The Key Non-Timber Forest Products of Central Africa:

State of the Knowledge

Edited by

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Contents

Foreword

The management of forest lands is complex, and never more so than when considering many competing and noncomplementary uses for the same area of forest. The forests of Central Africa exemplify this complexity. Here, forest-dwelling people living traditional lifestyles encounter Europe- or Asia-based logging companies that have leased the right to harvest timber on land used by local people but belonging statutorily to an often distant central government. The many services provided by the forests themselves—including timber, water, game, food, medicine, and watershed properties for streams, rivers and fishing—all require different sets of choices for managing the human, animal and plant populations of this vast area.

Not necessarily inimical in intent, the introduction of a new use often leads to multiple and unintended consequences. Building a logging road opens up forest areas not previously accessible, making valuable plants and animals easier to extract from the forest. People then enter using the road as a vector, settling and clearing forest for farming. For people concerned with managing the forest resources in a way that addresses human social and economic needs as well as issues of ecological sustainability, it is a complicated and challenging situation.

Making and carrying out the decisions needed to arrive at sustainable management of the forest— socially, economically and ecologically—is a lengthy, evolving process. The United States Agency for International Development (USAID) has implemented a long-term program to address this process, known as the Central African Regional Program for the Environment (CARPE). During its first five-year phase, CARPE became increasingly aware of the multiple values and often contradictory uses of central African forests. In consequence, in its present phase, CARPE is looking at ways to nurture processes that will rationalize and prioritize the many conflicting forest uses, while attempting to ensure that the full range of forest use options remains available.

During its first phase, CARPE partner organizations worked to gather data and information through a variety of channels, to paint as complete a picture as possible of the state of the natural resource world in central Africa. One key area that typifies the many conflicting uses of forest resources is that of non-timber forest products. The U.S. Department of Agriculture Forest Service took the lead in investigating this sector. An important output of the Forest Service's efforts was to join with the United Nation's Food and Agriculture Organization to convene the first International Expert Meeting on Non-Wood Forest Products in Central Africa at the Limbe Botanic Garden, Cameroon, in July 1998.

This seminal meeting brought together national and international experts and researchers to define and discuss the non-timber forest products sector in Central Africa. Part of the outcome of the workshop was a series of actions and recommendations in the sociopolitical, ecological and market-economic arenas. Of those, the Forest Service selected several initiatives for funding, including the Ecological Working Group's recommendation to complete state of knowledge reviews on selected non-timber forest product (NTFP) species with particular economic, ecological, or social and cultural values.

Independent researchers, together with institutions such as the Limbe Botanic Gardens in Cameroon or the Oxford Forestry Institute at Oxford University in Britain, have worked to produce state-of-knowledge reports on several taxa. These are all important, diverse NTFPs representing the range of conditions under which NTFPs are harvested and traded. Although not intended to be definitive monographs, these reports contain excellent social, economic and ecological information for these important non-timber forest products.

The reports included in this publication represent an important source of data for the future management of each of the species discussed, as well as other plant resources that are exploited in a similar way. Disturbingly, each report also concludes that questions of resource tenure, market demand and a lack of statutory or customary oversight addressing the sustainable management of the product in question pose serious concerns about the longevity of current uses of these species' wild populations. It is also clear that the biological and ecological information required to develop strategies for sustainable harvesting is woefully incomplete for even the most commonly traded NTFPs.

Each of the reports therefore identifies recommended future actions, including both research- and development-based interventions. It is to be hoped that the work presented in this volume will inspire others to carry on the much-needed task of formalizing, quantifying and documenting the nature of the trade in key NTFPs and their diverse social, ecological and economic roles in the Central African region.

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At the time of publication, $1 was equivalent to ca. 750 Central African Francs (CFA).

Chapter 1
CARPE:
Building Knowledge of the Non-Timber Forest Product Sector in Central Africa

Laurie Clark and Terry Sunderland

INTRODUCTION: THE CONGO BASIN

The Central African region is particularly blessed with a myriad of natural resources and a great diversity of flora and fauna. Until recently, its size, climate and sociopolitical history have left large sections of its natural forests intact (Vansina 1990). The heart of this region, the Congo Basin, is the second largest contiguous rainforest area in the world, harboring about 400 mammal species, more than 1,000 bird species, and over 10,000 plant species, of which 3,000 are endemic to the region (Laporte and Justice 2001). Within this region, more than 90% of the human population depends on natural resources, including agriculture and non-timber forest products, for food, medicine, income and timber; that same population is increasing at a rate of 2–3% per year (ibid.).

Rates of change are increasing as well, with forests being converted to agriculture, plantations and roads, or modified by timber harvest, shifting agriculture and other extractive activities. Satellite imagery from the early 1990s supports estimates that the Central African rainforests extend over 1.8 million km^2, and recent modeling studies suggest that secondary forest will predominate in the region by as early as 2030 (Laporte and Justice 2001). This mass conversion from primary to secondary forest has widespread implications for the flora, fauna and human populations of the region. Scientists and planners who value the forests for their regional ecological and climatic roles, and the people who live daily from the products of the forest, all have a stake in actively managing and planning the changes that are occurring in Central African forests.

An important field of study with regard to sustainable use of tropical forests—one that has developed only in the past 20 years—is that of "non-timber forest products" (NTFPs). As with many other issues involving the Congo Basin forests, before that time few quantitative data had been available regarding the scale and economic or biological importance of NTFPs to the forest sector. Yet, these products arguably form the majority of forest-dwelling people's use of the forest. Global research into the sector has considerably increased our understanding of the potential and actual roles played by these products in determining people's use of the forest, and the reports presented here further clarify the importance played by a range of important NTFP species.

WHAT ARE NON-TIMBER FOREST PRODUCTS?

