

Permo-Carboniferous Life Provinces, with Special Reference to India.

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AT the recent meeting in Amsterdam (Sept. 2-7, 1935) of the Sixth International Botanical Congress, the inter-relations of the Late Palæozoic floras were discussed by various geologists and palæobotanists. After Professor T. G. Halle's Presidential Address to the Palæobotanical Section, Professor A. C. Seward, F.R.S., opened the discussion with remarks on the "Nature and significance of geobotanical provinces". He dealt, *inter alia*, with the difficulties attending a decipherment of the records of the rocks, particularly those connected with the climatic implications of extinct forms of plant life. Perhaps the most striking observation in this masterly discourse, characteristic of a man of Professor Seward's authority and experience, was that today he knew less about the value of fossil plants as tests of climate than he did forty-three years ago, when he wrote his well-known Sedgwick Prize Essay for the year 1892. Among others who followed with papers on various aspects of the problem, was Professor Halle himself, who discussed the relation between the Late Palæozoic floras of Eastern and Northern Asia (pp. 227-228).¹ Professor R. Kräusel of Frankfurt a.M. spoke on the distribution of the Devonian flora. Professor W. Gothan of Berlin dealt in two papers with the inter-relations of the Permo-Carboniferous life provinces (pp. 226; 242-244). Professor W. J. Jongmans of Heerlen discussed the distribution of synchronous floras with special reference to the movement of the poles and of continental blocks (pp. 239-242). Professor A. Renier of Brussels offered remarks on stratigraphical correlations in and between the geobotanical provinces (pp. 244-245). Lastly, the present writer read a paper on the *Glossopteris* flora of India and its phyto-geographical relations (pp. 245-247), of which a summary is given below.

Immediately after the Amsterdam Congress, an international gathering of about eighty geologists and palæontologists met in Heerlen (Sept. 9-12) for the Second Congress of Carboniferous Stratigraphy under the auspices of the Geologisch Bureau of the

Nederlands. Here we had the advantage of the presence of the veteran geologist Dr. W. A. J. M. van Waterschoot van der Gracht, Mr. D. N. Wadia of the Indian Geological Survey and other geologists interested in tectonic problems connected with Asia. Among many interesting and important items on the programme, Professors Jongmans and Halle presented their Amsterdam papers again under these new auspices, and in this connection the writer also had the privilege of discussing that part of his paper which dealt with the relations of the Indian Gondwana flora with those of Siberia and China.

As the space allotted for the advance abstracts of the Amsterdam Congress was necessarily limited, and as the full paper will be delayed in publication, I propose to give below an extended summary in the hope that it may be of interest to readers of *Current Science*. The full paper will appear in the *Proceedings of the Indian Academy of Sciences* for 1936.

It is generally agreed that towards the end of the Palæozoic era there existed four more or less well-defined botanical provinces. In the southern hemisphere there was the Gondwana continent, with its very characteristic *Glossopteris* flora. This flora also extended into India, which now lies north of the Equator. Gondwanaland was separated by a great Mediterranean Ocean, the Tethys, from the other three provinces which had more or less distinct floras of their own. These were, *firstly*, the Arcto-Carboniferous province, inhabiting the area now occupied by parts of Europe and eastern North America; *secondly*, the province of the *Gigantopteris* flora, developed in parts of western North America and in China, but extending south into Sumatra; *thirdly*, the Angara province, stretching eastwards from near the Ural Mountains as far as the Pacific Coast, and southwards as far as the Tarbagatai Range, within a few degrees north of Kashmir. The floras of these three northern provinces have more in common with each other than any one of them has with the Gondwana flora. Their geographical relations are best understood by viewing the globe from the Arctic pole (Fig. 1).

¹ These page references are to the *Proc. 6th Internat. Bot. Congr.* (Sec. PB), Amsterdam, 1935, Vol. II.

