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Boswellia papyrifera (Del.) Hochst: a tropical key species in northern Ethiopia

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ABSTRACT

Boswellia papyrifera (Del.) Hochst is a dryland tree species native to Ethiopia and widely known for its frankincense production. Besides, it has also other numerous environmental, socio-economic, traditional and industrial benefits. However, the population of the species is declining at an alarming rate due to extensive human encroachment. This paper presents the importance of the species, techniques of tapping, harvesting and grading of its frankincense in Ethiopia. Moreover, the current population status of the species, its regeneration pattern and rehabilitation efforts in Tigray (northern Ethiopia) are also analyzed. Results of natural regeneration studies on closed and open areas in Tigray revealed that there is significant ($p<0.05$) improvement of natural regeneration of the species in sites that are protected from both livestock and human interference. However, plantation efforts have limited success mainly due to the lack of knowledge on seed collection, nursery practices and post-planting care. It has been concluded that livestock damage poses a serious threat for the species in northern Ethiopia. In this regard, the closure of sites from grazing has become an effective way of promoting natural regeneration of B. papyrifera in northern Ethiopia.

Key words: *Boswellia papyrifera*; frankincense; rehabilitation efforts; area closure; Ethiopia

1. INTRODUCTION

Ethiopia is endowed with unique habitats that harbor many endemic species of plants. Of the 6500-7000 species of vascular plants in Ethiopia, 12% are endemic (Sebsebe, 1993). According to the Environmental Protection Authority of Ethiopia, annually over 144,000 ha of forest is destroyed in Ethiopia (WIC, 2002). Human interference, mainly for subsistence and economic reasons, is the most important reason for the fast depletion and serious degradation of forest resources in the country. This has brought adverse effects on the tourism industry, land productivity, availability of forest products, biodiversity and the economy as a whole in general. *B. papyrifera*, better known for its frankincense production, is among those important woody species that are in endangered state. In addition to Ethiopia, the species is also found in Nigeria, Cameroon, Central African Republic, Chad, Sudan, Uganda and Eritrea (Vollesen, 1989). This

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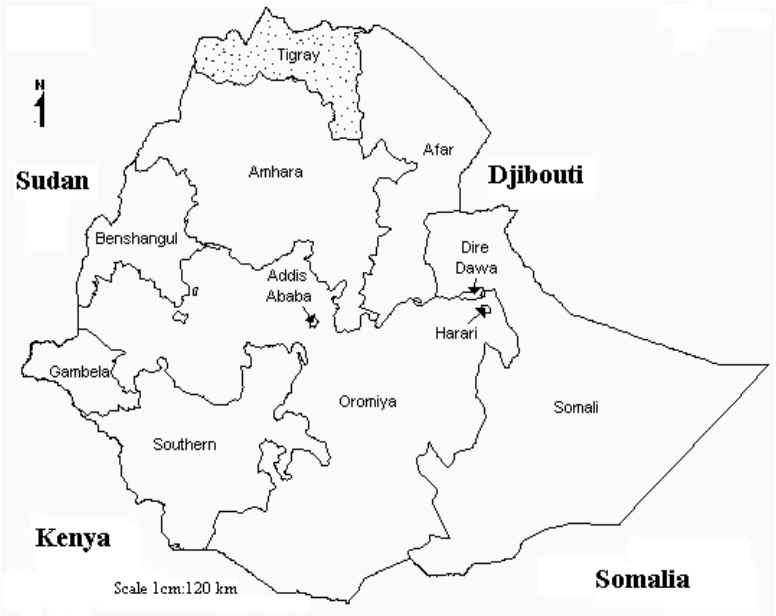
paper presents the importance of the species, techniques of tapping, harvesting and grading of its frankincense in Ethiopia. Furthermore, it analyses its current population status, regeneration pattern and rehabilitation efforts in Tigray region.

