PART I.

GENERAL INTRODUCTION.

By Gilbert J. Fowler.

The methods of lac cultivation and of the manufacture of shellac and button-lac have been frequently described,[1] but for the convenience of readers unfamiliar with the subject, it may be well to recall here in brief outline the essential features of the industry, and at the same time take the opportunity to correct certain small omissions and errors, which recur in published descriptions.

The raw material from which the various products of the lac industry of India are produced is known as stick-lac, and is a secretion from the body of the lac-insect, *Tachardia lacca*, which attaches itself to the tender twigs of certain trees, and converts their juices into three main substances, lac-resin, lac-wax and lac-dye.[2]

The Indian lac industry comprises (*a*) the cultivation of stick-lac, (*b*) the marketing of stick-lac, (*c*) the crushing, sieving and washing of stick-lac with production of 'grain-lac' or 'seed-lac,' together with sundry by-products, among which is an impure lac-dye, (*d*) the production from seed-lac of shellac and button-lac, as well as certain by-products, (*e*) the marketing of the finished materials.

Attention may be directed to the outstanding features of these various branches of the industry.

(*a*) *Cultivation of Stick-lac.*—The process of cultivating lac consists in inoculating suitable trees or host-plants with 'brood-lac,' i.e., twigs from a former crop encrusted with lac, in the interior of which the larvæ of the insect are just ready to swarm. Small bundles of brood-lac are affixed to the host-plant at convenient points, so that

[1] See particularly :—
'Lac and its Industrial Treatment,' by G. L. Hautefeuille, *Bulletin Economique de l'Indochine*, No. 116, 1915.
'Report on Lac and Shellac,' by H. A. F. Lindsay and L. M. Harlow. *The Indian Forest Records*, vol. viii, Part I, 1921.
'The Cultivation of Lac on the Plains of India,' by C. S. Misra. Pusa Bulletin No. 142, 1923.

[2] The 'lac' thus produced is quite distinct from Japanese lac, which is the sap of a specific tree, known as the Tonquin lac-tree (*Rhus succedanea*. Linn.) Japanese lac blackens on exposure to air, through the action of an enzyme, 'laccase,' and is the raw material of Japanese lacquer.

the larvæ can swarm out and travel along the branches or twigs to which they ultimately attach themselves. When the larvæ have ceased to swarm, say in a week or a fortnight or possibly longer, the now empty stick-lac, or 'phunki' lac as it is then termed, is removed and sold to the dealer who sells it to the merchant or manufacturer.

The larvæ of the lac-insect, having attached themselves to the twigs by means of their slender probosces, begin immediately to suck up the juices of the plant and to exude lac, and so to form the 'lac-cell.' The shape of the cell indicates whether the future insect is male or female. The male cell is elongated, the female spherical or hemispherical. Neither cell attains any great thickness till the males mature, when they emerge from their cells, crawl over the female cells and fertilise the female through an aperture in the cell. From this time the female begins to produce lac much more freely, and the thickness of the cell increases till within a few weeks of the ultimate swarming of the larvæ from the body of the female insect, and the consequent initiation of a new crop.

The period intervening between inoculation and the emergence of the males, and between this event and the final swarming of the new brood, varies in different localities and with different species of lac-insect. Generally the whole period occupies six months, so that there are two broods in the year. In Mysore it has been proved that three broods emerge in rather more than a year, albeit one may be relatively small.

The main lac-growing area in India is a broad belt including Chota Nagpur, Orissa and the north-eastern half of the Central Provinces. Lac is also grown in Assam, Burma and Indo-China, and in small quantities in other parts of India, notably Mysore.

The chief host-plants or trees on which lac grows readily are Palas (*Butea frondosa* Roxb.), Kusum (*Schleichera trijuga* Wittn.), Ber (*Zizyphus Jujuba* Lack.), Pipal (*Ficus religiosa* Tinn.) and Arhar (*Cajanus indicus* Spreng.). In Mysore the chief lac-bearing tree is *Shorea talura* Roxb.

(*b*) *Marketing of Stick-lac.*—The production of stick-lac in India reaches a total of rather more than one million maunds or approximately 40,000 tons. The methods and conditions of cultivation are such that each cultivator is responsible only for a few seers of this amount, a circumstance involving a large number of small agents or middlemen, who sell to the merchants from whom the factories purchase in bulk.

(*c*) *Production of 'grain' or 'seed-lac.'*—On arrival at the factory, the stick-lac is crushed, sieved and winnowed, generally by hand, in such a way that all the lac is separated from the twigs, and sorted into larger and smaller granules, and residual dust which still contains an appreciable percentage of lac, along with wax and insect bodies. The larger granules are then washed by treading with the feet under water, yielding a liquid highly coloured with lac-dye which is generally precipitated with alum or lime in settling tanks, when the deposit is worked up into cakes and sold as crude lac-dye. The washed granules, generally about $\frac{1}{10}$ inch in diameter, i.e., rather smaller than peppercorns, are known as 'grain' or 'seed-lac.' The coarser siftings are termed 'molamma' and the finer dust 'pank.'