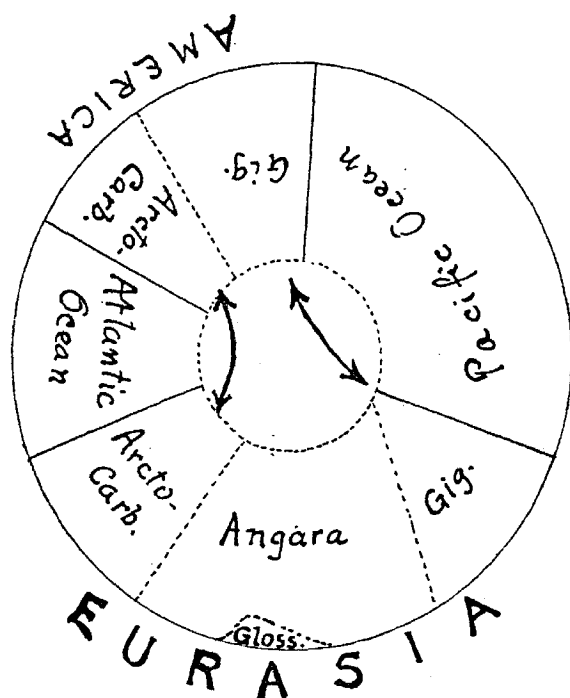


Fig. 1.

It is noteworthy that both the Arcto-Carboniferous province and the *Gigantopteris* province are cleft longitudinally into two blocks each, the blocks of each pair being separated by wide oceans, the Atlantic in the one case, the Pacific in the other. But towards the pole the two halves of each province tend to approach each other, although their actual meeting has not yet been proved. In Eurasia, the Angara flora is wedged in between the other two floras. In its affinities, so far as they are understood at present, the Angara flora is perhaps the most interesting of all, because it contains elements of all the other three floras in addition to a large proportion of genera and species peculiar to itself. The synthetic nature of the Angara flora is perhaps best understood if we look at the globe from, say, the Altai Range: Angara Land is then seen to occupy a central position, as one amongst the four life provinces. Lastly, the *Glossopteris* flora, although containing stray elements of the "northern" type, is for the most part a distinct assemblage, strongly characteristic of the southern hemisphere. This province is perhaps best seen from the southern pole, although from there India goes out of the view.

The present relative positions of these four life provinces raise palæogeographical problems which have led to much speculation. If, as seems probable, these floras were largely contemporaneous, it is difficult to imagine that two floras so distinct from

each other as, for example, those of India and Sino-Sumatra should have evolved and flourished side by side, where we now find them on the map: almost cheek by jowl and crossing much the same latitudes. On the other hand, there is the equally puzzling anomaly that countries with closely related floras lie on the opposite sides of the biggest oceans of the globe: China and western North America; eastern North America and Europe; India and the southern continental blocks. But these are only a few of the problems with which the whole subject bristles. The satisfactory solution of all these problems is a thing of the distant future; but that future has been brought somewhat nearer by the recent work in Central and Eastern Asia of Swedish, American and Chinese investigators, and elsewhere by a host of workers on different aspects of the subject.

In the following necessarily condensed account, I shall first record my conclusions regarding the geological range of the Indian *Glossopteris* flora and the climatic conditions in which it was probably evolved, and then pass on to a brief discussion of its relation with the contemporary floras of Siberia and China.

THE *Glossopteris* FLORA OF INDIA AND ITS PHYTOGEOGRAPHICAL RELATIONS.

1. In India the *Glossopteris* flora probably ranged from the Upper Carboniferous to the Trias. The lower limit is indicated by the relations of the Talchir glacial beds and the earliest plant-bearing Gondwanas with marine fossiliferous horizons of determinable age, particularly in Kashmir and in the Salt Range.

Beginning in all probability as a meagre cold temperate flora in the latter part of the Talchir (Upper Carboniferous) period, it rapidly became richer as the climate became warmer (Damuda = Permian). In the Panchet stage (Lower Trias) stray elements of the then widespread *Dicroidium* (*Thinnfeldia*) flora became mingled with a still dominant *Glossopteris* flora. In the Parsora stage the *Dicroidium* element seems to have predominated over a waning *Glossopteris* flora. *Glossopteris* itself has not been recorded from Parsora itself but *Neggerathiopsis Hislopi* and other characteristic Lower Gondwana plants co-existed with several species of *Dicroidium*, which abounded. The Parsora beds cannot possibly be of Jurassic (Upper

Gondwana) age, as C.S. Fox² believes: they clearly belong to the Permo-Triassic part of the Lower Gondwanas and may be even as old as the Upper Permian, as Professor Seward has suggested.³

2. The meagre evidence available supports the current idea that the main part of the *Glossopteris* flora was developed in a temperate climate. There is certainly no evidence that it was in any sense a glacial flora, although in sheltered spots early members of the flora may well have co-existed with the retreating ice. Nor is there any clear evidence of tropical conditions such as are believed to have existed in the Arcto-Carboniferous province.