This publication follows Clark (2001a), who defines NTFPs as materials derived from forests, excluding timber. They include bark, roots, tubers, corms, leaves, flowers, seeds, fruits, sap, resins, honey, fungi and animal products (although the last are not discussed in any further detail here). NTFPs are collected from a wide range of ecotypes, including high forest, farm fallow, otherwise disturbed forest, and farmland. They are used for food and medicine and are often the only means for forest dwellers to enter the cash economy. In Central Africa, NTFPs are consumed in both rural

and urban homes and are widely traded in local, regional and international markets. A number of high-value NTFPs also provide significant sources of income for forest dwellers, as well as for rural and urban entrepreneurs. Many people use NTFPs medicinally, either in addition to western pharmaceuticals or, often, as their sole means of primary health care.

TRADE IN NTFPS FROM CENTRAL AFRICA

Historical trade in NTFPs from Central Africa

While trade between different African peoples has existed for thousands of years, the sub-Saharan region was unknown to Europeans until the mid-15th century. However, extensive trade routes across the Sahara were established long before the advent of European influence. The conquest of North Africa by Arab peoples in the 7th century led to the development of these trade links (Townson 1992). From this period on, a number of high-value products were transported from the forested regions of West and Central Africa for consumption and sale in the Muslim-dominated areas of North Africa. Aside from palm oil, slaves and ivory, kola nuts (*Cola acuminata* and *C. nitida*), in particular, were traded extensively from the Guinea and Akan forests to the sub-Saharan Sudanic belt (Oliver 1999). In the early medieval period, another forest product, melegueta pepper or "grains of Paradise" (*Aframomum* sp.), began to be transported to Europe for use as a spice and condiment (van Harten 1967). Its recorded use in Europe as early as 1214 A.D., long before direct European trade, testifies to the influence and extent of these trans-Saharan trade routes (ibid.).

During the 16th and 17th centuries, Europeans began to explore the African coastline and, aside from their involvement in the lucrative slave trade, realized there was also considerable potential for "legitimate" trade (Isichei 1997). An extensive network of trading stations was established at strategic points along the coast, and iron goods, cloth and weapons were transported from Europe to be exchanged for spices and condiments, palm oil and ivory (Oliver 1999). Subsequently, these trading stations provided the stepping-stones to colonial expansion, and many European powers used their trading influence to annex considerable areas of land during the "scramble for Africa" (Iliffe 1995). The colonial period was characterized by the conversion of large tracts of forest lands to plantation agriculture and direct exploitation of both timber and non-timber resources. For example, before plantations began to supply Brazil rubber (*Hevea brasiliensis*), wild sources of rubber for tire manufacture were highly valued. Exploitation of African rubber (*Funtumia elastica*) from the Congo Free State led to a brutal and exploitative policy of enforced collection for the brief period during which the activity was economically viable (Hochschild 1998).

Today, most trade in central African NTFPs is within and between African nations. This trade has been facilitated by the development of better transport networks and greater access to forest areas. Ndoye et al. (1999) found that the value of four important NTFPs sold in markets in the humid forest region and border markets of Cameroon amounted to US $753,000 from January to June 1995. (The NTFPs studied included nuts from *Irvingia* spp. and *Cola acuminata* and the bark of *Garcinia lucida* and *G. kola*.) A recent NTFP valuation model tested in the South-West and North-West provinces of Cameroon estimated that the value of NTFP production and marketing in this area exceeded US $19 million in 1999, representing 2.8% of the regional economy. Timber revenues in this predominantly logged-over area contributed only 5% (van Dorp et al. 2001).

Cameroon acts as an important "breadbasket" of agricultural and NTFP goods in regional trade. Sunderland and Obama (1999) remark that although many of the popular NTFPs grow in the forests of Equatorial Guinea, most of those NTFPs found in its markets are imported from Cameroon. Similarly, Yembi (1999) notes that with the exception of *Gnetum africanum*

Njangsang, bush mango and other natural products on sale in the Limbe market

leaves, most of the NTFPs sold in urban markets in Gabon are sourced externally and sold by African expatriates.

Though NTFPs are harvested primarily by rural people, urban dwellers in Africa and the African diaspora in Europe and North America drive considerable market demand for these products. In the Limbe market of Cameroon, *Gnetum africanum* leaves sold in late 2001 for the equivalent of US $1.60. Although members of the African diaspora in France are willing to pay up to US $17/kg for fresh *G. africanum* (Tabuna 2001), the volume of international trade is tiny compared to that supplying the national markets. Interestingly, the high demand for NTFP spices has driven up prices so much that some families are now replacing them with the much cheaper manufactured "Maggi" seasoning in their cooking (Kann, pers. comm. 1999).

However, the most significant revenues from marketed NTFPs are from plants of herbal and pharmaceutical value. Extracts from the bark of the *Pausinystalia yohimbe* (yohimbe) tree are traded internationally for use as an aphrodisiac and stimulant in North America and Europe (see Sunderland et al., this volume). The total value of yohimbe bark exports from Cameroon was US $600,000 in 1998 and is growing each year (ibid.). Similarly, the bark of *Prunus africana* (pygeum) is used to extract a chemical cocktail used for the treatment of benign prostate hyperplasia. The value of the international trade of *Prunus* products is estimated to be more than US $220 million per year (Cunningham et al. 1998). Although Cameroon contributes up to 62% of the *Prunus* bark in world trade, and the international value of the bark is US $2/kg, in-country prices are less than US $0.10/kg of bark (Cunningham et al. 1998; Ndam and Ewusi 1999; Ndam et al. 2000). Hence, the vast majority of the overall product value is captured by the pharmaceutical companies.

IS NTFP HARVESTING SUSTAINABLE?

Although NTFPs have been used for millennia, growing demand will intensify stresses on wild populations. When the value of an NTFP and the intensity of its exploitation are low, human impact on that product is likely to be minimal, and little if any formal management of the resource is required. However, when the value of an NTFP and the intensity of its use are extremely high, it is highly likely that the resource is being overexploited; supplies of it may be exhausted, causing it to become locally extinct.

Logging and other forest disturbances (for example, shifting and mixed agriculture) are not necessarily inimical to NTFP production (Laird 1999). Some NTFPs

are found in primary forests, but many, including *Ricinodendron*, *Aframomum*, rattans, *Gnetum* and *Cola*, are also found in secondary forest, roadsides and fallow farmland (Zapfack et al. 2000; Guedje et al. 1998; Laird 1999; Sunderland 2001). Forest management activities that appear contradictory, such as timber extraction and NTFP management and harvest, will have much greater success when logging plans are able to take into consideration and adjust for the biological, economic and social values and needs of NTFPs and their consumers. Furthermore, it is important to recognize that in many cases, threats to wild populations of NTFP species stem from overharvesting pressures— the lack of effective management of the populations—rather than mere loss of habitat through logging or conversion to agriculture.

