been made of the solubility and gelation limits of shellac in a mixture of two latent solvents, *e.g.*, acetone-glycol, methyl acetate-glycol,

or in a solvent-latent mixture, *e.g.*, alcohol-acetone. The results have been incorporated in a paper now ready for publication.

The theoretical implications of these results are helping to understand the mechanism of film formation in varnishes and are affording an insight into such vexed questions as solvent power, optimum solvent composition and allied topics. The immediate practical application of these results has been to evolve a suitable method of manufacture of the pure resin of shellac (α-lac), as discussed in a later section of this report.

(B) Volume and surface resistivity of lac mouldings

As reported in the last Annual Report of this Institute, a study was undertaken to determine the volume and surface resistivities of a number of shellac moulded discs of different compositions. Preliminary experiments had shown that the resistivity was too high to be measured with an ordinary, sensitive D.C. galvanometer. An apparatus was, therefore, assembled using a Philips 4060 electrometer triode for the determination of this high resistivity using the electron-tube method. Mercury electrodes were used and most of the determinations were made at a constant potential of 150 volts. The effect of humidity was studied over a wide range and the temperature variation of volume resistivity of a few compositions was also recorded. It has been observed that at ordinary temperatures (25-35°C.) and 50 per cent. relative humidity the volume resistivity of shellac moulded discs of various compositions usually lies within $3{\cdot}5\times10^{13}$ and $2{\cdot}5\times10^{14}$ ohm-cms. Thus, shellac plastics may safely be classed among those materials which have a high value of volume or surface resistivity.

The results of this investigation have been included in a short paper which is under publication in a scientific journal.

(C) The effect of surrounding medium on the dielectric strength of lac and lac moulded materials

As the knowledge of the dielectric strength of insulating materials in different surrounding media is of utmost practical importance, a study was undertaken to find the effect of such media on the breakdown voltage of shellac moulded materials. The electrodes used were a sphere and a plate made of brass and the rate of application of voltage was approximately 0·5 kv. per second. The voltage was measured on the secondary side of the H.T. transformer by means of an electrostatic voltmeter. Six liquids, *viz.*, transformer oil, xylol, kerosene, turpentine, castor oil and a mixture of xylol and acetone were used successively in the test-jar, and discs of different thicknesses were employed in order to find out the effect of thickness on the breakdown-voltage in each liquid medium.

It was observed that castor oil gave the lowest dielectric strength values among the liquids used for shellac as well as the shellac-urea-formaldehyde-woodflour composition. The liquids when arranged in the ascending order of dielectric strength are castor oil, transformer oil, kerosene oil, xylol, spirit of turpentine and a mixture of xylol and 12 per cent. acetone.

The variation of breakdown voltage with thickness of lac as well as lac moulded material has been found to follow the logarithmic law. The nature of breakdown has also been studied carefully and it has been found that the puncture is almost invariably associated with a small crater formed by the melting of the resin.

These results have also been included in another paper which is under publication.

6. The Improvements in the Manufacture of Shellac, etc.

(A) Improved seedlacs

The manufacture of improved seedlacs by the Institute process has been undertaken by a manufacturer in Ranchi. Shipping difficulties have, however, prevented his exporting such lacs to foreign countries. Some of the paint firms in India have approved of the quality of such improved seedlacs as obtained by the Institute process of washing and salt flotation. With a general demand for improved seedlacs, whether at home or abroad, this method will, it is hoped, be taken up by manufacturers in future.

(B) Low-wax shellac for the particular industries

From the information received through the Special Officer Lac Inquiry, London, it is found that the electrical industry definitely prefers low wax-content shellac for their work. By suitable blending of different grades of seedlac, a low wax-content shellac with not more than 3·5 per cent. wax has been prepared by the indigenous method of manufacture. As a matter of fact, a firm in Ranchi produced a fairly large quantity of this special shellac by this method, samples of which were forwarded to the Special Officer Lac Inquiry, London, who, after getting them tested by the electrical and gramophone-record industries, has expressed a favourable opinion and who now wishes to inaugurate a regular trade between India and England in this type of shellac.

(C) Pure resin of shellac

Processes have been developed for the preparation of pure resin from shellac by treating it with pure ethyl acetate or the same diluted with an equal volume of benzene. The process yields pure resin (α-lac) containing less than one per cent. soft resin and less wax in a one-step treatment at room temperature and is free from filtering and solvent recovery difficulties due to sticky residues. Details of the process have already been published (*vide Jour. of the Ind. Chem. Society, Industrial and News Edition,* 1942, Vol. V, No. 1).

(D) Improved bleached lac

Lac bleached by hypochlorite, as is well known, tends to lose its solubility in alcohol on continued storage, more especially, in a warm climate. By the use of a small percentage of polyhydric alcohols, the solubility of bleached lac can be indefinitely maintained. This discovery would go a long way in improving the marketing possibility of bleached lac which is required for various industrial purposes.

7. Gramophone Records and Sound-Recording Discs

The work under this heading started about three years ago and several compositions, mainly containing shellac, were tried for sound reproduction. Whilst some of these

were found to be suitable for pressing with the gramophone master with metal or laminated-paper cores, they were not found suitable for instantaneous sound recording, the chief disadvantages of such compositions being want of balance between elasticity and hardness. On the one hand, shellac is brittle and too hard and on the other, shellac-acetic acid-glycerine ester compositions are too soft. A mixture of the two, however, gave promise of satisfactory sound reproduction with this difficulty, however, as noticed in the early stages of the experiment, that there was considerable "orange-peel" effect. To overcome this difficulty, use of various high-boiling solvents and incorporation of waxes were resorted to, resulting only in slight improvements. Esterifying lac with higher fatty acids in general, a marked improvement in sound reproduction quality was noticed, but it was still far short of the standard demanded of high-grade commercial discs. After numerous experiments, the following composition has been found to give the desired result:

> Linseed oil fatty acids (30 gms.) are heated with vigorous stirring to 140°C and dewaxed lac (100 gms.) is added in small lots. The temperature is then raised to 175°C. and glycerine (9·5 gms.) is added. The mixture is maintained at this temperature for one hour, cooled to 120°C. and dissolved in alcohol (900 cc.).
>
> 200 cc. of this solution are then diluted with 240 cc. of alcohol and vigorously stirred; 100 gms. powdered dewaxed lac is now dissolved in this solution to which is also added 60 cc. of n-butyl alcohol. The varnish may be coloured by any desired alcohol-soluble dye.

The varnish prepared as above is filtered through chamois leather or centrifuged and applied to the disc (aluminium, glass or paper) by spinning on a turn-table protected from dust and baked at 85-90°C. for ½ hour. Six to eight coats are necessary for a finished disc.