3. The only other Carboniferous flora known in India is the geographically important Himalayan outpost of the *Rhacopteris* flora in Spiti (Thabo stage of the Po Series) which, as Gothan has suggested, is probably of Lower Carboniferous age, not Middle Carboniferous as formerly believed.

4. In several parts of Gondwana Land, particularly in South America and South Africa, species related to or identical with members of the European flora have been found associated with the indigenous southern flora. These so-called "northern" elements have generally been regarded as immigrants, but I am inclined to interpret them as remnants or descendants of the pre-existing southern flora. They occur chiefly in the earlier Gondwanas and have been compared or identified with European Upper Carboniferous or Lower Permian forms. Some of the lycopods are comparable with pre-Gondwana southern types. They may have persisted through the glacial period in regions relatively free from the rigours of the ice.⁴

5. The relations of the Indian *Glossopteris* flora with the Palæozoic flora of Angara Land are still very imperfectly known. The Angara flora, of which our modern knowledge is based chiefly upon the works of Professor Zalessky and of Miss Neuburg, contains (i) a large indigenous element, peculiar to Angara Land, (ii) a very considerable Arcto-Carboniferous element, (iii) a small but

important *Gigantopteris* element, quite recently discovered, and (iv) a large number of forms more or less resembling, and a few perhaps identical with, plants characteristic of Gondwana Land. Although the Gondwana affinities may have been somewhat over-emphasised in the past, as Halle and others have suggested, there seems no doubt that the two floras were not evolved independently: some means of intermigration must have existed. Whether this was by a direct route, through Kashmir, as suggested by the writer in 1926, or by an indirect route, possibly through China, is an open question. Meanwhile, a critical comparison of typical specimens of the two floras is urgently needed; a comparison of the faunas should also be helpful. The Lower Gondwana flora of northern India, particularly that of Kashmir and the Salt Range, should be further explored; and any acquisitions of plant-fossils from the ancient coast-line of Gondwana Land, which lay along the southern margin of what is now the Himalayan chain and on the east from Assam to Burma, should be closely examined. Investigations in the intervening region between northern India and the Altai range may possibly bridge the already narrow gap between Kashmir and the southernmost Angara localities in the Tarbagatai. In that case, as tentatively suggested in 1926 (*loc. cit.*, p. 241) the Kashmir flora may be only a southern outpost of the Angara flora.

But, on the other hand, it may after all turn out that the suggested affinity of the still meagrely known Kashmir flora with that of Angara Land was only apparent, or less close than imagined. Certain geological considerations would seem, indeed, to preclude any means of terrestrial migration from Kashmir to Siberia during the late Palæozoic. D. N. Wadia's important work in N.-W. Kashmir and Hazara⁵ seems to have established that the chain of the Himalayas, representing the uplifted and folded marine sediments of the Tethys, is structurally continuous round the great re-entrant angle in our northern mountain barrier. Unless further investigations reveal evidence of a break in the marine zone, either here or further to the west or east, the marine barrier between India and Siberia must have been a truly formidable one: it is now represented, as Dr. van der Gracht

² Fox, C. S., "The Gondwana System and related formations," *Mem. Geol. Surv. Ind.*, 1931, 58, 189-190.

³ Seward, A. C., "Fossil Plants from the Paisora Stage, Rewah," *Rec. Geol. Surv. Ind.*, 1932, 66, (ii), 242.

⁴ Sahni, B., "The Southern fossil floras, a study in the plant-geography of the past," *Proc. 13th Ind. Sci. Congr.*, Pres. Addr. to Geol. Sec., Bombay Meeting, Jan. 1926, p. 241.

⁵ Wadia, D. N., "The syntaxis of the N.-W. Himalayas," *Rec. Geol. Surv. Ind.*, 1931, 65, (ii), 189-220.

emphasised at Heerlen, by some of the highest mountain ranges in the world, including the Himalayas and the Karakorum. In the face of these considerations, Zalessky's hypothesis of a connecting isthmus or a chain of islands across the Tethys does seem bold, but then the Gondwana resemblances of the Angara flora, which, I believe, are undeniable though they may have been exaggerated, must be explained by an indirect route, still to be discovered. This is a point on which investigations not only in China and Central Asia but also along the old Gondwana coast-line in the Nepal-Assam-Burma region may be expected to throw light.