2. MATERIALS AND METHODS

2.1. The study area

The study was undertaken at two levels. General information on the socio-economic importance of the species and harvesting of frankincense was compiled at country level (Ethiopia) whereas detailed studies on regeneration pattern and rehabilitation efforts were undertaken in central and western Tigray. Tigray lies between l2 °15' to14°50' N latitude, and 36°27' to 39°59' E longitude in northern Ethiopia (Figure 1). Many areas in Tigray are characterized by frequent drought, deforestation and high soil erosion due to long human settlement. According to Hurni and Perich (1992), soils of Tigray have lost 30-50% of their productive capacity compared to their original state some 500 years ago. The mean annual rainfall and temperature at a typical *Boswellia* site in Tigray are 952 mm (mainly falling from June to August) and 22.3 °C respectively.

Figure 1. The location of Tigray region in Ethiopia



2.2. Methods

The study has different components. Non-structured interviews were conducted to understand the multiple use of *B. papyrifera* in general and of frankincense in particular; the techniques of harvesting and grading of frankincense and its socio-economic significance both in the export and domestic market of Ethiopia. For the regeneration study, a transect survey was undertaken using ten 10m x 10m plots in 1996 in an area which used to be dominated by *B. papyrifera* in order to understand the existing vegetation composition. A second study was undertaken from 2000 onwards, in which the effect of two management strategies on the natural regeneration of *B. papyrifera* was studied at four sites. The first management strategy involves closure of sites from livestock grazing and cutting, while the second strategy allows free grazing but no cutting of trees. The first two sites (denoted as Site I and Site II) fall in the first management strategy while the other two sites (denoted as Site III and Site IV) fall under the later. In each of the four sites,

sixteen plots with a size of 20 m x 20m (0.4 ha) were randomly selected. A total of 64 plots have been placed in the study area. In all plots, newly emerging seedlings were counted three times in July 2001, October 2001 and January 2002. The number of seedlings is presented on a hectare basis. In addition, survival rates of recent plantation attempts, i.e. in 1999 and 2000 in the western zone of Tigray are also presented.

3. RESULTS AND DISCUSSION

3.1. *Boswellia papyrifera*: its importance in Ethiopia

International trade: More than 4000 years ago, Ethiopia was the main trader of frankincense with Egyptians and Phoenicians. Hepper (1969) indicated that frankincense from *B. papyrifera* might have been important in the international trade since ancient times owing to the easy land routes from these parts of tropical Africa to Egypt. Frankincense is still exported from Ethiopia to the EU, Poland, Middle East and Asian countries particularly to Japan and China (Coppen, 1995). However, the export market from Ethiopia has been weakened due to inconsistent supply and ambiguity of grades. Only 7728 metric tons of frankincense was exported in the period between 1995 to 1999.

Uses in foreign markets: incense is burnt in many churches worldwide and used as oil extract in a number of applications, such as modern perfumery, traditional medicine, pharmaceuticals, fumigation powders, fabrication of varnishes, adhesives, painting, and chewing gum industries. It also gives a flavor in food industry, e.g. bakery, milk products, different alcoholic and soft drinks (Tucker, 1986; Coppen, 1995; Girma, 1998).

Domestic sales in Ethiopia: In Ethiopia, there are over 15,000 churches, which consume approximately 20,500 quintals of frankincense per annum, i.e. 1.5 quintal per year per church (Tilahun, 1997). As the supply of incense from *B. papyrifera* is not adequate, natural gums from other *Boswellia species* and *Acacia species* are often mixed. Domestic sales between 1990 and 1993 were low due to the civil war in the main *Boswellia* growing area in northern Ethiopia.

Employment generation: Incense collection offers off-farm employment for many farmers. In western Tigray alone, annually about 7000 seasonal laborers are employed; among which 31% are women. Men are mainly involved in tapping and collecting incense from the forest while women undertake sorting and grading of the same. A tapper can collect about 10–15 quintals of incense per annum and receives a net income of US $ 100 to 150 (Aregawi, 1997). Women accrue an average income of US$ 16 per month (Tilahun, 1997). Moreover, a growing number of investors and permanent workers are involved in the business. For instance, the Ethiopian Natural Gum Processing and Marketing Enterprise, one of the many enterprises involved in frankincense collection, has deployed, a total man power of 2515 per annum, on average (Table 1).