Whilst this composition maintains its cuttable properties for any length of time, a very much simpler composition has also been devised, which, however, suffers from the disadvantage of poor keeping quality. The defects are of two kinds, (i) continuous hardening on keeping to a degree which renders it unfit for cutting after a time, and (ii) cold flow after cutting. This second defect may, however, be rectified by chemically hardening the surface immediately after cutting. A typical composition of this type, which may be recommended, is prepared as follows:

> Dewaxed lac (60 gms.) is dissolved in alcohol (100 cc.) and the solution refluxed for 12-18 hours with tricresyl phosphate (24 gms.) and zinc oxide (1·8 gms.). The resulting solution is thinned with about 160 cc. of a mixture of alcohol, benzene and tolouene in the proportion of 62·5 : 25 : 12·5 and coloured with nigrosine black. The varnish is applied as described above and the baking is carried out at 45°C. for ½ hour after each coat.

8. Semi-Large-Scale Preparations

(1) A process for the manufacture of formalin from ethyl alcohol (and not methyl alcohol) was mentioned in the previous Annual Report. Details of concentrating

weak solutions of formaledhyde have been worked out in the current year and a pilot plant, which is nearly ready, will reveal its commercial possibilities during the early months of the next financial year.

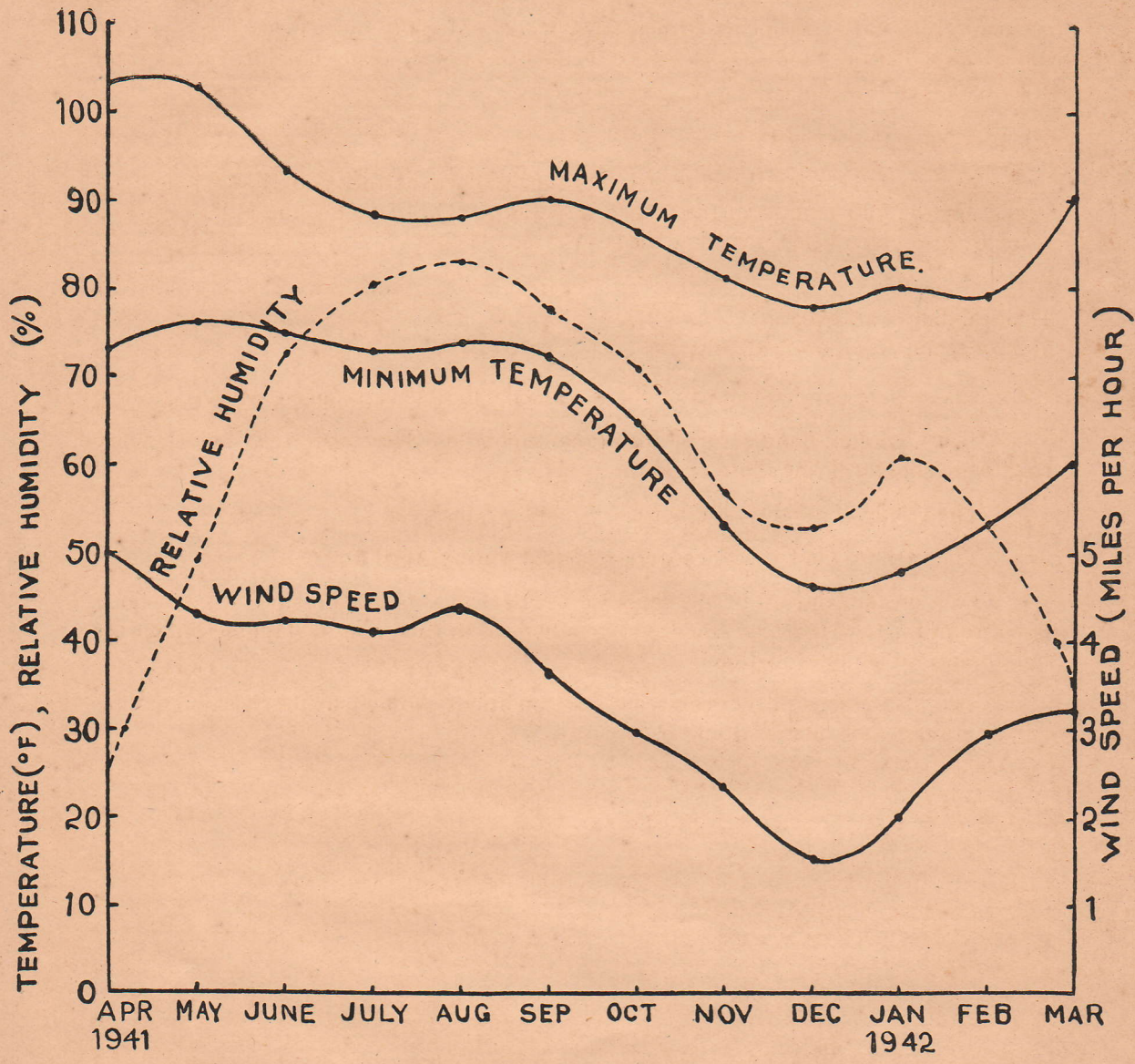
(2) Further experiments on the technical preparation of urea from calcium cyanamide have been carried out, resulting in somewhat increased yields than in the past. The method for the preparation of thiourea (*loc. cit.*) has also been developed. The Lac Products Ltd. is constructing a plant for the technical manufacture of urea from ammonia and carbon dioxide, which is being erected in Calcutta. This will very considerably improve the prospect of manufacturing shellac moulding powders, as urea is the only chemical which had for so long to be imported from abroad.

(3) Manufacture of tartaric acid was taken up initially for emergency supply to the Medical Department of the Government of India. All details for its manufacture from tamarind have been worked out at the Institute. There is reason to believe that this acid in a modified form is also likely to be of use in the moulding powder and the varnish industries depending upon shellac.

9. 'Ad hoc' Investigations

Experiments were undertaken for and suggestions given to the following enquirers. In most cases, samples of powders and products were also supplied.

Asiatic Trading Co., Ltd. ..	Anti-gas fabrics.
Brown & Dureau Ltd., Australia ..	Injection moulding powders.
Mr. Gurusharan Lal of Gaya ..	Shellac moulding powder manufacture.
Asbestos & Engineering Co. ..	,,
Plastics Products Ltd. ..	,,
Rohtas Industries Ltd. ..	,,
Schaffermann Bros., Palestine ..	,,
Burmah Oil Co., Rangoon ..	Insulation boards.
Strawboard Mfg. Co., Saharanpur ..	Water-proof emery paper.
Do do ..	Use of bagasse as filler in shellac moulding compositions.
All-India Radio, Delhi ..	Sound-recording blanks.
Army Headquarters, Simla ..	,, ,, wax.
National Radio & Engineering Co. ..	Radio components of laminated paper and moulding powders of shellac.
India Moulding Co. ..	Insulation boards.
India Electric Works Ltd. ..	,,
The Lahore Foundry & Workshop Ltd.	,,
Viswakarma Ltd. ..	Moulded screw caps.
Radio Lamp Works, Karachi ..	Cement for fixing electric bulbs to brass sockets.
Mazda Electric Stores, Lucknow ..	Empire cloth and insulating tapes.
India Electric Works, Calcutta ..	Empire cloth.
Rohtas Industries Ltd. ..	Finishing varnish for artificial leather board.
Premier Stores Supplying Co., Ltd. .. Calcutta.	Moulding powder.


