***Review Article***

# *Boswellia serrata* Roxb. ex Coleb.: A Threatened t~~T~~ree ~~that Needs Conservation~~


## Abstract

*Boswellia serrata* Roxb. ex Coleb. commonly known as Indian Olibanum or Indian Frankincense tree belongs to the family Burseraceae. Its ~~Distribution~~ distribution is confined to ~~in~~ dry, rocky ridges, slopes and flat terrain habitats of Tropical Dry Deciduous Forest of India. ~~Found in dry, rocky ridges and slopes, as well as flat terrain~~. It grows at altitudes up to 1,150 m in regions with annual temperatures between 0-45°C and annual rainfall between 500-2,000 mm. *B. serrata* has been listed in the threatened species of India. Slow growth and poor regeneration are principal threats, while population trends and habitat trends are stable. It is a commercially important tree which exudes volatile oil, resin and gum. The oil obtained from this tree is very similar to turpentine oil. and ~~The oil has been~~ found suitable for paint making, varnish and used as printing ink in textile industries and in making distempers. It has been reported as a unique non coniferous source of turpentine employed for the manufacture of paints and varnishes. The resin obtained from this tree is used for preparation of varnishes. The tree exudes of *B. serrata* resembles Canada balsam in colour and consistency. It is mainly used for medicinal purposes and incense. A detailed review covering its taxonomy and nomenclature, distribution in India, reproductive biology, wood properties, processing and harvesting, genetic resources available, reasons for its deterioration, and its uses is presented in this article.



Key Words: *Boswellia serrata*, wood properties, genetic resources, threatened species




## Introduction

### Taxonomy and Nomenclature

*Boswellia serrata* Roxb. ex Coleb. commonly known as Indian Olibanum or Indian Frankincense Tree belongs to the family Burseraceae has a chromosome number of 2n=44 [1]. The vernacular names are Shallaki, Salai (Hindi), Kungilyam (Malayalam) and Parangisambrani (Tamil). The word Olibanum is derived from the Arabic ‘al-luban’ and it means ‘the milk’ [2].

Table 1. Taxonomy and Nomenclature of Plantae

| | |
|---|---|
| Kingdom | Plantae |
| Sub kingdom | Tracheobionta |
| Super division | Spermatophyta |
| Division | Magnoliophyta |
| Class | Magnoliopsida |
| Subclass | Rosidae |
| Order | Sapindales |
| Family | Burseraceae |
| Genus | Boswellia |
| Species | *Boswellia serrata* Roxb. ex Coleb |

**Botanical Descriptions**

*Boswellia serrata* is a deciduous tree ranging from 5 to 20m in height. The bark is yellowish-white with dark blotches. Exfoliations thin, papery, smooth flakes. The leaves are imparipinnate, arranged in an alternating manner and apically clustered. The leaflets can range from 15 to 31cm. The flowers are bisexual, small and white. The flowers are arranged in axillary or sub terminal fascicled racemes with five to seven lobes and petals [3]. Flowers appear from the end of January to March and the fruit ripen in May-June [4]. The species is self-incompatible and cross-pollinated flowers allowed normal pollen germination [5].

**Comment [G1]:** Add Photoplate showinh Plant habit, Leaves, Inflorescence, fruits for better understanding of reader

**Distribution and Environmental Conditions**

Distribution is in Tropical Dry Deciduous Forest of India. Found in dry, rocky ridges and slopes, as well as flat terrain. It grows at altitudes up to 1,150 m in regions with annual temperatures between 0-45°C and annual rainfall between 500-2,000 mm [6]. Occurrence of *B. serrata* has been reported in the natural forest of following states namely, Andhra Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal [7, 8]. In addition, the species has been planted as part of Trees Outside Forests programme in the states of Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Nagaland, Odisha and Rajasthan [7].

*B. serrata* has a wide distribution in 17 out of the 28 states of which India is composed, and climatic suitability for the species prevails in ca. 22% of the overall Indian territory. In seven states exist detailed population assessments. The combined total species count in these seven states is estimated at 44 million individuals [9].