NTFPs prized for their leaves, roots or bark are particularly prone to unsustainable use, because harvesting either damages or kills the parent plant. Demand for *Gnetum africanum* and *G. buchholzianum* has driven wild populations of this leafy vine to local commercial extinction in Nigeria and much of southwestern Cameroon (Shiembo 1999; Clark et al., this volume). Also, current "sustainable" harvesting practices that partially strip bark from live trees such as *Garcinia lucida*, *Prunus africana* and *Pausinystalia yohimbe* expose them to ring-barking and to stem-boring insects that can cause 50–90% post-harvest tree mortality (Guedje 2001; Ndam et al. 2000; Mahop et al. 2001; Sunderland et al., this volume).

Though harvesting seeds and fruits only adds to what is normally high seed mortality, and may not adversely impact plant regeneration, inappropriate harvesting techniques can put some fruit and seed NTFP species at risk. *Piper guineensis* fruits are widely harvested, dried and used as a spice in local dishes. Unfortunately, rather than picking the seeds from the live plant, harvesters typically uproot the plant and then strip all its seeds (Blackmore, pers. com. 2000). This practice is clearly unsustainable, as it both destroys the plant and reduces seed production and plant regeneration. However, in the case of *Aframomum* (*A. citratum* and *A. melegueta)* only the fruits are harvested, and because these taxa reproduce via both seed and rhizome, the populations are not seriously threatened by that particular harvest method (Guedeje et al. 1998).

The harvest of wild-sourced NTFP can be sustainable. However, sustainably harvesting a particular plant requires:

- understanding the plant's growth and reproductive characteristics, and
- applying harvesting practices that permit adequate reproduction or regeneration of the plant.

Unfortunately, even this basic information is woefully incomplete for most taxa.

WHAT ROLE CAN NTFPS PLAY IN A HOLISTIC APPROACH TO FOREST MANAGEMENT?

Since the 1970s, NTFPs have emerged to take their place among the many aspects of forest use that guide natural resource decision-makers. In the 1980s, NTFPs were hailed as a potential alternative to forest uses such as logging that would lead to deforestation. Some NTFPs have strong market value; it was postulated that the long-term value accruing from the harvest of these products could override the short-term gain of converting that forest or individual tree to other uses such as timber, agriculture or plantations. The attention of both conservation and social development communities was captured. Through the harvest of NTFPs, the often marginalized forest peoples of the world might capture income, provide social benefit and contribute to the conservation of natural forests. If this were so, then developing and formalizing the NTFP sector could meet both of the often-contradictory goals of development and conservation.

In discussions with key players in the Central African NTFP sector, Clark et al. (1998) reported that government and conservation and development projects

had been working with NTFPs and were familiar with the issues. To the question of whether development of the NTFP sector could help to reduce deforestation rates and increase conservation of biodiversity in the region, most of the experts interviewed responded, "Yes, but…" The individuals then went on to catalog the many reasons why NTFPs were only one of a bundle of options to consider in building an integrated agenda for sustainable forest management.

Many who approach the NTFP sector begin with a set of basic assumptions. It is assumed that natural forest will have greater long-term benefits if left standing; that local people will tend to manage their forest resources more sustainably if they directly benefit from doing so; and that poverty in forest communities is both caused by, and a result of, degradation of the forest system. The logical conclusion is that if poverty can be alleviated through harvesting forest products, then there will be greater incentive to conserve those forests (Neumann and Hirsch 2000). Experience in the Central African forests indicates that the reality is more complex than this set of assumptions. Fundamental issues such as the need to sustain income levels and to deal with external forces (e.g., commercial logging, the transition to a cash economy, and unstable land tenure) play a large role in determining the forest management choices made by forest users.

The NTFPs presented in this publication are all economically important. Each of the species discussed faces threats of some sort to its wild populations, through destructive or uncontrolled harvest practices, loss of habitat, and a lack of statutory or customary oversight to guide its management. However, all show promise of conservation through cultivation or domestication programs or, more desirably, through improved forest management techniques.

Many of the problems concerning conservation of popular or economically valuable NTFP species in Central Africa are not intractable, nor are those facing managers of the forests in which they grow. It is true that over a short time span, any given NTFP in a productive timber stand is unlikely to provide enough income to offset the profit that forest would yield if logged (Godoy et al. 2000; van Dorp et al. 2001). However, trees yielding NTFPs can add value in other ways; for example, Newman and Shiembo (1997) found that intercropping agricultural crops with trees yielding NTFPs can add substantially to the total value of that land's production. Similar observations are noted in the *Cola* case study (see Tachie-Obeng and Brown, this volume). NTFPs are one of many options forest and agricultural land managers have to increase the value of their land.

NTFPs are not esteemed only for their market price; cultural, social and spiritual attributes also add to the value of the products. Though not easily quantified, these characteristics may sometimes be as important to people as the crop's economic value (Davidson-Hunt et al. 2001; see also Mahop et al. in this volume). The wide-ranging economic, social and biological roles played by NTFPs are themselves resources for forest land managers in the pursuit of holistic forest management strategies for Central Africa.

USER RIGHTS AND RESOURCE TENURE ISSUES

Studies show that as NTFPs increase in value, there is a trend toward overharvesting of wild resources, increased on-farm production, and exclusion of resource users by resource managers, a situation further complicated if land tenure is unstable or insecure (Wilkie 1999; van den Berg et al. 2001). This tendency suggests that few if any commercially valuable NTFPs can be harvested sustainably from the wild, given present resource access and ownership laws (Malleson 2001; van Dijk 1999; Sunderland and Tchouto 1999).