110
100
90
80
70
60
50
40
30
20
10
0
TEMPERATURE(°F), RELATIVE HUMIDITY (%)
WIND SPEED (MILES PER HOUR)
5
4
3
2
1
MAXIMUM TEMPERATURE.
MINIMUM TEMPERATURE
RELATIVE HUMIDITY
WIND SPEED
APR 1941
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
JAN 1942
FEB
MAR

Moulding powders were sent out to several firms and it may be mentioned that Messrs. Siemens Electrical Co., Ltd., have found the product entirely satisfactory. By personal visits and experiments at their own works, Messrs. India Electric Works Ltd. and Messrs. Plastic Products have been helped to produce many moulded articles for urgent war requirements.

METEOROLOGICAL REPORT

The rainfall during the year was very much above normal and so was the total rainfall for the four months of the monsoon period. The data for the two preceding years are also given below for comparison—

	1941-1942.	1940-1941.	1939-1940.
Total rainfall (April-March) ..	75·25 ins.	50·32 ins.	57·85 ins.
Monsoon rainfall (June-September) ..	58·65 „	42·33 „	41·54 „

There were two hailstorms of slight to moderate intensity during May 1941.

The minimum temperatures during November and December 1941 and January 1942 were slightly below those of the previous year.

The relative humidity was normal throughout the year.

The highest wind velocities were recorded during April 1941.

Data on the hours of bright sunshine per day could not be obtained due to shortage of recording charts which could not be obtained in time due to shipping difficulties and absence of supplies in India.

The fluctuations in the meteorological conditions throughout the year are graphically represented on the foregoing page.

ENTOMOLOGICAL SECTION

1. Demonstration Campaign

Demonstration work was continued in Chota Nagpur Division and Santal Parganas in Bihar, and Malda and Murshidabad districts in Bengal. The campaign was extended to Mirzapur district in U. P.

Baisakhi 1940-41 crop—In Bihar, demonstration was given on 161 *ber* (*Z. jujuba*) and 309 *palas* (*Butea frondosa*). Special attention was given to *ber,* as practically all the crop from it is cut *ari* (immature) and the cultivators who cultivate lac on *ber* alone have to resort to purchase of brood to grow the next *Katki* crop. After a great deal of persuasion, a few villagers adopted on 19 third-grade trees the method of partial pruning developed by the Institute *to preserve brood lac on ber in summer*, but even out of these, the owners of only six trees allowed the brood to mature on them. Even though the summer of 1941 was extremely severe, brood lac survived to maturity on four trees ; 23 seers and 8 chattacks of brood lac were obtained from these four trees. The ratio of brood to *ari* scraped lac varied from two to nearly four. It was the first time that preservation of *Baisakhi ber* brood lac was demonstrated on the villagers' own trees.

Katki 1941 crop—The brood lac obtained from 3 partially pruned *Baisakhi ber* trees was put by a cultivator on 5 of his *ber* trees to grow the *Katki* crop. The brood to yield ratio of scraped lac in the resulting *Katki* crop was 1:2·5. In the Santal Parganas, where the last *Baisakhi* crop had died due to parasitisation, brood was again supplied from Namkum and the ratio of brood to yield was 1 : 2·4.

Jethwi 1941 crop—The two *Kusmi* crops (the *Aghani* and *Jethwi*) are generally cultivated on *kusum* (*S. trijuga*) which takes about one and a half years after pruning to put forth shoots fit for lac cultivation. In the absence of pruned trees and to demonstrate to the villagers that even *kusum,* which is the most green of all the lac hosts, requires regular pruning to ensure profitable cultivation, demonstration was given on 25 unpruned *kusum* trees. The brood to yield ratio varied from 1 : 0·4 to 1 : 3·2 depending on the type of shoots available on different trees.

Aghani 1941-42 crop—116 unpruned *kusum*, 5 *khair* (*A. catechu*), an alternative host with *kusum* recommended by the Institute, and 1 *ber* were used. Luckily one lot of *kusum* which contained 41 trees had good shoots. Due to rise in prices of lac, thefts of lac forced the owners to cut the crop *ari*, though the Institute is not in favour of *ari* cutting particularly from *kusum*. The owners of two lots of trees did not keep any record of *ari* lac cut, but the owners of the other two lots containing 41 and 68 trees kept a record and the ratios of brood to yield, in these two cases, were 1 : 8·7 and 1 : 3·7 respectively. The owner of 68 trees is the Lal Sahib of Palkot who is cultivating lac along improved methods on a co-operative basis between him and some of his tenants. The Lal Sahib, as desired by the Institute, was not in favour of cutting the crop *ari*, but the tenants did so without his permission and it was by the personal intervention of the Entomologist that the tenants could be persuaded to keep lac intact on a few trees at least for brood purposes. The yield figures (1 : 8·7) from 41 *kusum* and 5 *khair* trees are particularly interesting, and it is a pity that one of the cultivators whom the

Institute has been helping since January 1941 is not co-operating now when he has systematically pruned trees for cultivation.

Baisakhi 1941-42 crop—Since September 1941, in regard to *Rangini* crops emphasis is being laid on demonstration of (i) advantages of cultivating lac on trees by

TABLE I

Number of partially pruned *Ber* trees and percentage which had put forth new foliage by February 1942 and condition of new growth

AREA	TIMES OF PARTIAL PRUNING					
	A few days before infection Sept.-Oct.		After infection Nov. 4th week — Dec. 1st week		After infection Dec. 4th week — Jan. 1st week	
	No. partially pruned	% with new growth and foliage	No. partially pruned	% with new growth and foliage	No. partially pruned	% with new growth and foliage
CHANDWA, Palamau	6	100% with new shoots upto 14″ long & a second set of new leaves	6	100% with new shoots upto 14″ long & a second set of new leaves in large numbers	5	40% with new shoots upto 3″ long
VILLAGES NEAR LATEHAR, Palamau	4	100% with new shoots upto 2′ long & a second set of new leaves	5	100% with new shoots upto 2′ long	5	100% with new shoots upto 1′ long
*MAKO GOVT. ORCHARD, Palamau	50	20% with new shoots upto 1½′ long & a second set of new leaves	100	2% with new shoots upto 6″ long	20 in last week of Dec. 80 in second week of Feb. as the Forest Dept. had no money left in the budget to prune in Dec.	15% with new shoots upto 9″ long So far no new growth
KHUNTI, Ranchi			7	100% with new shoots upto 6″ long	30	100%
PALKOT, Ranchi	5	100% but due to faulty pruning, the foliage withered	6	No response, faulty pruning	6	No response, faulty pruning
BALRAM-PUR, Manbhum	9	100% with new shoots upto 2′ long	9	33% with new shoots upto 3″ long. Partial pruning not satisfactory	10	100% with new shoots upto 8″ long
**PAKUR, Santal Parganas	27	No response	24	No response	23	No response

* In this area the reasons for poor response are (1) *ber* thrives well in or around cultivated fields or grazing grounds, but the orchard is full of wild grass and (2) the infection was rather heavy.

