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GOVERNMENT OF MADRAS

REVENUE

DEPARTMENT

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No. 94. Read the following letter. C. J. LYALL, Esq., Under-Secretary to the Government of India, Department of Revenue, Agriculture, and Commerce, (Forests,) to the Secretary to the Government of Madras, dated Calcutta, 29th June 1874, No. 65:—

I AM directed to forward herewith three copies of a Note on Lac, compiled by Mr. J. E. O'Connor, Registrar in this Department, and to request that you will be good enough, with the permission of His Excellency the Governor, to cause them to be distributed to forest officers, the information contained in the Note will, in the opinion of the Governor-Council, prove very useful.

No. 95.

ORDER THE

1 July 1874, No. 868.

Forests, No. 2.

ORDERED accordingly that thirty copies of the Note, received with this letter, be forwarded to the Board of Revenue for distribution to forest officers.

act.)

Signed)

C. G. MASTER,

Acting Secretary to Government.

To the Board of Revenue.
" the Inspector of Forests.

Ed. F. R. Bantleman

NOTE ON LAC.

By J. E. O'CONNOR.

LAC is a resinous incrustation formed on the bark of the twigs and branches of various trees by an insect, commonly called the lac insect and known to entomologists as the *Coccus lacus*, appertaining to the natural order *Hemiptera*, family *Gallinsecta*. The species of the order known in Asia are, according to Dr. Balfour, three in number,—viz., the *Coccus cacti* (the cochineal insect), the *Coccus lacca*, and the *Coccus maniparis*, of Arabia, "which punctures the *Tamarix gallica*, and causes the exudation of Arabian ma'ina."

2. The incrustation formed by the lac insect is of a cellular nature, of a more or less deep red or orange colour, semi-transparent and hard, breaking with a crystalline fracture. The substance is mainly formed by the female insects, which largely outnumber the males. Each of the females inhabits one of the cells, and the substance is evidently intended to serve as a nidus or protection for the ovum and the larvæ after it has been hatched. As soon as she is completely covered by the resinous secretion which she forms, the female lays her eggs and dies. The young on being hatched work their way out through the body of the mother, which is filled with a red substance to which they fix themselves by the insertion of their beak or proboscis, and at once commence the secretion of the lac. They are produced in such vast quantities that the branch looks when they are swarming as if it were covered with red powder; but great numbers perish either for want of nutriment, or killed by birds.

3. The red colour is due to the substance contained in the body of the mother, on which the young feed while they are working their way out after being hatched. This substance produces the dyeing material called in commerce lac-dye. The process of manufacture of this article, its constituents and uses, will be described further on in this paper.

4. A careful and intelligent observer, Dr. H. J. Carter, F.R.S., had a very favourable opportunity in 1860 of observing the processes of impregnation, evolution of the young, and the development of the insect through the several stages of its existence. The insects swarmed over a custard-apple tree (*Anona squamosa*) in the grounds attached to the Bombay Mint, and were minutely watched by Dr. Carter from about the 5th July, when the young or larvæ, about the fortieth of an inch long began to issue, to the time (20th September) when, impregnation having been completed, the males died out, and the females were completely buried under the incrustation,* and he watched them through a second evolution in the same year. Dr. Carter's account of his observations is so complete and interesting that I have reprinted it in full for ready reference at the end of this note. It will be observed that he contests the

* This is not the only instance of the lac insect, which is ordinarily an inhabitant of remote wilds, having been found in the midst of the busy haunts of man. Some years ago the insect was found swarming over the "wings of a litchi tree (*Nephelium litchi*) in the heart of Calcutta. The other day the Chief Commissioner of British Burmah found it very busy on a tree in the centre of Rangoon with civilisation had not apparently caused the savage to be noticed that Dr. Carter considered that contact the lac to degenerate.

accuracy of the frequently repeated statements that there is only one male to five thousand females, that the resinous incrustation is formed from the juices of the bark punctured by the insect, and that the male insect is furnished with four wings. Dr. Carter asserts, as the result of his personal observations, that in some cases the males are very nearly as numerous as the females; that they begin to secrete the resinous substance even before they have fixed themselves to the bark; and that the male insect is provided with only two wings, and that even these were not observed on all, and on none at all in the first of the two evolutions which take place in the year. In connection, however, with the notion that the incrustation is formed from the exudation from the tree on which the insect exists, it has been pointed out by Mr. H. G. French (*Journal of the Agricultural and Horticultural Society of India for 1865*) that the trees on which it chiefly occurs all yield more or less a gummy, resinous, or saponaceous fluid. From the *Butea frondosa* exudes in October and November a bright blood-red fluid, which hardens quickly and assumes a brilliant polish. The three species of *Ficus* (*religiosa*, *indica*, and *infectoria*) when tapped in the cold weather yield a viscid fluid of which fowlers make birdlime. From the *Zizyphus jujuba* is obtained a gum; and the *Croton lacciferum* abounds in April, May, and June with a fluid from which cowboys blow off large and strong air-bubbles. Mr. French therefore thinks it "is natural to conclude that the insect requires some such juices to exist upon, and that its functions are to form lac and lac-dye according to the quantity and quality it draws from each description of tree. For instance, it secretes when on the koosum (*Schleichera trijuga*) the most seed-lac of a light colour which makes the best shell-lac, and on the palas (*Butea frondosa*) a redder stuff from which is obtained a garnet-coloured shell-lac and a larger quantity of the deepest lac-dye, in the same manner as bees produce the best tasted honey and the deepest red wax from orange-flowers, and the poorest honey and light-coloured wax from the flowers of orchids." Mr. Baden-Powell also says—

"If at this stage" [i.e., after the insect has completed the formation of lac] "a little piece of the lac incrustation is broken off, the insect is perceived as a little bag of red liquid (which yields the dye), and the place where the wood of the twig has been punctured bears a snow-white mark, as if the place had been touched with a point of chalk. I have removed an entire piece of lac incrustation from the twig, and observed the bark underneath covered with these little white dots, one in every cell, and one under every insect. Under the microscope they clearly appear to be specks of a semi-crystalline saline efflorescence, at the place punctured by the insect." Further and detailed investigation into the question is desirable. The preference of the insect for inaccessible jungles has been opposed to such investigations; but in the lac-plantations about to be established by the Chief Commissioner of British Burmah, the subject might advantageously be studied.

Natural propagation

5. As the insect never wanders from the branch of the tree to which it first attaches itself, and as the branch in course of time, after having afforded nourishment to millions of the insect, dies up and dies, it would seem at first sight that its speedy extinction must ensue. But nature has provided a remedy, the insect being carried to great distances by birds and larger insects to which, when they alight on a branch, the *Coccus laccu* frequently attaches itself. In this manner it is propagated through a vast extent of country. Artificial propagation by man is also, as will be seen further on, an easy and tolerably well-known process.

Trees on which it is found

6. Lac is found in most of the provinces of India, and in some it abounds to a very great extent. It occurs on trees of many orders and species, of which I attach a list:—

1. *Acacia* (N. O. *Leguminales*).
2. *Albizzia* (N. O. *Euphorbiaceae*).
3. *Anona squamata* (N. O. *Anonaceae*).
4. *Butea frondosa* (N. O. *Leguminales*).
5. *Carissa spinarum* (N. O. *Apocynaceae*).
6. *Celtis* (sp.) (N. O. *Ulmaceae*).
7. *Croton Draco* (N. O. *Euphorbiaceae*).
8. *" sanguiferum* (N. O. *Euphorbiaceae*).