Table 1. Man power deployed by the Ethiopian Gum Processing and Marketing Enterprise (1996/97 – 1999/200)

Type of employees	Budget year			
	1996/97	1997/98	1998/99	1999/2000
Collectors	800	1700	1131	1634
Sorters	1000	1150	693	915
Permanent employees	227	221	204	199
Contract workers	36	52	46	51

(Source: Ethiopian Gum Processing and Marketing Enterprise, unpub.)

Wood products: The wood and its branches are used mainly for fencing, making agricultural implements and household furniture. Moreover, the wood is suitable for matchboxes, splints, particleboard, pencils, plywood, picture frames and veneers.

Traditional medicine: The resin is used as a febrifuge, and the leaves and roots of the species are used against lymphadenopathy (Fitchl and Admasu, 1994) and the bark is chewed to treat stomach disturbances. Incense is burnt as a mosquito repellent in the tropics and also chewed by lowlanders to quench thirst during hot days (Tilahun, 1997). Frankincense was considered as a stimulant and was once used to treat leprosy in China (Tucker, 1986).

Livestock feed and Bee fodder: *B. papyrifera* is a drought resistant species that continues to produce leaves and flowers even at times of drought. Its long flowering period is very helpful in bee colony maintenance and boosts honey production. Honeybees frequently visit flowers of *B. papyrifera* during the dry season. Moreover, leaves and seeds of the species are highly valued as fodder for goats, camels and other livestock. The succulent stem is also used as fodder during dry season.

Environmental role: *B. papyrifera* can grow in dry and rocky sites where other tree species often fail. In Tigray, *B. papyrifera* trees are found in steep slope with an average gradient range of 30-40%. It should be noted that the majority of the soils (60-80%) in Tigray (where *Boswellia* grows) are about 20 cm deep (Hurni, 1988). The species makes economic use of the marginal areas on which other species could not grow. In those sites, it provides plant cover and produces higher biomass and hence protects the soil and provides shade. Since growing *B. papyrifera* is economically and socially attractive, it increases the attention for the conservation of these degraded sites.

3.2. Tapping and harvesting of frankincense

Techniques of tapping and harvesting of frankincense stayed virtually the same since ancient times (See Groom, 1981). Tapping of *B. papyrifera* in Ethiopia is carried out by shaving a very thin (1 mm deep and an area of 2.5 cm^2) layer of the bark. A tree could be tapped 8-12 times during the year at an interval of 15 to 25 days starting from September (beginning of the dry season) and ending in June (before the rainy season starts). Each tapping involves a moderate widening of the tapping spot, which reaches 6 cm at the end. At every stage, the resin comes forth as milky juice and hardens on exposure to air into globular, pear-, or club-shaped tears (Tucker, 1986). It will normally be ready for collection after two to three weeks of each tapping. One to three kg of frankincense is collected from a tree per year. The amount varies depending on the diameter, site productivity and season. Collected frankincense is then sorted and graded in accordance to size, color and purity immediately after harvesting. In Ethiopia, there are five grades of frankincense from *B. papyrifera*. The first three grades are exported while 4^{th} and 5^{th} grades are sold locally for domestic uses in Ethiopia. In all cases, larger and whiter lumps are valued more than the smaller, powdered and darker lumps. Black or brown color results from excessive exposure to heat, dirt, insect attack, and poor handling.

3.3. Potential frankincense production in Ethiopia

B. papyrifera is known to occur in various parts of Ethiopia including Tigray and the Amhara regions (Sebsebe, 1993). Nevertheless, accurate and comprehensive information on area coverage, population of *B. papyrifera* and frankincense production is lacking. At present, *B. papyrifera* grows in up to 332,562 hectares in central and western zones of Tigray. These can produce more than 21,596 tons of frankincense annually. Moreover, there exists also about

604,000 hectares of land that could provide about 200,000 tons of incense and gum in the Amhara region (WIC, 2001). Nevertheless, the average annual production of gum and incense is very low as compared to the potential. Between 1978 and 1991, it was about 1500 ton. Since 1992, production has leveled to about 2000 tones per annum (Girma, 1998).

