

Bark Stripping from Forest Tree Species in Madjadjane, Southern Mozambique: Medicinal Uses and Implications for Conservation

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Abstract

Tree bark is one of the most important non-timber forest products. In less developed countries, it is used for multiple purposes, particularly in traditional medicine. This paper addresses the question of bark exploitation, uses, and impacts in Madjadjane village, southern Mozambique. For that, we have conducted an ethnobotanical survey and analysed the level of damage of the ten most exploited tree species. Bark was mainly used for medical purposes, spanning 13 different applications. Most of the species had more than one medical application constituting potential sources of valuable biocompounds. In general the level of damage caused by debarking was not critical, but should be seen with caution. An upgrade and update of the results will be of utmost importance to estimate with more accuracy the current conservation status as well as to predict future impacts and define better conservation strategies. We suggest the expansion of ethnobotanical surveys as well as their integration in broad programs aimed at the preservation and valorization of local heritage. This will encourage equitable access and benefit sharing of biodiversity as well as the promotion of bio-based economy.

Keywords

Bark, Ethnobotany, Traditional Knowledge, Conservation, Mozambique

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1. Introduction

Forests and woodlands are key providers of social, economic and ecological services that go far beyond timber exploitation. Tree bark is one of the most important non-timber forest products. In many regions of the developing world, bark has been used for a wide range of purposes such as beehives, fiber, tannin, and in particular traditional medicine [1].

The term bark refers to all tissues outside the vascular cambium, comprising dead and live tissue. The dead tissue (rhytidome) corresponds to the outer layer of bark, functioning as a physical barrier that protects the tree against desiccation, fire, insects, herbivores and diseases. The live tissue (phloem) constitutes the inner bark, playing a key role in nutrient transport [2]. Thus, if no appropriate measures are taken, debarking may impose irreversible injuries, compromising tree survival, growth and reproduction.

In Mozambique roughly 90% of the country's population depends on plant resources to fulfill its housing, food, energy and health needs. In fact, some 15% of the local flora (5500 species) has a multipurpose function [3]. However, good conservation outcomes of these resources will depend highly upon users and their livelihood strategies. Like elsewhere in the region, livelihood strategy allied to trends of population growth is among the major threats to the ecosystem health. These may compromise resource availability particularly in countries with low human development indices where incremental expansion of cultivated lands restrains the potential of ecosystem services [4]. In Mozambique, for example, natural ecosystems are over-exploited and conservation projects are a major challenge [5]. On the other hand, the traditional use of plant genetic resources is progressively reduced, due to the exodus of young people from rural to urban places [6]. Thus, the documentation of local plant uses is of utmost importance, not only to preserve traditional knowledge, but also to facilitate conservation efforts.

In this paper we present the results of a survey on the use of bark of ten tree species as well as the estimation of the level of damage due to debarking, in Madjadjane village, district of Matutine, Maputo Province. The work was integrated in the Natural Resources Management program under the International Union for Conservation of the Nature (IUCN).

2. Methods

2.1. Study Area

This study was carried out in Madjadjane, Matutuine district, Maputo province (26°25' and 26°32'S; 32°17' and 32°22'E) (Figure 1). The climate is subtropical with two main seasons, wet from October to April and dry from May to September. The mean annual rainfall is 1000 mm. The mean annual temperature is over 24° and relative humidity varies from 55% to 75%.

2.2. Ethnobotanical Data Collection (Bark Use)

The work was initiated following a meeting between researchers, community leaders and the Commission of Natural Resources Management, in order to: 1) explain the aim and importance of the work; 2) receive cooperation and permission to use the cultural heritage; 3) collect information for structuring the interviews; 4) give orientations for the selection of informants by age and gender; and 5) plan the field activities. Sixty six informants (out of 600 inhabitants) were selected as the best traditional knowledge holders. The selection criteria were based on the size of the study site, the vegetation homogeneity and on the indications provided by the community (*i.e.* traditional medicine practitioners, collectors and traders, people dealing with arts and crafts). Using standard methods [7], the data were collected through intensive structured interviews and complemented by semi-structured interviews in the local language (*i.e.* Ronga). Questions included common and local names of the plants as well as applications.

