S. Ranganathan

INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1940-41

1941

CONTENTS

PREFACE

In reviewing the work of the Indian Lac Research Institute during the year 1940-41, attention may be drawn to the fact that due to the difficulty of procuring chemicals and apparatus, the work of the Institute had to be restricted considerably. The activities were, however, directed towards certain problems that assumed importance due to the War. Mention must be made in this connection of certain requirements of the Supply Department for which enquiries were made of the Institute, either directly or indirectly. The most important of these were the supply of shellac plastics in large quantities, gas-proof and water-proof varnishes for fabrics, insulating boards, materials for identity discs, supply of medical requisites like ointment slabs, dredgers, kidney-shaped trays, anti-insect cream containers, etc. Whilst it was possible to undertake to supply some of the items required by the Medical Department, the supply of moulding powders could be effected only in small quantities, as the existing plant in the Institute could turn out no more than 50 lbs. per day. Even this was possible because the Institute had obtained some quantity of urea and formaldehyde prior to and during the early months of the present War. These two chemicals cannot be imported now and, as such, their manufacture is being worked out on a technically profitable, small scale at the Institute. According to reports, about 300 tons of bakelite moulding powder are consumed by the moulding establishments in India. These powders are not available, or are available only with great difficulty, and to replace them about 25 tons of urea and 75 tons of formalin would be necessary. Shellac moulding powders have definitely created a demand in the country, but its supply from the Institute, in large quantities, is obviously impracticable. Yet the availability of such a powder in the market would not only give a fillip to the shellac moulding industry at the present time, but would find its way, as a result of use, into post-war plastic industry in this country, due both to the cheapness and the variety of uses to which shellac moulding powders could be put. Demonstrations of the suitability of these powders were given by working on commercial scales in moulding establishments in Calcutta, Bombay and Cawnpore.

Since the compression moulding powder from shellac is dependent upon the supply of urea and formaldehyde from outside countries, various attempts are being made at the Institute to evolve a plastic dependent upon indigenous materials only. Whilst the compression powder is as yet dependent upon imported chemicals, in the region of injection moulding, shellac has made considerable progress. The use of ammonia as an accelerator and waste jute as a filler for shellac moulding powders has opened up very great possibilities. Indeed 12,000 electrical switches were manufactured out of such a composition, which stands heat upto 72-75°C. and which have reasonable resistance to water. In Australia, two factories have already interested themselves in this powder and one of them, as far as the report goes, is already using two tons of shellac moulding powder per week for producing injection-moulded articles. Whilst it cannot be said that the injection moulding powder has come to a stage

of perfection, it may be maintained that its use in the manufacture of electro-technical goods and ordinary domestic articles has already begun with a very fair amount of future prospect. Further work in this direction is being continued to improve the quality of the injection moulding powder, as by this process quicker output with considerably diminished capital outlay is possible. The plastics made out of shellac-casein and shellac-coal-tar and shellac-cashew-shell oil have also given a fresh impetus to the moulding industry. These combinations, according to the method of preparation, can be used either for compression moulding or for injection moulding, and their very low cost of production would seem to find a place for them in the plastic industry. Their water resistance, however, is distinctly poorer than that of articles from shellac-urea-formaldehyde moulding powder.

With the outbreak of the War the difficulty of importing wood-flour for use as a filler in the manufacture of moulding powders was so great that processes had to be devised at the Institute for making wood-flour from sawdust obtained from some of the cheapest of Indian woods. A work of considerable importance was initiated at the Institute in this direction depending upon the digestion of sawdust with alkali under pressure. This material after grinding has yielded a filler which gives decidedly greater shock-resistance to moulded articles made with it. The normal practice of manufacturing wood-flour by grinding particular varieties of sawdust to 80 to 100-mesh has also met with conspicuous success, and, in fact, *Gangwa (Excocaria Agallocha)*, the cheapest variety of wood available in Bengal, has given the best results after simple grinding and sifting.

Whilst general progress under all items of research was maintained, satisfactory progress was made specially in the region of laminated boards, both out of paper and fabrics, in the manufacture of stoving enamel and unbreakable gramophone records. Work on water-proofing and gas-proofing of fabrics coated with modified shellac varnishes also progressed to a great extent, and the castor oil plasticising of shellac to adapt the resin to its use as surface coatings also advanced. Composition for making identity discs out of Kraft paper was successfully formulated answering to all specifications demanded by the military authorities.

Work on the technical possibility of using lac-dye under war conditions was also started during the year under review and a certain amount of fundamental work on the constitution of the lac-dye has been done , with the discovery that there is a definite complex between the dye and the protein which accounts for most of the water insoluble dye, the water soluble portion being only of the order of 1 per cent. on the lac whilst the protein dye complex is about 3 to 4 per cent.

Of great technical importance is the working up of seedlac with garnet lac for the production of low wax-content shellac, appreciated by the electrical industry. Such low wax-content shellac (3 per cent.) has been prepared and its chemical and physical examination shows its suitability in this industry, indicating a major outlet

for about 30,000 maunds of *Kiri* annually produced as a bye-product in the shellac industry.

The combination of shellac with rubber is another problem which deserves notice. Sheets have been produced which are now being examined for abrasion-resistance by actual use and a moulding powder has also been made which gives articles showing flexibility and toughness. Further work in this direction is expected to create a greater outlet for shellac in the rubber goods manufacturing industry.

In the section of Entomology, good results were obtained in the biological control of lac pests. The *Kusum* experimental area at Hessal yielded a very good quality as well as quantity of lac, which was utilised as brood-lac for reinfection of the experimental trees in the same area and for free distribution in the demonstration areas. The ratio of brood to yield at Hessal was about three times as high as in the control area at Namkum. A *Kusum* area at Berwari adjoining Hessal was acquired this year to serve as control, so that both the experimental and control areas may be, as far as practicable, similar in their topographical, soil and host conditions. Fresh areas for biological control work with *Palas* or *Ber* hosts are also being acquired.

The demonstration work in connection with lac cultivation was intensified and the campaign is being extended to new areas at the request of the inhabitants. Promising results have been obtained in the lac cultivation demonstration areas, particularly at Khunti, Ranchi, where on a few trees in the compound of the S. D. O., in addition to a good *Baisakhi* crop, two mds. of brood-lac were also obtained, which is rarely the case with *Ber* in *Baisakhi* season. People seem to be developing faith in the methods advocated by the Institute, and the free distribution of brood-lac and pruning instruments has helped a good deal to gain their confidence. Attempts are also being made to enlist the support of Zemindars to popularise the use of improved methods for lac cultivation amongst their tenants by cultivating lac on a co-operative basis, and success has been attained in the case of the Bara Lal Sahib of Palkot, one of the biggest Zemindars of Chota Nagpur. The campaign is progressing satisfactorily and it is hoped that the present fillip, which the lac industry has received, will induce the common growers to avail themselves more and more of the methods advocated by this Institute.

H. K. SEN.

INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT FOR THE YEAR 1940-41

ADMINISTRATIVE SECTION

General.—During the year under review, the work of the Institute again showed all-round progress. Many members of the Indian Lac Cess Committee as also a large number of visitors visited the Institute. Amongst them were —

The Bishop of the See and Metropolitan of India, Burma & Ceylon; The Bishop of Chotanagpur; Mr. H. H. MAHMOOD, Officer on Special Duty in the Department of Industries, Punjab; Members of the Mining, Geological and Metallurgical Institute of India; DR. R. R. HATTIANGADI of Khalari Cement Works; PROFESSOR S. P. ROY CHOWDHURY and 15 advanced students of Chemistry of the Dacca University; The staff and the students of the Indian Forest Ranger's College, Dehra Dun; Mr. V. K. B. PILLAI, I.C.S., Director of Industries, Bihar; The American Consul-General in India.

Roads and Buildings.—The construction of the following buildings was carried out during the year:

1. Extension to the office building
2. Two bath rooms in the old A-type quarters
3. Extension to the Experimental Lac Factory
4. Construction of a dark room
5. Extension to the Entomologist's office room
6. Three C-type quarters
7. Labour Supervisor's quarters
8. Extension to the scraping godown

Annual repairs to the estate roads and buildings were also carried out.

Sanitary Installation.—The scheme of sanitary installation was completed during the year under report.

Power House.—All the Institute plants were kept in good condition. The proposal for taking current from public supply was sanctioned by the Central Government and the Ranchi Electric Supply Company, Limited, started supplying current from the 18th February 1941. The changing of motors, fans, etc., is not yet complete.

Gas was supplied to the laboratories (Chemical and Entomological) throughout the year with the help of the retort devised by the Director. This has now worked for the fifth year satisfactorily.

Workshop.—Though the Institute workshop is not yet fully equipped, the facilities availed of from the existing equipment were very appreciable in the shape of repairs, construction of new apparatus, moulds, etc.

Staff Club.—The grant of Rs. 600 from the Indian Lac Cess Committee enabled the Club to effect various inprovements. As in previous years, several prominent persons delivered lectures before the members of the Club on different subjects.

Exhibitions.—The Institute participated in the following exhibitions :

All-India Swadeshi Exhibition, Ranchi.
The Annual Agricultural & Industrial Exhibition, Khunti.

The Institute sent complete sets of exhibits with relevant explanatory notes to—

The School Exhibition of the Board High School, Trivarur,
National Industries & Fairs, Monghyr,
All-India Industrial Exhibition, Bhagalpur,
The Industrial and Agricultural Exhibition, Jalbetiar (Gwalior),
All-India Exhibition, Patna,
Khadi & Industrial Exhibition, Lucknow.

Exhibits were also forwarded to—

Birla Intermediate College, Pelani, Jaipur State,
University Commercial Museum, Calcutta,
Science Club, Calcutta,
Government Commercial Museum, U.P.,
City College, Commerce Department, Calcutta,
Jagannath Intermediate College, Dacca,
Islamia College, Peshawar Cantonment.

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

Staff.—Dhirajnath Sahay, farash, Entomological Section, retired from the service of the Institute on the afternoon of the 15th May, 1940. The services of Mr. C. B. Guha, B. A., stenographer, were terminated from the 20th February, 1941.

During the year under review, the following appointments were made—

(a) MR. T. P. BHOWMIK, M. Sc., Junior Assistant, Chemical Section.
(b) MASIDAS MINZ, farash, Chemical Section.
(c) GOMEYA URAON, factory boy.
(d) PANOO GORAIT, temporary khalasi in a leave vacancy.
(e) JUGAL SINGH, farash, Entomological Section.
(f) MR. SUKUMAR GUPTA, B. Sc., temporary analyst in a scheme provided for giving aid to manufacturers.
(g) MR. P. M. KUJUR, Demonstrator.
(h) MR. C. BANERJEE, B.Sc., temporary laboratory assistant in a leave vacancy.
(i) MR. N. K. BOSE, temporary accounts clerk in a leave vacancy.
(j) MR. C. R. DUTTA GUPTA, temporary typist-clerk in a leave vacancy.
(k) MR. A. BH. CHATTERJI, temporary typist-clerk in a leave vacancy.
(l) MR. M. N. BANERJEE, temporary typist-clerk in a leave vacancy.

CHEMICAL SECTION

1. FUNDAMENTAL RESEARCHES

(A) Solution of shellac in mixtures of non-solvents

With a view to throw light on the fundamental question of the dissolving power of different solvents on shellac and other resins, the extreme case of dissolution of shellac in a mixture of two non-solvents has been studied. Two pairs of non-solvents have been investigated in the period under review: (1) acetone-ethylene glycol mixture, and (2) methyl acetate-ethylene glycol mixture, and the results obtained have been compared with similar results obtained with acetone-water mixture, which were reported last year and have been published in the present year (*Journ. Ind. Chem. Soc.*, 1940).

Experiments were conducted on the following three lines:

(i) Determination of the solubility limit of shellac in a particular composition of the two non-solvents; (ii) determination of viscosity of different concentrations of shellac solutions in various compositions of the solvent mixture with changes of temperature; and (iii) the gelation and precipitation temperatures of such solutions. Detailed results are being published in the form of a paper, but the most salient points are summarised below:

(a) If shellac dissolves in a mixture of two non-solvents, for increasing proportion of shellac to any one of the non-solvents, the proportion of the other non-solvent necessary to effect complete solution decreases at a rate somewhat higher than linear.

This relationship has been found to hold good in the case of shellac in acetone-water, acetone-glycol and methyl acetate-glycol mixtures as well as, so far as preliminary experiments show, for kauri copal and ester gum in suitable mixtures.

