# Notes on Dipterocarps.

## No. 3. The seedling of *Shorea robusta*, Roxb., and the conditions under which it grows into pure forests.

By I. H. Burkill.

In this *Journal*, 1917, pp. 163—167, outline figures of the seedlings of some Malayan Shoreas were given; and the remark was made that the Indian *Shorea robusta*, well known as *Sal*, differs from them in the elongation of the stalks of its cotyledons. It is now possible to illustrate the remark by an outline figure of the seedling of *Shorea robusta* at the same stage as the Malayan species: and if the reader, after glancing at it, will turn back to the pages named, he will see at once how wide is this difference.

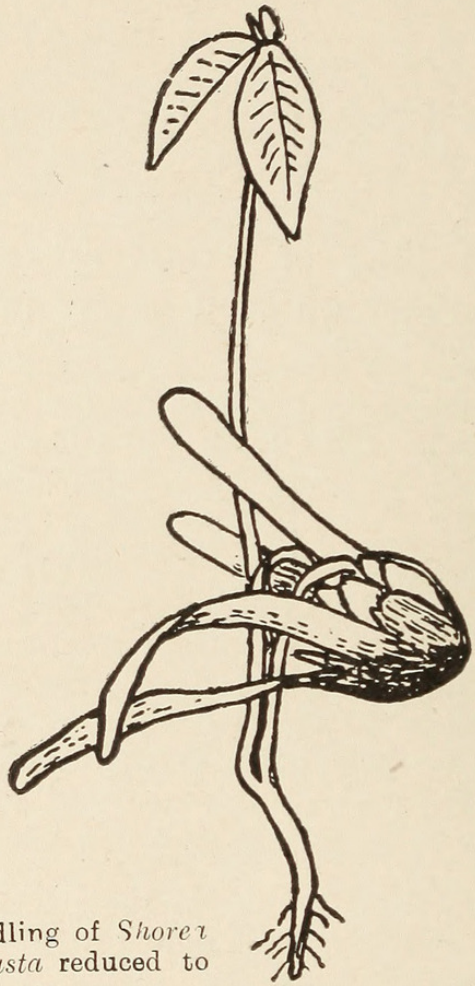
In my material of *S. robusta* the stalks of the cotyledons attained 6 cm. in length; whereas those of the Malayan species figured before never exceeded 1 cm.

I owe the material to the kindness of Mr. R. S. Hole of the Indian Forest Service, Botanist at the Imperial Forest Research Institute, Dehra Dun.

*Shorea robusta* is one of the most important of Indian Forest trees: for instance, Pearson estimated in 1913 that the annual production exceeded eight million cubic feet (Economic Value of Shorea robusta, *Indian Forest Memoirs*, ii. part 3, 1913, p. 70); and while the Government conserves large forests of it, there are also considerable areas privately owned and worked. The distribution of the Government forests may be gathered easily from Caccia's paper entitled "Development of Sal" in the *Indian Forest Records*, vol. 1, part 2, 1908, p. 85, to which a map is appended. The privately owned forests lie in the same regions, which may be summarised thus:—

(i) a belt, extending along the base of the Himalaya, and up its slopes to about 4000 feet (in favoured localities somewhat higher) between the Kangra valley on the west and the Darrang district in Assam on the east.

(ii) the country east of the Bengal plains comprised in the Garo, Khasi and Jaintea hills, and the hilly district of Nowgong to the north.



Seedling of *Shorea robusta* reduced to 2/3.

(iii) the hills south west of the Bengal plains, westward to Pachmarhi, and southward into the Circars, as far as Jeypur.

In a general way these three areas are together the rim of the cup into which the monsoon current from the Bay of Bengal pours its moist air from May to September, with precipitations from June. At the extreme western points the average annual rainfall is reduced to below 40 inches. In other places the precipitation is upward of five times as much. On the hills and also to some extent in the plains, Sal withstands frost. Everywhere it demands good drainage.

The Sal tree flowers in March or April when the dry season is on, changing its leaves rapidly just previously or at the same time; and this in every year: but a good seed crop is only yielded about once in three years. McIntyre (*Notes on Sal in Bengal,* Forest Pamphlets Series, 1909, p. 2) attributes to unfavourable weather the failure to yield annually: but this is a point which demands investigation. The seeds are ripe in the commencement of the rains, and are ready for immediate growth; in fact they often germinate on the tree (vide Brandis, *Forest Flora of the North-west and Central India,* 1874, p. 27, and also earlier writers): if drought follows their fall to the ground, they are likely to die.