** The demonstrator could not persuade the villagers to give a proper trial to partial pruning, which was done very indifferently. This area, however, is very interesting both from the point of view of demonstration and experiments in cultivation. The last *Baisakhi* crop was a failure in this area due to 53·3 per cent. parasitisation by *Chalcidoidea*. In the present *Baisakhi* crop, the *Chalcidoidea* attack is 41·5 per cent. and there is preponderance of males (75 per cent.); this crop therefore will again be a failure. It is intended to investigate the problem more critically during the coming year.

coupe system, (ii) preservation of *ber* brood lac in *Baisakhi* crop by partial pruning, (iii) in localities where *palas* and *ber* are both owned by one owner, the cultivation of *palas* for the *Baisakhi* crop and of *ber* for the *Katki* only. In this season, it has been possible to persuade the cultivators to try No. (ii) only. Experience has shown that optimum times for partial pruning are not the same for different localities even in the same district and therefore the first attempt is to find these for each locality where demonstration is being given. The results so far obtained are shown in Table I.

Jethwi 1942 crop—Demonstration is being given in two areas of Ranchi district and as a preliminary trial, in Mirzapur district, U.P.

Brood lac distributed free of cost

	Quantity Mds. Sr. Ch.	Cost Rs. As. P.	Remarks
Rangeeni	23 5 0	672 8 0	
Kusmi	11 18 8	273 10 0	

The Bengal demonstrators report that the cultivators are adopting the improved methods of cultivation.

In addition to routine work, demonstrators also attend various exhibitions on resquest from the authorities.

The Provincial Governments of Bengal and the United Provinces have agreed to inaugurate schemes of extensive demonstrations of improved methods of lac cultivation in a certain number of centres in their provinces.

2. Plantation

Bogamedallor *(Tephrosia candida)* was first sown in 1937, in the *kusum* plot No. 21, with a view to improve the soil and the growth of *kusum* (*S. trijuga)* trees. Since then, it was allowed to stand in the plot and seed collected every year to propagate it in other plots. After a trial for 4 years, it was found that 11 *kusum* trees had died, 86 were so badly affected that they had to be cut near the base to allow regeneration, and out of 492 trees in 12 rows pruned two years previous to June 1941, only 240 were found infectable in June 1941. This shows that the continuous existence of bogamedallor is harmful to *kusum;* it has, therefore, been uprooted from most of the plots, and during the next two years, it will be tried only as a green manure. Guinea (*Panicum maxicum*) and sabai grass are progressing satisfactorily. Yields of various products are as follows:

	Mds.	Sr.	Ch.
* Scraped lac yield including lac used as brood ..	12	17	8
Sabai grass	40	7	0
Guinea grass	24	2	0
Bogamedallor seed	0	36	0
Tung oil seed	0	1	8
Arhar seed	0	25	0

* N. B.—Over and above this, 5 maunds of *Khair* brood lac was sold for Rs. 150/-.

In spite of the severe summer, *Albizzia lucida* and *Dalbergia lanceolaria* this year too proved good *Baisakhi* brood-carrying hosts. However, several more trials are necessary to establish the fact. The *Jethwi* crop was good this year.

Since *kusum* and *palas* trees have been taken on lease near about the Institute for biological control experiments, cultivation of lac on *palas* and *kusum* in the whole plantation and on *ber* in one block has been stopped so that they may improve in growth. These trees were used for experimental cultivation from age 2 to 5 years with the result that their normal growth has been very much retarded. This is best illustrated by the fact that out of all *palas* trees which are about 20 years old now, only 6 have flowered this year for the first time.

3. Insect Enemies of Lac Host Trees

(1) *Tesaratoma javanica*, Thumb. (Pentatomidæ).—It was controlled on *Schleichera trijuga* by hand picking.

(2) *Aspidiotus orientalis*, Newst. (Coccidæ).—The coccid was not prominent.

(3) *Termites*.—143 termitaria were fumigated. Petrol proved the most satisfactory fumigant.

(4) *Pachonyx quadridens*, Chevr.—The weevil causes galls on *Palas (Butea frondosa)* leaf petioles. It is found in fair numbers in Kundri.

4. Bionomics of Laccifer Lacca (Kerr.)

1. Parthenogenesis—The fifth generation of the strain is developing satisfactorily. The average fecundity in the third generation was 177·2 and in the fourth 259·7.

2. Selection—The fifth generation of the yellow strain is in the field now. So far, there is no change in colour, but mortality is very high.

3. Mortality and fecundity

	Strain	Average mortality %	Fecundity
Baisakhi 1940-41—	Ber × Ber	52·7	265·2
	Ber × Palas	50·9	329·1
	Palas × Palas	54·7	432·2
	Palas × Ber	53·7	280·5
Jethwi 1941—	Kusum × Kusum, Hesal	53·1	309·6
	Kusum × Kusum, Berwari	60·5	319·6
Katki 1941—	Ber × Ber	50·0	204·8
	Ber × Khair	44·6	331·0
	Ber × Palas	46·1	388·8
	Palas × Palas	43·3	398·2
	Palas × Khair	43·4	365·0
Aghani 1941-42—	Kusum × Kusum, Hesal	70·0	245·3
	Kusum × Kusum, Berwari	70·0	143·3
	Kusum × Khair	54·0	156·0

Fecundity in the *Baisakhi* strains was lower than in the previous year, probably due to comparatively severe summer. Mortality in *Kusum* × *Khair* strain is less than in the pure *Kusum* strains, but much importance cannot be laid on this because in Berwari the crop was raised on unpruned trees and in Hesal the shoots resulting from pruning were on the whole rather too thick for the lac insects to survive in large numbers.

4. Improved cultivation on Palas (*Butea frondosa*)

(*a*) *Preservation of the Baisakhi Palas brood lac of the lac insect*

Palas is the most widely prevalent host for lac in India. But at least two-thirds of the *Baisakhi* crop has to be cut *ari* (immature) in April-May. The chief reason for cutting the crop *ari* is that due to leaf-fall, *Palas* is practically naked in the first half of the summer season and therefore, in hot districts, the majority of the female lac insects die due to drought and the low biological activity of the host. The result is that (i) the cultivator gets only about half the quantity of lac that he would get if the insects survived in normal numbers till maturity as they do in the *Katki* crop when such adverse conditions are absent; (ii) there is scarcity of brood lac to infect the next crop and therefore an extremely disproportionate distribution of trees to grow the *Katki* and *Baisakhi* crops.