(b) The well-known viscosity minimum at some optimum composition of the two non-solvents has been demonstrated to exist only in solutions which have the capacity to gel on cooling. The concentrations of such solutions may be very high, *e.g.*, for glycol-methyl acetate, the concentrations of shellac necessary to produce the viscosity minima are about 45 per cent. and higher; for lower concentrations there is no indication of the presence of minima. Temperature is also a dominant factor in producing the viscosity minimum, and generally speaking, the higher the temperature, the less pronounced is the viscosity minimum.

(c) Gelation and precipitation temperatures, which are generally supposed to be a measure of solvent power, have been found to be so only in special circumstances, details of which are set forth in the paper to be published.

All these results essentially corroborate our viewpoints as developed in our study of shellac solutions in acetone-water mixture and extend the same in some important respects. This study will be of assistance not only in elucidating the general question of solvent-solute relationship for resinous solutes, but also in making our choice of suitable solvents and plasticisers, particularly in utilising mixtures of otherwise excellent plasticisers so far generally supposed to be incompatible with shellac. Attempts have also been made, on the basis of these findings, to evolve a suitable solvent-mixture which will preferentially dissolve out the soft resin component of shellac in one operation leaving the pure hard resin in an easily filterable, flaky, porous form. Compositions comprising a cheap hydrocarbon like benzene or toluene, a latent solvent like acetone or ethyl acetate to counteract the sticky gel-forming tendency of the hydrocarbon, and butyl alcohol, which confers the necessary solvent power to the solvent mixture, show some promise. Similar compositions containing ethyl or methyl acetates or acetone as main component are also very effective, but the purity of the solvent and the freedom from moisture of the shellac and the solvent are of predominating influence on the efficiency of the process This study is under progress.

(B) Specific heat of lac

The results of this investigation have been published during the year in *Bulletin No. 36.*

(C) Thermal conductivity of lac and lac mouldings

Measurement of the thermal conductivity of insulating materials generally used in electrical industries is very important from the standpoint of power output of machineries in which these are used, since power is affected by the amount of heat which can be dissipated per unit of time through these insulating materials. A knowledge of the thermal conductivity of such insulating materials is, therefore, essential. A comprehensive investigation into this property of moulded sheets of various lac compositions was therefore, undertaken. The apparatus constructed for the determination of this property was similar to that used by Lees in his double disc method. An arrangement for varying incumbent pressure was also made. Details of this apparatus will be published in an appropriate journal. The effect of water on this property after immersion for a definite period was also observed. In general, water immersion gave increased conductivity for most of the moulding compositions. The effect of temperature on thermal conductivity has also been observed. The results are being compiled now for a communication on the subject.

(D) Volume and surface resistivity of lac mouldings

Preliminary measurements on the volume and surface resistivity of several lac moulded discs showed that they are too high to be measured by ordinary galvanometers. An apparatus for this purpose has been constructed with an electrometer tube and it has been found satisfactory. Work is now progressing on the measurement of resistivities.

(E) High tension experiments

Preliminary experiments for the measurement of dielectric constant and power factor of shellac-moulded plates at supply frequency have been completed during the year. For this, a flat plate and a mercury electrode have been constructed at the Institute workshop. Metal foil electrodes have also been used. Arrangements for the determination of the breakdown voltage under oil and in air have also been completed during the year under review. The high voltage generating equipment comprises a D. C. motor-sine wave generator set and a testing tranformer with a 230 v/100 kv ratio.

(F) Isolation of shellac acids

Mention has been made of the production of aleuritic acid from shellac or *kiri* by extracting with lime (*vide* ANNUAL REPORT 1939-40). The mother liquor after separating the aleuritic acid from the lime extract was concentrated and the organic acid contained therein isolated as the barium salt. The barium salt on treatment with the calculated quantity of sulphuric acid yields an aqueous solution of the new acid. On evaporating this to dryness on the water bath, a brownish powder is obtained. This is taken up in alcohol, boiled with animal charcoal, filtered and the alcoholish solution evaporated. The residue is taken up in ether, filtered and the ether evaporated when a colourless thick syrup is obtained. On drying in vacuum, a very fluffy colourless crystalline product is obtained. This acid closely resembles shellolic acid. Its identity is being examined.

(G) Lac pigments

Systematic work was carried out to find out the exact nature of the lac-dye. It has been observed that the whole of the dye can be removed from the fresh brood lac by crushing and extracting with water containing a little ammonia. The colouring matter can be divided into three fractions :

(a) Pigment associated with protein
(b) Water-soluble pigment
(c) Fat-soluble pigment

The ammoniacal extract of the dye, on acidification with dilute acetic acid, gave a precipitate showing the characteristic properties of a protein. The remaining pigment in the extract can be completely precipitated by the addition of calcium chloride, barium chloride or a lead acetate.

Experiments were carried out to find out the nature of the pigmented protein. Pigmented protein was isolated from fresh *kusum* brood as well as from fresh *ber*. The protein was isolated by extracting with water, containing a few drops of ammonia, and precipitated by the addition of dilute acetic acid. The protein was repeatedly purified by redissolving in dilute ammonia and reprecipitating by dilute acetic acid. The protein thus obtained was found to contain a waxy matter which was removed by

extracting it with petroleum ether and ether. The wax was nearly pure, obtained in needle shaped crystals. The pigmented protein was extracted with alcohol and acetone to find out whether the pigment is only in the adsorbed state, but the protein still possessed the pink colour showing that the pigment part is still in combination with the protein.

The values obtained for total nitrogen, ash content as well as the nitrogen distribution for both *kusum* as well as *ber* proteins, are nearly equal.

	Protein from Kusum Brood	Protein from Ber Brood
Total Nitrogen	9·42%	9·55%
Ash content	3·77%	3·97%

Nitrogen Distribution

	Kusum	Ber
Humin nitrogen	3·57%	4·15%
Amide ,,	12·24%	12·10%
Basic ,,	32·65%	31·03%
Non-basic ,,	51·00%	52·50%
	99·46%	99·78%

This indicates that the protein part of the pigment is the same. During the acid hydrolysis of the protein for nitrogen distribution, the pigment is severed from the protein and it has been found that the whole of the pigment is precipitated in the humin fraction. Thus it was found possible to separate the protein from the pigment.

The water-soluble pigment is completely precipitated as barium or lead salt and it is decomposed by the addition of sulphuric acid. The filtrate on evaporation did not crystallise but was found to be a sticky mass.

The real nature of the two parts of the pigment is under investigation.

(H) Flow test on shellac

A comparative study of the three principal methods of carrying out the flow test on shellac came to an end during the year under review and a report discussing the merits of the three methods tested from various angles was submitted to the Lac Cess Committee. The investigation showed that the Westinghouse method proved to be the most suitable for this purpose where electricity was available and that the V-Tube method might be considered as the next best.

(I) Storage experiments

The periodical analyses of sticklacs, seedlacs and shellacs in both ordinary and air-conditioned godowns at Calcutta have so far shown that certain properties of seedlac and shellac deteriorate to a smaller extent in air-conditioned storage than when stored under ordinary conditions. The experiments are being continued with a view to get the results of a longer storage and the report will be ready during the current year.

2. Manufacture of Shellac

Garnet lac and shellac with low wax content

The possibility of preparing refined lac from waste materials like *kiri* and also from seedlac by means of solvent extraction has already been indicated in previous reports. The marketing of such lacs in the form of shellac, however, offers practical difficulties. Owing to the comparatively small fluidity and short life of the lac recovered by solvent extraction, as a result of the heat treatment it undergoes, the molten lac coming out of the still cannot be kept hot sufficiently long, to be stretched out into thin sheets. Besides, owing to the very small percentage of wax, which is known to function as a natural plasticiser for the shellac, the lac will not have sufficient elasticity to withstand the necessary pull.

Subsequent tests have, however, indicated the possibility of mixing such a solvent-extracted lac with good quality seedlac and converting it to the form of shellac. In such an event, the molten lac is just discharged from the still on to the floor when ready and allowed to cool. The lac is then broken up into small pieces by passing through a disintegrator, mixed with the necessary proportion of seedlac and stuffed into bags for the manufacture of shellac in the usual way.

One part of lac recovered from *Kiri* mixed with three parts of *Baisakhi* seedlac gave a shellac which is of first grade pure TN quality, both in appearance and by analysis. It may be presumed that the lac from *Kiri*, marketed in this form, would fetch a higher price than when rolled into sheets of garnet lac.

There appears to be a fairly insistent demand in certain important industries for shellacs with a lower wax content than normally met with. These industries would require a shellac containing only about 3·5 per cent. wax. While some types of pure shellac are found to contain wax of the above order or less, and this matter is being further investigated, the marketed samples of shellac may contain wax up to about 5 per cent. The method mentioned above indicates one of the possibilities of manufacturing shellac which answers to this special industrial requirement. It may also be remarked in this connection that if seedlac, instead of *Kiri*, is extracted with solvent for this purpose, the resulting shellac may be expected to be even better.

3. Shellac Baking Varnishes for Coating High Resistances

In the Annual Report of the Institute for 1939-40 it was reported that an investigation on the use of a few baking shellac varnishes for coating high resistances of the graphite-on-glass type was undertaken. This investigation was completed during the year under review, and the results have been incorporated in a short note which has been communicated to a scientific journal for publication. It has been found generally that shellac baking varnishes containing maleic anhydride and linseed oil fatty acids are very satisfactory for the purpose.

4. Black Baking Varnish from Kiri and Refuse Lac

Mention has been made in the previous Annual Report of the preparation of a black baking varnish starting from *kiri* or any other refuse lac. The main difficulty experienced with the composition mentioned therein was the slow thickening and final gelling of the varnish. Incorporation of alcohol or the lower boiling fraction from *kiri* distillation reduced considerably the rate of thickening though the eventual gelling was not prevented entirely. It has since been found that if the thinning is done by a mixture of kerosene and turpentine in equal volumes instead of kerosene alone, the gelling is completely avoided. A varnish prepared under these modified conditions was found to work very satisfactorily.

The production of this varnish from *kiri* in all its stages was demonstrated to a representative of the Napier Paint Works, Calcutta, and one gallon of the prepared varnish was supplied to them for examination at their factory. A satisfactory report was received from them together with a request for a few gallons of the *kiri* oil for trials which was complied with. A detailed report is expected.

During the preparation of the black baking varnish from the oils obtained by the distillation of *kiri*, refuse lac, etc., large quantities of a low boiling fraction (up to 180-200°C.) are obtained as by-products. Experiments were therefore undertaken to investigate the nature and utility of these oils.

By fractional distillation, separate portions were collected having boiling ranges of 70-80°C., 80-90°C. and so on up to nearly 200°C. All these fractions were neutral in reaction, containing practically no matter that could be extracted with dilute sulphuric acid or sodium hydroxide solution. They were also free from ketonic or aldehydic compounds. The fractions up to 110°C. were colourless when freshly distilled, but became discoloured on standing. They are miscible in all proportions with alcohol, acetone and the hydrocarbon solvents, and have the property of dissolving raw rubber to a certain extent. They decolourise bromine water and potassium permanganate in the cold and react violently with concentrated mineral acids. It has also been established that only one portion (approximately about 50 per cent.) of the oil is affected during the treatment with concentrated mineral acids, the other portion being a saturated hydrocarbon having a powerful kerosene smell and is inert to most reagents.

The fraction boiling between 110-120°C. has been successfully used in place of toluene in shellac-nitrocellulose lacquers. Further work is in progress.

The iodine value varies from 200 in the lowest fraction to about 106 in the highest.

5. Lac-Oil Varnish

Experiments to make lac-oil varnish suitable for coating fabrics to render them resistant to the action of water and petrol were carried out during the year under report. Additional interest to this particular work was roused by military requirements, in connection with which several samples were prepared and supplied for examination. The Institute process for preparing lac-oil varnish (Chapter XI, *Practical Applications of Recent Lac Research*) was found to yield a material fairly suitable for fabric coating answering to most of the requirements insisted upon. The chief difficulty, however, that was encountered with was the rather longer periods and higher temperatures required for drying the coated fabric tack-free on the application of the second coat. The colour of the finished product was somewhat deeper-brown than in the case of certain proprietory varnish coated fabrics. Further work is in progress.