Clearly, any sustainable forest management or forest conservation plans or activities will need to begin with

a clear understanding of local land and resource tenure and access rights. Research conducted in Cameroon concludes that even for economically valuable NTFPs, few management techniques are applied under traditional harvest practices (van den Berg et al. 2001; Malleson 1999). Overlapping layers of class privilege, educational advantage, financial power and statutory rights overlying these basic traditional tenure guidelines will all affect the way innovations and management options are implemented, and together these relationships will play a direct role in management success or failure.

Trends towards cultivating several NTFPs further complicate this picture. Efforts to domesticate different NTFPs such as *Gnetum* and *Irvingia* and integrate them into agricultural systems show promise, and field trials are demonstrating the potential for on-farm cultivation of *Gnetum* and rattans (Nkefor 2001; Sunderland et al. 1998). In fact, *Irvingia*, *Cola* and other trees such as *Dacryodes edulis,* valued for its tart fruit, are under de facto cultivation in that they are planted around compounds and in fields, and when clearing the forest for farms, farmers tend to leave the wild trees standing.

On-farm cultivation, however, amounts to privatization of NTFP production. As wild stocks are depleted, this process will further reduce access of landless families to NTFPs. Intensification of labor inputs to a piece of land often increases users' rights (van den Berg et al. 2001; Sunderland and Tchoutou 1999). For example, on land where people customarily go to collect the fruit of *Irvingia gabonensis,* conflicts may develop if a customary user wants to plant *Irvingia* trees for his or her own use on that same land.

Few of the major, marketed NTFPs fall under statutory controls and harvest guidelines. Unclear and unenforceable NTFP access and management rights leave most NTFPs vulnerable to overharvesting. *Prunus, Pausinystalia* and *Gnetum* are among the few taxa in Cameroon whose NTFPs are governed, in principle, through a permit system. However, it is in the form of well-constructed and applied harvest permits, tax collection points and export tariffs that much of the trade in these most valuable NTFPs could be formalized, with tax revenues and some accountability provided to encourage rational decisions about resource management.

CENTRAL AFRICAN REGIONAL PROGRAM FOR THE ENVIRONMENT (CARPE)

What is CARPE?

The Central African Regional Program for the Environment (CARPE), a long-term initiative supported by the United States Agency for International Development (USAID), addresses deforestation and biodiversity conservation in the Congo Basin forest zone of central Africa. Its core philosophy is to facilitate the meaningful involvement of African partners in this work and to ensure that African decision-makers have access to use information critical to rational forest resource management, as well as the capacity to use that information. The expanded knowledge base and enhanced individual and institutional capacity that result from the initiative will serve as the essential foundation for a longer-term (15- to 20-year) effort to manage forest resources sustainably, thus conserving the region's biodiversity and averting potentially negative changes in regional and global climate. CARPE has engaged local non-governmental organizations (NGOs), individuals and government agencies in activities to evaluate threats to forest integrity and identify opportunities for minimizing resource degradation while putting people's livelihoods on a surer foundation.

CARPE activities are designed to fill gaps in our knowledge and build on the experience of others, thus extending rather than duplicating our collective knowledge of the forests of Central Africa. CARPE seeks to involve Central Africans in pilot forest-management activities in the region and strengthen the capacity of

Central African decision-makers and civil society to participate in priority-setting for and management of the region's unique forest resources.

CARPE works with nations within the Congo River watershed, including Cameroon, Central African Republic, Equatorial Guinea, Gabon, the Republic of Congo, the Democratic Republic of Congo, Rwanda, Burundi, and São Tomé and Príncipe. Within the United States, CARPE partners include American private voluntary organizations (PVOs) and different federal agencies.

CARPE has finished its first phase (1995–2000) and, drawing from the information and lessons learned up to that point, has identified several key concepts that guide its activities in the present phase. These are summarized below (Wilkie and Somé 2001).

Key Concepts Identified after Phase I of CARPE

- Environmental governance

A basic premise of CARPE is that Central African forest management should reflect societal values and priorities rather than individual interests alone, and that benefits from forest use should be shared as equitably as possible. Small grants to Central African NGOs, individuals and university faculty and students have proven to be an effective mechanism for building the human capital and conservation constituency that together form the foundation of effective environmental governance.

- Protected areas

Biodiversity conservation must include parks and reserves as elements of conservation strategies. This must be implemented at both the landscape and community levels of natural resource management. Protected areas serve as core spaces for the long-term persistence of ecological and evolutionary processes largely unfettered by human influence, with most forms of human use precluded or strictly limited. These core spaces are especially important for conservation of (1) flora and fauna that are particularly sensitive to human presence and habitat disturbance, and (2) resources that have low economic value but high global intrinsic value.

- Private sector engagement

Logging companies exercise de facto control of forest resources in more than 50% of Central African forests outside of protected areas (Collomb 2001). In many cases, poor management practices and technical shortcomings cause needless damage and degradation in and around logging concessions and stimulate uncontrolled exploitation of resources such as bushmeat and gemstones. Pilot projects with conservation NGOs and timber companies working together have shown that efforts to "green" private sector practices through better planning, site management and access restrictions have considerable potential to generate significant conservation payoffs at relatively low cost. In some cases, they can also provide economic benefits for concession operators. In the absence of an appropriate framework and checks and balances, private sector activities are apt to cause short-term damage while manifesting long-term unsustainability.

- The bushmeat crisis

Hunting wildlife to supply meat for urban markets and logging settlements may represent a more immediate and significant threat to forest conservation than deforestation. Loss of wild animals that are important seed predators, seed dispersers and landscape engineers affects tree species regeneration and forest composition and productivity. Solving this crisis will require efforts to reduce demand in urban areas and to better enforce existing laws regulating hunting and marketing of wildlife products. It will also require working with logging companies to ensure they provide appropriate food for employees and their families and take effective action to curb the use of logging trucks and roads to transport hunters, firearms and bushmeat.

CARPE's work with NTFPs, 1995–2000

In the first phase of CARPE (1995–2000), the U.S. Department of Agriculture (USDA) Forest Service served as team leader for the subcomponent dealing with NTFPs. The basic question posed by the Forest Service was: "Can the development of the NTFP sector contribute to the conservation of biodiversity and the reduction in rates of deforestation in the Congo Basin?" (Clark et al. 1998: 13).