2.3. Plot Design and Species Identification

Twelve stratified transects were established. The distance between transects was 100 m. Data were scored in five plots (20 m × 20 m) per transect, separated from each other by a distance of 50 m [8]. Species identification was carried out in the field and by comparing voucher specimens with specimens deposited at the Herbarium of the Faculty of Sciences, Eduardo Mondlane University (LMU, Maputo, Mozambique). The scientific names were confirmed through specialized bibliography [9] as well as the African Plant Database [10].

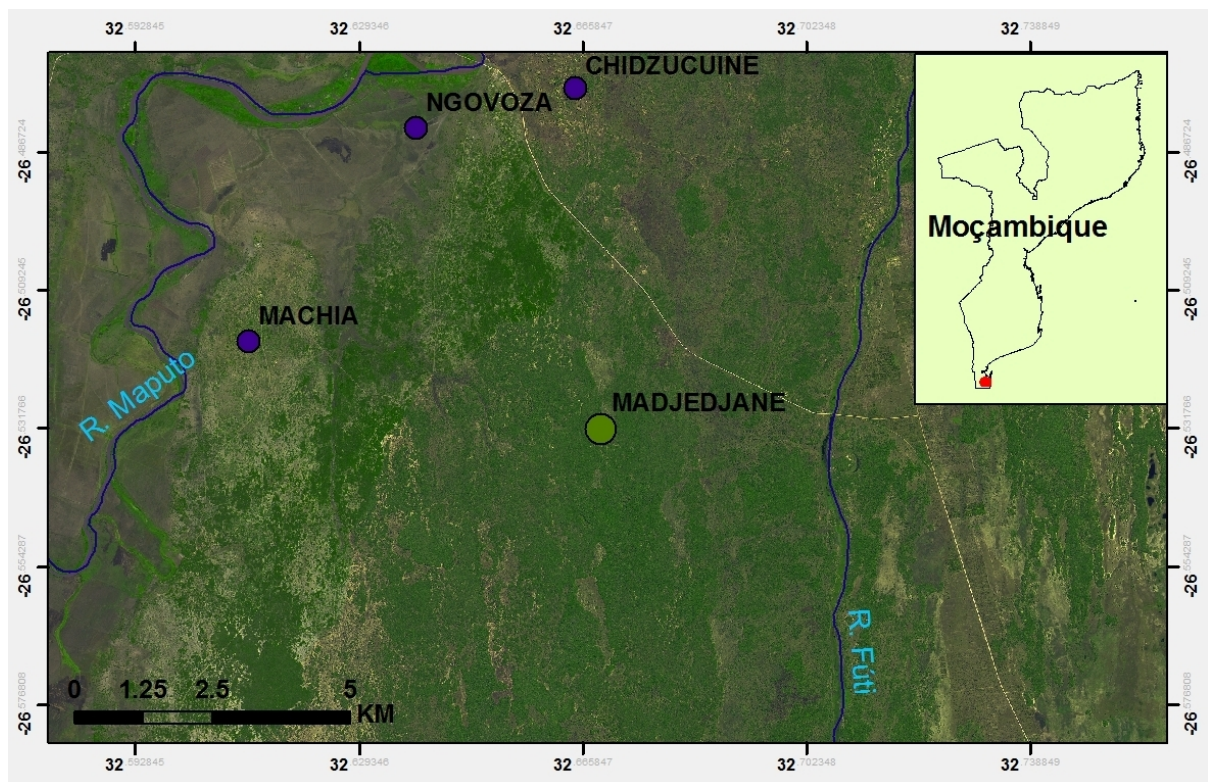


Figure 1. Map of the study site. R. Futi = Futi River; R. Maputo = Maputo River (Hugo Mabilana, Department of Biological Sciences, Faculty of Sciences, Eduardo Mondlane University).