6. Sound Recording Discs

The previous report has indicated the possibility of coating aluminium or cardboard discs with a thin film of shellac composition and stamping them against the master for producing satisfactory sound records. A leading gramophone record company was, however, prepared to give trials only to records on bases other than aluminium as the requirement of aluminium for war purposes further made it imperative to confine the tests to cardboard base.

Although one or two sound records on cardboard base had come out satisfactorily in the preliminary tests, the preparation of perfect blanks on cardboard offered great practical difficulties, owing to the very coarse, absorbent paper used for making the cardboard sheets and the dirt contained in them; specially prepared shellac-paper laminated boards were also tried which gave a much better surface for spraying. A number of records were taken out with the kind co-operation of the Gramophone Company at Calcutta. While the records reproduced the music fairly satisfactorily, they were not found to be perfect enough owing to the surface noise produced. A certain amount of buckling of the records is also noticed which would detract from the value of such records for commercial production. The reasons for these defects and the possibilities of eliminating them are now under investigation.

7. Shellac Varnishes

(A) Lacquers and enamels

Further practical tests were carried out during the year under report on the use of pigmented shellac lacquers or enamels for high-class finishing jobs. As has been

mentioned in the previous report, shellac enamels were formulated containing one part of nitrocellulose for every four parts of shellac. Since the presence of wax was a handicap for spraying compositions, dewaxed lac was used in these experiments. The solvent composition was also so formulated that the film dried nearly as quickly as in the case of imported enamels and thereby rendered the spraying job comparatively trouble-free. Two motor cars were painted with finishes prepared at the Institute on the lines indicated above and by a professional spray-painter. Besides the use of finishing enamel based on shellac, the primer, surfacer and putty used for this purpose were all formulated with shellac base and prepared at the Institute. In the case of one job, the bonnet of a car was scraped down to the metal and refinished. In the other job, the under-coat, which was presumably of a high-class imported make, was retained and the refinishing was carried out with only surfacer and finishing coats on the old undercoat. In both cases, the painting was satisfactory in spite of carrying out the job under conditions which were far from ideal for spray-painting. The report of the painter on the performance of the various materials was quite favourable and in his opinion, the materials would find a ready market. An approximate estimate of the cost of finishing a motor car also indicated that it would only be a third of the charges made at present for repainting with high-class imported materials.

The possibility of the preparation of these finishes without the use of materials which would not be available in this country in times of war, as at present, is now receiving attention.

With the development of the shellac-moulding industry to the stage of commercial production, the possibility of formulating clear or pigmented lacquers for coating these articles, especially the electrical switches, was also tested with a view to improve the gloss of the article and enhance its weather resistance. Shellac-nitrocellulose pigmented lacquers have been tried with success for this purpose and with the necessary manipulation of solvent composition, a semi-matt or highly glossy finish is found to be attainable at only a little extra cost.

(B) Shellac-coal-tar varnishes

The treatment of an alcoholic solution of shellac with the neutral or whole fraction obtained on distillation of coal tar is also found to yield a clear lacquer which is suitable for this purpose. Such a composition is comparatively cheap as both the nitrocellulose and the necessary plasticiser could be omitted and a glossy finish could be obtained on the article which, after a short baking, could confer the required weather resistance.

(C) Shellac-melamine varnishes

The main difficulties experienced with the common French polishes are (i) the ready tendency to blush when in contact with water or even when applied in excessive-

ly humid atmosphere, and (ii) excessive softening even when exposed to moderate heat, *e. g.*, when a cup containing hot tea is placed on the surface. Experiments were undertaken to eliminate these defects, thereby ensuring wider use of this varnish on simple treatment with reagents. Urea, obviously, is the first choice. But the varnish made from urea showed a tendency to gel on standing and the films obtained were found to have poor adhesion.

When melamine was used in place of urea, the results were better. When an excess of melamine is boiled with an alcoholic solution of dewaxed lac, only about 6 per cent. on the weight of lac goes into solution, the rest remaining unchanged. This solution on standing overnight sets into a jelly which does not go into solution in alcohol or any of the usual organic solvents. When the percentage of melamine is progressively reduced, the time for gelling increases until when only 3 per cent. of melamine on the weight of lac is used, the solution (containing 25-30 gm. lac in 100 cc. alcohol) does not show any more tendency to gel. This varnish on applying on a wooden panel dries rapidly to a glossy film. After standing overnight, if boiling water is poured over the film or even if the panel is dipped in cold water for 24 hours, the film does not blush. A hot water beaker, when placed on such a panel, does not stick and shows no tendency to make a mark. If such a film is baked for one to two hrs. at 100°C., it resists boiling water for three to four hours. It is hoped this varnish will be of great use as a non-blushing and heat-resistant French polish. Such varnishes can also be pigmented as desired, for coloured finishes.

8. Shellac Plastics

(A) Shellac-formaldehyde-urea moulding powder

Investigations on the improvement of the shellac-formaldehyde-urea moulding compositions, particularly with regard to flow, heat and water resistance, mechanical strength, etc., were continued during the year under report. It was found that during the preparation of the modified shellac resin composition, addition of 4-5 per cent. of carbolic acid or salicylic acid or resorcinol improves the flow and gloss of the moulding composition, while on the other hand, the incorporation of small percentages of acids like tartaric, citric, etc., increases the heat and water resistance of the moulded articles.

Owing to the high cost and the difficulty of obtaining foreign wood flour from America or Europe, attempts were made to utilise the indigenous saw-dust in place of the imported variety. Saw-dust digested with weak alkali under pressure, washed and dried, was found to be a good substitute, and moulded articles prepared with this as filler have better strength and appearance than those prepared from imported wood flour. For all practical purposes, it has been found that simple saw-dust ground in stone-rollers to 80-100 mesh, gives satisfactory mouldings. Large quantities of moulding

powder (about 10-15 cwt.) were prepared and sent to various bakelite moulding factories in India. Several of these factories have expressed satisfaction on the working of the powder, as it was possible for them to mould these powders without any modification in the technique of moulding or change in their existing machineries.

Some efforts were also made to popularise the modified shellac moulding powders by frequent visits to and demonstration in factories, thereby establishing closer contacts with practically all the important moulding factories in India. Among these, particular mention may be made of Bake-O-Brass, Ltd., Bombay, Bestolite Moulding Co., Bombay, Plastics Products, Ltd., Cawnpore, India Moulding Co., Calcutta, and Swadeshi Industries, Ltd., Calcutta. Towards the end of the year under review, about ¾ cwt. of moulding powder was taken to Bake-O-Brass Ltd., Bombay, for commercial trials and several electro-technical and domestic utility articles like soap boxes, bottle caps, powder boxes, ribbon boxes, picnic pots, bowls, etc., were successfully moulded with practically the same time-cycle as with bakelite. As a result of this successful demonstration, the firm is seriously considering the proposal for putting up a plant for large-scale manufacture of shellac-moulding powder.

A conference of the bakelite moulding firms in India to suggest further steps to establish the shellac plastics industry on a firm basis in India could not be held within the year, but during the first week of April 1941, the conference met at Calcutta and put forward definite proposals for consideration at the next meeting of the Indian Lac Cess Committee. At this conference, several varieties of moulded articles from modified shellac were shown to those present.

Close contact was kept with India Moulding Co., Calcutta, with whom the Institute has a scheme of co-operative research. Many varieties of powders, with modifications with regard to strength, flow, cheaper methods of manufacture, etc., were tested by the firm during the year. This firm is at present mainly engaged in the manufacture of electro-technical goods from the modified shellac moulding powder, and during the past six months or so, it has placed several thousands of switches and ceiling roses in the market.

The method hitherto followed in the manufacture of the improved shellac moulding powder is the ' wet process ' using alcohol or rectified spirit as the medium. With a view to eliminate the use of alcohol and also to make the process simpler and more economical, attempts were made to make the moulding powder by the ' dry process ', making use of hot-rollers. As a result of these experiments, optimum conditions for making the mixture, the proportion of filler to resin, time of contact on the rollers, etc., have all been worked out and a research note describing in detail all the experiments done in this connection has been published during the year.

Apart from the chief utilisation of the modified shellac moulding powder in the manufacture of electo-technical goods, the prospect of utilising them in other fields

has come to light recently as a result of many enquiries. The Medical Stores Department of the Government of India have found this powder suitable for the manufacture of certain of their items hitherto prepared from vulcanite, and have placed an order with the Institute for a supply of certain articles like dredgers, slabs 7″x7″x¼″, anti-insect cream pots, etc.

The India Electric Works, Calcutta, have enquired whether it would be possible for us to supply them large numbers of insulation boards for fan regulators moulded from the shellac moulding powder. Another great demand from the several bakelite moulding firms is for the manufacture of transit plugs for shells. To meet this requirement alone, several tons of the moulding powder are needed.

The large-scale preparation of the modified shellac moulding powder is dependent on the cheap and ready availability of urea or melamine, formaldehyde and wood-flour, all of which are at present imported from foreign countries. Owing to conditions created by the war at the present moment, it has been found difficult to import these products, and hence attempts were made at the Institute to prepare them in large quantities so as to make it self-sufficient so far as manufacture of moulding powder is concerned. Preliminary and semi-large scale experiments on the preparation of urea both from calcium cyanamide and by the synthetic process from ammonia and carbon-dioxide have given encouraging results so as to justify the putting up of a pilot plant. In this connection, it may be mentioned that, recently, the Board of Scientific and Industrial Research has granted Rs. 5,000 towards the equipment required for the large-scale preparation of urea. The necessary apparatus has already been ordered, and it is expected to be delivered at the beginning of the next financial year.

Working details for the manufacture of formaldehyde from methyl alcohol were also completed during the year. The manufacturing details together with the nature of equipment required and the cost of production of urea, melamine and formaldehyhe have already been published in the recent publication of the Institute—*Practical Applications of Recent Lac Research.* Further experiments are in progress for the preparation of formalin from ethyl alcohol, which is expected to be very much cheaper than from methyl alcohol, in this country.

A scheme for the semi-large scale manufacture of wood-flour from indigenous woods by the cheapest method is also projected.

(B) Laminated products

The alcoholic solution of the resin obtained by the modification of shellac with urea or melamine and formaldehyde has been used for the preparation of laminated boards of paper, canvas, asbestos, etc. Boards of varying thickness ranging from $\frac{1}{16}$″ to ½″ have been prepared and these were found to have good mechanical and shock resistance. Heat and water resistance of these boards were found to be satisfactory. The use of these boards for insulation purposes and also as bases for radio valves has

been suggested. As a result of an enquiry in connection with war supplies, laminated boards capable of withstanding punching and stamping with heat resistance up to 110-115°C. and low water absorption have been developed. These boards have been tested and pronounced to be satisfactory by the Ordnance Department for the purpose of identity discs.

Attempts were also made to make the cost of preparation of laminated boards cheaper by using aqueous emulsions of shellac in ammonia in the presence of fatty acids, soaps, etc. These products were found to have high heat resistance, but suffered from lack of water resistance. Experiments are being conducted with a view to overcome the latter defect.

(C) Shellac-formaldehyde-melamine moulding powder

Mention has been made in the previous annual report about the preparation of a moulding powder from shellac by compounding with formaldehyde and melamine. All attempts to prepare from these a powder for the production of transparent articles have been so far unsuccessful. The articles are very brittle. But when plasticisers are used, the articles are either too brittle or too soft. Valuable results have, however, been obtained for the production of fibre-filled moulding powder for opaque objects.

When shellac and melamine are boiled in equimolecular proportions in alcoholic solution, only a portion (roughly 50 per cent.) of the latter goes into solution. A moulding powder made from this solution by suitably compounding with fibrous filler, pigment and mould lubricant, after air drying, shows a tendency to blister, though only slightly, when moulded at temperatures between 130 and 150°C. and ejected at the moulding temperature. A slight drying in the air-oven or in vacuum makes the powder practically infusible and such a powder has very little flow. With smaller amounts of melamine, the tendency to blister is enhanced, but the flow remains poor. Introduction of formaldehyde, however, eliminates the tendency to blister and increases the flow. As a result of a series of experiments, the following composition has been found to yield the best results—

Shellac	...	100 parts
Formalin	...	20 ,,
Melamine	...	5 ,,
Wood flour	...	100 ,,
Pigment	...	3 parts
Ca. stearate	...	2½ ,,
Alcohol	...	—

The powder is made exactly like the shellac-formaldehyde-urea powder. The drying is best effected at 75-80°C. and 20" vacuum. The powder may be used for moulding at 140-145°C. using a pressure of ½ to ¾ of a ton per inch. Even comparatively thick articles may be ejected from the mould at the temperature of moulding. The water resistance is good and the impact strength is 6 to 7 cm. kg. per sq. cm. The

heat resistance (Marten's) is 72-74°C. The powder has been made in large quantities and tested at bakelite moulding factories in Bombay and Calcutta with success.