9. *Erythrina Indica* (N. O. *Leguminales*).
10. *" monosperma* (N. O. *Leguminales*).
11. *Feronia elephantum* (N. O. *Aurantaceae*).
12. *Ficus elastica* (N. O. *Moraceae*).
13. *" Indica* (N. O. *Moraceae*).
14. *" infectoria* (N. O. *Moraceae*).
15. *Ficus religiosa* (N. O. *Moraceae*).
16. *Joga dulcis* (N. O. *Leguminales*).
17. *Mangifera Indica* (N. O. *Anacardiaceae*).
18. *Mimosa cinerea* (N. O. *Leguminales*).
19. *Nephelium litchi* (N. O. *Sapindaceae*).
20. *Prosopis spicijera* (N. O. *Fabaceae*).
21. *Schleichera trijuga* (N. O. *Sapindaceae*).
22. *Urostigma religiosa* (N. O. *Artocarpaceae*).
23. *Vatica laccifera* (N. O. *Dipterocarpaceae*).
24. *Vismia laccifera* (N. O. *Hypericaceae*).
25. *" mierantha* (N. O. *Hypericaceae*).
26. *Zizyphus jujuba* (N. O. *Rhamnaceae*).

Some additions to the above list may possibly be rendered necessary by further enquiry. The best lac is generally found on the *Butea frondosa* (palas, prass, or dhak), *F. religiosa* (peepal), and *Schleichera trijuga* (koosum).

7. The vernacular names for lac are Sanskrit, *Laksha*; Hindi, *Lakh*; Tamil, *Komburruki*; Telugu, *Kommalaka*; Chinese, *Lakada*. The names derive their origin from the Sanskrit word *laksha*, meaning a hundred thousand, in allusion to the multitude of insects. Sir William Jones, as quoted by Dr. Birdwood, says: "The Hindus have six names for lac, but they generally call it *laksha* from the multitude of small insects which, as they believe, discharge it from their stomachs, and at length destroy the tree on which they form their colonies."

8. Lac does not appear to have been known to the ancients beyond India. Dr. Birdwood states that amongst Western writers it is first mentioned by Abu Hanifa. Dr. Balfour, on the other hand, says that, previous to the discovery of cochineal, the colouring matter of the lac insect was universally employed as a red dye by the ancients, and that the crimson of Greece and Rome "and the imperishable reds of the Brussels and Flanders schools" were derived from this source. Dr. Balfour does not give authority for this statement, the accuracy of which seems open to question. It is affirmed by Dr. Birdwood and other authors, that the dyes used before the introduction of cochineal were obtained from *hermes*, being insects of different varieties of the species *Coccus ilicis*, which live upon the *Quercus ilex* and *Quercus coccifera*. This word *hermes* is Arabic in its origin,—viz., *kirmij*, meaning a little worm, whence the dye obtained in the Middle Ages the Latin term *vermiculus*, whence again *vermeil* and *vermillion*. From *kirmij* perhaps also is derived *crimson* and *carmine*.

9. I extract the following account of the chemical constituents of lac from Ure's *Dictionary of Arts, Manufactures, and Mines*, 6th ed., 1872:—

According to the analysis of Dr. John, stick-lac consists in 120 parts of:—		
An odorous common resin	...	80.00
A resin insoluble in ether	...	20.00
Colouring matter analogous to that of cochineal	...	4.50
Bitter balsamic matter	...	3.00
Dun yellow extract	...	0.50
Acid of the stick-lac (laccic acid)	...	0.75
Fatty matter like wax	...	0.50
Skins of insects and colouring matter	...	0.25
Salts	...	0.75
Earths	...	0.75
Loss	...	...
Total	...	120.00

"According to Franke, the constituents of stick-lac are, resin 65.7, substance of the lac 28.3, colouring matter 0.6."

Analyses.

10. An analysis by Mr. Hatchett, quoted by Mr. G. W. Strettell, Deputy Conservator of Forests in British Burma, gives for stick-lac in 100 parts—

Resin	...	...	...	...	...	68.00
Colouring matter...	...	...	...	...	...	10.00
Wax	...	...	...	...	...	6.00
Gluten	...	...	...	...	...	5.50
Foreign bodies	...	...	...	...	...	6.50
Loss	...	...	...	...	...	4.00

Analyses of seed-lac and shell-lac differ from the foregoing in the exhibit of an increase in the percentage of resin corresponding to a diminution in the amount of colouring matter, wax, and foreign bodies, which eliminated during the processes of manufacture into shell-lac. The colour matter, which amounts to 10 per cent. in stick-lac, is reduced to 0.5 per cent. in shell-lac, the dye being carefully extracted, as will be shown in the seed treating of manufacture.

I quote again from Ure's Dictionary:—

"The resin may be obtained pure by treating shell-lac with cold alcohol, and filtering solution in order to separate a yellow-grey pulverulent matter. When the alcohol is distilled off, a brown, translucent, hard and brittle resin of specific gravity 1.139 remains, melts into a viscid mass with heat, and diffuses an aromatic odour. Anhydrous alcohol solves it in all proportions. According to Jobel fat oils, while the other is little soluble in alcohol, and is insoluble in ether and the volatile oils. Unverdorben, however, has detected less than four different resins and some other substances in shell-lac. Shell-lac dissolves in dilute muriatic and acetic acids, but is soluble in concentrated sulphuric acid. The resin shell-lac has a great tendency to combine with alkalis, as with caustic potash, which deprives of its alkaline taste. This solution, when re-dissolved in both water and alcohol, is precipitated in a colourless state. When this precipitate is washed and dried, it forms, with an excellent pale-yellow varnish, especially with the addition of a little turpentine and oil. With the aid of heat, shell-lac dissolves readily in a solution of borax. The substances Unverdorben found in shell-lac are the following:—1, a resin soluble in alcohol and 2, a resin soluble in alcohol, insoluble in ether; 3, a resinous body, little soluble in alcohol; 4, a crystallisable resin; 5, a resin soluble in alcohol and ether, but insoluble in leum, and uncrystallisable; 6, the unsaponifiable John; 7, an extractive colouring matter."

11. The quality of the lac produced in Burmah has a high reputation. Latterly there have been complaints of deterioration in the article exported from Rangoon. Assam lac is also remarkably good, and the lac of Siam is to be highly esteemed. Lac is also found in China, but we have no particulars of the production. I confine my remarks in this note to Indian lac. The goodness of lac in commerce depends upon the business of the colour and the thickness of the incrustation round the insect. It is sometimes nearly half an inch thick, completely encircling the insect. To obtain lac in its best condition it should be gathered before the young have eaten their way out. If the lac-gatherer delays until they have effected exit, the colouring matter is much diminished, and the resin is pierced through at the top. There is but little dye to be obtained from the lac in this condition. As there are two evolutions of the insect in the year, so there are got also two gatherings, the first being in March and the second in October.

12. The quantities produced at different places vary greatly in different provinces according to circumstances, certain forests being rich in lac which have never been touched owing to difficulty of access and cost of carriage. The place of manufacture and port of shipment. In Bengal lac is produced abundantly in the forests of Assam and the jungle-tracts of Beerboom, Nagpore, and Orissa. A portion of the production of Assam is manufactured at Dacca, and the rest is sent to Calcutta. A lac factory was established years ago at Gowhatty, but the speculation failed, and has not been re-opened. The European settlers in the province having devoted their energies to the cultivation of sugar.

13. In July 1867, the Deputy Commissioner of Pooreolia in Nagpore reported that the lowest average yearly supply from the district was 15,000 maunds, though the actual yield was, he believed, considerably more. From Singhboom at the same time, he reported that the yield was about 2,250 maunds of lac were exported. In the Gya district the

was estimated at 12,000 maunds; in Kamroop, about 5,000 maunds, with great capacity for development; in Hazaribagh, 2,000 maunds.