Table: 2. State wise estimated number of stems of *Boswellia serrata* in Forest at Country level (in '000') [7].

Comment [G2]: Is it year of publication?

| State | Diameter Class(cm) | | | Total |
|---|---|---|---|---|
| | 10-30 | 30-60 | 60+ | |
| Andhra Pradesh | 5179.966 | 1249.114 | 0.000 | 6429.079 |
| Bihar | 2135.314 | 318.985 | 0.000 | 2454.299 |
| Chhattisgarh | 7402.115 | 12659.830 | 694.038 | 20755.983 |
| Goa | 20.134 | 0.000 | 0.000 | 20.134 |
| Gujarat | 2182.300 | 188.058 | 0.000 | 2370.358 |
| Haryana | 97.402 | 0.000 | 0.000 | 97.402 |
| Jharkhand | 5463.006 | 695.735 | 82.271 | 6241.012 |
| Karnataka | 169.378 | 169.378 | 0.000 | 338.755 |
| Madhya Pradesh | 9947.954 | 12527.338 | 295.321 | 22770.613 |
| Maharashtra | 9370.200 | 7029.736 | 0.000 | 16399.935 |
| Meghalaya | 179.047 | 0.000 | 0.000 | 179.047 |
| Odisha | 2787.052 | 2068.289 | 0.000 | 4855.341 |
| Rajasthan | 7288.921 | 2772.845 | 0.000 | 10061.767 |
| Tamil Nadu | 792.471 | 426.715 | 0.000 | 1219.186 |
| Telangana | 3125.509 | 4475.791 | 71.012 | 7672.311 |
| Uttar Pradesh | 640.679 | 439.315 | 0.000 | 1079.994 |



Table: 3. State wise estimated number of stems of *Boswellia serrata* in TOF at Country level (in '000') [7].

Comment [G3]: ?

| State | Diameter Class(cm) | | | Total |
|---|---|---|---|---|
| | 10-30 | 30-60 | 60+ | |
| Bihar | 0.000 | 6.958 | 0.000 | 6.958 |
| Chhattisgarh | 29.074 | 11.879 | 0.000 | 40.953 |

| | | | | |
|---|---|---|---|---|
| Gujarat | 56.070 | 0.000 | 0.000 | 56.070 |
| Jharkhand | 91.758 | 33.887 | 0.000 | 125.645 |
| Karnataka | 0.139 | 6.291 | 0.000 | 6.430 |
| Madhya Pradesh | 46.002 | 15.004 | 0.000 | 61.006 |
| Maharashtra | 32.888 | 0.000 | 0.000 | 32.888 |
| Nagaland | 0.000 | 37.184 | 0.000 | 37.184 |
| Odisha | 97.027 | 32.129 | 0.000 | 129.156 |
| Rajasthan | 317.930 | 10.684 | 0.000 | 328.614 |

Table: 4. Estimated number of stems by species and diameter class in Forest at Country level (in '000') [7].

Comment [G4]: ?

| Diameter Class(cm) | | | Total | Percentage |
|---|---|---|---|---|
| 10-30 | 30-60 | 60+ | | |
| 56,781 | 45,021 | 1,143 | 1,02,945 | 0.75 |

Table: 5. Estimated volume by species and diameter class in Forest at Country level (in million cum) [7].

| Diameter Class(cm) | | | Total | Percentage |
|---|---|---|---|---|
| 10-30 | 30-60 | 60+ | | |
| 11.05 | 41.93 | 3.65 | 56.63 | 1.33 |

**Distribution in Kerala**

- Palakkad Division: Dhoni and Sappal Catchment, Parapetty Catchment Olavakkode Range [10].
- Idukki District [11, 12].
- 250 mature individuals in the dry deciduous track of Chinnar Wildlife Sanctuary of Munnar Wildlife Division

**Distribution in Tamil Nadu:**

- Coimbatore, Dharmapuri, Dindigul, Salem, Tiruchchirappalli, Tiruvannamalai, Viluppuram [11].
- Dindigul [12].
- Nilgiris South Division [13].