(D) Shellac-protein plastics

Several cheaply available seeds were tried for the preparation of proteins that could replace casein in the manufacture of shellac plastics. Soyabean and karanj cake gave good yields of proteins suitable for plastics. Proteins were isolated from the powdered seeds and cake by extracting with sodium chloride, sodium carbonate and sodium hydroxide. The proteins so obtained were found to be always contaminated with a little oily matter. So the crushed seed was first extracted with solvents like petroleum ether, acetone, hexane, etc. The proteins, isolated from the fat-free meal were found to be of good quality.

The yield of protein obtained from soyabean rose from 25 to 40 per cent. after the removal of the oily matter, and that from karanj cake from 10 to 12 per cent. Tamarind seed protein as well as the seed itself were used as sources of protein and gave fairly good results when substituted for casein from milk.

A moulding composition containing 30 parts of shellac, 4·5 parts of soyabean or karanj cake protein, phenol 1·2 parts, pigment 2·5 parts, calcium stearate 1·25 parts, lime 0·6 part and wood-flour 30 parts, after sufficient mixing, kneading and drying, can be worked on the bakelite technique by pressing at 145°C. and removing at the same temperature after 2-3 minutes' curing. Some of the chief physical properties of the compositions are given below :

(1)	Impact strength	4 cm. kg. per sq. cm.
(2)	Water absorption (24 hours)	10-12 per cent.
(3)	Heat resistance	94-95°C.

The resin solution can be utilised for leather finishing and for the preparation of laminated sheets.

Casein and shellac in different proportions (1 : 1, 1 : 2, 1 : 4 respectively) dissolved in dilute ammonia were mixed and to the mixture were added 10 per cent. of potassium stearate on the total weight of casein and shellac. The casein-shellac complex was next precipitated by the addition of aluminium sulphate solution in water with vigorous stirring. The precipitate was filtered at the pump, washed free from any sulphate and dried in air. The dry compound was powdered and pressed at 130°C. but could be removed only at 100°C. The composition obtained with 1 : 4 ratio of casein-shellac was found to be completely water resistant and translucent, but the one with 1 : 1 ratio was found to absorb more water than 1 : 2. The moulded articles were found to be sufficiently strong for use in many instances.

During the precipitation, the casein-shellac composition was mixed with 20 per cent. of wood flour. The composition so obtained by precipitating with aluminium

chloride was found to have a higher heat resistance, but it was affected appreciably by water. This composition was found to have greater strength than the mere casein-shellac composition.

(E) Cashewnut shell oil-shellac combination

Combination of shellac with cashewnut-shell oil in optimum proportions and subsequent treatment with formaldehyde, urea, etc., has been found to give improved moulding compositions suitable for compression as well as injection moulding. The moulded articles obtained from some of the compositions have been found to possess greater resistance to water. In a typical case, the water absorption found was of the order of 1-1·5 per cent.

(F) Injection moulding

The use of shellac in the production of injection moulding powder was described in the previous annual report. The main difficulties experienced as reported therein are the low heat resistance of the articles produced as well as the risk of the powder getting " burnt " in the barrel, thereby choking the nozzle. Experiments were, therefore, continued to overcome these difficulties. Chemicals other than urea were tried and it has been found that nitrogenous substances, which are distinctly basic in reaction, *e.g.*, guanidine carbonate, guanyl urea, etc., raise the heat resistance and retard the curing in the barrel. Use of formaldehyde in conjunction with these resulted in a powder, which is almost perfectly thermoplastic, showing no tendency whatsoever to polymerise in the hot barrel, however long it may be allowed to remain in the same. By suitably adjusting the amounts of fibrous and mineral fillers with lac modified as described above, it has been found that the heat resistance may be raised to as high as 70°-72°C., the articles showing no tendency to blister or deform at this temperature. In the best composition so far made, guanyl urea has been preferred to guanidine carbonate in view of its easier preparation and consequently lower price.

Of the fibrous fillers tried so far, waste jute is the cheapest and gave the best results. Waste fabric gave articles of extraordinary strength, but the powder was too fluffy and consequently difficult to feed into the barrel and the flow was difficult. A typical formula for the production of injection moulding powder is as follows—

Shellac (ground to 30-mesh) ...	300	parts
Barytes (finely ground) ...	300	,,
Waste jute (ground to 30-mesh)...	200	,,
Pigment	15	,,
Stearic acid or calcium stearate ...	9	,,

These are mixed together uniformly and then thoroughly kneaded with an aqueous solution containing guanyl urea sulphate (25 parts) which has been treated with enough milk of lime or baryta to just precipitate the sulphuric acid completely. The

powder so obtained is allowed to dry at the room temperature and then run through hot rollers till uniform and is obtained in the form of blankets. These are crushed coarse after cooling (5 to 10-mesh) and cured in a steam oven for 1½ to 2 hours according to the flow desired.

Articles produced from such a powder were found to be sufficiently strong (impact strength 4 to 4·5 cm. kg. cm.^{2}) and glossy and do not show signs of blistering or deforming at 70-72°C. A number of kit-kat switches were moulded by continuous working and no difficulty whatsoever was experienced. The switches were placed on the market through the India Moulding Company of Calcutta who fitted the metal parts, and these have been reported to be in demand.

In reply to enquiries, samples of this powder were sent to moulding companies in and outside India together with complete details for the production and working of the same. Detailed reports from these sources are awaited. One firm in Australia is already manufacturing articles out of such a composition.

9. Rubber-Shellac Combinations

(A) Moulding compositions

Research work on this problem was initially started with a view to meet a number of enquiries received pertaining to the manufacture of water-proof and gas-proof fabrics, rubber shoe-heels and soles, petrol-proof washers. The most important objective, however, is to evolve a suitable standard process for incorporating lac in rubber compositions. Preliminary investigations were mainly directed to find out a cheap method for bringing about intimate mixings of lac and rubber. The methods known so far fall under the two following main groups, *viz.*, (A) dry mixing, (B) liquid mixing.

(A) Suitable machinery necessary for dry mixing of lac and rubber being not available at the Institute, the work on this aspect of the problem could not be undertaken in great detail.

(B) This method has been found to be cheap and convenient, and after a large number of trials it has given very satisfactory results. It is briefly described below :

(i) To start with, a 30 per cent. ammoniacal solution of lac is prepared by boiling lac in dilute ammonia, to which ammonia-stabilized 30 per cent. rubber latex is added in required proportions. The mixture is stirred vigorously for 30 minutes at a temperature of 90°C. Rubber and lac are thus homogenized in solution form. Softening, dispersing and stabilizing agents, such as stearic, oleic and other fatty acids, vegetable

oils, tar, pitch, rosin, casein, triethanolamine and phenols are mixed, if necessary, during the early stage of dissolution of lac in ammonia.

(ii) Dry and inert materials, such as kaolin, kiesulghur, barytes, oxides of iron, zinc, magnesium, etc., to be used as pigments and fillers are separately ground in the ball mill. They are further wetted and mixed by stirring in lac-rubber solution. The pasty mass thus obtained is poured out in an open pan and dried in air.

(iii) The dried material is further worked on hot rollers until the rubber is softened thoroughly and intimately mixed with other ingredients and the last traces of moisture removed. The material thus treated on rollers finally lends itself to be easily drawn into thin sheets. It is at this stage that vulcanizing agents, such as sulphur and urea, are added and mixed in the product. Rubber-lac combinations thus drawn into thin sheets are finally precured by heating in a steam oven for a period of 2 to 3 hours in a vacuum steam oven. The sheets thus prepared are ready for moulding. Depending on the proportions of lac and rubber in the mixture, vulcanization temperature of 140-145°C. for 3 minutes at 10-ton pressure has given the best results. The moulded articles can be removed hot.

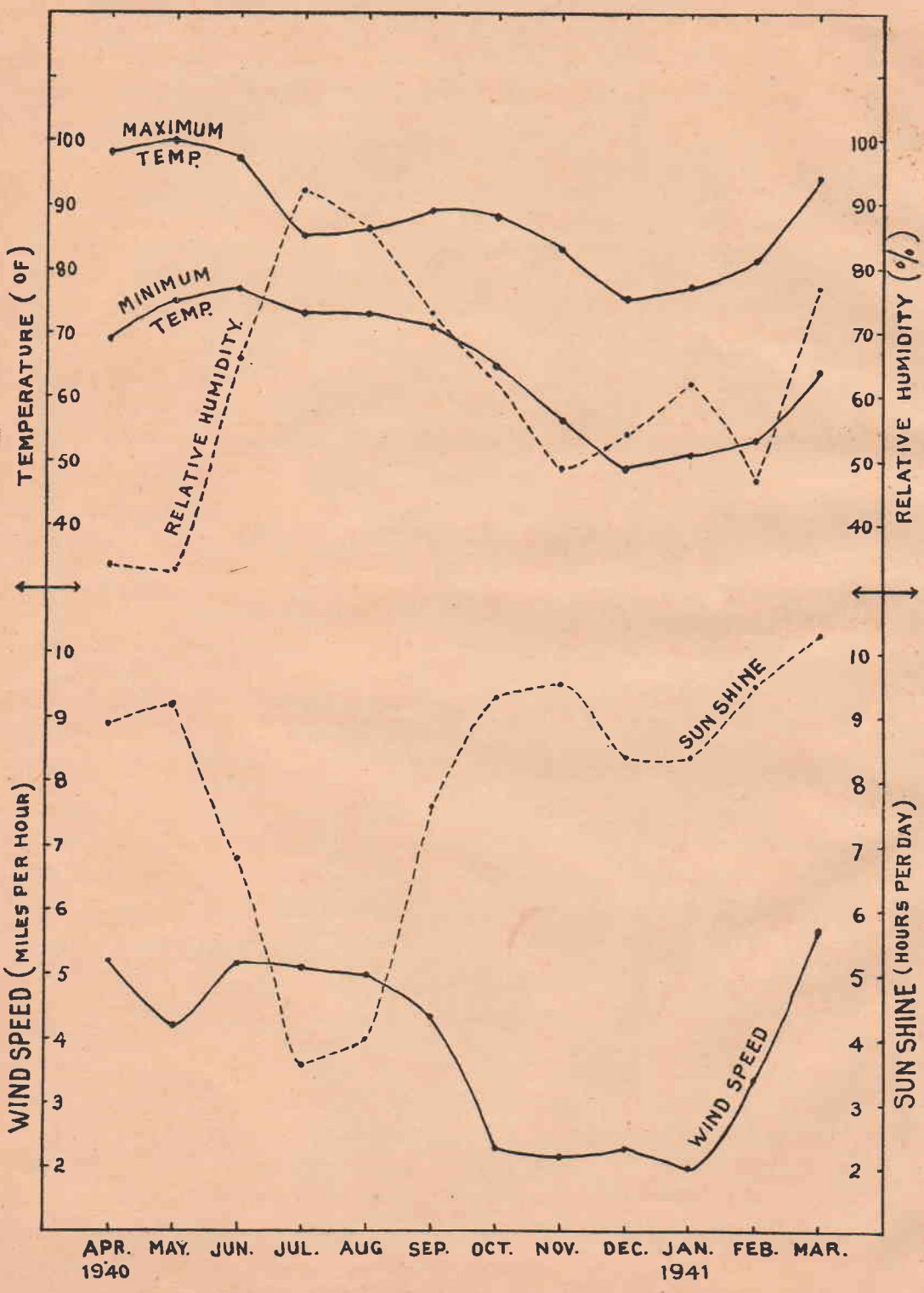
An ammoniacal solution of lac acts as a stabilizer for rubber. By a slow and cautious process of curing, both can be vulcanized at the same time. Lac resin imparts hardness and stiffness to the article moulded. By this process, lac and rubber can be mixed in all proportions. It may be mentioned finally that in all the experiments undertaken, locally available ingredients required for compounding have been used as far as possible. Vulcanizing and accelerating agents, which are being sold under patent names, have not been tried.