6. Further east across the Tethys, in China, there flourished a vegetation which had much more affinity with that of the Euramerican continent, and some affinity even with that of Angara Land. With the Gondwana flora there was much less in common. But although essentially a northern flora, the *Gigantopteris* flora crossed the equator into Central Sumatra⁶ where it appears to have pushed itself like a wedge into the Gondwana province. I believe that this peculiar dovetailing of the sharply contrasted northern and southern floras can only be explained on the view that originally the two provinces were far separated by the ocean (Fig. 2), but have since been brought into contact by a horizontal drift of one or (as I consider much more probable) both land areas (Fig. 3). The old Gondwana promontory of N.-E. Assam may be regarded as a pivot round which the Burmo-Chinese mass, formerly situated much further to the north, moved southwards and westwards; along the arc of a circle.

How far this suggested syntaxial bend round N.-E. Assam, compared with that which Mr. Wadia has so ably demonstrated in the N.-W. Himalayas, is supported by structural geological evidence, is for the future to show. The idea was suggested to me by purely palæobotanical considerations but, as I learned subsequently, several geologists have previously expressed the belief that the chain of the Himalayas is continued southwards round Assam into

Burma and the Malayan arc of islands. The alternative view of Kingdon Ward that the Himalayas continue eastwards through China, as far as the Pacific Coast, seems quite untenable, as the region of China where his supposed eastward continuation would lie was a land area inhabited by the *Gigantopteris* flora.

It may be that the present region of Sumatra formed a southward promontory of the northern continent, round which the sediments of the intervening geosyncline, lying to the north of the Indo-Australian mass, became folded and bent into an angle or arc, in much the same way as round the Kashmir and Assam promontories. But the position in this region seems much more complicated, and in any case the subject is beyond our present scope. The main point one may venture to suggest is that palæobotanical explorations in the Malayan

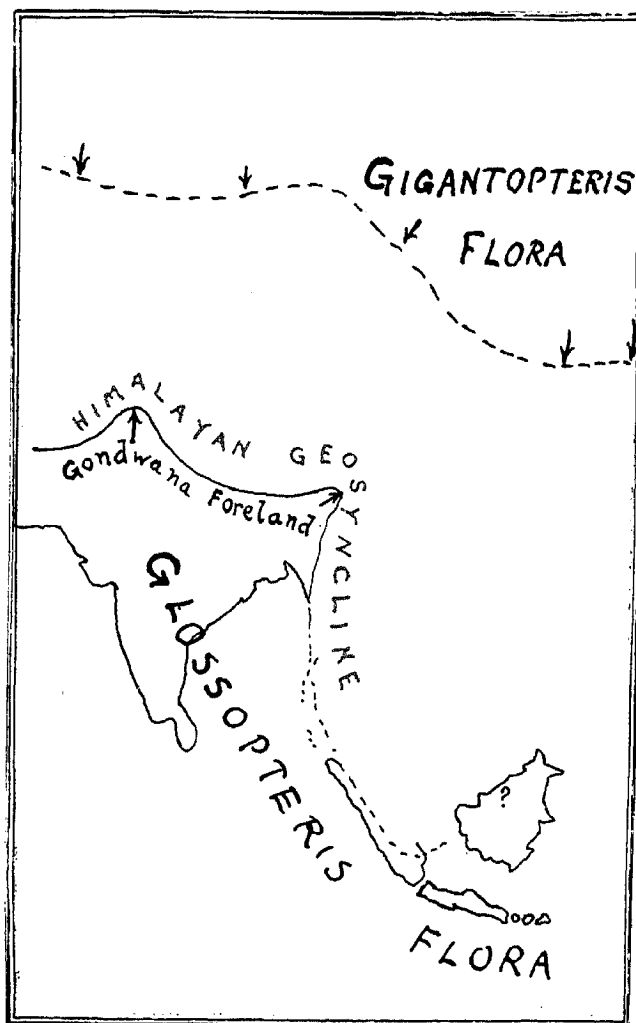


Fig. 2.

arc and further to the east should probably establish the eastward or north-eastward continuation of the tectonic boundary between Gondwana Land and the *Gigantopteris* province.

⁶ Jongmans and Gothan, "Beitr. z. K. d. Flora des Obercarbons von Sumatra," *Med. Geol. Bur. Nederl. Mijngebied*, 1925, No. 2; Posthumus, O., "Palæozoic flora of Djambi," *Proc. Kon. Acad. Wet., Amsterdam*, 1927, 30, (6); Jongmans and Gothan, (1935) "Die palæobotanische Ergebnisse d. Djambi-Expedition," *Jaarb. Mijnw. in Nederl.-Ind.*, 1930, "Verhandelingen".