2.4. Specific Density and Level of Damage

Species density was calculated according to [8]: $D = N/A$, where D = specific density; N = number of individuals; A = plot area. The level of damage was calculated for the ten most exploited species, selected according to the interviews, species density and the literature [11] [12]. The area of the removed bark was calculated assuming it was rectangular: $A_r = C \times L$, where A_r = stripped area; C = length of the wound (removed bark); L = width of the wound. The volume of the stripped bark was also determined according to the formula: $V_b = A_r \times T$, where V_b = volume of the stripped bark; A_r = stripped area; T = thickness of the removed bark. The potentially exploitable bark volume was calculated according to the following formula: $V_{pe} = V_1 - V_2$, where V_{pe} = potentially exploitable bark volume; V_1 = total stem volume [$V_1 = \pi \times r_1^2 \times h_{max}$ where, r_1 = stem circle radius = diameter-at-breast height (dbh)/2; h_{max} = maximum wound height]; V_2 = volume of the inner stem [$V_2 = \pi \times r_2^2 \times h_{max}$ where, r_2 = stem circle radius – thickness of removed bark]. The percentage of damage was finally calculated: $\% \text{ Damage} = V_b \times 100/V_{pe}$, and grouped into three categories: low (<30%); medium (30% - 60%) and high (>60%). Data were compiled and analysed with the excel package from Microsoft Office 2007.

3. Results and Discussion

3.1. Bark Use Survey

According to the interviewed informants, the top ten exploited species were: *Sclerocarya birrea* (A. Rich.) Hochst. (Anacardiaceae), *Kigelia africana* (Lam.) Benth. (Bignoneaceae), *Garcinia livingstonei* T. Anderson (Clusiaceae), *Terminalia sericea* Burch. ex DC. (Combretaceae), *Albizia adianthifolia* (Schumach.) W. Wight, *A. versicolor* Welw. Ex Oliv., *Dialium schlechteri* Harms (Fabaceae), *Trichilia emetica* Vahl (Meliaceae), *Manilkara discolor* (Sond.) J. H. Hemsl. (Sapotaceae), and *Strychnos* sp. (Strychnaceae). The results of the ethnobotanical survey are summarized in **Table 1**. With the exception of *Strychnos* sp., the barks of all cited species were mainly used for medicinal purposes, spanning 13 different applications (**Table 2**). The number of species used for medicinal purposes and their potential applications reflect the rich ethnomedicinal knowledge in the

Madjadjane community. Similar potentialities were also referred in other surveys carried out in Mozambique [6] [13] [14] as well as in the region [e.g. [15]-[17]].

Several species were found to be used against major ailments such diarrhea (*A. adianthifolia*, *G. livingstonei*, *K. africana*, *S. birrea* and *T. emetica*), anal wounds (*A. adianthifolia*, *A. versicolor*, *G. livingstonei*, *K. africana*, *T. emetica* and *T. sericea*), and stomach ache (*A. adianthifolia*, *G. livingstonei*, *K. africana*, *S. birrea*, *T. emetica* and *T. sericea*). In Mozambique digestive system disorders have long been associated with a complex array of illnesses. Amongst them, dysentery and cholera usually have a high mortality rate if not treated promptly [6]. Together with the observations of [6] [13] [14] our results confirm the key role of traditional medicine in controlling digestive system-associated diseases.

Three species (*K. africana*, *M. discolor*, *S. birrea*) were used to treat tooth ache and two served as cough suppressants (*A. versicolor* and *S. birrea*), disinfectants (*K. Africana* and *T. emetica*) and wound treatments (*A. adianthifolia* and *D. schlechteri*). Only one species was cited for the remaining applications: burn care (*D. schlechteri*), female infertility and flu (*S. birrea*), malaria (*G. livingstonei*), menstrual pain (*T. emetica*) and rheumatism (*D. schlechteri*). Considering the three major national health concerns, namely diarrhea/dysentery, malaria and HIV-AIDS a considerable number of bark potentialities seem to be available only for the first group (five species). This does not necessarily suggest that there are fewer medicinal plant options for malaria and HIV-AIDS. First, alternative species or sources other than bark may be used for malaria and HIV-AIDS control in the surveyed community. Second, it may reflect the incipient nature of ethnobotanical and ethnopharmacological research in the country and in the region. In fact, among the ten surveyed species, besides *G. livingstonei* (this work and [18]), *K. africana*, *S. birrea* and *T. emetica* were previously referred as potential sources of anti-malarial compounds [11] [19] [20].