(B) Shellac-latex water varnishes

Experiments undertaken to find out a cheap and simple method for preparing water varnishes containing lac and rubber for waterproofing silk and cotton fabrics have resulted in the discovery of a satisfactory method, which is described below :

> 30 gms. lac, 5 gms. linseed oil fatty acids, 2 gms. glycerin and 2 gms. triethanolamine are dissolved in dilute ammonia by boiling. Ammonia-stabilized latex containing 70 gms. rubber and 3 gms. urea are added to the lac solution and stirred for 30 minutes at 90°C. The volume of water is so adjusted from the beginning that the final mixture contains 20 gms. of lac and rubber combined per 100 c.c. Vulcanizing materials, *e.g.*, 3 gms. sulphur, 3 gms. zinc oxide and pigments are ground separately to a fine condition in a ball mill. Proportions of vulcanizing agents and pigments to lac-rubber mixture will vary depending on the type and quality of reagents used.

The ground material is incorporated in rubber-lac solution either by stirring or grinding in the ball mill. The pigmented varnish is coated immediately on fabrics by


MAXIMUM TEMP.
MINIMUM TEMP.
RELATIVE HUMIDITY
TEMPERATURE (°F)
RELATIVE HUMIDITY (%)
100
90
80
70
60
50
40
SUN SHINE
WIND SPEED
WIND SPEED (MILES PER HOUR)
SUN SHINE (HOURS PER DAY)
10
9
8
7
6
5
4
3
2
APR. 1940
MAY.
JUN.
JUL.
AUG
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JAN. 1941
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spraying, and it dries within 30 minutes if exposed to open air in the sun. The coated fabrics are flexible, non-tacky and become perfectly water resistant on baking for 3 hours in a steam oven. Research work on the same line is in progress with a view to prepare petrol-proof and gas-proof fabrics.

10. Meteorological Report

The meteorological conditions were normal throughout the year except for small variations.

The rainfall was slightly less than normal, but the monsoon rainfall was as usual and a comparison for the last three years is as below—

	1940-41	1939-40	1938-39
Total rainfall (April-March)	50·32 ins.	57·85 ins.	57·89 ins.
Monsoon rainfall (June-September)	42·33 ,,	41·54 ,,	44·90 ,,

There were practically no hailstorms during the year except a very slight one on the 19th January, 1941.

The night temperatures were slightly higher than normal during the cold weather, *i.e.*, November, December, 1940 and January, 1941.

The relative humidity was lower than usual in September 1940 due to less frequent showers.

Wind velocities were the highest during April and June, 1940 and March, 1941.

The longest spells of bright sunshine were during March, 1941 when it was as much as 10·3 hours per day on the average.

The data are represented graphically on the facing page.

ENTOMOLOGICAL SECTION

1. Demonstration Campaign

Demonstration work was continued in Chota Nagpur Division in Bihar and Malda and Murshidabad Districts in Bengal. The campaign was extended to the district of Santal Parganas in Bihar.

Four more demonstrators, appointed for Bihar, have been trained and are doing demonstration work.

The *Baisakhi* crop in the demonstration areas was very promising, but contrary to our directions the cultivators cut the crop *ari*. However, five *Ber* (*Z. jujuba*) trees in the compound of the Subdivisional Officer, Khunti, which were cultivated according to the improved methods and crop on which was allowed to reach maturity, not only yielded a good *Baisakhi* crop but also two maunds of brood lac, which is rarely the case with *Ber* in the *Baisakhi* crop.

In the *Katki* 1940 crop, 53 trees in Khunti area, in addition to the lac left on a number of trees for self-infection, yielded 5 mds. and 12 srs. of brood lac.

In order to demonstrate to the villagers conclusive results and persuade them to adopt our methods, the demonstration campaign was intensified in a few villages in the districts of Ranchi, Palamau and Santal Parganas since October last.

In the Latehar and Chandwa areas of Palamau District, 33 pruning instruments were distributed free. In the Chandwa area, cultivation of lac is mostly confined to *Ber* which seldom carries the *Baisakhi* crop to maturity. The cultivators therefore cut all the crop *ari* and do not generally get any *Katki* crop. To infect the *Baisakhi* crop they have to purchase brood lac every year. The improved methods, being demonstrated, will enable the cultivators to get over this difficulty and they will have both the *Katki* and *Baisakhi* crops without resorting to purchase of brood lac.

13 maunds of brood lac costing about Rs. 85/- was distributed free in October 1940. Out of this 5 maunds was infected in Santal Parganas where the crop died towards the end of January. The examination of the crop revealed 45·1 per cent. mortality due to natural death, which is about the normal, and 53·3 per cent. mortality due to *Chalcidoid* attack. This high parasitism by Chalcids shows how regional and dangerous the parasite attack can be. The matter will be investigated further next year with local as well as imported brood lac.

7 mds. and 26 srs. of *Kusmi* brood lac costing Rs. 382/8/- was distributed free in the Ranchi and Palamau districts. For want of pruned trees the brood has been infected on unpruned trees and the settlement of lac insects is, therefore, patchy.

The Bengal demonstrators report that the cultivators are taking interest in demonstration and are adopting the improved methods.

Free distribution of brood lac and pruning instruments seems to be gaining the confidence of villagers to some extent and it is expected that those cultivators who have received brood lac from us will co-operate in carrying out the improved methods.

It has also been possible to enlist the co-operation of Lal Saheb of Palkot for lac cultivation along improved methods on a co-operative basis between him and some of his tenants. Lal Saheb is one of the biggest Zamindars in Chota Nagpur ; his co-operation should prove very helpful.

In addition to the routine work, demonstrators also attended various exhibitions on request from the exhibition authorities and delivered lectures on improved methods of lac cultivation, simple methods of pest control and utilisation of lac.

Inauguration of schemes of extensive demonstrations of improved methods of lac cultivation, in co-operation with the Provincial Governments of Bihar, Bengal, U. P., C. P. and Assam is still pending decision on their financial implications.

2. Plantation

Bogamedallor (*Tephrosia candida*) has established itself as a cover crop. But contrary to expectations, crushed boga seeds failed to prove a suitable manure for nursery beds. Guinea (*Panicum maximum*) and sabai grass are progressing satisfactorily. Arhar (*Cajanus indicus*) gave good results. Yields for the year are as follows :

	Mds.	Srs.	Chitaks.
*Scraped lac yield including yield from lac used as brood	26	12	15½
Sabai grass	17	24	0
Guinea grass	25	32	0
Bogamedallor seed	27	35	0
Tung oil seed	0	24	0
Arhar seed	3	37	0

Experiments on the effect of contour trenching were given up as the results did not indicate any improvement, and the Imperial Agricultural Chemist, Delhi, has advised the Forest Department, Bihar, to adopt a new technique to note the effect of contour trenching.

During the *Baisakhi* crop, good results were obtained from infection of *Palas* brood lac on *Dalbergia lanceolaria* and *Khair* brood on *Albizzia lucida*. If further trials confirm the above results, *D. lanceolaria* and *A. lucida* might be introduced as *Baisakhi* hosts in Bihar. In the *Katki* crop good yield was obtained from *Palas* brood lac on *Ber*, *Porho* and *Palas*, and *Pakur* brood lac on *Khair*. *Jethwi* crop was poor but *Aghani* crop was better than that of the last year.

*N. B.—Over and above this 4 mds. 5 srs. and 8 ch. brood lac was supplied to cultivators.

3. Insect Enemies of Lac Host Trees

1. *Tessaratoma javanica*, Thumb. (Pentatomidae).—The attack of the bug on *Schleichera trijuga* (Kusum) is on the decrease. Hand picking was found satisfactory control.

2. *Aspidiotus orientalis*, Newst. (Coccidæ).—The prevalence of the coccid is on the decrease partly because most of the *Ber* trees, due to stunted growth, have been heavily pruned and partly probably due to systematic control adopted in the previous year.

3. *Termites.*—Petrol and mysto proved satisfactory fumigants.

4. *Desmidophorus hebes*, Fabr. (Curculionidæ).—This weevil appeared as a pest of ornamental *Hibiscus*. Hand picking was resorted to.

5. Identifications of the following insects were received —

	Insect	Host
(i)	*Arhopala amantes*, Hew.	*Shorea robusta* and *S. trijuga* leaves.
(ii)	*Paectes subapicalis*, Wlk.	*Shorea robusta* leaves.
(iii)	*Lophoptera illucida*, Wlk.	do.
(iv)	*Arhopala rama*, Koll ?	*Shorea robusta* and *S. trijuga* leaves.
(v)	*Endaeus buteae*, Flet.	*Butea frondosa* flowers.
(vi)	*Enarmonia stirpicola*, Meyr.	do.
(vii)	*Acroclita cryptiolitha*, Flet.	do.

4. Bionomics of Laccifer lacca (Kerr.)

1. Parthenogenesis.—The third generation of the strain, started in October 1939, is developing satisfactorily. Average fertility in the first generation was 269·6 and in the second 334·8.

2. Selection.—The selection was successful ; third generation of the yellow strain is in the field now. So far there is no change in colour.

3. Mortality & Fertility.

	Strain	Total mortality %	Fertility
Baisakhi 1940-41—	Palas × Palas	83·7	815·7
	Palas × Ber	85·1	537·1
	Ber × Ber	85·2	490·2
	Ber × Palas	84·3	629·5
Jethwi 1940—	Kusum × Kusum	85·4	354·2

Katki 1940—	Ber × Ber	68·2	313·3
	Ber × Palas	68·9	261·5
	Ber × Khair	72·2	290·0
	Palas × Palas	64·8	335·7
	Palas × Ber	63·1	263·4
Aghani 1940-41—	Kusum × Kusum	71·6	110·0
	Kusum × Khair	65·9	163·5

Mortality in the *Baisakhi* and *Jethwi* crops was practically the same as in the previous year. The same was the case with fertility of all the *Baisakhi* strains but *Palas* in which the fertility was very high compared to every other strain in the previous and current year. Fertility in the *Jethwi* crop was higher than it was in the previous year. Mortality in the *Katki* as well as *Aghani* crop was lower than in the previous year. Fertility in the *Katki* crop was practically the same as in the previous year, but it was lower in the *Aghani* crop compared to that of the previous year. This is due to unfavourable weather conditions at the time of crop cutting.

4. Preservation of the Baisakhi Palas Brood Lac of the Lac Insect.—Most of the lac on *Palas (Butea frondosa)* dies in summer before reaching maturity and therefore two-third of the crop has to be cut *ari* in April-May, by which time the lac females have not produced all the resin they are capable of producing. Further, the lac that is left on the trees to mature survives on few trees only resulting in scarcity of brood lac in June-July and uneven distribution of trees for cultivation of the *Katki* and *Baisakhi* crops.

To overcome the above difficulties an experiment has been started in the Bihar Government Forest, Kundri, from October 1940. One hundred control trees were infected according to villagers' method and the same number of experimental trees were dressed by removing $\frac{3}{4}$ of the leaves with stalks and infected. With the new technique 1 md. and 9 srs. of less brood lac was used to infect the experimental trees than the control, because $\frac{3}{4}$ of the leaf stalks, which share the settlement of lac larvæ with twigs, had been removed from the experimental trees. The leaves were removed to induce earlier new foliage than naturally occurs in *Palas*. By the end of March 1941, 20 per cent. of experimental trees had put forth new foliage against 4 per cent. of the control.

5. Insect Damage to Stored Lac— To determine the actual amount of damage caused by insect enemies to stored lac in godowns and its effect on the quality of lac, experiments have been started with *Rangini* as well as *Kusmi* lac.

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. Of the minor pests *Chrysopa sp.* is more important, the damage caused by it is not generally observed.

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

2. Parasite Enemies— The average percentage of parasitism in the Institute plantation was 6·0 only. But the *Baisakhi* 1940-41 lac crop in three villages of Santal Parganas under demonstration showed 53·3 per cent. parasitism. This indicates how the parasite attack may vary from locality to locality and how dangerous it can become.

The following eight species of parasite of *L. lacca* were bred during the year :

(i) *Eupelmus tachardiae*, How. (Eupe]midæ).
(ii) *Tachardiaephagus tachardiae*, How. (Encyrtidæ).
(iii) *Tachardiaephagus 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 purpureus*, Cam. (Eulophidæ).

A chalcid parasite on *Apanteles sp.* was bred for the first time, but since there is only one specimen available it could not be sent for identification.

6. Control of Insect Enemies

A. Artificial Control

Results of water immersion and of chemical examination of the shellac produced from the water immersed sticklac will be publised during the next year.