They are starchy (about 60 per cent of starch on dry weight); but they fail as a food on account of tannins present to the extent of 8 per cent. These tannins act on man as poisons causing indigestion, constipation and ultimately death (see Reinherz, in *The Agricultural Ledger*, 1904, No. 5, pp. 33—36). It is obvious that they serve to protect the seed, but not altogether;* for many animals feed on them†: and, as with all vegetation, there are specialised insect-enemies.‡

The seeds of the Malayan Shoreas seem very similar in being relatively rich in tannins; and to have similar enemies.

The parent Sal tree many attain 20—25 feet in girth, but it is recorded that it may be a seed-bearer with as little girth as $7\frac{1}{2}$ inches (Troup in *Forest Bulletins,* New Series, No. 8, 1912). Troup was unable to show any laws of variation relating to the viability of seed got from trees of different sizes, of different degrees of soundness, of different localities, or of seed ripened in the beginning, middle or end of the seed-time, but he suspected a possible law in regard to the last, the middle of the season being best. Haines (*A Forest Flora of Chota Nagpur,* 1910, p. 178), has said that the earliest are generally bad.

There is no albumen around the embryo plant in the seed, but all its store of food is in its gorged bilobed cotyledons. It has been shown for *S. leprosula* (this *Journal,* 1917, p. 161) how the lobes of the cotyledons, enwrapping in their growth the placentae and the sterile cells of the ovary, push themselves into the apex of the fruit. In *S. robusta* the two lobes of the inner cotyledon alone attain it, shutting out the outer, as suggested in the illustration above.

The seeds, upon falling to the ground, thrust the radicle to the soil chiefly by the growth of the stalks of the cotyledons, the cotyledons themselves remaining loosely apposed, and scarcely functioning as assimilatory organs. Herein is a great divergence from what is to be found in those Malayan Shoreas that are known to me, a divergence which carries *S. robusta* to a position in the order close to the genus *Dipterocarpus;* for the cotyledons in *Dipterocarpus* remain imprisoned within the wall of the fruit, do not assimilate, and as the young plant grows are depleted of their food through their stalks which elongate, although not exactly to plant the radicle as those of *S. robusta,* but accomodatingly to the elongation of the hypocotyl.

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* Tannins are present also in the bark of the Sal tree to the extent of 8—10 per cent (vide Pearson, Economic value of Shorea robusta, in *Indian Forest Memoirs,* ii. part 3, 1913).

‡ In Mr. Hole's experiments porcupines were troublesome (*Indian Forest Records,* v, part 4, 1916, p. 52).

† E. B. Stebbing describes the Indian insect enemies of *Shorea robusta* in a paper entitled *some Assam Sal insect pests,* Forest Bulletin Series, 1907.

This relationship of *S. robusta* to the genus *Dipterocarpus* finds confirmation in the anatomy as determined by Heim. Heim, (*Recherches sur les Dipterocarpacées,* Paris, 1890, p. 40), having divided *Shorea* into nine sections, and having put *S. robusta* into the first of them, called *Eu-Shorea,* wrote of it, "This section seems to make connection with the genus *Dipterocarpus* especially by reason of the distribution of its vascular bundles in the leaf-stalk, and in the number of resin canals; but in the shape of the stamens it diverges more than do other sections such as *Antho-Shorea.*"

Unfortunately of Heim's Eu-Shoreas there are many species yet to study.

*S. robusta* at its best, where the drainage is excellent and the soil is deep, makes pure forests, of a beautiful dark green, and often with the ground coated by seedlings struggling up under the parent trees. Hole (*Indian Forest Records,* v., part 4, p. 52) has found that the seedlings will grow healthily under an artificial shade which reduces the light to .015, demonstrating so how well the species is able to tolerate, when young, the deep shade those forests, wherein it asserts itself continuously against other trees. This power of making pure forests is possessed by some other Dipterocarps; *Dipterocarpus* itself possesses it, and *Dryobalanops Camphora,* and *Shorea assamica,* none in competition against another, but each in its own particular geographic region:—*S. robusta* round the rim of the Bengal plains, *S. assamica* in Upper Assam, *Dipterocarpus* chiefly through Burma, Siam and Indo-China, and *Dryobalanops* in Sumatra, Borneo and the Malay Peninsula.