The bark of seven out of the top ten cited species had more than one medical application (Table 2). *S. birrea* was the most versatile (six applications), followed by *K. africana* and *T. emetica* (five), *A. adianthifolia* and *G. livingstonei* (four), *D. schlechteri* (three), and *A. versicolor* and *T. sericea* (two). Compared to other studies in Mozambique [6] [13] [14] [21] [22] and in the region [23] [24], it can be seen that *S. birrea* is one of the most

Table 1. List of 10 most used surveyed species and local uses of bark.

Scientific name*	Local/Common names	Medicinal uses of bark	Other uses
Anacardiaceae			
<i>Sclerocarya birrea</i> (A. Rich.) Hochst.	Canho/Marula	Cough; Diarrhea; Female infertility; Flue; Stomach ache; Tooth ache	Detergent; Firewood
Bigoneaceae			
<i>Kigelia africana</i> (Lam.) Benth.	Pfungura/Sausage Tree	Anal wounds*; Diarrhea; Disinfectant; Stomach ache; Tooth ache	None
Clusiaceae			
<i>Garcinia livingstonei</i> T. Anderson	Phimbi/Africanmangosteen	Anal wounds*; Diarrhea; Malaria; Stomach ache	None
Combretaceae			
<i>Terminalia sericea</i> Burch. ex DC.	Nkonola/Silvercluster-leaf	Anal wounds*; Stomach ache	Detergent
Fabaceae			
<i>Albizia adianthifolia</i> (Schumach.) W. Wight	Gowana/Flat-crownalbizia	Anal wounds*; Diarrhea; Stomach ache; Wounds	Detergent
<i>Albizia versicolor</i> Welw. ex Oliv.	Mphisso/Poison-podalbizia	Anal wounds*; Cough	Detergent
<i>Dialium schlechteri</i> Harms	Ndziva/Sherbettee	Burnings; Rheumatism; Wounds	Beehives; Strings
Meliaceae			
<i>Trichilia emetica</i> Vahl	Kalhu/Natal-mahogany	Anal wounds*; Diarrhea;Disinfectant; Menstrual ache; Stomach ache	Pottery
Sapotaceae			
<i>Manilkara discolor</i> (Sond.) J. H. Hemsl.	Nheve/Forest milkberry	Tooth ache	None
Strychnaceae			
<i>Strychnos</i> sp.	-/-	-	House construction; Strings

*Associated to diarrhea/dysentery, parasites, hemorrhoids or obstipation.

Table 2. Medical applications of the bark from the top-10 cited species.

Category	Species
Anal wounds	<i>Albizia adianthifolia</i> , <i>A. versicolor</i> , <i>Garcinia livingstonei</i> , <i>Kigelia africana</i> , <i>Terminalia sericea</i> , <i>Trichilia emetica</i>
Burnings	<i>Dialium schlechteri</i>
Cough	<i>A. versicolor</i> , <i>Sclerocarya birrea</i>
Diarrhea	<i>A. adianthifolia</i> , <i>G. livingstonei</i> , <i>K. africana</i> , <i>S. birrea</i> , <i>T. emetica</i>
Disinfectant	<i>K. africana</i> , <i>T. emetica</i>
Female infertility	<i>S. birrea</i>
Flue	<i>S. birrea</i>
Malaria	<i>G. livingstonei</i>
Menstrual ache	<i>T. emetica</i>
Rheumatism	<i>D. schlechteri</i>
Stomach ache	<i>A. adianthifolia</i> , <i>G. livingstonei</i> , <i>K. africana</i> , <i>S. birrea</i> , <i>T. sericea</i> , <i>T. emetica</i>
Tooth ache	<i>K. africana</i> , <i>Manilkara discolor</i> , <i>S. birrea</i>
Wounds	<i>A. adianthifolia</i> , <i>D. schlechteri</i>