To overcome the above difficulties an experiment was started in the Bihar Government forest, Kundri, in October 1940. About three-fourths of the leaves with their long leaf-stalks (4″ to 7″) were removed from 100 trees in October 1940 and infected with lac, and another 100 comparable trees without any treatment were infected as control. The experimental technique resulted in the economy of brood lac to the extent of 1 maund and 9 seers, because most of the leaf-stalks, which share the settlement of lac larvæ equally well with twigs, had been removed from the experimental trees. The leaves were removed to induce new foliage earlier than it naturally occurs on *palas*. By the end of March 1941, 20 per cent. of the experimental trees had put forth new foliage against 4 per cent. of the control. At crop maturity, due to the severe summer, the control trees did not yield practically any brood lac, while the experimental trees yielded 1 maund 23 seers and 8 chhattacks of brood lac.

This year from 68 trees pruned in March, three-fourths of the leaves were removed in the first half of September instead of October, *i.e.*, about a month prior to infection of *Baisakhi* 1941-42 crop. 73·5 per cent. of these trees had begun to put forth new leaves or buds by the time of infection of *Baisakhi* crop in October. Practically speaking, no settlement of lac larvæ took place on the new leaf-stalks. Another lot of 98 trees, which was pruned in the end of May for *Baisakhi* infection, had not put forth suitable shoots, but to get some idea of their behaviour, three-fourths of the leaves from this lot were removed just before infection in October; by the first week of November, 20 per cent. of the trees had begun to put forth new leaves. By the first week of February, out of 69 partially defoliated in September, 81·1 per cent. had some early-developed new leaves, 10·1 per cent. had begun to put forth a second set of new leaves and 8·1 per cent. of the trees had not responded. Out of the second lot of 98 trees, 60 per cent. of the trees had begun to put forth new leaves. In the control trees the new leaves had not yet begun

to appear. But in both the experimental coupes there was a high mortality in the winter-developed buds.

(*b*) *Artificial infection and pruning period*

The recorded opinion of the Forest Officers, Bihar, is that artificial infection of *palas* in the *Katki* (June to October) season is a failure in hot arid areas like Kundri. The chief reason given for the failure is that the shoots resulting from pruning *palas* in February to March are unsuitable for the *Katki* infection. But as artificial infection is preferable to natural infection for various reasons, an attempt was made to get over this difficulty.

100 trees were pruned in early February and 100 in the end of March. On both occasions, shoots not more than $\frac{1}{2}''$ in diameter were pruned. At the time of the *Katki* crop infection in July it was found that both February and March prunings resulted in shoots upto 7 feet long, but on the whole shoots resulting from early February pruning were better. The resulting *Katki* crop, in spite of the poor quality of brood lac used and thefts of lac, was satisfactory.

5. Insect damage to stored lac—During the rains, the roofs of the godowns where lac was stored leaked badly and the samples became unfit for an accurate evaluation of damage in storage.

5. Insect Enemies of Lac

1. Predator enemies—*Eublemma amabilis*, Moore (Noctuidæ) and *Holcocera pulverea*, Meyr. (Blastobasidæ) continued to be the major enemies of lac, but the latter was more prevalent than the former. Of the minor pests, *Chrysopa sp.* continued to be the more important and the damage caused by it does not appear to be as negligible as is generally believed.

Work was concentrated on the biological control of *E. amabilis and H. pulverea.*

2. Parasite enemies—The average parasitisation in the Institute plantation was 4·6 per cent. in the *Katki*, 8·0 per cent. in the *Baisakhi* and 6·8 per cent. in the *Aghani*. In the biological control areas, it was lowest in the *Jethwi* crop, being 3 per cent., 10·5 per cent. in the *Baisakhi* and 13·4 per cent. in the *Aghani*. But the parasitisation in the current *Baisakhi* crop in the villages of Santal Parganas under demonstration was 41·5 per cent. against 53·3 per cent. of the last crop.

The following eight species of parasites of *L. lacca* were bred during the year as usual:

(i) *Eupelmus tachardiæ*, How. (Eupelmidæ)
(ii) *Tachardiæphagus tachardiæ*, How. (Encyrtidæ)
(iii) *Tachardiæphagus somervilli*, Mahd. (Encyrtidæ)
(iv) *Parechthrodryinus clavicornis*, Cam. (Encyrtidæ)
(v) *Erencyrtus dewitzi*, Mahd. (Encyrtidæ)
(vi) *Coccophagus tschirchii*, Mahd. (Aphelinidæ)
(vii) *Marietta javensis*, How. (Aphelinidæ)
(viii) *Tetrastichus purpurius*, Cam. (Eulophidæ)

6. Control of Insect Enemies

A. Artificial control

Water immersion—A research paper on the subject is under publication. Water immersion is within easy reach of every cultivator. All portions of crop cut at various times of the year except the one which is selected for brood lac should be tied into bundles and immersed in water, after cutting and before scraping, for three days either in running water or stagnant ponds; in the latter case, the water level should remain over two feet high above the immersed bundles of lac. The selected portion of the crop which has been used as brood should also be removed soon after the lac larvæ have swarmed out from it and similarly treated. This procedure prevents a large number of enemy insects emerging from the cut crop and stored lac in godown and reinfecting the standing crops.

It also makes scraping of lac easy and reduces the quantity of dust in the scraped lac.

Shellac manufacture and the physical and chemical properties of the manufactured shellac are not adversely affected.

B. Biological control

So far as parasites of lac are concerned, no naturally occurring, known hyperparasite seems to be good enough and likely to prove a successful biological control. Control of predators of the lac insect by the following continued to be studied:

(*i*) *M. greeni* and *M. hebetor*—Work was concentrated on the control of the predators *E. amabilis* and *H. pulverea* by *M. greeni* and *M. hebetor*.

(*ii*) *Trichogrammid egg parasites*—Breeding of both species *Trichogrammatoidea nana*, Zehnt., and *Trichogramma minutum*, Riley, was continued satisfactorily.

Both the species parasitise *E. amabilis* eggs readily and develop in them, but to emerge out, the adult finds considerable difficulty in cutting a hole of sufficient dimensions in the egg-shell of the host. To facilitate cutting a bigger hole, external moistening of the egg-shell by application of water, normal salt solution, etc., was tried but the results did not prove very encouraging. However, it is expected that when work is concentrated on the chalcids, it may be possible to breed a strain which will easily cut a hole of suitable size.

(*iii*) *Other parasites of lac predators*—The following were observed and bred during the year and are given in order of their importance:

(a) *Apanteles tachardiæ*, Cam. (Braconidæ)—It is the most important indigenous parasite of *H. pulverea* and deserves a trial when *M. hebetor*, the introduced parasite, has been fully explored and its value as a biological control in the field has been assessed.