3.4. Resource degradation - the case of Tigray

In the late 1970's, about 510,000 ha of land was covered by *B. papyrifera* in Tigray (Wilson, 1977) as compared to the existing 332,562 hectares of *Boswellia* forest. Hence, more than 177,438 ha of *B. papyrifera* forest were destroyed in the last 20 years. Moreover, the existing population consists of mainly matured trees. In western Tigray, more than 76% of the existing *Boswellia* trees are greater than 30 cm (Table 2). Hence, no wonder why *B. papyrifera* is listed by TRAFFIC, wildlife trade monitoring program of WWF and IUCN, among the species, which are endangered and need priority in the conservation of the medicinal and wildlife resources in East and Southern Africa (Marshall, 1998).

Table 2. Population, density and proportion of matured trees of *B. papyrifera* forest in western Tigray

District	Boswellia forest (ha)	Average density	Trees >30 cm DBH (%)
Kafta Humera	97500	389	0,75
Tselemiti	48125	353	0,78
Tahtay Adiabo	55539	280	0,77
Asigede Tsimibila	62000	369	0,77
Tsegede	9801	389	0,75
Welkayt	54450	280	0,77
Total	**327415**	**343,1915**	**0,76**

The decline of *B. papyrifera* is further noted through changes in the vegetation composition of its growing areas in Tigray. Table 3 presents the vegetation composition of an area in central Tigray that was once dominated by *B. papyrifera* (Wilson, 1977). *B. papyrifera* is not dominant any more and the current degraded vegetation is dominated by *Acacia etbaica* (Table 3).

Table 3. Vegetation composition in Central Tigray, northern Ethiopia

Tree species	Density (N/ ha)		Total density (N/ha)
	Seedlings (N/ha)	Trees with diameter > 10 cm	
Acacia etbaica	392	22	414
Lannea fruiticosa	0	2	2
Cassia singuena	18	0	18
Acacia tortilis	5	3	8
Acacia nubica	127	0	127
Acacia polycantha	2	0	2
Ozoroa insignis	0	2	2
Terminalia brownii	0	3	3
Boswellia papyrifera	0	11	11
Combretum molle	0	14	14
Total	**544**	**68**	**601**

Decline in the population of *B. papyrifera* is also observed elsewhere. According to Ogbazghi (2001) there were no trees falling in the diameter class intervals of 1-2 cm and 2-4 cm in many

areas in Eritrea. The export of frankincense from Eritrea has also dropped from 2000 tons in 1974 to 400 tons in 1998.

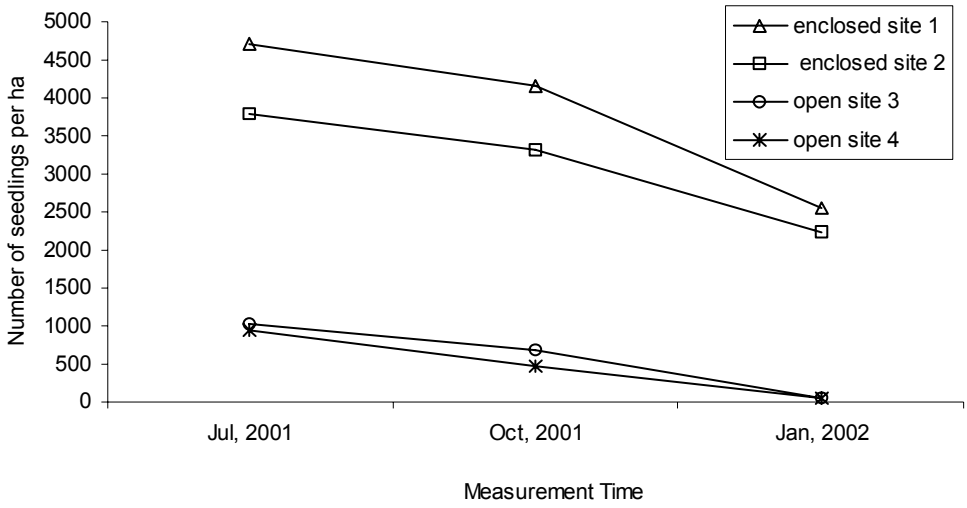
3.5. Reforestation efforts through area closures and plantations

To reverse the fast depletion of *B. papyrifera* population, some efforts are underway in Tigray, which include the closure of degraded lands from livestock grazing and/or by planting seedlings raised in nurseries.