culturally important medicinal tree. It is a “multi-purpose, whole plant use”: roots, stems, bark, leaves, branch and fruits are employed to treat various ailments (e.g. cough, intestine and stomach disorders, anemia, tooth ache, and ear infections) [3] [6] [13] [14] [21]-[24]. The species also has several non-medical cultural values, including myths and beliefs, ornamentation, food, handicrafts and wood [13] [21] [22]. Recently, the anticancer [25], anti-microbial (respiratory infections) [26], anti-diabetic and anti-oxidant ability of *S. birrea* [27] as well as a set of compounds and molecules related to these diseases [28] have been reported. In addition, the fruits of this species are highly nutritive, with unusually high contents of micronutrients, protein (ca. 30%) and fat (ca. 60%) [21] [22]. To a lesser extent, excepting *M. discolor*, the remaining species also represent potential sources of bio-compounds (e.g. [11] [15]-[17] [20] [23] [29] [30]).

The bark of seven species was also used for non-medical purposes (Table 1), especially as a detergent (*A. adianthifolia*, *A. versicolor*, *S. birrea* and *T. sericea*). Other applications include strings (*D. schlechteri* and *Strychnos* sp.), beehives (*D. schlechteri*), pottery (*T. emetica*), and house construction (*Strychnos* sp.). This reinforces the socio-economic importance of the reported species, placing them in a privileged position for conservation aspects and income-generating purposes.

3.2. Damage Level

The mean density of the top ten species varied from ca. 14 (*T. sericea*) to 0.70 individuals/ha (*K. africana*) (Figure 2). The most affected species was *K. africana* (ca. 80%) followed by *A. adianthifolia* (ca. 70%), *M. discolor* (ca. 50%), *T. emetica*, *S. birrea*, *T. sericea* and *G. livingstonei* (ca. 30%), and *D. schlechteri*, *Strychnos* sp. and *A. versicolor* (ca. 20%) (Figure 3). In general the level of damage was related to the species density. Low density species (below four individuals/ha) like *M. discolor*, *T. emetica*, *G. livingstonei* and *K. africana* exhibited medium (32% and 50%) or high (ca. 80%) damage, respectively, whereas medium to high density species (*T. sericea*, *A. versicolor*, *S. birrea*, *D. schlechteri* and *Strychnos* sp. presented lower damage (below 30%). *A. adianthifolia* was one of the most abundant species (ca. 9.5 individuals/ha) and it exhibited the highest level of damage (ca. 80%). The fact that this species is used for multiple purposes may explain this observation. When considering the exploitation of *S. birrea*, which exhibits a similar density as *A. adianthifolia* but lower damage, and whose bark has seven different medical applications plus one non-medical use, it is likely that *A. adianthifolia* is also among the most preferred species and that *S. birrea* bark has a higher regeneration capacity [31]. It is important to point out that none of the ten species mentioned in this work is in the National Plant Red Data (NPRD) List [30]. They are so far protected by umbrella laws—that appear to be superficial and unenforced, and thus fail to effectively address the conservation status of these species. Therefore, debarking could gradually lead to the loss of resources, particular due to the commercial bark extraction. Two points should be highlighted:

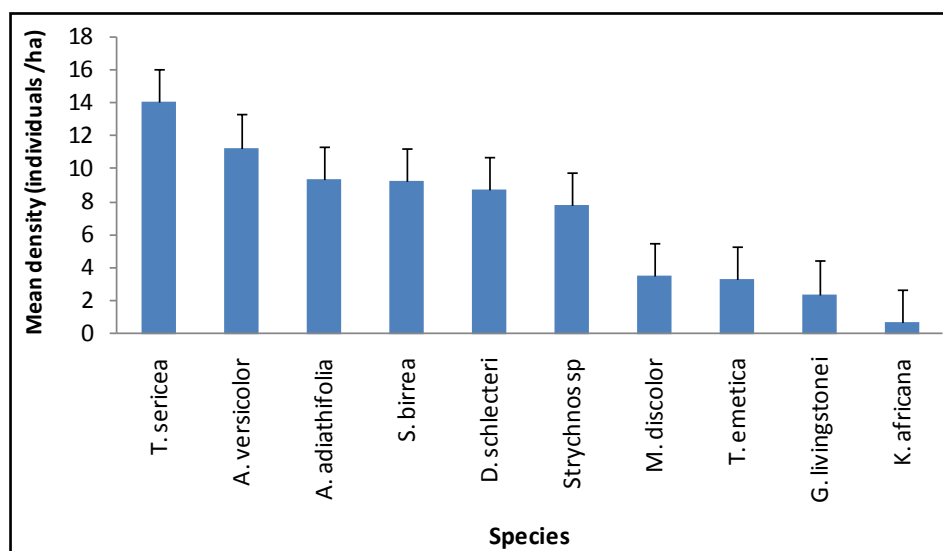


Figure 2. Mean density of the ten selected debarked trees species.

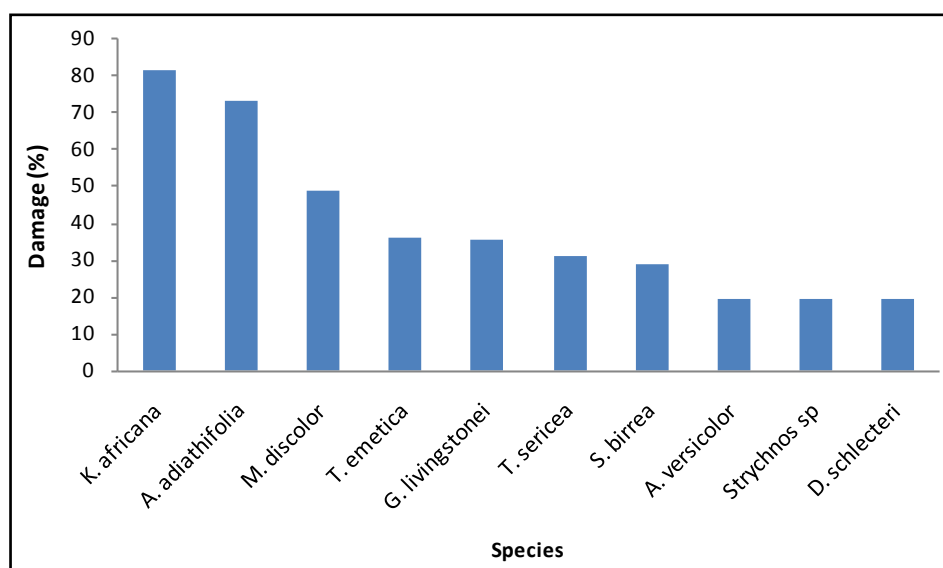


Figure 3. Damage level (%) caused by debarking on the most exploited trees.

1) the NPRD List is probably outdated; and 2) this survey did not include the quantification of bark per application (dosage), the number of users per species and the frequency of harvesting. Thus, an upgrade and update of the results will be of utmost importance to estimate with more accuracy the current conservation status as well as to predict future impacts and define better conservation strategies.

4. Concluding Remarks

The ecological impact of bark stripping is an emerging subject in Africa [31]-[35]. This was the first study in Mozambique to focus on the question of bark exploitation, uses, and impacts. We highlight the major uses of tree bark for medical and other purposes in rural communities, adding to the existing national and regional ethnobotanical databases, and thus minimizing the loss of traditional knowledge. We suggest that ethnobotanical surveys should be expanded in Mozambique, and that the results should be integrated into broad programs aimed at the preservation and valorization of local heritage. This will encourage equitable access and benefit sharing of biodiversity as well as the promotion of bio-based economy.

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