14. The increased prices ruling for some time past for both stick and shell lac have so stimulated production that these figures probably do not shew half the actual yield of the districts named, in most of which there are very extensive tracts of the koosum and paas trees on which the insect thrives. But the lamentable absence of statistical information in Bengal, and indeed in India generally, makes a correct estimate of the production of lac an impossibility. In Bengal lac is gathered twice a year, viz., from about the middle of October to the end of January, and from the middle of May to the middle of July. Some people, Mr. Crickton says, dip the lac-covered twigs in hot water to kill the young insects, it being supposed that a larger amount of dye is thus secured.

15. In the North-Western Provinces, lac is obtained in quantities from the Gurhwal forest; and Mr. Thomson, the Deputy Conservator, reports that it is largely exported to the plains. North-Western Provinces.

16. In the Punjab Mr. Baden-Powell says that the production of lac is universal. I understand, however, that it is much inferior in quality to the lac of Central India or Bengal. In Sindh, lac is only found in the forests about Hyderabad, twelve miles north and south, but in these abundantly. In the other forests of the province it either does not exist at all, or in such small quantities that its collection does not pay. The cause of its formation near Hyderabad is to be sought, says Dr. Schlich, in some peculiarity either in the soil or air, and he thinks the subject worth investigation. It is found on the *Acacia arabica* (babool), and is gathered from October till April or May. This tree seems while in full vigour to be exempt from the attacks of the insect; it is chiefly infested when in the semi-dry state, and is not unfrequently killed outright. The lac produced in Sindh is largely used in the manufacture of the well-known lacquered ware of Hyderabad. Punjab and Sindh.

17. In Oudh, lac is gathered in the more wooded parts of the south-eastern districts (Roy Barcilly and Pertabgarh) from various species of *Ficus*, especially *religiosa*. It is exported to the Mirzapore factories and elsewhere. The Chief Commissioner thinks that large supplies would also be procurable from the northern forests, but that the collection would be unprofitable owing to the want of manufactories within a reasonable distance. Government obtains half the produce in quantity or value from the gatherers. Oudh.

18. All the districts of the Central Provinces produce lac, but it is particularly abundant in the eastern districts. Large quantities are consumed in the towns in the manufacture of bracelets and other articles, but most districts also export it to a greater or less extent. These provinces, at a rough guess, could readily supply some 25,000 tons of stick-lac annually. Most of the lac produced in the district of Jubbulpore is consumed in a European factory in that town. It also comes to Jubbulpore and Mirzapore in large quantities from Raipore, Bilaspore, Saugor, and Mundla. In Mundla the right of collecting lac from the Government jungles has been leased to the owners of the Jubbulpore factory for Rs. 950 a year. In Sumbulpore, a Mirzapore firm (European) has for a long time practically held the monopoly of lac collection. Boorhanpore and Bombay receive supplies, though in small quantities, from the Nerbudda and Nagpore divisions. Central Provinces.

19. According to Major Lucie Smith, the Gonds believe that the lac insect is born of the morning mist. These rude people accordingly make no effort to propagate it artificially; but if there were a large demand the rearing of the insect would be systematically carried on, and result in a very great increase of the product. Mr. Grant, Commissioner of the Jubbulpore division, says that "in two places only is the production of lac assisted by human agency in propagating the insect from tree to tree. The great bulk of the lac is produced without any artificial assistance, and left entirely to the unaided exertions of the insect and its migration from tree to tree. The question whether it would pay the Government to undertake the establishment of lac-producing tracts of forests is one which naturally suggests itself in any discussion of lac." Jubbulpore and Mundla forests.

Chief Commissioner, dated 12th July, possessing a very intimate knowledge of the subject.

Commercial test of good lac.

Production.

Bengal and Assam.

Musore

*Propagation
of the insect.*

25. In 1860, the propagation of the insect was successfully effected in the territory of Kapurthala in the Punjab. About three maunds of lac containing the insect were sent up from Phagwar. The lac was taken from tied up in detached portions in little bundles, by the Rajah's agent there, the vessel in which it was received, and sent to the Government of the Punjab. These bundles were

27. The great bulk of the export trade in lac is confined to Calcutta, which is the entrepôt for all the shell-lac (except that which is locally used up) manufactured from the raw material supplied from the forests of Bengal as well as from those of Assam, Oudh, the Central Provinces, and Burmah. The following table shows the exports from British India to foreign countries of shell and stick lac and lac-dye, as far as the figures are distinguishable in the returns:—

Shell and Stick Lac.		Lac-dye.	
	Cwts.		Cwts.
1863	56,479	1863	12,004
1864	58,441		17,748
1865	72,542	1869	19,557
1866	72,551	1870	12,500
1867	49,910	1871	17,437
1868	55,531	1872	15,849
1869	56,810		
1870	59,115		
1871	48,590		
1872	58,363		
Average of ten years	57,828	Average of five years	15,849

23. Now, turning to the figures representing the exports of shell-lac from Calcutta, we have—

	To Great Britain.	To Europe.	To America.	To all other places.	Total Cwts.
1873	45,829	2,515	14,930	592	63,866
1872	42,284	3,290	19,827	814	66,215
1871	42,200	2,163	15,265	885	60,923
1870	26,789	1,516	12,388	1,156	41,849
1869	45,795	2,031	8,999	1,862	61,087
1868	32,155	2,950	10,450	963	46,527
1867	28,111	4,950	4,360	2,033	38,525
1866	42,791	1,021	5,860	3,239	53,412
1865	46,219	3,522	6,087	1,990	58,518
1864	42,791	3,522	3,556	343	50,189
Average of ten years*	39,505	2,037	10,444	1,337	54,325

* These figures are given on the authority of Reulmin's Circular

Calcutta has thus almost a monopoly of the export trade. The two largest customers are the United Kingdom and Italy are increasing, and form a very appreciable proportion of the shipments. 29. The import and export trade in stick-lac in the Central Provinces for the last three years for which statistics are available, is represented by the following figures:—

IMPORTS	1870-71	...	Mds.	8,565	...	Value in Rs.	1,29,882
	1871-72	...	"	4,578	...	"	71,510
	1872-73	...	"	1,217	...	"	14,164
EXPORTS	1870-71	...	"	16,423	...	"	2,17,957
	1871-72	...	"	26,889	...	"	5,47,438
	1872-73	...	"	2,581	...	"	6,45,457

Of the imports a large proportion is brought to Hoshungabad from the adjoining native states of Central India, and most of the balance comes to Jubbulpore from Northern India *via* Mirzapore to feed the local factory of shell-lac; of the exports the great bulk is sent to Calcutta *via* Jubbulpore. The remainder is taken up in small parcels in various directions.

30. Small quantities of lac are exported from Sindh chiefly to Bombay, and from the latter port to Europe.

31. The trade in lac in Burmah is developing rapidly; but no attempt at manufacture has yet been made in that province. A good deal is sent to Madras (1,700 cwt. in 1871-72) and Singapore, which exports stick-lac to Europe, also receives a certain amount from Burmah; but most of the stick-lac brought down to Rangoon and Moulmein is sent to Calcutta, where it is manufactured. The quantity exported in

1869-70	amounted to	12,385	maunds, value	1,57,003	rupees.
1870-71	"	11,361	"	1,88,020	"
1871-72	"	11,364	"	1,72,511	"
1872-73	"	15,334	"	2,96,817	"

The value in the year last mentioned shows an enormous increase, corresponding to the rise in price in the Calcutta and London markets; and prices seem to maintain their high level, although the quality of the stick-lac exported is said to have deteriorated. It is doubtful whether Burmah would offer, for a long time to come, a good field for enterprise in the manufacture of lac. The present production is small; the freight from Rangoon to Calcutta, inclusive of all charges, is comparatively insignificant (about 2 rupees a maund), while the first cost of a large factory would be very great; and the value of all kinds of labour in Burmah is so high that the maintenance of a factory would be found most expensive. On the other hand, it is questionable whether at any rate at first the competition in manufacture with the well-known market of Calcutta would offer any chance of success. But undoubtedly much profit would be derived from systematic efforts to develop the supply of stick-lac from the State forests. These considerations have approved themselves to the judgment of the Chief Commissioner, who has decided to confine exertion in this branch of industry for the present to the increased production of the raw material.