B. Biological Control

The control of chalcid parasites of the lac insect by hyper-parasites has been discussed in previous reports and shown impracticable by hitherto known hyper-parasites. Control of predators of the lac insect only by their parasites is therefore being studied at present.

(i) M. greeni and M. hebetor— Work was concentrated on control of the predator *E. amabilis* by *M. greeni* and *M. hebetor* and of *H. pulverea* by *M. hebetor*. During the year under report it was discovered that *M. hebetor* is an indigenous parasite of an *Ephestia sp.* pest on *Bassia latifollia* (Mahua). *Bassia latifollia* is common in the lac growing areas of Chota Nagpur ; as such it remains to be seen if *M. hebetor* will go in for predators of lac in preference to its own natural hosts which are many and more easily accessible than the predators of lac.

To tide over the scarcity of host larvæ for breeding *M. greeni* and *M. hebetor* at certain times during the year, experiments were started to preserve *E. amabilis* and

H. pulverea larvæ by injections of chemicals and repeated paralysation at intervals by the braconids. The chemicals used for injections were 2 per cent. to 5 per cent. solutions of acetic, formic and lactic acids and 10 per cent. glucose and glycerine. The host larvæ could be kept soft for the maximum period of 10 days with acid injections. The braconids generally did not oviposit on injected hosts, but when injected hosts were offered to middle stage braconid larvæ, they fed on them and developed into adults. Repeated paralysation at intervals by the braconids kept the host larvæ soft to a maximum of 18 to 29 days but in only one case an egg developed into adult by feeding on one such larva.

The possibility of preserving the host larvae by above methods as well as by cold storage will again be tried during the coming year.

(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. Special attention will be paid to this aspect during the coming year.

In the laboratory, *Ephestia sp.* is a good and handy host to breed the *Trichogrammids* but the larvæ, hatching from unparasitised eggs, attack and damage eggs that have been parasitised, so also behave *H. pulverea* larvæ. To overcome this trouble various repellants were tried but they adversely affected the emerging *Trichogrammids* also. Ultimately, linseed oil was found to be the best repellant ; it repels the host larvæ and does not have any ill effect on the emerging *Trichogrammids* provided the cards carrying the parasitised eggs are not over moistened. The technique requires further development.

(iii) Other Parasites of Lac Predators—The following were observed and bred during the year :

(a) *Pristomerus testaceicollis*, Cam. (Ichneumonidæ).—It is an endo-parasite of *H. pulverea* but, for the first time, this year it was found to be an endo-parasite of *E. amabilis* also.

(b) *Apanteles tachardiæ*, Cam. (Braconidæ).—It is the most important indigenous parasite of *H. pulverea* and deserves trial in the field, if *M. hebetor*, the introduced parasite, continues to give indifferent results.

A. tachardiæ emerged in numbers from parasite cages both from mature and immature lac.

(c) *Chelonella cyclopora*, Franz. (Braconidæ).
(d) *Apanteles fakrulhajiæ,* Mahd. (Braconidæ).
(e) *Brachymeria tachardiæ,* Cam. (Chalcididæ).

(f) *Elasmus claripennis*, Cam. (Elasmidæ).
(g) *Eurytoma palidiscapus*, Cam. (Eurytomidæ).
(h) *Periseriola sp.* (Bethylidæ).

7. Field Experiments on Biological Control

A. JETHWI 1940 CROP (Jan.-Feb. to June-July)

(a) *Host and brood.* –It was for the first time in *Jethwi* 1940 crop that pruned trees were infected in the experimental area at Hessal. But due to failure of the previous crop, good brood lac was not available, therefore the trees had to be infected with good, bad and indifferent brood. In the control area only good brood was used.

(b) *Crop yield.*

	Control Mds.	Sr.	Ch.	Experimental Mds.	Sr.	Ch.
Brood used	0	14	10	6	26	0
Crop obtained in weight of lac sticks	1	5	4	4	2	0
Brood : Crop ratio ...	1 : 3·1			1 : 0·6		
				According to the quality of the brood, the ratio varied from 1 : 0·1 to 2·2		

(c) *Parasites released.*

	Males	Females
M. greeni	460	653
M. hebetor	941	1256

(d) *Prevalence of parasites and predators in the crop during the season.*

	Microbracon greeni Control	Experimental
Length examined	69·0"	191·0"
Total *E. amabilis* larvæ found	14	19
E. amabilis larvæ parasitised	nil	nil
Average percentage of parasitisation ...	nil	nil
	Microbracon hebetor	
Length examined	69·0"	191·0
Total *E. amabilis* larvæ found	14	19
E. amabilis larvæ parasitised	nil	nil
Average percentage of parasitisation ...	nil	nil
Total *H. pulverea* larvæ found ...	15	15
H. pulverea larvæ parasitised	nil	1
Average percentage of parasitisation ...	nil	6·6

(e) *Storage experiments—*

Emergence of adults from per 11·2 lbs. stored lac

	Lac stored	E. amabilis	H. pulverea	M. greeni	M. hebetor
Control	Mature fresh	270	1980	nil	nil
Experimental	„	34	412	nil	10
Control	*Phunki* brood	265	380	20	nil
Experimental	„	315	488	65	nil

B. AGHANI 1940-41 CROP (June-July to Jan.-Feb.)

(a) *Host and brood.*—It was the first time in this crop that pruned trees after the necessary 1½ years' rest were infected with good brood lac in the experimental area.

(b) *Crop yield.*

	Control Mds.	Srs.	Ch.	Experimental Mds.	Srs.	Ch.
Brood used	1	27	10	11	37	0
Crop obtained in weight of lac sticks ...	2	17	0	52	16	8
Brood : Crop ratio (lac sticks)	1 : 1·4			1 : 4·3		
(scraped lac) ...	1 : 0·7			1 : 2·4		

(c) *Parasites released.*

	Males	Females
M. greeni	10,162	16,075
M. hebetor	3,556	6,913

(d) *Prevalence of parasites and predators in the crop during the season.*

	Microbracon greeni Control.	Experimental
Length examined	130"	935"*
Total *E. amabilis* larvæ found	119	63
E. amabilis larvæ parasitised	19	13
Average percentage parasitisation	15·9	20·06

	Microbracon hebetor	
Length examined	130"	935"*
Total *E. amabilis* larvæ found	119	63
E. amabilis larvæ parasitisation	nil	1
Average percentage parasitisation	nil	1·5
Total *H. pulverea* larvæ found	57	205
H. pulverea larvæ parasitised	nil	2
Average percentage parasitisation	nil	0·9

*This length does not include the leaf stalks examined from experimental lac in September 1940 as no leaf stalks were examined from the control lac.

(e) *Storage experiments.*

Emergence of adults from 11·0 lbs. of stored lac up to March 1941 only.

	Lac stored	E. amabilis	H. pulverea	M. greeni	M. hebetor
Control	Mature fresh	100	605	150	nil
Experimental	,,	9	652	28	nil
Control	*Phunki* brood	125	440	140	nil
Experimental	,,	17	285	5	nil

The range of distribution of the released braconids was for the first time observed from November 1940. So far *M. greeni* has been found to distribute itself to the maximum distance of 300 feet from the centre of release. No released *M. hebetor* could be recovered, therefore its range of distribution is not yet known.

The *Kusum* (*S. trijuga*) trees in Namkum, which served as control to experimental trees in Hessal, were too small and young to be comparable and therefore a new control area has been taken up in Berwari, an area adjoining to Hessal, having almost the same topography and trees of about the same size and age.

The technique of the experiment is being modified to enable a statistical interpretation of data to be obtained.

Jethwi 1941 crop.—Pruned trees were not available in Berwari, in the control area, therefore 78 unpruned trees were infected with 13 mds. and 38 srs. of brood lac. Pruned trees will not be available for control experiments till February 1942 at the earliest.

In Hessal, the experimental area, 60 trees were infected with 11 mds. 20 srs. and 9 ch. of brood lac.

Trees were pruned in the control area. In the experimental area, now crop cutting on the whole automatically serves the purpose of pruning.

At the time of *Aghani* 1941 crop cutting and infection of *Jethwi* 1941 crop, the climatic conditions were adverse. The emergence and settlement of lac larvæ was therefore affected. The crop, however, is developing satisfactorily. So far suitable stages of predators for parasitisation are absent and no braconids have therefore been released.

APPENDIX I

INSTITUTE PUBLICATIONS, 1940-41

I. Annual Reports (for financial years ending 31st March)

*1. Annual Report, 1925—1926.
*2. Annual Report, 1926—1927.
*3. Annual Report, 1927—1928.
*4. Annual Report, 1928—1929.
*5. Annual Report, 1929—1930.
6. Annual Report, 1930—1931.
*7. Annual Report, 1931—1932.
*8. Annual Report, 1932—1933.
*9. Annual Report, 1933—1934.
*10. Annual Report, 1934—1935.
*11. Annual Report, 1935—1936.
*12. Annual Report, 1936—1937.
13. Annual Report, 1937—1938.
*14. Annual Report, 1938—1939.
15. Annual Report, 1939—1940.

II. Bulletins

A. CHEMICAL

		Year of publication.
*1.	Bulletin No. 1. Physical Properties of Shellac Solutions, Part I. By M. Rangaswami and M. Venugopalan	1928
*2.	Bulletin No. 2. Physical Properties of Shellac Solutions, Part II. By M. Rangaswami and M. Venugopalan	1929
*3.	Bulletin No. 3. Wax and Resin Secretion by the Lac Insect on *Butea frondosa*. By M. Venugopalan	1929
4.	Bulletin No. 4. Properties of Shellac Films. Resistance of shellac films from various varnishes to action of water and chemicals. By M. Venugopalan and M. Rangaswami. Reprinted from *Industrial and Engineering Chemistry,* Vol. XXII, No. 8, Industrial edition, August 1930	1930
*5.	Bulletin No. 5. Humidity and Storage of Button Lac. By R. W. Aldis. Price 8 annas	1930
*6.	Bulletin No. 7. Orpiment and the Iodine Value of Shellac. By M. Rangaswami and R. W. Aldis. Price 8 annas	1932

*Not available.

		Year of publication.
*7.	Bulletin No. 8. The Iodine Value of Shellac. By R. W. Aldis. Price 8 annas	1932
*8.	Bulletin No. 10. The Influence of Orpiment in Shellac on the Protective Properties of the Varnish. By M. Rangaswami. Price 8 annas ...	1932
*9.	Bulletin No. 12. Shellac Drying-Oil Combinations. By R. W. Aldis. Price Re. 1-8-0	1933
*10.	Bulletin No. 13. Orpiment in Shellac. By R.W. Aldis. Price Re. 1-0-0	1933
11.	Bulletin No. 14. The Heat Curing of Shellac, Part I. The life under heat. By S. Ranganathan and R. W. Aldis. Price Re. 1-8-0 ...	1933
*12.	Bulletin No. 17. The Refractive Index of Shellac. By Ananta Krishna Thakur and R. W. Aldis. Price Re. 1-0-0	1934
*13.	Bulletin No. 18. Modification of Shellac, Part I. The effect of sulphur. By M. Venugopalan. Price Re. 1-0-0	1934
*14.	Bulletin No. 19. The Heat Curing of Shellac, Part II. Depolymerisation. By M. Rangaswami and R. W. Aldis. Price Re. 1-0-0 ...	1934
*15.	Bulletin No. 25. The Use of Quinhydrone and Antimony Electrodes for Potentiometric Titrations of Resin Solution. By Narasimha Murty and Harold Weinberger with Wm. Howlett Gardner	1936
*16.	Bulletin No. 26. Estimation of Orpiment in Shellac. By M. Rangaswami and H. K. Sen. Price 2 annas	1937
17.	Bulletin No. 29. Contribution to the Study of the Bleaching of Lac, Part I. The action of the chlorine-bleach on the resin constituents of lac. By Narasimha Murty. Price 2 annas	1937
18.	Bulletin No. 30. Shellac Plastics, Part I. By S. Ranganathan. Price 2 annas	1938
19.	Bulletin No. 31. Fluorometric Determination of the Acid and Saponification Values of Lac. By Narasimha Murty and H. K. Sen. Price 2 annas	1938
20.	Bulletin No. 32. Contribution to the Study of the Bleaching of Lac, Part II. Factors which influence the keeping quality of bleached lac. By Narasimha Murty	1939
21.	Bulletin No. 33. Studies on the Constitution of the Shellac Complex, Part I. Interaction of tolyliodochloride with shellac. By M. Venugopalan, H. K. Sen and S. C. De	1939
22.	Bulletin No. 34. Studies on the Constitution of the Shellac Complex, Part II. Unsaturation in shellac. By Y. Shankaranarayanan, M. Venugopalan, Syama Charan De and H. K. Sen	1939

* Not available.