[14] reported that ~21.95% of the geographical area in India is presently climatically suitable for *B. serrata*. With a substantial area distributed in the states of Madhya Pradesh, Uttar Pradesh, Karnataka, Rajasthan, Maharashtra, Haryana, Chhattisgarh, and Jharkhand. A portion of the climatically suitable area also extended into the states of Uttarakhand, Gujarat, Tamil Nadu, Himachal Pradesh, Bihar, Punjab, Andhra Pradesh, Jammu & Kashmir, and Kerala. This prediction is based on MaxEnt model (MaxEnt software ver. 3.4.1) the author compiled 147 occurrence records of *B. serrata* from various regions of India. Ssampling undertaken in various parts of Central India covering the Vindhyan and Satpura mountain ranges in Madhya Pradesh and peninsular India. However, Substantial area in peninsular India is expected to lose climatic suitability in 2050. It is suggested that long-term conservation strategies for *B. serrata* be prioritized within future areas that are projected to retain climatic suitability.

Comment [G5]: Give detailed distribution for other states lilke Kerala and Tamilnadu also provide distribution map for India

**Reproductive Biology and Breeding System**

*Boswellia* is a sexually reproducing tree that regenerates naturally from the seeds. The plants are dioecious, having separate male and female individuals. These trees are self-incompatible, meaning it requires pollen from other individuals for fertilization, and thus depends on outcrossing. The rate of natural propagation of *B. serrata* is too slow where older trees get propagated through root suckers. However, the root sucker technique has not been exploited commercially. Poor fruit setting (2.6 to 10 %) under open pollination, inadequate production of viable seeds and scanty seed germination (10–20 %) restricts the distribution and therefore limits the availability of natural source [15]. Conventional method of propagation of *Boswellia serrata* is by stem and root cuttings. These methods are season dependent and time consuming [16]. [17] reports a successful procedure for micropropagation of *B. serrata* using cotyledonary node segments.

**Seed Production**

*Boswellia serrata* tree fruits are 1.3 cm long, trigonous, with three valves and three heart-shaped, 1-seeded pyrenes, winged, along the margins. Reported weights for seed range from 13,400-25,600 seeds per kilogram. Seeds are collected manually by hand picking. Seeds are stored in dry tins, for not more than 6-9 months [18].

**Threatened Status**

*Boswellia serrata* has been listed in the threatened species of India [19.] Slow growth and poor regeneration are principal threats, while population trends and habitat trends are stable [20]. Indiscriminate exploitation for its high economic value, the tree has been identified by the government of India for its genetic improvement. There are several constrains in the cultivation of *Boswellia serrata* under natural conditions. Seed viability is very poor and germination percentage is very low (10-12%). the seeds require high humid conditions for germination. Shrinking habitats, forest degradation, over-exploitation, changing climate, and soil conditions are major threats facing in India. Research indicates that trees are being over-tapped to meet international demand in India [9].

**Reasons for Deterioration**

Intensive population assessment has shown a reduction in the distribution range of *B. Serrata*. Over-exploitation for traditional medicines, shrinking habitats, forest degradation, climate change, soil-related changes, and grazing of saplings by fauna such as the Indian boar (*Susscrofa cristatus*) have been attributed to changes in the regeneration of *B. serrata* [14].

**Wood Properties**

*B.* serrata is also a timber yielding tree. The sap wood is soft and moderately value [16]. The wood fiber length along with the thickness is considered to be the most important characteristics for the mechanical strength of wood and for the making of high-quality groundwood in paper industries. The wood fiber length of the species ranged between 0.803 mm to 1.397 mm with average of 0.968±0.11 mm (11.36% CV) and the wood fiber width of the species ranged between 0.019 mm to 0.030 mm with average of 0.025±0.002 mm (8.75%

CV) [21]. Total demand for *B. serrata* for national consumption and international trade is estimated at 745 tonnes per annum, with the majority used in Ayurvedic medicine, and annual exports approximating 90 tonnes [20].