32. The price of stick-lac delivered at the factories in Calcutta varies a present from about 30 to 40 rupees per maund, according to the percentage of woody matter and rubbish; and in the country marts adjacent to the places of production, from 20 to 30 rupees. The price fluctuates according to the places of ruling for the manufactured article in the market. Lately the price of shell-lac has gone up to a prodigious extent in Calcutta, fine qualities fetching as much as 100 rupees a maund,—the price in London being correspondingly high.

33. In its raw condition, incrustations round the twigs of the tree on which the insect feeds, lac is called technically stick-lac. The twigs are generally for convenience of transport, brought to market cut up in lengths of two or three inches. It is probable that a great deal of material is wasted in this process. The objects of the manufacturer are, first, to separate the resinous incrustation from the wood; second, to free the resin from the colouring matter; third, to convert the resin into what is known as shell-lac; and, fourth, to form from the colouring matter cakes of dye known as lac-dye. As generally practised, these processes are conducted in a primitive manner. A good account of the manufacture in accordance with the ordinary processes is given in the following

extract from a paper by Mr. H. A. Crichton, of Ranchec, which was published in the Supplement to the *British Burmah Gazette* for 11th April 1874:—

The first thing to be done is to strip the twig of its covering of lac, and for this purpose the coated twigs may be placed under a roller on a platform. The roller being rapidly passed over the twigs (called stick-lac), the coating comes off, leaving only a small part adhering to the twig, which last must be separated by hand-picking. The wood of course is rejected. The coating when separated (which I call *dall*) must then be reduced by rolling or other means until it will pass through a moderately coarse sieve,—for instance, one whose squares should measure a quarter of an inch.

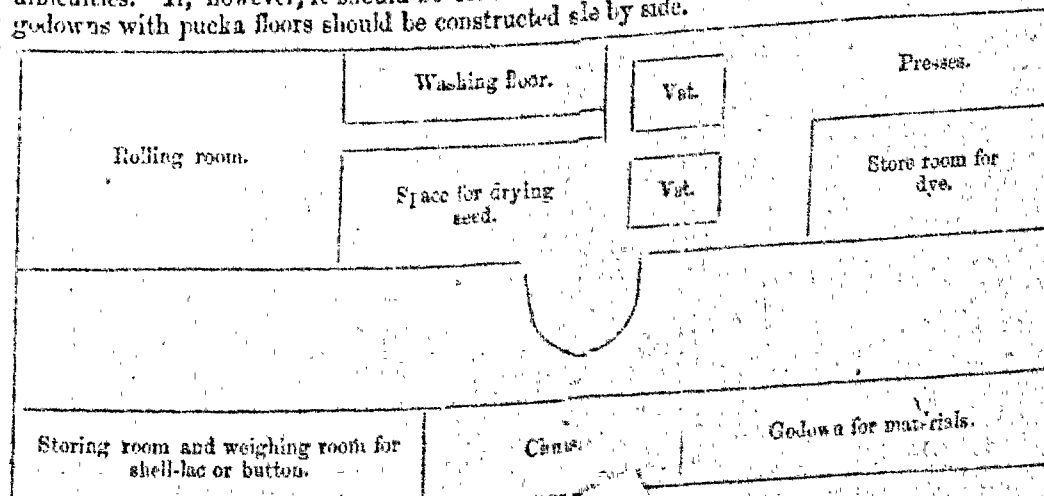
The result of this will naturally be the collection of a quantity of grains of matter partly resinous and partly gummy, impregnated with scarlet colouring matter.

Dye.—The grain is first placed under *dehis*, or triturated in some other manner, and water is poured or flows over it at the time of trituration, the result being that the colouring matter passes from the grain, which remains of a golden colour, into the water.

The grain is then dried and stored for making shell-lac. The dye containing water is run off into a vat, and allowed to remain there till the dye is precipitated, looking like dark mud at the bottom of the vat. The surface water is then run off, and the precipitate removed from the vat. The water is first expressed by placing the precipitate in cloths and allowing the water to pass away through the cloth. Frames should be prepared, about 18 inches square, having compartments about 1½ inches square; the frames to be fitted with loose tops and bottoms, the whole susceptible of compression. When the muddy matter is tolerably consistent, the compartments should be filled with it and put into a screw press. The water will then be expressed, and when the cake is firm it may be thrown on a clean floor to dry thoroughly, and will be a cake of lac-dye and fit for the market.

Shell-lac.—I call the golden coloured grain after the dye has been washed out "seed-lac." It is placed in long bags about two inches in diameter, of American drill or other cloth, and is then ready for roasting; *chulas* being prepared with a good draft, a bag is placed horizontally in front of the *chula* and over a narrow shallow trough projecting from the *chula*. The bag is held in one hand by the roaster, the other end of the bag being held by his mate. The two cause the bag to revolve slowly in front of the fire and the result is that a matter something like golden coloured sealing-wax exudes from the bag and drops into the trough. Close to the roaster is a cylinder of porcelain or other smooth hard substance hollow and filled with some heat-absorbing matter. The roaster twists the bag with his left hand, while with his right he wields a wooden ladle with which he mixes the melted lac in the trough, and then lifts a spoonful on to the cylinder, which should be inclined at a slight angle to the ground; a third person stands ready over the cylinder, holding in both hands a piece of bark or other substance which may appear necessary or well adapted to the purpose, and with this draws down the melted substance in a thin coating over the cylinder. He then detaches the coating from the cylinder with both hands, and lays the sheet on one side, and recovering his bark is ready to repeat his operation. The coating or leaf is golden coloured and called *sell-lac*, and is now ready for the market.

Button-lac.—The only difference between this and shell-lac is in form. Instead of being drawn over a cylinder, the melted lac is allowed to drop on to a plane, and is in shape like a large-sized flat gingerbread nut, about 3 inches in diameter, and one-sixth of an inch thick. I have thus described the details of the manufacture, omitting in some cases to say what materials I consider best suited for particular purposes. But these materials, or some equally efficient ones, will no doubt suggest themselves, after a few trials have been made, to any intelligent handicraftsman. The processes are mentioned in order, and the purpose thereof plainly stated. Although I may be supposed to be interested in a failure to manufacture shell-lac successfully in Burmah, I will state that I think, though on very inadequate data, that Mr. Eden would be well advised to devote such part of his attention as he spares to the price of labour and the climate of Burmah, I believe the manufacture would be attended with difficulties. If, however, it should be considered desirable to try the manufacture, two long godowns with pukka floors should be constructed side by side.



Cleanliness in all the processes is essential.

34. Mr. Erskine, of Elambazar, says that "many native manufacturers dispense with vats and filtering tables. Earthenware pots, straining cloths, charcoal, and manual labour constitute a lac-factory—a cheap and primitive stock-in-trade."