(b) *Periseriola sp.* (Bethylidæ)—An ecto-parasite of *H. pulverea* larva.

(c) *Elasmus claripennis*, Cam. (Elasmidæ)—This is an ecto-parasite of *E. amabilis* larva but one species of this which has not yet been identified was for the first time found parasitic on *H. pulverea* larva this year.

(d) *Pristomerus testaceicollis*, Cam. (Ichneumonidæ)—It is an endo-parasite of both *E. amabilis* and *H. pulverea* larvæ.

(e) *Eurytoma paldiscapus*, Cam. (Eurytomidæ).

(f) *Brachymeria tachardiæ*, Cam. (Chalcididæ)—A pupal parasite of *H. pulverea* and *E. amabilis*.

(g) *Apanteles fakrulhajæ*, Mahd. (Braconidæ).

(h) *Chelonella cyclopora*, Franz. (Braconidæ).

7. Field Experiments on Biological Control

M. greeni was used to control *E. amabilis* and *M. hebetor* to control *E. amabilis* as well as *H. pulverea*. The experiments were continued on the *Kusmi* crops on *kusum* (*S. trijuga*) and extended from October 1941 to *Rangeeni* crops on *palas* (*B. frondosa*). Parasites were generally released twice a week and samples collected for examination every week. The crop yield figures given below are not illustrative of the parasite effect, because large portions of the crops were cut to examine and estimate the population density of predators and their parasites. The objective of the experiment at present was to find the difference between the population of the predator *E. amabilis* and *H. pulverea* during the period of one crop in the experimental and control areas due to introduction and parasitisation of the parasite in the experimental area.

A. Jethwi crop 1941 (Jan.-Feb. to June-July)

The control trees were unpruned and the experimental ones pruned.

(a) *Crop yield*—

	Control			Experimental		
	Mds.	Srs.	Ch.	Mds.	Srs.	Ch.
Brood used ..	13	38	0	11	20	8
Crop obtained in weight of lac stick ..	40	13	8	25	2	4
Brood : Crop ratio (lac sticks)		1 : 2·9			1 : 2·2	
(scraped lac)		1 : 1·3			1 : 2·1	

It should be noted that over 320 ft. of lac sticks were cut from control and over 295 ft. from experimental areas for examinations.

(b) *Parasites released*—

	Males	Females
M. greeni ..	1,479	2,124
M. hebetor ..	1,935	6,541

(c) (i) *Population density of E. amabilis and percentage parasitisation by M. greeni and M. hebetor per 100".*

Month and week	Trees examined	Parasitisable stage of E. amabilis			Percentage parasitisation by			
					M. greeni		M. hebetor	
		Control	Experimental	Difference	Control	Experimental	Control	Experimental
April 4th week Initial examination	18	3·0	2·6	0·4	nil	4·5	Not expected, absent	nil
May 1st week	6	3·8	3·1	0·7	nil	14·3	,,	,,
,, 2nd ,,	6	6·8	7·4	—0·6	25·0	18·7	,,	,,
,, 3rd ,,	6	3·3	2·0	1·3	55·5	nil	,,	,,
,, 4th ,,	6	2·3	1·7	0·6	40·0	25·0	,,	,,
June 1st ,,	6	1·4	0·4	1·0	100·0	nil	,,	,,
,, 2nd ,,	6	3·4	0·9	2·5	25·0	100·0	,,	,,
,, 3rd ,,	6	7·9	0·4	7·5	6·5	nil	,,	,,
,, Final examination	18	4·7	1·3	3·4	35·6	5·5	,,	,,
Average mean	..	4·0	2·2	-1·8	31·8	18·6	,,	,,

Percentage parasitisation of *E. amabilis* by *M. greeni* is not very helpful in the interpretation of the data. However, the difference in population density of the predator which was the objective of the experiment shows that the initial difference between the control and experimental was only 0·4, but after the introduction of *M. greeni* for one month, the differences on the whole greatly increased. Though due to large variations in the samples the differences are not statistically significant, the indication is that *M. greeni* releases have been effective.

(ii) *Population density of H. pulverea and percentage parasitisation by M. hebetor per 100".*

Month and week	Trees examined	Parasitisable stage of H. pulverea			Percentage parasitisation by M. hebetor	
		Control	Experimental	Difference	Control	Experimental
April 4th week Initial examination	18	9·3	14·3	—5·0	Not expected, absent	nil
May 1st week	6	9·9	12·8	—2·9	,,	,,
,, 2nd ,,	6	5·1	12·1	—7·0	,,	,,
,, 3rd ,,	6	4·9	11·1	—6·2	,,	,,
,, 4th ,,	6	6·7	9·9	—3·2	,,	,,
June 1st ,,	6	10·5	18·9	—8·4	,,	,,
,, 2nd ,,	6	8·9	13·7	—4·8	,,	,,
,, 3rd ,,	6	6·1	4·3	1·8	,,	,,
,, Final examination	18	7·7	9·4	—1·7	,,	,,
Average mean	..	7·6	11·6	-4·1	,,	,,

There was no parasitisation by *M. hebetor* in the experimental area where 8,476 (1,935 males + 6,541 females) of *M. hebetor* were introduced in two months. The experimental area was infested more with *H. pulverea* than the control.

B. Aghani crop 1941-42 (June-July to January)

The control trees were unpruned and the experimental ones pruned.

(*a*) *Crop yield*—

	Control Mds.	Sr.	Ch.	*Experimental* Mds.	Sr.	Ch.
Brood used	9	21	0	7	34	1
Crop obtained in weight of lac sticks..	25	35	0	18	10	8
Brood : Crop ratio (lac sticks) ..		1:2·7			1:2·3	
(scraped lac) ..		1:2·3			1:1·7	

It may be mentioned that over 522 ft. of lac sticks were cut from control and over 523 ft. from the experimental areas for examinations. Though the trees had been pruned in the experimental area, they put forth very thick shoots because the trees had not been cultivated for about 15 years before this and therefore, the mortality in the insects was very high.