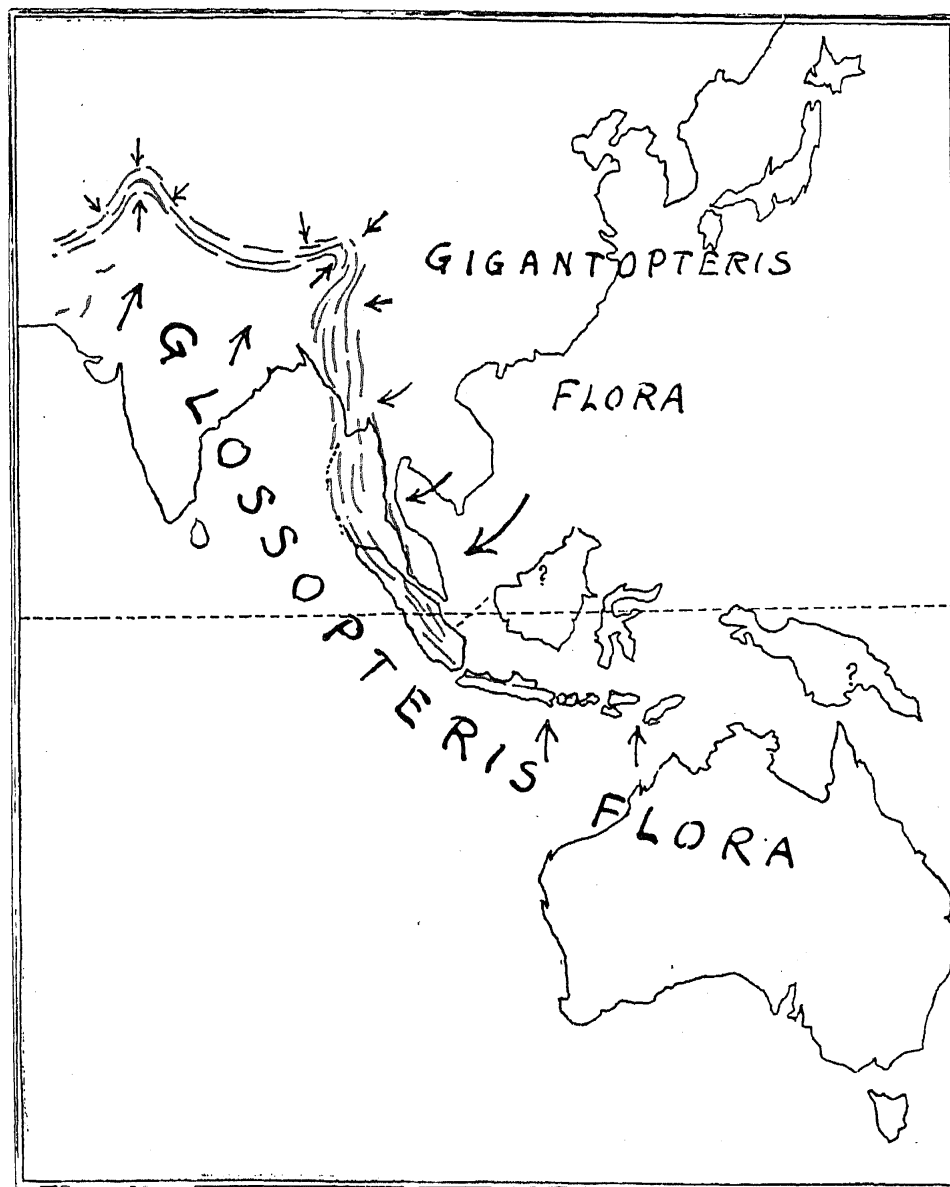


Fig. 3.

It remains to add that while the above ideas were arrived at independently I owe the original impetus for them to certain suggestive remarks made by Professor Halle, in his classical memoir on the Shansi flora,⁷ where he drew attention to the close proximity of the Indian and Chinese floras and hinted that this anomalous position may have had something to do with the tectonic features of the intervening region. The above hypothesis would also explain the apparent anomaly of two climatically distinct floras lying, as they now do, athwart the same latitudes. There need not, therefore, be any serious difficulty, at least on geographical grounds, in accepting the idea that while the "Arcto-Carboniferous" flora (including its Sino-Sumatran phase) was developed in a relatively warm and humid climate, the *Glossopteris* flora was essentially a temperate flora.