**Insects/ pests/ Fungal dieses and control**

Comment [G6]: Add

**Genetic Resources and Tree Improvement**

Research wing of Maharashtra Forest Department has maintained Seed Production Areas on various research fields. Seed Plot of 5 Ha. at Palaskheda (Jalgaon) having 173 trees is being managed by research wing exclusively for seed collection. The seeds collected are distributed to territorial wing for plantation. Saplings are also raised continuously. For sustainable harvesting of gum, research is being conducted in collaboration with TFRI. [14] records that 147 occurrence of *B. serrata* from various regions of India.

**Economic Importance**

*Boswellia serrata* is a commercially important tree which exudes volatile oil, resin and gum. The oil obtained from salai is very similar to turpentine oil. The oil has been found suitable for paint making, varnish and used as printing ink in textile industries and in making distempers. It has been reported as a unique non coniferous source of turpentine employed for the manufacture of paints and varnishes. The resin obtained from salai is used for preparation of varnishes. The tree exudes of *B. serrata* resembles Canada balsam in colour and consistency.

Uses of *B. serrata* in India [20].

Table 6. Uses of plant part or product

| Plant Part or Plant Product | Uses |
|---|---|
| Bark | Used as cordage (Cite reference |
| Boswellic acids | Isolated boswellic acids used for pharmaceutical therapeutic Applications.<br><br>Collected by local people as one source of income from NTFPs<br><br>Indian herbal extraction companies produce standardized and non- standardized *B. serrata* extracts for the export market, mainly Japan, Singapore, UAE and USA |

Comment [G7]: Cite reference

Comment [G8]: Cite references

| | |
|---|---|
| Exudate (Oleogum resin) | After removal of the polysaccharide fraction, the only non-coniferous source of turpentine and resin in India.<br><br>Active ingredient of traditional Ayurvedic medicinal formulations for treatment of asthma and arthritis and of traditional Unani medicinal formulations for the treatment of renal disorders |
| Extracted gum | Used as a binding agent in pharmaceutical tablet formulations |
| Fodder | As a substitute fodder for buffaloes |
| Green leaf twigs | Utilized as fodder in the Sariska tiger Reserve situated in the Aravalli hill range |
| Tree | Reported new use in West Bengal as a lac host<br><br>Used for fuel; charcoal made from it is used for iron smelting |
| Wood | Wood fibre mixed with 25-40% long fibred bamboo pulp to make paper.<br><br>Used to produce local furniture , storage boxes, packing cases, cement barrels, matches, plywood and veneers |

**Comment [G9]:** Cite references

**Comment [G10]:** Cite references

**Comment [G11]:** Cite references

**Comment [G12]:** Cite references

**Comment [G13]:** Cite references

**Comment [G14]:** Cite references

**Comment [G15]:** Add references after each use

## Medicinal Uses

In Ayurveda, the gum is used to treat a number of inflammatory diseases affecting skin, eye, gums, gastrointestinal tract (GIT) in addition to the respiratory inflammatory disorders such as asthma, bronchitis, laryngitis etc., [22]. Bark is used to cure dysentery, diarrhoea and antiseptic to wounds, cuts, burns, boils and fractured bones for early healing. and resin is used to cure diseases like boils and wounds, incense, cardiac diseases, haemorrhage, cough, dysponea, polyuria, leucorrhoea, oligospermia skin diseases, urinary disorders, urethritis, piles, ulcers, burns, purgative, diabetes, diarrhoea, dysentery, pulmonary affections and cutaneous troubles [23].

## Olibanum

Olibanum is a natural oleo gum resin that exudes from tapping in the bark of *Boswellia* trees. Frankincense is a complex mixture composed of about 5-9% highly aromatic essential oil (mono and sesquiterpenes) 65- 85% alcohol- soluble resins (diterpenes, triterpenes) and the remaining water-soluble gums (polysaccharides) [16.]