The answer is that NTFPs and the NTFP sector are valuable tools for developing ecologically, socially and economically sustainable natural resource management systems (Clark 2001b). However, the wild harvest of NTFPs is an activity, like shifting agriculture, that is ecologically sustainable only when human populations are low and the amount of intact forest is high.

Typically, growing human populations and the development of roads and other infrastructure will open forest to large-scale exploitation, first for timber, then for valuable NTFPs. People move into newly accessible forest and begin to farm, clearing and harvesting from the forest. The combination of increased human populations and increased intensity of forest use suggests that wild harvest of NTFPs alone will not be sustainable.

It is true that many NTFPs are harvested only for their fruit or leaves. If managed well, such harvesting can provide a relatively sustainable offtake of products, providing nutritional and economic benefits while not damaging the plant or its population. However, this requires management and a degree of secure land and resource tenure that are, at best, rare in much of Central Africa. Therefore, *in situ* and *ex situ* efforts to conserve the wild populations as well as the wider genetic base must be combined with identification of the most economically valuable NTFP species for further commercialization.

The first International Expert Meeting on Non-Wood Forest Products in Central Africa

An important step in the work of the USDA Forest Service in CARPE's first phase was to convene the first International Expert Meeting on Non-Wood Forest Products in Central Africa in May 1998. Co-hosted by the USDA Forest Service, CARPE, and the United Nations' Food and Agriculture Organization, this seminal workshop brought together scientists and stakeholders in the NTFP sector from the Congo Basin and beyond (see Sunderland et al. 1999). A principal purpose of the workshop was to identify short- and medium-term activities that would clarify ways of using NTFPs to better manage Central African forests. These activities addressed three priority areas within the NTFP sector: ecological, sociopolitical and market-economic.

As Wilkie (1999) summarized, working groups were asked to identify a prioritized set of short- to mid-term actions to promote the sustainable use of NTFPs, building on past and ongoing work. The first priority of the ecological working group was to identify a short list of key NTFP species, based on (1) high value for domestic or market consumption, and (2) demand for the product exceeding supply. They then recommended preparing and disseminating state-of-knowledge reports on these prioritized species.

State-of-knowledge reports

The USDA Forest Service and CARPE commissioned several state-of-knowledge reports on the prioritized NTFP species. Information for the reports was gathered through an extensive search of the literature, including "gray" literature[1]; contacting others known

[1] The U.S. Interagency Gray Literature Working Group, "Gray Information Functional Plan," January 18, 1995, defines gray literature as "foreign or domestic open source material that usually is available through specialized channels and may not enter normal channels or systems of publication, distribution, bibliographic control, or acquisition by booksellers or subscription agents."

to be working or interested in the taxa concerned; and the results of appropriate original research.

These state-of- knowledge reports detail:

- Ecology and related subjects:

  Phylogeny—taxonomy (assessing biological uniqueness and importance)

  Synecology—including forest type, community structure

  Autoecology—including life form (shrub, tree, climber, etc.), recorded natural distribution and density, preferred habitat (secondary forest, montane forest, etc.)

  Reproductive ecology—pollination, seed morphology, dispersal, etc.

  Regeneration—rates and success

- Sustainability issues:

  Plant part(s) harvested, harvesting methods

  Known rates of growth

  Level or rate of harvesting

  Who is harvesting?

  Known wild management schemes, if any

  Domesticated or cultivated? If so, how, where, and by whom?

- Market and trade issues:

  Levels of trade or use (domestic, local, regional, international, etc.)

  Known trade routes and price variations

  Presence in local markets, relative availability and expense

  Relative scarcity of product (more or less scarce than in the past, according to traders/collectors)

  Market potential; is the product becoming more popular, widely traded, or used?

- Institutional issues:

  Any known (accessible) legislation pertaining to the exploitation of the plant?

  Who else is working on the species; what is the research?

  Identify gaps in knowledge of the species and its exploitation, recommend further research needs

  Characterize opportunities for and constraints to promotion of sustainable use

- Full bibliography for each taxon.

Of the completed reports, those selected for this publication include moabi (*Baillonella toxisperma*), kola nuts (*Cola nitida* and *C. acuminata*), bush mango (*Irvingia gabonensis* and *I. wombolu*), njansang *(Ricinodendron heudelotii*), eru *(Gnetum africanum* and *G. buchholzianum*), iboga *(Tabernanthe iboga*), and yohimbe (*Pausinystalia yohimbe*). These studies, which provide unparalleled information on the NTFP species concerned, have been edited for technical content and continuity of presentation, peer reviewed, and are here published in a stand-alone publication. Although they are not meant to be definitive botanical monographs of the taxa involved, they provide quality information summarizing the state of knowledge for each.

In addition to these contributions, a further state-of-knowledge study of the African rattans was undertaken through organizing an international expert workshop on the rattans of Africa, also funded by CARPE. The proceedings of this meeting have been published by the International Network of Bamboo and Rattan (INBAR) (Sunderland & Profizi 2003).

IN SUMMARY

Taken together, these reports provide an excellent overview of the status of some of the most valuable NTFP species in West and Central Africa. While each species' products are different, the reports share similar concerns about the impact of overharvesting on the wild resource, market sustainability and traditional land and resource tenure practices. Similarly, promising domestication, cultivation and sustainable wild management initiatives are noted in each of the studies, while streamlined conservation, transformation and marketing practices are widely recommended to improve efficiency and profits. Improved taxation, monitoring and distribution of profits across most marketed NTFPs is recommended as well, to enhance the value of NTFPs in terms of both income generation and efficient use of forest resources. The similarity of all of these concerns and recommendations highlights the importance of holistic, rather than species-specific, management of natural and managed forest systems and resources.