Natural regeneration in closed areas

The number of seedlings per ha was significantly higher in enclosed sites, Site I and Site II ($P<0.05$) as compared to Site III and Site IV, where open grazing is practiced (Figure 2).

Figure 2. Natural regeneration of seedlings among sites under different management strategies



In the three counts from July 2001 through January 2001, in the enclosed sites, Site I and II, more than 50% of the seedlings were still growing well. However, in the open sites, Site III and IV, only less than 7% of the seedlings were still alive as compared to the first count. The mortality rate of the seedlings in the open grazing sites was very high. This demonstrates the fact that grazing inflicts a serious damage to young *B. papyrifera* seedlings. It was noted that seedlings of *B. papyrifera* are highly preferred for browsing and also suffer trampling by the same. Grazing on *B. papyrifera* seedlings results in the total removal of all vegetative parts, because of its shallow root.

Artificial Reforestation

A number of nurseries in Tigray are now raising seedlings of *B. papyrifera* for reforestation However, the success is so far limited. In the year 1999 and 2000, only 4.5% and 8.7% of those planted in western Tigray have survived, respectively. The low survival rate can be attributed to the lack of silvicultural knowledge of the species which include time of seed collection, nursery practices, choice of appropriate planting sites and post planting care. A significant number of seeds, collected from the field by the first author, were already damaged by insects and other organisms. Most of the seedlings were as small as 10 cm during planting and little attention was given for planted seedlings in the field.

3.6. Factors for the decline of *B. papyrifera* population

B. papyrifera is threatened as a result of several interrelated factors, which are discussed below:

i. Extensive farming: In many *B. papyrifera* growing areas, there has been increased population pressure. This has resulted in the conversion of *Boswellia* woodlands to agricultural lands at a faster rate.

ii. Grazing: Unregulated overgrazing has damaged natural regeneration of *B. papyrifera*. It is known that seeds and seedlings of *B. papyrifera* are particularly highly preferred by goats and other livestock.

iii. Improper incense tapping practices: It is not uncommon to see over-tapping and use of inappropriate tapping methods by unskilled laborers. There is little supervision during tapping. More accessible trees are often tapped continuously with no rest periods. Ogbazghi (2001) reported that seeds from un-tapped stands had high germination rates (94% and 80%) compared to seeds from tapped stands (14% and 16%) in Eritrea. There were more empty seeds in over-tapped stands.

iv. Termite and other insect infestation: Tilahun (1997) presented a high incidence of insect attack (17.5%) and Ogbazghi (2001) also reported that between 20 and 25% of the bulk seeds were attacked by insects.

v. Wind damage: As the roots of *B. papyrifera* are shallow, substantial damage is also caused by wind.

4. CONCLUSIONS

More efforts in the rehabilitation of *B. papyrifera* are essential. Otherwise, the various advantages related to increased bee and livestock fodder, local employment opportunities, export earnings, medicinal values and the potential role of the species in the rehabilitation of degraded lands will not be met any more in the medium-term. Towards this end, closure of degraded sites from livestock grazing has been very effective. The natural regeneration was highly enhanced by avoiding the damage that would have been caused by livestock. Hence, it can be concluded that livestock browsing is a major driving force for the lack of natural regeneration. In order to promote artificial plantations, however, more silvicultural work remains to be done. In this regard, specific requirements of *B. papyrifera* seedlings in terms of seed collection, nursery life span, planting time and post planting care need to be investigated.

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