35. By the kind courtesy of Mr. Elliott Angelo, of Cossipore, I was privileged to see his extensive lac-factory, where the manufacture is conducted on an improved and civilised system by the aid of machinery worked by steam power. The lac is first separated from the twigs by the action of rollers, worked by steam. Of these rollers there are three sets, each consisting of an upper and under roller with a sieve attached. Between these the stick-lac passes from a feeder, and the lac is, by the turn of the roller, separated from the wood and broken up, falling on to a sieve while the twigs are thrown off aside in a heap. If the lac has not been sufficiently broken up by the first roller to pass through the sieve, some of the twigs not having been separated, it passes on to the second roller, and goes through the same process, passing again if not still fine enough to the third, whence the lac is dropped, as the sieve is filled, into a series of small troughs arranged on an endless chain working with the machine, and is projected thence as the chain moves into a heap on the floor. The twigs are thrown off on to a platform on the other side. These are afterwards again examined by women, and all the remaining lac separated by hand, and, as far as it may be worth while, used in manufacture. The refuse is bought by natives for the manufacture of *choories* and other articles made of lac. The sticks are used for fuel in the furnace of the steam-engine.

36. The lac is now placed in a horizontal cylinder furnished internally with arms arranged on a bar, passing through the cylinder from end to end. These arms are worked by steam power, and their action, combined with water with which the cylinder is filled, breaks up the lac into very small pieces, and separates the colouring matter which forms lac-dye. In the liquid thus obtained the lac is left to soak for twenty-four hours in a large vat, the liquid being then drawn off by the removal of plugs into a vat on a lower level, and there left to settle in the same way as indigo, the colouring matter being precipitated to the bottom. The clear water at top is drawn off, and the sediment, after having been passed through a strainer, much of the same nature as that used by paper-makers for the straining of pulp, is finally allowed to settle and consolidate, when it is pressed in frames into cakes which are afterwards dried in the sun. These cakes are the lac-dye of commerce.*

37. The lac, now called "seed-lac" after maceration, is thoroughly boiled in a close vessel, heated by steam, and thence conducted into open shallow troughs, also heated by steam, where the boiling continues. Some resin is here mixed with the lac, in order to prevent the lac from burning and adhering to the vessel. The resin, which is probably useful for this purpose, flies off, at least in great part, during the process of ebullition. But I may remark here that the complaints in Calcutta of the adulteration of shell-lac with resin by some unscrupulous native manufacturers are loud and bitter. It is said that what is offered as lac often consists of resin to the extent of 50 and even 60 per cent. Lac thus adulterated may be detected by its smell when broken.

38. Ranged round the troughs are a series of zinc columns, inclined outwards at an angle of 15°. These columns are hollow and supplied by pipes with tepid water, which keeps them at a certain temperature. They must never become too hot, or the fluid gum would not consolidate; nor must they become too cool, for then the gum would harden at once, and break up into small fragments which would adhere to the surface of the column. A quantity of lac is taken up in the concavity of a piece of plantain-bark, this being the material best adapted to the purpose, and dexterously flung on by a workman to one of the columns. Here the liquid mass is spread evenly and thinly over the surface by a man who makes use for the purpose of a leaf of the pine-apple plant or some other tough fibrous material. The leaf being held in both hands, its edge is drawn over the liquid until the mass is properly spread over the surface of the column to the required degree of fineness. It begins to consolidate at once, and becomes of a pliable, leathery texture. As soon as the lac consolidates, it is taken off by a workman, while still so hot that it would burn the

* The smell in a shell-lac factory while the colouring matter, which is in fact the dead insect and its contents, is being separated from the lac, is intolerably offensive.

fingers of any person not accustomed to the work, a considerable section of the upper portion of the sheet of lac being torn off because it is thicker there than in the rest of the sheet, and thrown back into the trough to be boiled again. The sheet is placed on a rod held in readiness by a woman, each extremity of the sheet hanging down like a towel on a rack, and the whole is hung up to dry in a large drying-shed, the sticks supporting the lac being ranged on supports running across the shed from side to side, just like a tobacco drying-house. The next day it is fit for despatch, and it is then packed in boxes and sent away.

39. The points in which Messrs. Angelo's machinery differs from the ordinary processes are—(1) the triple system of rollers and sieves, and the endless chain of receivers; (2) the strainer for lac-dye, which is made of metal; (3) the system of boiling the seed-lac by the action of steam; and (4) the hollow zinc columns with the arrangement for keeping them at an equable temperature. The natives use stems of plantain-trees, which do not last of course for more than a day, and the European improvement of porcelain and stone columns is in many ways inferior to Mr. Angelo's invention. This factory turns out an average of 100 maunds of shell-lac a day, from 20 maunds of stick-lac, for six months in the year, working from October to April; and if there were sufficient raw material available, it could turn out 150 maunds a day during the whole year.

40. The various qualities of shell-lac are known by different names and marks, and there is a considerable range in prices from "Fine Orange DC," to "Livery," "Garnet," "Native Leaf," and "Button." The last quality is so named from the lac not being made in sheets, but dropped from a height, and solidifying into masses. Yellow arsenic (orpiment) is frequently used in the manufacture of lac to impart a fine yellow colour to the resin. Dr. Chevers says that the use of this poison gives rise to miliary eruptions on the bodies of the workmen.

41. In India lac is used chiefly for the manufacture of bracelets (*choories*), rings, beads, and other trinkets, worn as ornaments by women of the poorer classes. It is also used as a varnish in many cases the dye being left in the lac to produce a coloured varnish, and by the turners of wooden toys which are coated neatly with lac. In Japan lac predominates in lacquered ware, and by goldsmiths for the colouring of the metal. Japanese lacquered ware is made of an entirely different material, being a varnish obtained from the gum exuding from certain trees, among which are the *Melanorrhæa usitata*, *Rhus vernix*, *Simarouba vernicia*, and others.

42. In Europe lac is chiefly used in the preparation of varnishes and by hatters. The body of all the silk hats in common use is rendered stiff and water-proof by the liberal application of a composition of shell-lac, sandarach, mastic, and other resins, dissolved in alcohol or aether. The brim is always imbedded more thickly than the body with this varnish. Lac is also extensively used in the manufacture of sealing-wax, which is formed of an amalgam of shell-lac, Venice turpentine, colophony, and coloring matter, the quantity of lac used being equal to that of all the other ingredients put together. Lac also enters largely into the composition of lithographic ink.

43. In India lac-dye is mostly used to dye silk, and to some extent it is also employed in the dyeing of leather. It is not much used as a dye for cotton, on account of the expense. The following extract from Ure's Dictionary, already quoted, gives a good account of the manner of employment of lac-dye in Europe:—

Dr. Macleod of Madras states that he prepared a very superior lac-dye from stick-lac by digesting it in the cold in a slightly alkaline decoction of the dried leaves of the *Memecylon tinctorium* (perhaps the *M. capitellatum*, in which the natives of Malabar and Ceylon obtain a saffron yellow dye). This solution being used along with a mordant consisting of a saturated solution of tin in muriatic acid was found to dye woollen cloth of a very brilliant scarlet hue.

The cakes of lac-dye imported from India, stamped with peculiar marks to designate their different manufacturers, are now employed in dyeing scarlet cloth, and are found to yield an equally brilliant colour, and one less expensive than that produced by cochineal. When the lac-dye was first introduced by perspiration than that produced by pulverised cakes, but as muriatic (hydrochloric) acid was the solvent applied to the found to answer, it has to a great extent supplanted it. A good solvent (No. 1) may be prepared by dissolving 2 pounds of tin in 60 pounds of muriatic acid of specific gravity 1.17 with 14 pounds of the cloth is made by mixing 27 pounds

Uses to which lac is applied in India.