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Chapter 2
BUSH MANGO
(*Irvingia gabonensis* and *I. wombolu*)

Lesley Ainge and Nick Brown

INTRODUCTION

The two species that comprise the bush mango resource, *Irvingia gabonensis* (Aubrey-Lecomte ex O'Rorke) Baill. and *I. wombolu* Vermoesen, are highly valuable, much-used tropical African trees. They were identified as high-priority species for state-of-knowledge reports at the Non-Timber Forest Products (NTFP) workshop held in Limbe in May 1998, funded by the Central African Regional Program for the Environment (CARPE). *I. gabonensis* and *I. wombolu* have enormous potential, both in economic terms and as species for sustainable production, and could play a significant role in the conservation of the Congo Basin forests. Improvements in their breeding stock for cultivation, as well as in their cultivation itself, are possible and would further increase the benefits and importance of these species.

At present, there is no central focus for information for *I. gabonensis* and *I. wombolu*. This paper attempts to draw together the current knowledge of these taxa, characterize their economic potential and identify areas for future research. Information regarding current research is also given, obtained from others working on these species. It is hoped that this paper will serve as a reference work for the two *Irvingia* species, helping to direct future research and contributing to their development as high-value NTFPs.

TAXONOMY AND ECOLOGY

Taxonomy

Nooteboom (1966) found the Irvingioid group of taxa to be well placed as a subfamily within the Simaroubaceae, despite the lack of quassiin and other related bitter principles. Some have agreed with this placing, but others have maintained that *Irvingia* has a closer relationship with other families (e.g., Fernando et al. 1995). It is now generally recognized that Irvingiaceae is a distinct family, containing the genera *Irvingia, Desbordesia and Klainedoxa* (Harris 1996). The genus *Irvingia* is represented by six species (Harris 1996). Prior to Harris's 1996 revision, two forms of *Irvingia gabonensis* were recognized (1975): *I. gabonensis* var. *gabonensis*, which has a sweet edible pulp, and *I. gabonensis* var. *excelsa*, which has a bitter inedible pulp. Harris (1996) raised the *excelsa* variety to species rank, recognizing Vermoesen's previously described taxon, *Irvingia wombolu*.

I. gabonensis and *I. wombolu* are morphologically very similar, and indeed are often difficult to tell apart from herbarium specimens alone (Harris 1996). However, there are characteristics that distinguish the two taxa, most noticeably the palatability of the fruit mesocarp. Harris (1996) also mentions the density of fibers in the mesocarp, the amount of mucilage in the cotyledons, the size of the endosperm, the height of first branching, the disc shape in fertilized flowers and the shape of the tree as diagnostic characters (see also Appendix 1).

Habitat and distribution

The preferred habitat of the majority of *Irvingia* species is undisturbed lowland tropical forest (Van Dijk 1999). These species are better adapted to utisol soils in high-rainfall areas than to less acidic soils (Kang et al. 1994), but within these areas the two species of bush mango differ. Okafor (1975) states that *I. gabonensis* prefers well-drained sites, while *I. wombolu* thrives in wetter conditions.

Both *Irvingia* spp. occur in the humid lowland forests of tropical Africa in Angola, Cameroon, Central African Republic, Congo-Brazzaville, Equatorial Guinea, Gabon and the Democratic Republic of Congo (Harris 1996). *I. wombolu* extends as far west as Senegal (Ndoye et al. 1999).

I. gabonensis and *I. wombolu* are planted and maintained on farms throughout their range in Central and Western Africa. Planting is common in Nigeria (Ejiofor et al. 1987), more predominantly on outlying farms than on compound farms (kitchen gardens) (Okafor 1983). Van Dijk (1999) states that bush mango (although she does not indicate which species) has a moderate density in the south of Cameroon (2.1 stems/ha average, 3.6 stems/ha maximum), reporting that it has an even distribution and appears in every habitat type. However, Agbor (1994) relates that the density of both species in the tropical moist forest zone (TMFZ) of Nigeria is low, reputedly as a consequence

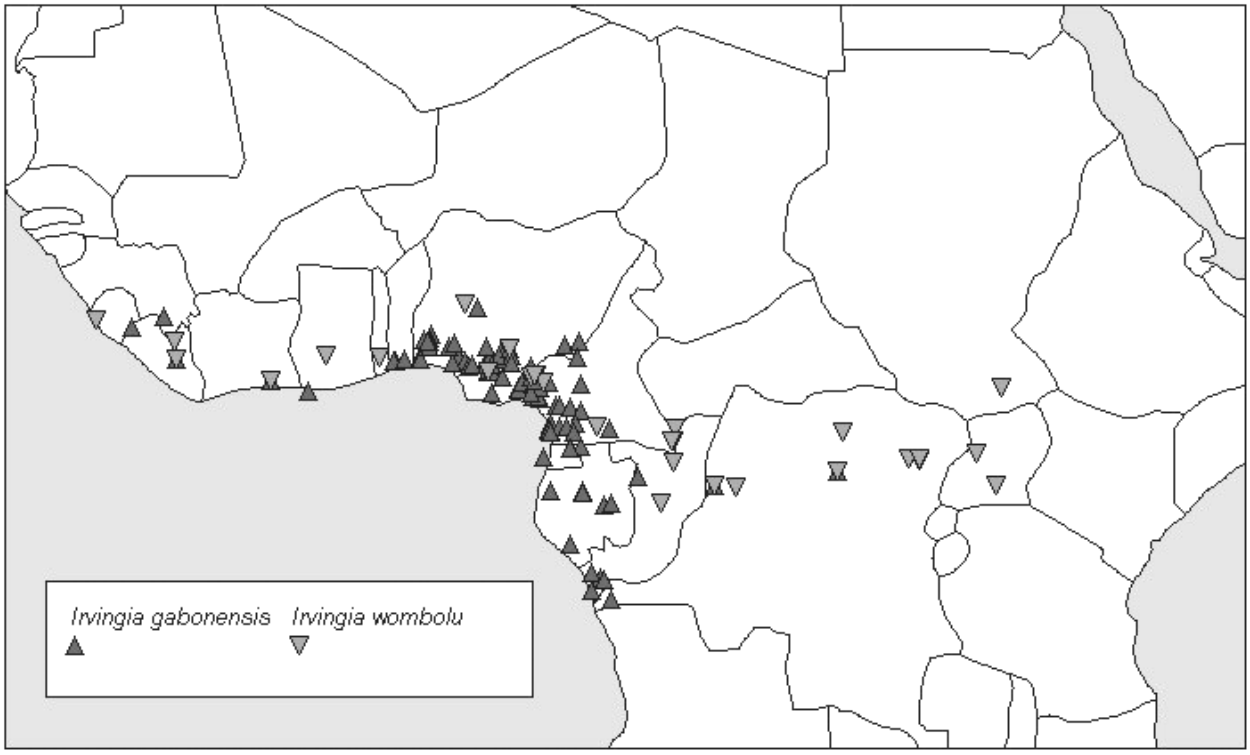


Figure 1. Distribution of *I. gabonensis* and *I. wombolu*. Only records from wild trees were used in this analysis. Harris (1996) records no wild records of *I. gabonensis* from countries around Liberia and has questioned the accuracy of the identifications of *I. gabonensis* in and around this region (Harris, pers. comm.).