Year of publication.

23. Bulletin No. 35. Contribution to the study of the Bleaching of Lac, Part III. Factors affecting bleaching quality of seedlac By Narasimha Murty, B. Gross and Wm. Howlett Gardner 1939
24. Bulletin No. 36. Specific Heat of Lac. By Girendra Nath Bhattacharya 1940
25. Bulletin No. 37. Measurement of Gloss, Transparency and Colour. By Narasimha Murty 1940
26. Bulletin No. 38. Seedlac. Factors which affect the flow. By Wm. Howlett Gardner, L. Koprowsky and Narasimha Murty ... 1940
27. Bulletin No. 39. Physical Chemistry of Resin Solutions, Part I. Anomalous solubility of shellac and other natural resins in organic solvents. By Santi Ranjan Palit 1940
28. Bulletin No. 40. A New Method of Preparation of Hydrosols of Shellac and other Natural Resins and their Properties. By Santi Ranjan Palit 1940
29. Bulletin No. 41. Physical Chemistry of Resin Solutions, Part II. Nature of resin solutions in organic solvents. By Santi Ranjan Palit ... 1940
30. Bulletin No. 42. The Viscosity of Shellac-Urea Solutions. By Girendra Nath Bhattacharya 1940
31. Bulletin No. 43. Refractive Index of Lac. By Girendra Nath Bhattacharya 1940
32. Bulletin No. 44. Physical Chemistry of Resin Solutions, Part III. Viscosity of shellac solutions in mixed solvents. By Santi Ranjan Palit 1940

B. Entomological and General

*1. Bulletin No. 6. The Effects of Temperature and Humidity on Oviposition. Incubation and emergence in the lac insect, *Laccifer* (*Tachardia*) *lacca*, Kerr. (*Coccidæ*), and on the resulting crop. By P. M. Glover, Pratap Singh Negi, Mahabir Prasad Misra and Sri Narayan Gupta. Price Re. 1-4-0 1932
*2. Bulletin No. 9. Comparative Study on Lac Hosts with Special Reference to *Acacia catechu and Cassia florida*. By Ananta Krishna Thakur. Price 8 annas 1932
*3. Bulletin No. 11. Resin Secretion on Different Host Plants by the Lac Insect. By M. Venugopalan. Price 8 annas 1932
*4. Bulletin No. 15. Notes on the Use of *Schleichera trijuga* (Kusum) in Lac Cultivation, Pruning and Cropping. By Dorothy Norris. Price Re. 1-4-0 1933

*Not available.

Year of publication.

*5. Bulletin No. 16. *Aspidiotus* (*Furcaspis*) *Orientalis*, Newstead (*Coccidæ*). Its economic importance in lac cultivation and its control. By P. M. Glover. Price Re. 1-4-0 1933

*6. Bulletin No. 20. Further Notes on the Use of *Schleichera trijuga* (Kusum) in Lac Cultivation. By Dorothy Norris. Price 8 annas ... 1934

*7. Bulletin No. 21. A Check-List of the *Chalcidoidea* bred at Namkum from the Lac Insect, *Laccifer lacca*, with some Notes as regards their Function, Economic Importance and Control. By P. M. Glover. Price Re. 1-0-0 1934

*8. Bulletin No. 22. Further Notes on the *Chalcidoid* Parasites, *Laccifer lacca*, Kerr. By P. M. Glover. Price Re. 1-0-0 1935

9. Bulletin No. 23. Some Simple Methods of Reducing the Damage done by Insect Enemies to the Lac Crops. By P. M. Glover. Price 1 anna (Revised and enlarged) 1936

*10. Bulletin No. 24. The Use of *Schleichera trijuga* (Kusum) in Lac Cultivation. By Dorothy Norris. Price 9 pies 1936

11. Bulletin No. 27. A Technical Process for Washing and Refining Sticklac. By A. K. Thakur. Price 3 annas 1937

12. Bulletin No. 28. Conservation of the *Baisakhi Ber* (*Zizyphus jujuba*) Brood of the Lac Insect, and Possibilities of Effecting Better Returns from Lac Cultivation on *Ber*. By Pratap Singh Negi. Price 4 annas ... 1937

III. Research Notes

1. Research Notes on Lac, to replace Nos. 1-18,—
   - (i) Some Effects of Baking Shellac Varnish Films. By M. Rangaswami and R. W. Aldis 1933
   - (ii) Shellac-Castor Oil Combinations. By R. W. Aldis 1933
   - (iii) A Note on Wax-free Shellac. By M. Rangaswami 1933
   - (iv) Treatment of Shellac Varnish with Thiourea and Urea. By M. Venugopalan, S. Ranganathan and R. W. Aldis 1934
   - (v) Utilisation of *Kiri* for Plastic Mouldings. By S. Ranganathan and R. W. Aldis 1934
   - (vi) A Further Means of Dispersing Polymerised Shellac. By M. Venugopalan and R. W. Aldis 1934
2. Research Note No. 19. Injection Moulding of Shellac Plastics. By S. Ranganathan 1938

*Not available.

Year of publication.

3. Research Note No. 20. Preliminary Note on the Modification of the Soft Resin in Shellac. By M. Vanugopalan and H. K. Sen ... 1938
4. Research Note No. 21. Shellac-Casein Moulding Powder. By M. Venugopalan and H. K. Sen 1940
5. Research Note No. 22. Modifications of Shellac and Shellac Components with Melamine and Formaldehyde. By Y. Sankaranarayanan and H. K. Sen 1940
6. Research Note No. 23. Shellac-Coal-Tar Moulding Powder. By M. Venugopalan and H. K. Sen 1940
7. Research Note No. 24. Note on the Basicity and Molecular Weight of Shellac. By Santi Ranjan Palit and Girendra Nath Bhattacharya 1940
8. Research Note No. 25. Manufacture of Shellac Moulding Powders. By M. Venugopalan, S. Ranganathan and H. K. Sen 1940

IV. Technical Notes

1. Technical Note No. 1. Some Analytical Data for Pure Shellacs ... 1937
2. Technical Note No. 2. Some Information and Advice to Shellac Manufacturers 1937
3. Technical Note No. 3. Preparation of Bleached (White) Lac. By Narasimha Murty. Price 1 anna 1937
4. Technical Note No. 4. Improved Method of Seedlac Manufacture by the Country Process. By Ananta Krishna Thakur, Tarapado Bhowmik and H. K. Sen 1939
5. Technical Note No. 5. Shellac Plastics. By M. Venugopalan, S. Ranganathan and H. K. Sen 1940
6. Technical Note No. 6. Shellac-Nitrocellulose Lacquers. By M. Rangaswami 1940

V. Pamphlets and Leaflets

*1. Comprehensive Report covering the Activities of Indian Lac Association for Research from Its Inception in August 1921 down to 31st March 1926 1926
*2. Lac Research in India. An Address by Mrs. Dorothy Norris, Director of the Indian Lac Research Institute, before the United States Shellac Importers' Association, 28th April 1927 1927
*3. A Short Account of the Work of the Indian Lac Research Institute, 1930 1930

*Not available.

		Year of publication.
*4.	A Report on the State of Lac Cultivation and General Condition of the Lac Industry in Burma. By Dorothy Norris	1931
*5.	Advice on the More Profitable Use of *Kusum* tree as a Lac Host. By Dorothy Norris	1934
*6.	A Simple Method for the Forecast of Emergence of Lac larvæ. By Pratap Singh Negi	1934
7.	The Shellac Industry	1936
8.	Map of India showing Areas where Lac is grown	1938

VI. Articles in other Papers and Journals

A. On Chemistry of Shellac

*1.	A Note on the Determination of the Melting Point of Resins. By M. Rangaswami. Reprinted from the *Journal of the Oil and Colour Chemists Association,* Vol. XIII, page 287, 1930	1930
*2.	Developments in Lac Research. Proceedings of the Institution of Chemists (India), Vol. IX, Part IV, December 1937	1937
3.	Plastics. By S. Ranaganathan and H. K. Sen. Reprinted from the Proceedings of the Institution of Chemists (India). Vol. IX, Part III, 1937	1937
4.	The Fluorometric Determination of the Acid and Saponification Values of Lac. By Narasimha Murty and H. K. Sen. Reprinted from the *Analyst,* Vol. LXIII, No. 744, pp. 181-182, March 1938	1938
5.	The Determination of Orpiment in Shellac. By M. Rangaswami and H. K. Sen. Reprinted from the *Analyst,* Vol. LXIII, No. 742, pp. 36-37. January 1938	1938
6.	Separation of Hard Lac Resin by Cold Polymerisation and Fractional Precipitation. By M. Venugopalan and H. K. Sen. Reprinted from the *Journal of the Society of Chemical Industry,* October 1938 ...	1938
7.	A Note on the Modification of Shellac with Organic Acids. By M. Venugopalan. Reprinted from the *Current Science,* Vol. VIII, No. 1. ...	1939
8.	Shellac in Moulding and Varnishing Industries. By H. K. Sen. Industrial and News Edition of the *Journal of the Indian Chemical Society,* Vol. II, No. 3, 1939	1939
9.	Utilisation of *Kiri,* Part I. Black baking varnish. By Y. Sankaranarayanan and H. K. Sen	1940

*Not available.

Year of publication.

B. Entomology and General

*1.	The Lac and Shellac Industry of India. By Dorothy Norris. (*Capital*, Indian Industries and Trade Supplement, 13th December 1928) ...	1928
*2.	A Contribution to the Life-History of the Lac Insect. By Pratap Singh Negi. Reprinted from the *Bulletin of Entomological Research*, Vol. IX, Part IV, March 1929	1929
*3.	An Investigation into the Plant Requirements of *Zizyphus jujuba* during Growth and under Lac Cultivation, Part I. By Dorothy Norris, M. Rangaswami, M. Venugopalan and S. Ranganathan. Reprinted from *Indian Forester*, October 1929	1929
*4.	A Preliminary Note on the Use of *Acacia catechu* (Khair) as a Host Alternative with *Schleichera trijuga* (Kusum) for the Cultivation of *Tachardia lacca* (Lac). By Dorothy Norris, H. T. Bates and M. Rangaswami. Reprinted from *Indian Forester*, January 1930 ...	1930
*5.	Ants and the Lac Insect (*Laccifer lacca*). By Pratap Singh Negi, Mahabir Prasad Misra and Sri Narayan Gupta. Reprinted from the *Journal of the Bombay Natural History Society*, 1st March 1930 ...	1930
*6.	The *Noctuid* Moth (*Eublemma amabilis*, Moore). By Mahabir Prasad Misra, Pratap Singh Negi and Sri Narayan Gupta. Reprinted from the *Journal of the Bombay Natural History Society*, 15th January 1930	1930
*7.	The Lac Industry in India. By Dorothy Norris. (*Journal of the Oil and Colour Chemists' Association*, Vol. XIII, July 1930)	1930
*8.	Entomological Aspects of Lac Research in India. By P. M. Glover. Reprinted from the *Bulletin of Entomological Research*, Vol. XXI, Part III, October 1930	1930
*9.	Shellac. By Dorothy Norris. (*Capital*, 20th March 1930) ...	1930
*10.	Paper on Lac Plantations. By P. M. Glover. (Proceedings of Bihar and Orissa Forest Conference, Ranchi)	1930
*11.	The Lac and Shellac Industry of India. By Dorothy Norris, (*Capital*, December 1930)	1930
*12.	Shellac. By P. M. Glover. (*The Oil and Colour Trades Journal*, Vol. LXXVII, page 1884, 1930)	1930
*13.	Some Aspects of the Bionomics of the Lac Insect. By Pratap Singh Negi, Mahabir Prasad Misra and Sri Narayan Gupta. Reprinted from the *Journal of the Bombay Natural History Society*, 15th June 1931...	1931

*Not available.