## Harvesting / Collection of Gum Resin

**Method of harvesting/tapping:** Usually trees of 90 cm girth and above at breast height are tapped for the gum-resin. Trees of lower girth classes should not be tapped since any damage done to them may adversely affect their growth. A thin band of bark of about 30 cm in length and 20 cm wide is shaved from the trunk of the tree at a height of about 0.75 m from the ground. Thus, the reddish phloem in which the resin canal and ducts lie is exposed. The blaze is freshened after every fourth or fifth day. The first collection of the gum-resin is made after 2 weeks. Collection is done by a scraper keeping a tray having a semicircular edge around the blazed surface. Freshening of the blaze is done from time to time and the original blaze is slowly widened.

**Comment [G16]:** Cite references

**Period of harvesting:** Tapping and collection of *Boswellia* gum generally started from November and continued up to end of May every year. It closes on the onset of monsoon. The gum may be collected after a month of initial blazing. Subsequent freshening of the blazes and collection may be done fortnightly.

**Comment [G17]:** Cite references

**Yield:** Average annual yield of *Boswellia* gum per tree is estimated to be about 1 kg, though a well grown tree yields up to 2 to 2.5 kg of gum-resin in a year. The yield of the gum is found to vary according to season, locality, and size of the tree. Generally larger the girth of a tree, the greater is the yield. Yield has generally been found to be poor in moist region and from trees which are old with black bark, dwarfed and suppressed. Middle aged, sound and vigorous trees give comparatively better yield [24].

**Comment [G18]:** Cite references

**Processing and Value Addition**

*Boswellia* gum is collected in a semi-solid state. After collection, the bark and other impurities are removed manually. The crude gum-resin is allowed to remain in a bamboo basket for up to a month during which the fluid portion, locally known as 'ras', flows out. The ras forms about 8 to 10 per cent of the raw material and is used in paints and varnishes. Remaining semi-solid to solid part is the gum resin, which is dried thoroughly and sometimes treated with soapstone powders to make it brittle. It is then broken into small pieces by wooden mallet or chopper. During this process, bark and other impurities are again removed manually. The gum-resin is then graded according to its colour and impurities. Generally, four grades are distinguished in the market as follows.

**Comment [G19]:** Cite references

Table: 7 Grade of *Boswellia serrate* gum-resin.

| Grade | Colour | Appearance |
|---|---|---|
| Superfine | Light yellow | Translucent |
| Quality-I | Brownish yellow | Translucent |
| Quality-II | Brown | Semi-translucent |
| Quality-III | Dark brown | Opaque |

**Active constituents:** The gum oleoresin consists of essential oils, gum, and terpenoids. The terpenoid portion contains the boswellic acids that have been shown to be the active constituents in *Boswellia serrata*.

**Comment [G20]:** Cite references

**Properties of Gum**

The colour of *Boswellia* gum varies from transparent golden brown to dark brown or dark greenish brown depending on the season of collection and impurities present. The gum contains on an average 10-11 per cent moisture, 8-10 per cent volatile essential oil, 45-50 per cent resin, 30-35 per cent gum and 4-5 per cent insoluble matters. Boswellic acid is one of the principal constituents in the gum resin, in the gum resin, which has shown anti-inflammatory atherosclerotic and anti-arthritic activities. It is soluble in most organic solvents. Its softening point varies from 65-72°C and melting point from 73-78°C. It burns readily and diffuses a pleasant odour. The resin portion has a specific gravity of ointments,

0.91, acid value of 1.87, saponification value of 65 ester value of 63.14, and iodine value of around 200. The gum portion contains mainly pentose with a high proportion arabinose.

Comment [G21]: Cite references

**Industrial Applications**

*Boswellia* gum resin is traditionally used as incense because of its very unique fragrance.

It is widely used in ayurvedic formulations for treating asthma and arthritis. *Boswellia* has been shown to be as effective and, in many cases, better than drugs like Phenylbutazone and other anti-inflammatory drugs. It is used in indigenous medicine for rheumatism, nervous disease as a diaphoretic, astringent and as an ingredient in certain ointments. It is also used for lighting fires.



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