of high mortality of younger trees, low recruitment rate into the mature age classes and the absence of intensive cultivation of this species. This may be the case for most areas in which *Irvingia* spp. occur.

Phenology

I. gabonensis and *I. wombolu* usually reach maturity and begin flowering at 10–15 years of age (Ladipo et al. 1996; Moss 1995). However, much earlier fruiting has been reported, and Ladipo et al. (1996) describe trees that produced fruit at six years of age. A study of the productivity of *Irvingia* spp. indicates that *I. gabonensis* is more productive than *I. wombolu* at the same age and in the same location (Kang et al. 1994). The researchers also observed that branching intensity seems to be a major factor in determining productivity.

The phenology of the two species of bush mango varies considerably. *I. gabonensis* generally flowers in February–March (Agwu 1985) and fruits in the rainy season from July–September (Ladipo et al. 1996), while *I. wombolu* flowers in October (Okafor 1975) and fruits in the dry season around January–March (Ndoye et al. 1998; Okafor 1975). However, it is important to note that flowering and fruiting times vary over the species' geographic range. In most areas, *Irvingia* spp. fruit once a year, but twice-yearly fruiting is not uncommon, and has been recorded in Gabon (Tutin & Fernandez 1993). In Nigeria, *I. gabonensis* is recorded as fruiting twice per year, once in January–February and then again in June–August. Within these fruiting seasons, trees fruit earlier or later depending on the region (Ladipo et al. 1996). Okafor (1975) also describes cultivated trees that fruit in both May–July and September–October. On the other hand, some individual trees produce fruit only every other year (Ladipo et al. 1996).

Pollination

The species of *Irvingia* are insect-pollinated (Tutin and Fernandez, 1993; Harris, 1996). Ladipo et al. (1996) state that very little is known about the mating systems and gene flow of *Irvingia* spp., except that *I. gabonensis* is known to have hermaphroditic flowers. They also report uncertainty about the level of outbreeding in this species, but a recent study indicates that 100% outbreeding occurs, implying that *I. gabonensis* is highly heterozygous.

Seed predation and dispersal

Aside from local people gathering the fruits of *I. gabonensis* and *I. wombolu*, many other mammals are reported to consume the fruits in the forest. *I. gabonensis* fruits comprise a significant part of the diet of forest elephants (*Loxodonta africana cyclotis*) (Tchamba & Seme, 1993), and Harris (1996) details squirrels and other rodents, as well as red forest hogs (*Potamochoerus porcus*), opening the fruits to feed on the seeds. It has also been reported that gorillas (*Gorilla gorilla gorilla*) eat the fruit (Howes 1948). Wild bees make honey from the nectar of *I. gabonensis* (Agwu & Akanbi 1985).

USES OF *IRVINGIA* SPECIES

Timber and wood

The timber of bush mango is used locally for construction (Leakey 1999b). Both species possess a fine-grained, hard, heavy timber (Ayuk et al. 1999), conferring strength and durability. The wood is also used for making poles and stakes (Ayuk et al. 1999), while live branches are made into walking sticks or thatched roof supports (Agbor 1994). Dead branches are used as firewood (Ayuk et al. 1999).

The fruit

The juicy fruit pulp of *I. gabonensis* is rich in vitamin C and is widely reported to be consumed as a dessert fruit or snack throughout Western and Central Africa (Ejiofor 1994; Leakey & Newton 1994; Vabi & Tchamou 1999; Vivien & Faure 1996). *I. gabonensis* pulp can be used for making jam, jelly and juice (Ejiofor

1994; Okolo et al. 1995). The fruit is sometimes also fed to pigs (Ayuk et al. 1999). The fruit pulp of *I. wombolu*, however, is bitter and tastes of turpentine, so it is not edible (Ejiofor 1994).

The seeds

The kernels of *I. gabonensis* and *I. wombolu* are classed as oilseeds (Leakey & Newton, 1994). *Irvingia* kernels form an important part of the West and Central African diet, providing carbohydrate and protein (Onyeike et al. 1995). The kernels are highly valued for the slimy consistency they produce. Okafor (1975) notes that while kernels from both *Irvingia* spp. are used in soup-making, *I. gabonensis* kernels can only be used when fresh, since they become too mucilaginous over time. Agbor (1994) reports that the kernels may be roasted to enhance their flavoring effect, and that crushed pieces of the roasted kernels may be used in frying vegetables. The kernels of *I. wombolu* are consumed by the Baka pygmies in southeast Gabon (Vivien & Faure 1996) and have a slightly bitter after-taste, although their overall flavor is not unpleasant (Howes 1948). The kernels of both species are ground with a pestle and mortar or on a stone into a paste or cake called "dika bread" (also known as *odiko*), which is used as a soup, stew or sauce additive, for flavoring and thickening (Agbor 1994; Leakey & Newton 1994; Vivien & Faure 1996). Dika bread may be sun-dried so that it can be stored (Vivien & Faure 1996).