Year of publication

*14. Some Simple Methods of Controlling the Insect Enemies of lac. By P. M. Glover. (Published by the Agricultural Department, Bihar and Orissa. Leaflet No. 2 of 1932) 1932

15. Research for Shellac. Reprinted from *Capital*, 2nd February 1933 ... 1933

*16. The Small Red Ant, *Solenopsis geminata* sub sp. *rufa.*, Jerdon, and Its Usefulness to Man. By Pratap Singh Negi. Reprinted from the *Journal of the Bombay Natural History Society,* 15th December 1933... 1933

*17. A Simple Method for the Forecast of Emergence of Lac Larvæ, and a Description of the Myology of the Adult Female Lac Insect, *Laccifer lacca*, Kerr, (*Coccidæ*). By Pratap Singh Negi. Reprinted from the *Indian Journal of Agricultural Science,* Vol. III, Part VI, December 1933 1933

*18. The Biology of *Holcocera pulverea,* Meyr, Its Predators, Parasites and Control. By Mahabir Prasad Misra and Sri Narayan Gupta. Reprinted from the *Indian Journal of Agricultural Science*, Vol. IV, Part V, October 1934 1934

*19. The Developmental Stages of *Bracon tachardiæ*, Cam. (Hym.). By P. M. Glover. Reprinted from the *Bulletin of Entomological Research,* Vol. XXV, Part IV, December 1934 1934

*20. The Alimentary Canal, Its Appendages, Salivary Glands and the Nervous System of the Adult Female Lac Insect, *Laccifer lacca,* Kerr. (*Coccidæ*). By Pratap Singh Negi. Reprinted from the *Bulletin of Entomological Research,* Vol. XXV, Part IV, December 1934 ... 1934

*21. Lac Cultivation and the Shellac Industry. By P. M. Glover. Reprinted from the *Tisco Review,* Vol. III, No. 1, 1935 1935

*22. Specificity of Parasitism by *Eublemma amabilis.* By P. M. Glover and Pratap Singh Negi. (*Current Science*, Vol. III, No. 9, March 1935)... 1935

23. The Hosts of *Eupelmus tachardiæ*, How. By P. M. Glover, Pratap Singh Negi and Sri Narayan Gupta. Reprinted from *Current Science*, Vol. 1V, No. 1, July 1935 1935

24. An Account of the Occurrence of *Chrysomphalus auranti,* Mask., and *Laccifer lacca,* Kerr., on Grape Fruit in Ranchi District, Chota Nagpur, with a Note on the Chalcidoid Parasites of *Aspidiotus orientalis,* Newst. By P. M. Glover. Reprinted from the *Journal of the Bombay Natural History Society,* 15th August 1935 1935

*25. A Preliminary Note on the Bionomics and Economic Importance of *Microbracon hebetor*, Say, a Braconid new to North India.

Not available.

Year of publication.

By P. M. Glover and Kamekhya Chandra Chatterji. Proceedings of the Indian Academy of Sciences, Vol. III, No. 3, March 1936 ... 1936

26. Indian Lac Industry. By H. K. Sen. Reprinted from *Science and Culture*, Vol. II, No. 9, pp. 454-459, December 1937 1937

27. *Eupelmus tachardæ*, How, and Lac Insect. By Pratap Singh Negi and Sri Narayan Gupta. Reprinted from *Current Science*, Vol. VI, No. 8, pp. 287-392, 1938 1938

28. Notes on the Biology and Larval Growth of *Aphrastobracon flavipennis*, Ashm. (*Braconidæ*). By P. M. Glover....*The Indian Journal of Entomology*, Vol. I, Part III, December 1939, pp. 1-14 1939

29. Lac—an Indian Monopoly. By P. M. Glover. *Indian Farming*, Vol. I, No. 2, February 1940 ... ...

30. The Practicability of Biological Control in the Lac Industry. By P. M. Glover and Sri Narayan Gupta. *The Indian Journal of Agricultural Science*, Vol. IX, Part III, June 1939 1939

*31. *Goryphus nursei*, Cameron (*Ichneumonidæ*). By P. M. Glover. *The Indian Journal of Entomology*, Vol. I, Part III, December 1939 ... 1939

32. Lac Cultivation. By P. M. Glover. Reprinted from *The Allahabad Farmer*, Vol. XIV, No. 1, January 1940 1940

VII. Books

*1. A Practical Manual of Lac Cultivation. By P. M. Glover. Price Rs. 2-0-0 1931

2. Bibliography of Lac. By Anakul Chandra Chatterjee. (Published by the Indian Lac Cess Committee). Price Rs. 2-8-0 1933

*3. Lac and the Indian Lac Research Institute. By Dorothy Norris, P. M. Glover and R. W. Aldis. 2nd Edn. Price Rs. 2-8-0 1935

4. Shellac Patent Index. Compiled by R. W. Aldis. Price Rs. 2-8-0 ... 1936

5. Lac Cultivation in India. (Being a second and revised edition of *A Practical Manual of Lac Cultivation*, by P. M. Glover, published in 1931). Price Rs. 2-0-0 1937

6. Uses of Lac. By H. K. Sen and S. Ranganathan. Price Re. 1-4-0 ... 1939

7. Practical Applications of Recent Lac Research. Edited by H. K. Sen. Price Rs. 1-8-0 1940

VII. Tung Oil Literature

*1. Notes on the Establishment of *Aleurites fordii* (Tung oil) in the Ranchi District of Chota Nagpur. By Dorothy Norris and H. T. Bates, Reprinted from *Indian Forester*, June 1930 1930

* Not available.

		Year of publication.
2.	The Establishment of *Aleurites fordii* (Tung oil) in the Ranchi District of Chota Nagpur. By Dorothy Norris and H. T. Bates ...	1933
3.	Instructions for Cultivation of *Aleurites fordii* (Tung oil) in Ranchi District, Chota Nagpur. A leaflet by Dorothy Norris	1936
4.	Hindi Translation of the above leaflet	1939

IX Lac Literature in Indian Languages

1.	Instructions for Crop Cutting ...	(Hindi) ...	1929
2.	Ditto	(Bengali)* ...	1929
3.	A Preliminary Note on the Use of *Acacia catechu* (Khair) as a Host Alternative with *Schleichera trijuga* (Kusum) for the Cultivation of *Tachardia lacca* (Lac) ...	(Hindi) ...	1930
4.	Ditto	(Oriya) ...	1930
5.	Advice on the More Profitable Use of the Kusum Tree as a Lac Host	(Oriya) ...	1934
6.	Ditto	(Hindi)* ...	1934
7.	A Simple Method on the Forecast of Emergence of Lac Larvæ	(Oriya) ...	1935
8.	Ditto	(Hindi) ...	1935
9.	Ditto	(Bengali)* ...	1935
10.	Some Simple Methods of Reducing the Damage done by Insect Enemies to the Lac Crops ...	(Oriya) ...	1936
11.	Ditto	(Hindi) ...	1937
12.	Ditto	(Bengali)* ...	1931
13.	The Shellac Industry	(Urdu) ...	1938
14.	Ditto	(Malayalam)* ...	1938
15.	Some Important Points About Lac Cultivation	(Bengali) ...	1938
16.	Bhashan. Being a Hindi translation of a lecture delivered at a demonstration held at the Lac Research Institute on 28th August 1938, by H. K. Sen		1938
17.	Lac Cultivation in India	(Bengali) ...	1939
18.	Ditto	(Hindi) ...	1939
19.	Ditto	(Oriya) ...	1939

IN THE PRESS

1. Practical Applications of Recent Lac Research (Hindi translation)

Note :—Copies of the publications can be had on application from the Director, Indian Lac Research Institute, Namkum, Ranchi, Bihar.

* Not available.

APPENDIX II

List of the Staff employed at the Indian Lac Research Institute, Namkum

(1940-41)

NAME	DESIGNATION	DATE OF APPOINTMENT
Administrative Section		
Dr. H. K. Sen, M.A., P.R.S. (Cal.), D.I.C., D. Sc. (Lond.), F.N.I.	Director	1st May 1936
Mr. S. N. Sahay, B.A.	Librarian & Indexer	7th July 1930
,, M. Bose	Head Clerk & Cashier	14th April 1927
,, J. K. Guha Roy	Second Clerk	1st April 1928
,, G. B. Thapa	Accounts Clerk	18th August 1925
,, J. M. Hazra	Typist	1st March 1927
,, C. B. Guha, B.A.	Stenographer	21st June 1937
,, Mohd. Sharfuddin	Stores Clerk	18th March 1933
,, Saheb Ali	Labour Supervisor	15th May 1935
,, K. C. Guha Roy	Chief Mechanic	8th June 1925
,, J. C. Bose	Asstt. Mechanic	1st March 1936
,, S. C. Dass	Turner	22nd April 1937
,, N. K. Bose	Temp. Accounts Clerk	30th August 1940 to 23rd December 1940
,, C.R. Dutta. Gupta	Temp. Typist Clerk	9th December 1940
,, A.B. Chatterji	,,	12th to 22nd Feb. 1941
,, M.N. Banerji	,,	3rd March 1941
Chemical Section		
Mr. M. Venugopalan, M.Sc., A.I.C., A.I.I. Sc.	Senior Assistant	2nd June 1925
,, M. Rangaswami, B.A.,A.I.I.Sc.	,,	2nd June 1925
,, S. Ranganathan, B.A.	,,	2nd August 1926
,, A. K. Thakur, M.Sc., A.I.I.Sc.	,,	1st April 1929
,, N. N. Murty, M.Sc., A.I.I.Sc. (on deputation to England)	Junior Assistant Cl. II	15th January 1931
,, G. N. Bhattacharya, M.Sc.	,,	4th August 1937
,, S. R. Palit, M.Sc.	,,	18th July 1938
,, Y. Sankaranarayanan, M.Sc.	,,	25th July 1938
,, S. C. De, B.Sc.	Analyst	23rd September 1930
,, P. M. Sivaramakrishnan, M.Sc.	Junior Asstt., Cl. III	23rd January 1940

NAME	DESIGNATION	DATE OF APPOINTMENT
Mr. T. P. Bhowmik, M.Sc. ...	Junior Asstt., Cl. III ...	1st April 1940
„ S. L. Rahaman ...	Lab. Assistant. ...	1st August 1925
„ B. Misra ...	„ ...	2nd April 1930
„ C. Banerji, B.Sc. ...	Temporary do. ...	3rd May to 1st July 1940
Aid to the manufacturers		
Mr. S. Gupta, B.Sc. ...	Junior Officer ...	15-5-40 to 14-11-40 22-11-40 to 21-12-40
Entomological Section		
Mr. P. M. Glover, B.Sc. (Leeds)... (on military duty)	Entomologist ...	27th July 1926
„ P. S. Negi, M.Sc. ...	Asstt. Entomologist ... (*now Offg. Entomologist*)	3rd July 1926
„ M. P. Misra, M.Sc. ...	1st Field Asstt. ...	7th September 1926
„ S. N. Gupta, M.Sc. ...	2nd „ „ ...	9th September 1926
„ E. Heber ...	Artist & Photographer	27th August 1924
„ J. N. Singh ...	Senior Fieldman ...	25th February 1926
„ K. C. Chatterji ...	Junior „ ...	19th February 1926
„ Ramprasad ...	„ ...	23rd October 1926
„ A. C. Chatterjee ...	„ ...	9th December 1929
„ B. Tirkey ...	Setter & Lab. Asstt. ...	30th July 1928
„ S. K. Bharadwaj, B.Sc. ...	Museum Assistant ...	7th September 1939

Demonstrators to the number of Ten.

The menial establishment comprises 28 persons.

APPENDIX III

A. Production of Sticklac (in maunds)

Year	*Baisakhi*	*Jethwi*	*Katki*	*Kusmi*	Total
1940	644,500	38,625	429,500	120,750	1,233,375
1939	1,123,000	25,500	201,500	44,000	1,394,000
1938	814,500	45,000	479,000	104,500	1,443,000

B. Exports of Different Kinds of Lac (quantity in cwts.)

Year	Button lac	Seedlac	Shellac	Sticklac	Refuse lac	Total
1940-41	...	...	...	...	...	597,864
1939-40	24,534	270,307	431,986	1,173	32,399	760,399
1938-39	20,002	206,051	382,480	2,885	30,636	642,054

C. Exports of Different Kinds of Lac (value in Rupees)

Year	Button lac	Seedlac	Shellac	Sticklac	Refuse lac	Total
1940-41	...	...	...	...	...	22,543,901
1939-40	827,719	5,473,457	12,284,871	17,848	515,669	19,119,564
1938-39	508,047	3,296,899	8,530,765	45,818	258,168	12,639,697

A—compiled from the reports of the Crop Statistician to the Indian Lac Cess Committee.

B and C—compiled from the records of the Director-General of Commercial Intelligence and Statistics, Calcutta.

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