(*d*) *Production of shellac and button-lac.*—The seed lac produced as above, is transferred to a long hollow cylinder, about 2 inches in diameter, of strong calico, together with a little orpiment, and a larger or smaller percentage, according to circumstances, of low-melting resin, such as colophony. This long bag is now taken by two workmen, one at each end, the more skilled of whom holds his end over a charcoal fire, while the other imparts a twisting motion to the bag. Under this treatment the lac granules at the heated end melt, and the melted resin oozes through the bag. The skilled workman scrapes up the melted lac with a spatula and bastes it into a homogeneous, molten mass, sprinkling it continually with water from a small pump in the floor convenient to his right hand.[1] If button-lac only is required, small portions of the melted mass are allowed to drop on the concrete floor and are stamped into the requisite shape. The production of shellac is more difficult and requires extraordinary skill. A lump of molten lac is spread on to the surface of a large stoneware bottle containing hot water, till it is flattened out into a slab about one foot square and $\frac{1}{8}$ inch thick. This is taken up by another skilled worker, and waved in front of the fire until it gradually stretches with the heat and at the appropriate moment is seized by the fingers, toes and teeth of the workman and stretched into a thin sheet some 3 feet square, of almost equal thickness throughout. These sheets, broken up, constitute the shellac of commerce.

The by-product from this process is the residue left in the long bag after the whole of it has been gradually twisted and squeezed over

[1] The object of adding orpiment (yellow sulphide of arsenic) is not merely to colour the lac yellow, but to remove, by a pyrochemical reaction with the orpiment, a certain amount of residual red or purple colouring matter which may be present in the lac granules. At the same time a sort of 'vulcanising' effect appears to be produced on the resin. Orpiment appears to be specific in its action and cannot be replaced by other sulphides. The colophony, or other foreign resin is added, not necessarily as an adulterant, but to increase the fusibility and ease of manipulation of the molten material. The water is sprinkled on for the same reason, as the melting point of lac resin rapidly rises with loss of water, owing to the formation of infusible anhydrides, and charring may readily occur.

the fire. This residue, which contains a large proportion of wax as well as resin, is known as 'kiri' and is recovered by boiling the exhausted bag with dilute alkali, or a little fuller's earth, when the bulk of the adherent lac and wax collects on the surface of the liquid and is removed and shaped into cakes, known as 'passewa', consisting of hydrated resin and wax, and residual mineral or woody matter.

Attempts to produce by solvent processes, e.g., solution in alcohol, shellac equal to that obtained by the process just described, have not so far been successful, but a considerable quantity of dark coloured, so-called 'garnet' lac is made by an alcohol solvent process.

(*e*) *The marketing of the finished products.*—The different varieties of shellac and button-lac find different markets according to their varied applications. Clear lac-varnishes require a resin as free as possible from colour. For hat making a certain proportion of added rosin is preferred and colour is of less importance, and for electrical varnishes the purest possible lac resin is required. Lac resin now finds its largest market in the manufacture of gramophone records, where again colour is of little moment.

From the above outline of the main features of the lac industry, it will be seen that it is practically a monopoly of India, and that its annual value is very considerable, the total exports of lac in favourable years amounting to nearly three crores of rupees or £1,750,000. Nevertheless the amount of detailed and accurate scientific information on any aspect of the industry is singularly scanty.

In the excellent and comprehensive report of Messrs. Lindsay and Harlow, only some forty references are given; many of these are short descriptive notes, and few have involved prolonged and detailed scientific study. The literature as a whole is descriptive rather than experimental. The reason for this is that the subject of the lac industry is so many-sided and presents so many problems that it can only be properly handled by team-work. An entomologist is required in the first place to study the life-history of the insect and its parasites, a botanist to deal with the physiological and botanical characteristics of the host-plants, a sylviculturist efficiently to maintain the plantations, a bio-chemist to investigate the chemical changes in insect, plant and soil, an organic chemist to deal with the chemical constitution of the resin, wax and dye produced under different conditions, and a technologist to apply the knowledge thus acquired to the processes of the factory. Finally, the business man will judge of the commercial practicability of the suggestions made by the scientific workers.

Such team-work pre-supposes command of a sufficient area of lac-bearing trees to be able to follow through several complete cycles of crops. The work also must continue for many years if the various perplexing problems which arise are to be even partially solved, and the industry placed upon a scientific basis. Such an organisation requires considerable expenditure for a prolonged period. The actual cultivation of lac is in the hands of numberless petty agriculturists, and those controlling capital are mainly merchants with little understanding of the scientific problems awaiting solution, or of the many possibilities of improvement.