(*b*) *Parasites released*—

	Males	Females
M. greeni ..	6,890	10,290
M. hebetor..	412	512

(*c*) (*i*) *Population density of E. amabilis and percentage parasitisation by M. greeni and M. hebetor per 100″.*

Month and week	Trees examined	Parasitisable stages of E. amabilis			Percentage parasitisation by			
					M. greeni		M. hebetor	
		Control	Experimental	Difference	Control	Exptl.	Control	Exptl.
August initial examination	18	11·9	8·4	3·5	9·2	3·5	Not expected absent	nil
August 4th week	6	17·0	7·5	10·4	31·8	nil	,,	,,
Sept. 1st ,,	6	6·3	7·5	—1·1	19·0	nil	,,	,,
,, 2nd ,,	6	11·8	5·5	6·3	29·6	7·3	,,	,,
,, 3rd ,,	6	17·9	6·1	11·8	23·5	4·8	,,	,,
,, 4th ,,	6	15·3	6·7	8·6	28·0	29·8	,,	,,
,, 5th ,,	6	3·2	3·9	—0·7	18·8	20·5	,,	,,
Oct. 1st ,,	6	8·7	5·1	2·6	19·5	49·4	,,	,,
,, 2nd ,,	6	7·6	6·1	1·5	13·2	31·2	,,	,,
,, 3rd ,,	6	6·1	7·2	—1·1	18·0	41·6	,,	,,
,, 4th ,,	6	9·6	5·8	3·7	29·5	10·3	,,	,,
Nov. 1st ,,	6	13·0	2·4	10·6	10·7	41·7	,,	,,
,, 2nd ,,	6	6·6	6·3	0·3	33·3	11·1	,,	,,
,, 3rd ,,	6	5·5	4·1	1·4	34·5	43·9	,,	,,
,, 4th ,,	6	6·8	2·3	4·5	48·5	nil	,,	,,
Dec. 1st ,,	6	6·7	4·5	2·2	10·4	40·0	,,	,,
,, 2nd ,,	6	12·2	3·7	8·5	27·0	8·1	,,	,,
,, Final ,,	18	9·8	5·9	3·9	12·2	18·6	,,	,,
Average mean		9·7	5·5	4·2	23·1	23·4	,,	,,

In the *Aghani* crop which followed the above *Jethwi* and for which the latter provided the brood lac, an initial difference of 3·5 between the control and experimental was marked. With the advance of the crop on the whole, these differences have been kept up, but due to large variations in the samples, it is not possible to say whether there is a statistically significant effect. The variation from week to week in the control plot is larger than in the experimental. There is an indication that the density has decreased both in the control and the experimental plot with the advance of the season, but this is more so in the experimental than in the control. Further, in spite of blanks in *M. greeni* percentage parasitisation data in some weeks in the experimental plot and lower density of *E. amabilis* in the experimental than in the control, the avarage mean parasitisation by *M. greeni* in the experimental plot is slightly higher than in the control; this also indicates that the *M. greeni* releases have been effective.

(*ii*) *Population density of H. pulverea and percentage parasitisation by M. hebetor per 100".*

Month and week	Trees examined	Parasitisable Stages of H. pulverea			Percentage parasitisation by M. hebtor	
		Control	Exptl.	Difference	Control	Experimental
August initial examination	18	15·3	15· 3	nil	Not expected, absent	nil
August 4th week	6	16·3	17·6	—1·3	,,	,,
Sept. 1st ,,	6	20·4	12·2	8·2	,,	,,
,, 2nd ,,	6	16·9	15·7	1·2	,,	2·5
,, 3rd ,,	6	12·5	9·2	3·3	,,	nil
,, 4th ,,	6	15·6	22·5	—6·9	,,	,,
,, 5th ,,	6	12·2	18·6	—6·4	,,	,,
Oct. 1st ,,	6	36·0	21·31	14·6	,,	,,
,, 2nd ,,	6	37·0	48·8	—11·8	,,	,,
,, 3rd ,,	6	19·7	26·1	—6·4	,,	,,
,, 4th ,,	6	29·8	38·2	—8·4	,,	,,
Nov. 1st ,,	6	35·6	27·9	7·7	,,	,,
,, 2nd ,,	6	21·2	24·9	—3·7	,,	,,
,, 3rd ,,	6	17·9	26·2	—8·3	,,	,,
,, 4th ,,	6	18·8	19·3	—0·5	,,	,,
Dec. 1st ,,	6	27·0	23·1	3·9	,,	,,
,, 2nd ,,	6	35·0	26·1	8·9	,,	,,
Final	18	31·6	25·7	5·9	,,	,,
Average mean	..	23·2	23·2	nil	nil	0·15

The control and experimental plots were equally infected by *H. pulverea*. One solitary larva was parasitised by *M. hebetor* in the experimental. The braconid did not breed well in the laboratory either on *Eublemma* or *Holcocera* and this is why less braconids were released than in the previous year.

The fact that *H. pulverea* population density was more in the experimental than in the control in the *Jethwi* crop, practically equal in the two areas in the *Aghani* crop and that *E. amabilis* population density in the experimental area was nearly half that of the control in the *Jethwi* as well as the *Aghani* crop, gives further indication in favour of effective *M. greeni* releases.

(C.) Baisakhi crop 1941-42 (Oct.-June)

The experiments were started on unpruned trees. Pruned trees will be available from June 1942. Some of the trees in the control plots partly received self-infection

and partly artificial. As in the experimental plots, all trees received artificial infection, the brood and yield figures for this crop have no experimental value. The crop is still in the early stage and does not indicate any evidence either in favour of or against releases.

After the *Jethwi* 1942 crop was infected, the climatic conditions became adverse for about a fortnight, and the emergence of larvæ was disturbed in all the brood lac and greatly delayed in that part of the brood in which emergence was due to take place a few days after infection. The control trees have received infection one year after pruning and the experimental trees about two years after pruning. So far, suitable stages of predators are absent and no braconids have been released.

8. General

One Range Officer from Indore State and another from Hyderabad (Deccan) are receiving training in improved methods of cultivation. Advice was given to a large number of cultivators from various parts of India and at the request of the authorities concerned, the forests of the Benares State were inspected and a scheme drawn up for lac cultivation. Some of the braconids, ichneumonids and chalcids collected from biological control areas have been sent for identification.