Uses of lac-dye.

pounds of nitric acid of 1.19, putting this mixture into a well-glazed stone bottle, and adding to it in small bits at a time grain tin, till 4 pounds be dissolved. This solution (No. 2) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing, three-quarters of a pint of the solvent No. 1 is to be poured upon each pound of the pulverised lac-dye, and allowed to digest upon it for six hours. The cloth before being subjected to the dyebath must be scoured in the mill with fuller's earth. To dye 100 pounds of pelisse cloth, a tin boiler of 300 gallons capacity should be filled nearly brimful with water and a fire kindled under it. When the temperature rises to 150° Fahr., a handful of bran and half a pint of the solution of tin (No. 2) are to be introduced. The froth, which rises as it approaches ebullition, must be skimmed off, and when the liquor boils, 10½ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1 and 3½ pounds of solution of tin No. 2 must be added in. An instant afterwards, 10½ pounds of tartar and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes. The bag being now withdrawn, 20 gallons of cold water with 10½ pints of solution of tin being poured into the bath, the cloth is to be immersed into it, moved about rapidly during ten minutes, the fire is to be then re-kindled, and the cloth winced more slowly through the bath which must be made to boil as quickly as possible, and maintained at that pitch for 24 hours. The cloth is to be next washed in the river, and lastly with water only in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint with a slightly purple cast. If a more orange hue be wanted, white florence argal may be used instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange scarlets.

To determine the tinctorial power of lac-dye by comparison with proved samples, a dye-bath is prepared as follows:—5 grains of argal, 20 grains of flannel or white cloth, 5 grains of lac-dye, 5 grains of chloride of tin, 1 quart of water. Heat the water to the boiling point in a tin or china vessel; add thereto the argal, and then the piece of cloth or flannel. Weigh off 5 grains of the lac-dye and pulverise it in a wedgewood mortar, with the 5 grains by measure of chloride of tin, and pour the whole into the hot liquor containing the cloth, taking care to rinse the mortar with a little of the hot liquor; keep the whole boiling for about half an hour, stirring the cloth or flannel about with a glass rod; then withdraw the cloth, wash and dry it for comparison.

ON THE NATURAL HISTORY OF THE LAC-INSECT (*COCCUS LACCA*).

By H. J. CARTER, ESQ., F.R.S.

(From the *Annals and Magazine of Natural History*, 1861.)

HAVING had an opportunity of examining the lac-insect just previous to the evolution of its young, and of watching the latter from this period up to the time at which they become incarcerated in the resinous substance which they secrete around themselves, known in commerce by the name of "lac," and finding that a description of the changes which the insect undergoes still remains unpublished, so far as I am aware, while that which has been stated on the subject is more or less incorrect, I am not without hope that the following observations may prove both new and acceptable.

Thus much is known: that the substance called "lac" consists of a resinous incrustation partly encircling or scattered over the small branches of several trees and shrubs of different kinds in India; that the incrustation is cellular, and that each cell indicates the position of one of the insects which secreted it; that the insect contains a red colouring matter called "lac-dye," which is also an article of commerce, and is allied to cochineal; and that, at a certain period of the year, vast numbers of young animals leave these cells, and, spreading themselves over the neighbouring branches, fix themselves to the bark, which they pierce with their beaks, and then begin to pour forth from their bodies the resinous substance above mentioned.

On the 25th of June last (1860), my attention was drawn to the subject more particularly by a fresh branch of the custard-apple tree (*Annona squamosa*) bearing portions of the lac having been presented to me by my friend, Major Burke. The branch was taken from a tree growing in the enclosure of the Bombay Mut, within a few yards of the sea, and in the midst of the smoke of steam engines, smelting furnaces, and the atmosphere of a crowded population; while the resinous incrustation and the red colouring matter, both in quality and quantity, did not appear to me to be less than that which is produced by the insect in localities widely spread as well from the sea as from all human habitations.

On receiving this branch and observing that it was fresh and that the insects in the incrustation were also living, my curiosity was directed to ascertaining the form and organology of the latter. Meanwhile the young began to pour forth, that is, on or about the 1st of July; and by the middle of that month the whole branch had become covered with them; but for want of nourishment, as they became stationary, so they died without apparently secreting any of the resinous substance around them; and thus I was obliged to visit the custard-apple tree itself for the purpose of examining the subsequent changes which the insect undergoes, which changes, together with a description of the form and organology of the full-grown insect, so far as I have been able to ascertain them, will now be related.

The first feature that strikes the eye on looking at the surface of the incrustation, when the insects which are within it are alive, is the presence of a kind of white powder like that observed about the cochineal insects; this is concentrated here and there into little spots, and on being examined more closely will be seen to be chiefly confined to three bunches of curly hair-like filaments, which radiate from three small holes in each spot. The holes are situated triangularly with respect to each other, two being closer together than the third, which is the largest, and which, by-and-by, will be found to be the anal, while the other two will be found to be spiracular apertures; all three are continuous with corresponding apertures in the insect, from which the white insects originally proceed, which filaments we shall hereafter observe to be the attenuated extremities of the trachea.

If we now examine the contents of the interior, which we may easily obtain entire by dissolving off the lac in spirit of wine (for, from their tenderness, they can hardly ever be extricated without rupture by simply breaking the incrustation), it will be observed that each cell is filled with a single insect, which is not almost as much unlike one as any object can well be unlike another,—consisting of a pyriform sac of a dark-red colour, smooth, shining, and presenting at its elongated end one, and at its obtuse end three papillary processes; the former, which is a continuation of the elongated end, is fixed to the bark; and the three latter, which project from the middle of the obtuse end, so with the three processes: one is much larger and longer than the other two, which latter are of the same size; the former is also further distinguished by having several hairs round the margin of the aperture which exists at its extremity,—a point which it is desirable to remember, as it will serve by-and-by to identify it with the anal extremity of the animal when in its insect form.

So far the spirit of wine assists; but when we come to the contents of the body, it is not only necessary to avoid using spirit of wine, from the disfiguration which it occasions by causing the tissues to contract, but also to extricate the body by fracturing the lac, and dissect the contents as quickly as possible, on account of the rapidity with which they pass into dissolution after death; this is probably the reason why this part of the history of the insect has remained unpublished up to the present time.

Directing our attention to the interior, after the rupture of the insect, which takes place more or less with that of the lac, we are at once struck with the voluminousness of the organ containing the red colouring matter, which organ thus obscures everything else; and it is not before a quantity of it is removed by gentle edulcoration that we can (still under water, for the anatomy of this insect can be studied in no other way) arrive at a view of the other organs of the body, when it will be observed that there is an alimentary canal, liver, trachea, and, last of all, the organ containing the red colouring matter, which we shall presently find to be the ovary. To each of these organs, then, separately and briefly, we will now give our attention.

The alimentary canal commences with an attenuated, shapeless oesophagus at the elongated end of the body, which is thus seen to be the oral extremity, and after passing upwards for about two-thirds of the length of the abdominal cavity, where it becomes enlarged and convoluted, turns back to make a single revolution, in the course of which it soon becomes diminished in calibre, and receiving the hepatic duct at this point, terminates at length in the rectum, which opens at the great papillary process. The liver consists of a single straight sacculated, beaded tube of the same size throughout, presenting a yellow colour, and giving off the hepatic duct a little nearer one end than the other; while the trachea are amassed into bundles, apparently without order, and send forth many of their extremities through the two small, as well as through the large, anal apertures, to terminate on the surface of the lac in the way above mentioned.