Manufacturers with capital are chary of investing much in experimental work, and not without reason, having seen the failure of many promising processes, and more especially knowing the present highly speculative condition of any business in lac. Under present conditions an accurate forecast of the lac crop is very difficult to make. The cultivation being in the hands of technically ignorant operators, the crop is subject to every kind of vicissitude: depredation from parasites, injury from storms or extreme drought, destruction of all or part of the brood by unskilful or wasteful methods of inoculation, or not infrequently by complete stripping of brood-lac at the end of a short lease with consequent failure to carry on to next season. In consequence of this uncertainty, large stocks of finished shellac are held in London, and these again affect in inverse ratio the price of stick-lac in India. It may thus often happen that by the time a highly priced stick-lac is worked up into shellac, the price of the latter will have fallen, and all the profits of manufacture will have vanished. This is clearly set out in diagram form in Messrs. Lindsay and Harlow's report and is the one important reason why solvent processes and machinery have not replaced the indigenous method of manufacture described above. Modern methods require considerable capital and consequent overhead charges. The small lac-manufacturer with a charcoal fire and a calico bag risks very little, and is dependent solely on his personal skill or the skill of those whom he can employ. Before modern industrial methods can be generally adopted, the great need is for the cultivation of lac to be brought under scientific control. At present the information necessary before this can be satisfactorily accomplished does not exist, although enough is known to enable great improvements to be made in the methods at present in vogue. If an adequate supply of lac for the world's markets could be guaranteed, there would be less inducement for speculation, and wholesome competition in efficiency and initiative would take its place.

The suggestion, therefore, of Messrs. Lindsay and Harlow that a laboratory of lac-research be founded at Ranchi in the centre of the

lac district, to be supported by the lac industry generally through a cess on lac exports, is highly commendable.

The investigation of the lac-problem was started in these laboratories in 1917 and has been continued to the present time. The progress of the work has been greatly facilitated by :—

(*a*) Grants from the Government of H. E. H. the Nizam of Hyderabad, which have enabled Mr. Mahdihassan to continue his biological investigations and which have also largely met the cost of illustrations connected with this part of the work.

(*b*) The generosity of the Government of H. H. the Maharajah of Mysore in allocating for the use of the Institute an area comprising 200 lac-bearing trees at Doraisanipalya.

(*c*) The courtesy of Dr. Leslie Coleman, Director of Agriculture in Mysore, in placing at our disposal the resources of his department both for photomicrographic work and for pot-culture experiments.

The main lines of the research work so far undertaken may be summarised as follows :—

(*a*) *The Experimental Area at Doraisanipalya.*—Here the work has consisted in the observation and harvesting of seasonal lac crops, the pruning of trees, the observation of borers and parasites, and of the manurial requirements of the soil.

(*b*) *General Field Experiments.*—A systematic search for new host-plants for lac has been maintained, separate records have been kept in the case of each plant studied, of the rate of growth of the brood, its date of emergence and its vitality number. Sylvicultural data have been obtained, such as the period of germination of the seeds of host-plants, the determination of the suitable age of plant and season for inoculation, etc.

(*c*) *Pot-Culture Experiments.*—Pot-culture experiments with *Cajanus indicus* as host-plant have been carried out in the Mysore Agricultural Department and further experiments are being undertaken in specially prepared small plots of soil on the Institute estate.

(*d*) *The technical preparation of Seed-lac and Lac-dye.*—A set of concrete tanks originally constructed for another purpose, have been modified to serve as washing tanks for stick-lac, and the problems concerned with the grinding, sifting and washing of stick-lac, the recovery of lac-dye and the disposal of the offensive effluent from the washing process can be studied under working conditions.

(*e*) *Laboratory Investigations.*—These comprise systematic analyses of host-plants under various conditions, and the study by chemical analysis of the rate of secretion of resin by the lac-insect at different stages of its life-history, and the resin-producing efficiency of different species of insect on different host-plants at different seasons. The composition and constitution of the resins and waxes produced by the insect under various conditions are being studied The natural history and physiology of the lac-insect is the subject of careful microscopical examination in the laboratory as well as in the field.

Samples of brood-lac have been forwarded to and received from lac-producing centres in other parts of India and the material received utilised in various directions of the inquiry.

Mr. M. Sreenivasaya has been placed in charge of the more purely chemical side of the foregoing researches, whether in the field or in the laboratory. He has been assisted by Messrs. Rege, Gupta, Venugopalan, Somayajulu and Rangasawmy, students in the Department of Bio-chemistry. Mr. B. Banerjee, Bacteriological Assistant, has helped in regard to the study of lac-yeasts, and has taken numerous photographs.

Mr. Mahdihassan has throughout been individually responsible for the entomological studies which are described by him.