Some observers have written of the success of *Shorea robusta* as connected with forest fires. Gamble pointed out that it drops its seeds after the season of fires is over, and shares the profit got thereby in its less pure forests with *Stereospermum chelonoides*—a rather constant companion which sheds its seeds at the same time. Brandis (*Forest Flora* XIII, p. 53) remarked that the reproduction of Sal may be materially increased by the circumstance that the seed falls after the fires have passed. Many foresters, the last Troup (*Indian Forester,* 1916, p. 57), have pointed out that if fire is withheld the coating of dead leaves on the forest floor prevents the sprouting seeds from sending their roots down, and betrays them by drying rapidly when a dry spell comes. Others have pointed to the way in which a coating of grasses and other herbs may hold the seed from off the ground by its wings, so that it germinates in the air, to be dried up soon: and that as these leaves and grasses are destroyed by the fires, a way is thereby prepared for the seed.

Haines (*Indian Forester,* 1917, p. 311) has stated that fires are advantageous in another direction, namely that they diminish the abundance in the forests of the fungi which attack Sal.

But if the fires be repeated too soon any occasional advantage is lost*. And after all what is the advantage where conditions are favourable to Sal, for there considerably over ninety-nine per cent of the seeds which fall must fail for want of room.

It cannot be that the liability of Sal or Dipterocarpus forests to fires assists at all in maintaining pure forest other than perhaps as Haines suggests in destroying fungi. So much is this recognised that every Indian forester of experience advocates fire protection, as a principle. But fire applied not more frequently than, say, triennially beyond the edge of pure forest may assist the Sal or Dipterocarpus in extending by clearing the way for the seed and damaging the competitors. Unfortunately forest fires where likely to occur, are annual. And under this view, the failure of the Malayan Shoreas to make pure forests is scarcely to be ascribed to their freedom from them.

It is on deep open soils that Sal makes the pure forests—soils such as happen to be peculiarly well developed by rapid rivers from out of the rocks of the Himalaya, soils where the water may sink in dry periods in such a way† as to injure many plants which compete elsewhere. Sal finds on these soils the combination of yet unanalysed conditions ideal to it: and obviously it has a peculiar physiological adaptation to their nature to which its success may be ascribed. This physiological adaptation it shares somewhat with *Shorea assamica*: for *Shorea assamica* makes its pure forests on just the same kinds of soil.

Sal seedlings have a wonderful power of replacing the primary stem if it be lost, even right from the axils of the cotyledons. So far I have seen nothing like it in the Malayan Shoreas. Not once only can the seedling make good the leader, but it may renew it again and again through some years. Hole has illustrated this process in three places (*Indian Forest Records,* v, part 4, 1916, plate 1; *Indian Forester,* 1916, plate 23, p. 336; and *Agricultural Journal of India,* Indian Science Congress Number, 1916, plate 1.)

This loss of the leader is usually caused by something which is not a forest fire, though forest fires may of course cause it; and in at least ninety per cent of cases it comes from some underground influence acting through the root. Hole finds that the mixing with the soil of leaves, especially of Sal leaves, increases it. and he suggests that a toxic body is produced in the process of their decomposition directly or indirectly. If this be so, then light forest fires by removing the leaves on the forest floor may do good.

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For the destruction of the Sal forests at the foot of the Himalaya between the rivers Gandak and Teesta, by repeated firing, see my note in the Journal of the Asiatic Society of Bengal, 1916, p. 267.

†Cf. Milward's statement (*Indian Forester,* xxviii, 1803, p. 411) that under excellent Sal in Oudh the water may be 40 feet down.

This dying back of Sal seedlings is most intense in the rains; the seedling in appearance dies back exactly as it does also from drought, as if the plethora of water at the roots works in the same way as its want. But Sal seedlings can be grown in water cultures, and therefore contact with water itself has nothing to do with it. It would rather seem to be something shut out from or brought to the roots (Hole's toxic body for instance) by the water. Death can be caused in pots without the neighbourhood of other plants, and and therefore by no toxic excretion of another plant (Hole in *Indian Forester,* 1916, p. 337). The Malayan Shoreas too die in wet periods, as far as I have observed, but there is this difference that Sal dies back only, whereas they die out. Herein is a difference between the two, perhaps connected with the greater success of the Sal (within its area),—a difference which demands investigation.

For the purpose in hand, namely to form a sound classification of the order to which these trees belong, two facts may be useful, (i) that the Indian species *S. robusta* and *S. obtusa,* are more able to make pure forests than any of our many Malayan Shoreas, and (ii) that *S. robusta,* at any rate, is in its seedling more similar to the genus *Dipterocarpus* which also forms pure forests, than are the Malay Shoreas, *S. leprosula,* Miq., *S. rigida,* Brandis, *S. macroptera,* Dyer, *S. bracteolata,* Dyer, and *S. gibbosa,* Brandis. The pure forests are not the creation of man through firing: but the mixed forests may carry his impress.