Lastly, we come to the ovary, which consists of a voluminous tree of tubes apparently branched dichotomously with each branch, large and small, bearing long elliptical pouches, in each of which, again, is a correspondingly shaped ovum,—the whole nearly filling the body, and terminating in a single oviduct, which opens (probably through the rectum) at the anal apertures. The ovum, on the other hand, consists of an elliptical transparent envelope filled with little cells, each of which contains oil (?) globules and globules filled with the red colouring matter. The oil-globules are spherical, uniform in size, and much larger than the red globules, which are also spherical, but distinctly separated from the oil-globules and from each other. Whether these bodies respectively have delicate cell-walls or not, I am ignorant; but while they are both distinctly defined in the ovum when the insect is first opened under water, both soon burst by imbibition and become lost to view by dispersion of their contents. Thus the red colouring matter exists originally in the form of distinct globules or in cells in the ovum.

The further changes in the ovum preparatory to the full development of the embryo, I have not followed; but about the beginning of July the young ones are perfectly formed, and issuing through the anal aperture in the incrustation, they creep to the neighbouring parts of the branch, and soon fixing themselves by inserting their beaks into the bark as before stated. Myriads issue in this way, as may be well conceived, when, at a guess, I should think each insect contained a thousand; but by far the greater number die; for although the branches become quite red with them, it is only here and there that a few, scattered or in groups, live; the rest still remain attached to the bark, but dried up and dead, which may arise, perhaps, from not having been sufficiently developed, or not being strong enough at their delivery to pierce the bark for subsistence.

On leaving the parent, the young female is of a minimum red colour, about 1-10th of an inch long, elliptical, obtuse anteriorly, without any division between the head and body, possessing six legs, two antennae, two small eyes, marginal and lateral, and two long hairs, growing from the penultimate segment of the abdomen; the body segmented regularly; the oral aperture ventral and placed at some distance from the anterior extremity; two tufts of white, powdery, hair-like filaments budding from the sides of the thorax respectively, in the place of wings, and a tuft of the same kind, bifurcated, and curling outwards on each side, projecting from the anal orifice. Anal orifices surrounded by a row of short, strong hairs.

At this period the insect is almost too small for examination organologically; but after it has crept off the incrustation and on to the bark of the branch, it soon becomes stationary, and enlarging, as the resinous secretion exudes from the surface of the body so as to surround all parts except the oral orifice and the three apertures from which the three white tufts issue, at the expiration of a month (that is, by the middle of August) it measures in length almost the eighteenth part of an inch.

If we now examine it minutely, it will be observed that the legs, antennae, and the whole of the chitinous part of the body have become almost undistinguishably incorporated with the resinous secretion, which, when dissolved from the insect by spirit of wine, leaves the body almost in a larval or caterpillar form, but without eyes or any other appendages save the three white tufts of hair-like filaments and the proboscis which is now fully developed. The proboscis consists of a fleshy projection situated at a little distance from the head, ventrally, presenting a depression in the centre, from which issue four long hairs or setae, based internally upon as many pyramidal inflations, situated almost at right angles to each other, and supported by other horny elements, which also appear to belong to the machinery of the tree is extracted; but whether they are hollow and do this individually, or form a single tube by combination for this purpose, I have not been able to determine.

On the other hand, the three apertures from which the white tufts proceed, and which are now seen to open through the incrustation, as observed to be situated in the thorax and at the tail respectively, thus identifying the latter, which still presents the circle of hairs round the anal orifice, with the large papilla or anal orifice of the full-grown insect, and the former or

thoracic apertures with the two other papillae, which appear to replace the wings. The white tufts projecting from all these we have already found to consist of the extremities of the trachea covered with a white powder.

Thus we see that the increase of size which takes place in the female insect, from its locomotive form to its ultimate development in the fixed state, is chiefly effected by an enlargement and elongation of the body between the middle, for the oral extremity simply becomes which the three white tufts project, on the one hand, and the three other openings of the body, on the other; and the three other openings of the body remain as near together, in the resinous incrustation, at the end as they were at the commencement, I am ignorant, further than that it does not dissolve in spirit of wine like the lac, which on the other hand, appears to be a secretion from the skin generally, analogous to the chitinous one which would be required under other circumstances.

MALE INSECT.

On the 8th of September I visited the enclosure of the parts where they were most congregated, observed, here and there, little red insects, which I thought they must be a few stragglers of a later evolution; but on inspecting them more particularly, they were observed to possess much larger antennae, and therefore it was concluded that they were males, which afterwards proved to be the case. Several of them were collected, and a small portion of one of the branches, more or less covered by the incrustation, was brought away, to show how the secretion of the lac was progressing.

The male is a little larger than the young ones at their exit from the parent; it has larger antennae, which are hairy-plumose and consist of three articulations, not including the two basal ones; four eyes, two lateral and two under the head; two long hair-like appendages, one on each side of the head, and a beak-like curved a little downwards and composed of horny extension from the last segment, which is covered, and forming together a cylindrical two members, an upper and a lower one, both of which are used by the female.

Thus the changes which the larva undergoes during incarceration, to produce the male, consist in an enlargement and alteration in form of the antennae; in the differentiation of the head, and the addition of two larger eyes under the antennae; in the replacing of the two enabling the male, as he crawls over the lac cover, male organ, and in the replacing of the two it that lead to the vulva; in the addition of the other side of the tail by two delicate, white hairs growing from the penultimate segment on the female having lost all traces of eyes, twisted cords, composed of the attenuated extremities of the trachea. There are further differences between the sexes at this period, in the taking place between the head and body, antennae, and legs, whilst, no differentiation has, but faint traces of the original segmentation. The female is reduced to a mere elliptical sac, with tufts of the trachea, which are absent in the male. From the thorax, however, project the two white hairs before alluded to having disappeared altogether; but the row of hairs round the anal aperture, which are now absent in the male, still remain in the female, and appear to serve the purpose chiefly of preventing the secretion of lac from covering up the anal aperture.

At this period only, the bodies of both male and female are about the same size (viz., about 1-27th of an inch long); but while the former has become more highly developed and eliminated, for the performance of his special function, the latter has become retrograde and permanently incarcerated for hers. So unsparing does Nature deal with her forms for the development of the new being!

Impregnation.—After having taken home the small portion of the branch above mentioned, which was covered more or less by the newly formed brood, on which there were no free males, I was astonished, on taking it up an hour or two afterwards, to observe that two had made their appearance, and were actively engaged in impregnating the females. This they do by drawing the organ before described downwards and inserting it; after which the male sits on the lac which leads to the anal orifice of the female, and withdrawing the penis, goes to another hole, as it were, for a few moments, and then returns to the female, and so on until his office is fulfilled.

I now watched the process for some time, and having sufficiently satisfied myself of the fact as just stated, the two males were removed for microscopic examination, and the branch left, as before, without any. Next morning, to my astonishment, I again found two more males on it, actively engaged in performing their duty. So I examined the latter, and soon saw that they must come from some of the incrustations on the bark,—one circular, slightly larger than the other, and when isolated from the rest (which I changed round the base, &c. on each side, presenting twelve notches or teeth symmetrically arranged from them as before described; with the three holes above, and the white tufts of the trachea, like that of the young insect, but without serrated base, holes, and elevated end, observed that the latter were frequently empty, while from others the tail of the male insect

Thus the origin of the male and the process of impregnation as to time and act were easily determined, while it was also observed that in some parts there were almost, if not quite, as many male as female incrustations present.

On the evolution of the young, therefore, all at first would appear to attach themselves to the bark and pierce it for nutriment—at first, all that live—preparatory to undergoing further general and generative development (as all that live—preparatory to undergoing further general and generative development). Then they respectively become changed (for all are alike, apparently, when first hatched) and the males for impregnating the females, and the females for secreting the lac and developing the new brood; but the latter, as before shown, does not appear until the month of July of the following year. Thus we see that the young *Coccus*, as we have termed it, merits rather the term of "larva" (from the metamorphosis which it subsequently undergoes to pass into the matured forms of male and female respectively) than that of "young insect."