APPENDIX I

TABULATED STATEMENT OF THE PROGRESS OF INVESTIGATIONS

Item	Comd. in	Progress during 1941-42	Future work
1. Shellac moulding powders—			
(a) Shellac-formaldehyde-urea powder	1938-39	Substitution of urea partly by aluminium chloride or completely by thiourea has given promising results.	Improving flow quality and heat-resistance. Substitution by other easily available chemicals.
(b) Shellac-casein powder	1939-40	Cheap laminated boards have been successfully prepared and a few modified varnishes have been evolved to secure water-resistance.	Improvement of water-resistance and evolution of moulding technique for articles of complicated shapes.
(c) Thermoplastic powder	1941-42	Quick moulding of simple-shaped articles.	Mould design for articles of complicated shapes.
(d) Cold moulding process	1941-42	Heat curing process determined.	Shortening period necessary for heat curing.
(e) Injection moulding powder	1939-40	Compositions of moderate strength and heat-resistance have been evolved by using only ammonia as both solvent and catalyst.	Improving toughness and heat and water resistance.
(f) Fillers	1941-42	Sieved saw-dust, bagasse, papermills waste fibres, jute waste fibres, etc., have been tested.	Evolution of the cheapest and most satisfactory fibrous filler.
2. Varnishes and lacquers	1941-42	An elastic baking varnish for the manufacture of water-proof emery paper has been developed. Suitable thinners for baking varnish from *kiri* which can prevent gelling have been found.	Increasing resistance to abrasion.
3. Adhesives	1937-38	A good adhesive has been prepared by modifying shellac with dibasic acids and oxidising agents.	Improving resistance to boiling water.
4. Shellac-rubber combination	1941-42	Effect of shellac on the process of rubber compounding has been studied. Portland cement and asbestos as fillers have given promising results. Coal-tar fractions have been used as vulcanisation accelerators.	Testing various compositions for specific applications.
5. Fundamental researches—			
(a) Analysis	1939-40	Effect of cold storage has been studied. Check-analyses of Agmark seedlacs were carried out.	Same work to be continued.
			,,
(b) Viscosity of varnishes in mixed solvents	1941	Study of shellac and other resins in mixed solvents has been completed.	nil
(c) Preparation of pure resin.	1941	A simple method has been evolved.	nil
(d) Stabiliser for bleached lac	1941	Use of traces of solvents to prevent insolubilisation on storage has given encouraging results.	Same work to be continued for a systematic study.
(e) Electrical properties of lac and lac mouldings	1940-41	Volume and surface resistivities have been studied for some specimens. Effect of surrounding medium on the dielectric strength has also been studied.	Further work along same lines, to definite conclusions.
			,,
6. Improvements in the manufacture of shellac, etc.	1931-32	Improved shellac samples were made and sent to paint firms in India and were approved by many of them.	
		Manufacture of low wax-content shellacs by the indigenous process. Reconditioning old lac.	

Item	Comd. in	Progress during 1941-42	Future work
7. Gramophone records & Instantaneous recording discs—			
(a) Gramophone records		Laminated paper discs used as core for pressing shellac compositions have given satisfactory results.	Improvements in the process are necessary.
(b) Home--recording discs	1941-42	A few varnishes have given promising results on aluminium and glass discs.	Standardisation of process and composition.
8. Semi-large-scale preparations		Details for the preparation of urea from cyanamide and tartaric acid from tamarind have been worked out.	Formalin from ethyl alcohol, thiourea from gas-liquor.
9. *Ad hoc* investigations		Anti-gas cloth, insulation board, laminated jute boards, ointment slabs, laminated paper boards for radio parts, water-proof emery paper, shellac cement, insulating tape.	
		ENTOMOLOGICAL SECTION	
1. Improvement in lac cultivation—			
(a) *Albizzia lucida*	1938-39	Proved good *Baisakhi* brood carrying host in spite of severe summer.	Omitted in the new programme.
(b) *Dalbergia lanceolaria*	1940	Carried good *Baisakhi* brood crops.	do
(c) *Butea frondosa*	1940	First year's results envisage success of experiment.	Investigations to find the optimum time of partial defoliation and pruning. Repeated trials for another 3 years.
2. Lac insect—			
(a) *Parthenogenesis*	1939	Fifth generation developing normally.	Omitted from next year's programme.
(b) Selection	1939	The yellow strain has bred true for four generations and the fifth generation is in the field.	Omitted from next year's programme.
(c) Fertility and mortality	1926	Fertility in the *Baisakhi* broods was lower than in the previous year due to severe summer.	It is a statistical work and requires repetition for several years more on various true and cross strains.
3. Insect enemies of lac	1926	*Chrysopa sp.* was found to be more harmful than it is generally supposed.	Ommitted from next year's programme.
4. Control of insect enemies—			
(a) Artificial control by water immersion	1928	Problem completed. A research paper is under publication.	Heat treatment has been included in the next year's programme.
(b) Biological control by *M. greeni and M. hebetor*	Improved technique from 1941	Last one year's results indicate that *M. greeni* releases are effective.	To be continued with a larger number of examinations to stabilise variations.
5. Enemies of host trees	1926	A weevil causing galls on *Palas* leaf stalks was discovered in one of the experimental area.	Omitted from next year's programme.
6. Practical aid to cultivators—	Specific issues taken from 1940		
(a) Demonstration		Preservation of *Baisakhi Ber* brood of the lac insect was demonstrated on villagers' own trees. Demonstration on *kusum* yielded good results.	Extensive demonstration work to be carried out in Bengal, the United Provinces and Bihar.
(b) Advice to cultivators		Advice was given to a large number of cultivators from all over India and Benares State Forests were examined and a scheme drawn up for lac cultivation.	To be continued.

N.B.—A new programme has been sanctioned by the Committee for the year 1942-43.

APPENDIX II

List of Publications during 1941-42

1. *Bulletin No. 45*—A comparative study of Principal Flow Tests on Shellac, by M. Rangaswami and S.K. Gupta.
2. *Bulletin No. 46*—Physical Chemistry of Resin Solutions Part IV. The Relationship between Solvent Power, Gelation Capacity and Viscosity of Shellac Solutions in Mixed Solvents, by S.R. Palit.
3. *Technical Note No. 7*—A Simple Method of Preparing Pure Resin from Shellac, by S.R. Palit.
4. *Research Note No. 26.*—A Note on the Use of Baking Shellac Varnishes for Coating Graphite on Glass Resistances in the Laboratory, by G.N. Bhattacharya.
5. *Practical Applications of Recent Lac Research* (Hindi translation).
6. *Shellac in Injection Moulding :* by Y. Sankaranarayanan and H.K. Sen. (Reprinted from the *J. Inst. of Chem. India*).

IN THE PRESS

1. *A Hand Book of Shellac Analysis,* by M. Rangaswami and H.K. Sen.
2. *Bulletin No. 47*—Thermal Conductivity of Lac and Lac-Moulded Materials, by G.N. Bhattacharya.
3. *Bulletin No. 48*—Physical Chemistry of Resin Solutions. Part V., by S.R. Palit.
4. *Bulletin No. 49*—Physical Chemistry of Resin Solutions. Part VI., by S.R. Palit.
5. *Research Note No. 27*—Volume and Surface Resistivity of Lac and Lac-Moulded Materials, by G.N. Bhattacharya.
6. *Research Note No. 28*—The Effect of Surrounding Medium on the Dielectric Strength of Lac and Lac-Moulded Articles, by G.N. Bhattacharya.
7. *What Every Lac Cultivator ought to know*, by P.S. Negi.
8. *Artificial Control of the Enemies of Lac Insects and Lac, Part I :* Water-immersion., by P.S. Negi.

A list of previous publications may be obtained from the Director, Indian Lac Research Institute, Namkum P.O., Ranchi.

APPENDIX III

Total Sticklac Production in India (in maunds)*

Year	Baisakhi	Jethui	Katki	Kusmi	Total
1941	8,74,000	91,000	2,89,250	1,66,250	14,20,500
1940	6,44,500	38,625	4,29,500	1,20,750	12,33,375
1939	11,23,000	25,500	2,01,500	44,000	13,94,000

* From the Crop Statistician's figures.

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