In reply to an enquiry my esteemed friend Mr. Wadia also wrote to me that he thought a N.-E. tongue of the Indian horst had much to do with the acute southward bend of the Assam mountains into Burma. To him and to Dr. F. R. Cowper Reed, I am indebted for references to geological literature on this aspect, which showed that the problem has already received attention from many geologists. To mention only the most recent instance, I learned that the idea of Assam as a resistant pivot, round which the far eastern block probably drifted southwestwards into its present position, has also been recently expressed on geological grounds by M. Fromaget,⁸ Director of the Geological Survey of Indo-China. Lastly, it was gratifying to find that at the Amsterdam Congress Professor Jongmans expressed ideas essentially similar to those presented in my paper, read the same day.

⁷ Halle, T. G., "Palaeozoic plants from Central Shansi," *Palaeontologia Sinica*, 1927, Ser. A. 2, (i), 288-290.

⁸ Fromaget, J., *Essai sur l'évolution paléogéographique de l'Indochine, etc.*, Hanoi, 1934.

With so much concurrence on the essential points, I think that we may feel satisfied about the stability of our main conclusions. About ten years ago, in an essay on a broad survey of the "Southern Fossil Floras",⁹ I said that it was the scattered distribution of the previously glaciated areas of Gondwana Land that provided the main support to Wegener's hypothesis: palæobotany did not

seem to me at the time to lend any clear evidence in favour of it. The Carboniferous glaciation of the southern hemisphere still appears to me to be the main pillar on which Wegener's idea rests. But I now feel that palæobotanical considerations, such as those set forth above add another, though modest, support to this remarkable theoretical edifice, at least so far as concerns the movement of continental masses through wide ranges of latitude and longitude.

⁹ Sahni, B., *loc. cit.*, 1926, 233.

Antiquity of Lac and Superstitions Connected with It.

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THE Indian Lac Industry enjoys a venerable antiquity dating as it does to the times of the Puranas. Reference to lac is made in "Mahabharata" in connection with the "Laksha Griha" or palace of lac, which was built to ensure and burn down the Pandavas. Kautilya mentions the product in his celebrated "Arthashastra". Coming down to very recent times Abu-l-Fazl who was in the Court of Akbar, refers to lac as being employed for varnish making.

In Ayurveda, lac is extensively employed, both for external application and internal administration. Shellac, finely powdered and mixed with honey, is given as a specific for hæmorrhage. It forms one of the main ingredients of a medicated oil known as *Lakshadi Thaila* which is reputed to bring down chronic fevers, cure rheumatic pains and help the growth of fœtus during pregnancy. Decoctions of lac are administered to consumptive patients with good effect. Germicidal, febrifuge and astringent properties are attributed to lac. It is not clear to which constituent of lac the medicinal property is attributable. When decoctions are made, the body fluids of the insect which go into solution are involved but when the medicated oil is prepared, the wax and the insect fat dissolving in the oil, constitute the effective ingredients. It is not clear whether brood lac consisting of all the living insect mothers or the "phunki" lac containing only the dead insect bodies, is used. Local information points to the conclusion that the most effective and potent preparations are those made from brood lac which is not always available to the Ayurvedic Pundit. It is quite conceivable that the medicinal value of the wild lac is higher than that of the commercial species.

This ancient industry is naturally connected with a number of "superstitions" some of which appear to have a sound scientific foundation. Those who generally cultivate lac form a caste by themselves in Mysore, and they observe these superstitions in a most religious manner. The uncertainty which characterises lac crops is signified by the saying that "the ferry boat, lac and Tasar depend on God". These three things cannot be controlled by human beings. It is believed that all lac-bearing plants are haunted by evil spirits which are responsible for all kinds of damages and crop failures. To propitiate these evil spirits and invoke their good favour, rams, goats and chickens are offered to them in sacrifice.

The solar or the lunar eclipse, especially when it synchronises with either the swarming of larvæ or the emergence of males, is believed to be fundamentally calamitous to lac crops. On such occasions it is not unusual to find liberal animal sacrifices being offered in the field.

Host plants need a change of physiological condition before they can bear bumper crops of lac and the desired change can be brought about by repeated lac infections and successive prunings for several consecutive years. This is an observation of great value and is fully borne out in modern field practice; but an adequate scientific explanation of this observed fact cannot at present be given. The successive infections and prunings will result in altering the ratio of top to root to the optimum point.

Brood lac should not be harvested until the larvæ are seen to swarm out of their mother-cells in pretty good numbers and