Again, all begin to secrete from their bodies the resinous substance even before they have fixed themselves to the bark, for those had it which were hatched from the lac on the branch that was first presented to me, after the latter was dry and dead; so that no doubt can exist of the lac being produced by the insect itself, and that it is not a mere exudation from the tree, which follows the insertion of its proboscis into the bark, as has been stated.

But while those which are to become males are entirely, though but temporarily, shut in by the lac which they subsequently elaborate from the juices of the tree on which they may be located, those which are to become females are reserved throughout the three apertures before mentioned, from which project the white tufts of tracheae.

These tufts, which previous to impregnation consisted of but a few filaments from each aperture, and thus in no way impeded the functions of the male, had so increased immediately after impregnation (that is, by the 3rd September) that every part of the branch covered with the new lac was rendered white by it, and although there were still a few females which were not impregnated, yet for the most part they were thickly covered by this cottony substance; and the few remaining males were inextricably entangled in it, that, together with the presence of dead ones also entangled in the mass, it may be inferred that this rapid evolution of the cotton-like substance at once indicated the death season of the males, and that impregnation has been fully performed.

One other observation I would add, which is more practical than scientific, viz., that to obtain as much resin and as much colouring matter as possible, the gathering of lac should take place towards the end of May or the beginning of June, just before the evolution of the young, which as will have been seen above, carry away with them the greater part of the colouring matter. In Ure's *Dictionary of Arts and Manufactures* correct account of this insect that I have met with, it is stated that the evolution of the young takes place in "November or December" while the lac is gathered twice a year in "April" and afterwards in "October or November" article that the male insect has "four wings" and that there is "one to every 5,000 females" (1859), page 374, that lac "exudes from certain trees through the punctures which have been made by the females."

It was this and sundry other statements examined successfully only in the country together with seeing that the insect could not be obtained here it lives, which induced me to avail myself of the opportunities presented to me of obtaining as much of its history as I could, for publication.

On the 25th June I received the branch of the custard-apple tree with the living lac-insect on it in its incrustation. At about the 5th July the young or larva, about 1-4th of an inch long, began to issue. On the 1st of August all were fixed to, and progressively enlarging, in incrustation, on the custard-apple tree. On the 8th of September the males were leaving their incrustations and impregnating the females, each sex being now about 1-2 inch long, and on the 20th of September the females were almost all concealed under the exuberant evolution of the white cottony substance (which we now know to be the attenuated extremities of the tracheae covered with a white powder) with a single male insect here and there alive, and many dead ones, entangled in it.

Further observations by Dr. Carter.

AFTER my observations on the evolution of the larva of the lac-insect, which I place at Bombay about the 1st of July, and continued my visits to the colony on the custard-apple tree in order to ascertain the truth of the statement that a second evolution took place during the year, and was fortunate enough to witness this also, as well as the succeeding changes in the larva, which, being somewhat different from those that took place after the first evolution, I will now relate, with modification in the practical deductions that the second evolution necessitates.

On the 13th of December I visited the custard-apple tree, and found the larva issued from the lac formed by the evolution of the first brood; besides many which had become fixed to the bark; so that we must date the commencement of this evolution a few days earlier, to the 7th of December. After this, the same changes took place in the incrustations as were observed in the evolution of the first brood. On the 27th of February the males were coming out of their cocoons or incrustations, and on the 4th of March I found some of them creeping over the cocoons of the females, which were dead and entangled, as before in the cotton-

substance, which, during the last few days, had become so exuberant from the females as to whiten all those parts of the branches covered with the new lac.

But the remarkable point here was, that this time all but a few of the males were provided respectively with two membranous, whitish, transparent, diptoneurose wings, which, being a little longer than the whole length of the body, extended, when closed, considerably beyond the last segment of the body, and made the insect look very much like the male of *Coccus cacti* or the cochineal insect.

Thus, on comparing the dates of evolution and metamorphosis, we find that the first evolution of the larva takes place about the 1st of July, and the second about the 7th of December. Hence the summer brood requires about five months and seven days, and the winter brood six months and twenty-one days, to prepare their young respectively for independent existence. But the metamorphosis of the larva into the males and the impregnation of the females take place about the same time after each evolution. Thus, in the evolution of July it took place about the 20th of September, and in that of December about the 1st of March, giving eighty-two days to the former and eighty-five for the latter; but in the latter instance almost all the males were provided with wings, as before stated, while in the former not a single winged male was observed.

The resinous secretion goes on more rapidly in the first than in the second evolution, owing probably to the greater quantity of sap which is present in the trees in the summer than in the winter or cool season; but the greatest amount of resin, comparing that produced by the brood of December 1859 with that of the brood of July 1860, appears to me to be produced by the December brood. In each instance the lac-insect perishes, whether it gives forth a new brood or not; so that the old lac thus becomes entirely lifeless.

Having previously assumed that only one evolution takes place during the year, it is necessary to modify the practical deductions which I have made. Thus I have stated that, as the colouring-matter or "lac-dye" is contained in the young ones, the lac should be gathered just before their issue, that is, "towards the end of May or the beginning of June," so that at once the greatest amount of "lac" and "lac-dye" might be obtained; and now it is necessary to add that a second gathering should be made, viz., in the month of November.

Then, as regards the propagation, branches of the tree bearing the lac with the insect in it should be gathered just previous to the evolution of the young, and tied to the trees on which it is desired to grow it, it being understood that, as their numbers increase by *larks* (100,000's) from which the name of "lac" according to Sir W. Jones, would appear to be derived, the trees must be thus sacrificed. And as regards self-propagation, it would be difficult to conceive how this could take place with the early incarceration of the females, did we not know that the larva are so light and so numerous that they might be conveyed from tree to tree in a hundred ways; and as to impregnation the females may be able to produce even more than one brood without this, as is notorious with the *Aphides*, which belong to the same order, and afford the oldest authenticated instance of parthenogenesis.

In the second volume of the *Asiatic Researches*, page 261 (ed. Lond.), there is a paper on the lac-insect by Roxburgh, to which my attention has been directed; and it is interesting to find that his description was written from an evolution of the larva which was taking place in Bengal on the 1st of December. His figure of the male, and its appearance at the same time with the larva, is of course erroneous.

FROM

C. J. LYALL

Under Government of India,

TO

*The Secy to the Government
of Madras*

Dept. of Revenue,
Agriculture and Commerce.

Forest.

Calcutta, the 29th June 1874.

SIR,

I AM directed to
compiled by Mr. J. E. O'Co
that you will be good enough

35 copies of a Note on Lac,
this Department, and to request
permission of His Excellency
to whom the information con-
to be distributed to Forest Officers,
Governor General in Council
Note will, in the opinion of the
useful.

be,

servant,

W. T. L. L.
Secretary to the Government of India.

GOVERNMENT OF INDIA.
DEPARTMENT OF REVENUE,
CULTURE AND COMMERCE.

FORESTS.

No. ²⁰
745.

Calcutta, the 29th June 1874.

Edg.

SUBJECT.

REPLIES Mr. J. E. O'Connor's Note on Lacc.

S. G. P.—No. 81a, B. A. & C.—29.6.74.—110.

Ordered accordingly that this
of the State received will
be forwarded to the
for distribution
of the same.

*For Mr. O'Connor's Note on Lacc. 29/6/74
Printed 7/7/74*

W. C. C.