Fat extracted from the kernels can be used for food applications, such as margarine or cooking oil, and is also suitable for soap, cosmetics and pharmaceuticals (Ejiofor et al. 1987). Flour can be produced from the kernels, but degrades within 6–9 months unless defatted. Defatted flour is still acceptable in terms of its color, taste, texture and drawability after 9 months' storage in ambient conditions; moreover, it is more viscous and has greater emulsifying properties than non-defatted flour (Ejiofor et al., 1987). Due to its ability to form gels at a lower concentration than many other oilseed flours, Giami et al. (1994) conclude that *Irvingia* kernel flour would be very effective in many industrial food applications that require a thickening agent. Improvements in drawability and possible storage time have enabled the flour to be considered for a range of processed products, particularly *ogbono* cubes. These are produced by cubing and packaging the flour, thus giving them a longer shelf life, and are sold as a convenient cooking ingredient. Ejiofor (1994) recommends using flour produced by milling the seed testa in formulating feeds for livestock. The chemical composition of the seeds is presented in Appendix 3.

Other uses

Agbor (1994) states that the roots, leaves and bark of *Irvingia* spp. are used medicinally, yet does not specify their uses. Other sources report that *I. gabonensis* bark is mixed with palm oil for use in treating diarrhea and is taken by women to shorten their breast-feeding period (Ndoye and Tchamou 1994). It is also administered for colic and dysentery (Okolo et al. 1995) as well as for hernias and yellow fever and as an antidote to poison (Ayuk et al. 1999). Ndoye and Tchamou (1994) report that the bark has antibiotic properties for healing scabby skin and that, particularly when boiled, it can be given as a painkiller for toothache. Okolo (1995) investigated the analgesic properties of the bark after finding that the Mende tribe in Sierra Leone grind it and form it with water into a paste which they use directly on the skin for pain relief. They found that it contains a narcotic-type analgesic agent and may also contain a non-narcotic active agent.

Fresh bark can be used to confer a bitter taste to palm wine if pieces are kept in the wine containers during tapping (Ndoye and Tchamou 1994). Mbakwe (1983) documents that stems from *I. gabonensis* are among several species harvested by local people as "chewing-sticks," which are chewed to assist in dental hygiene. Finally, farmers have been known to collect leaves from bush mango trees as fodder for their animals (Ayuk et al. 1999).

Potential uses

Much of the potential for *I. gabonensis* and *I. wombolu* lies in the expansion of current uses, particularly of the kernels, to industrial levels. However, researchers have suggested some novel applications. *I. gabonensis* fruit can produce a good quality wine, comparable in color, flavor, sweetness and general acceptability with a select German wine (Akubor, 1996). The wine possessed 8.12% alcohol content after 28 days' fermentation in a trial set up by Akubor (1996). This seems like a viable future product of bush mango, particularly after the success of other African alcoholic drinks made from native fruits, such as Amarula, a sweet cream liqueur made from *Sclerocarya birrea* fruits.

Joseph (1995) lists the potential industrial applications of bush mango kernel fat, including cooking oil, margarine, perfume, soap and pharmaceuticals. He notes that once the fat has been extracted from the kernels, the residue still possesses the consistency and thickening properties required for soup-making, so there are no wasteful by-products from the fat extraction process; both the fat and the residue can be used. Aside from its role as a thickener, the residual kernel cake could also be used as a binder in food or pharmaceutical products (Joseph 1995). Ndjouenkeu et al. (1996) extracted the polysaccharides from *Irvingia* kernels and from an analysis of their properties concluded that they have potential as an industrial gum.

I. gabonensis seeds have been studied as a dietary fiber useful for reducing the hyperglycemic effects and lipid metabolism disruption caused by diabetes mellitus (Adamson 1996). Adamson (1986) found that giving diabetic patients a dose of "dikanut" preparation daily for 4 weeks reduced blood glucose levels to normal and additionally increased the activity of three ATPases that usually fall significantly below regular levels in diabetics. Dikanut could therefore be a suitable alternative to guar, another viscous dietary fiber that has been shown to have similar effects but is unacceptable to patients at the dosage necessary. These dietary fibers work by delaying gastric emptying and thus reducing the intestinal sugar absorption rate. The reduced rate improves the sensitivity of the tissues to insulin, resulting in increased glucose uptake. Omoruyi and Adamson (1994) attempted to establish how *I. gabonensis* alters the lipid metabolism of diabetics by examining the plasma and liver lipids of streptozotocin-induced diabetic rats after 4 weeks on a dikanut-supplemented diet. They found that the dikanut affected phospholipid distributions and concluded that this may be how it helps in the hepatic control of plasma lipids. Joseph (1995) also notes that dikanut could be employed as a substitute for easily hydrolyzed carbohydrates in diabetic foods.

CULTIVATION, HARVESTING AND PROCESSING

Growing *Irvingia* spp.

At present, many farmers maintain mature bush mango trees that are already growing on their land. They will also transplant wild seedlings onto their farm or grow up new seedlings (Ayuk et al. 1999). They select seeds from trees that are known to produce high yields of good fruit, either on their land or on a neighbor's. Alternatively, they may plant market-bought seeds. However, the most common source of new stock for cultivation is the forest (Tchoundjeu et al. 1999).

Germination of *I. gabonensis* seeds takes upwards of 14 days, first requiring that the seeds be extracted from the fruit and dried for at least 2 days. Okafor (1999) reports up to 80% germination rates for seeds treated in this way. However, bush mango trees grown from seed may take over 10 years to start producing fruit, and although growing seeds may be the easiest way to improve cultivation, farmers would like to see a financial return much sooner (Moss 1995). Faster propagation techniques are also needed to produce trees for the selection of desirable phenotypes, which can then be used for further breeding. Hence, it has been recognized that if *Irvingia* spp. are to be domesticated, and if production is to be increased, then faster

and more successful propagation methods are needed. Several workers have investigated different methods of propagation for *I. gabonensis* and *I. wombolu*.

Shiembo et al. (1996) experimented with different methods for growing cuttings taken from mature trees. They found that the best medium for rooting is sawdust or a similar organic substrate and that the cuttings must have a leaf area of at least 80 cm^2 to survive and grow well. Applications of auxins (IBA) make no significant difference to growth and therefore do not seem to be necessary. This technique is ideal for farmers in tropical Africa because it does not require electricity or piped water. However, according to Tchoundjeu et al. (1999), propagation by stem cuttings is notoriously difficult because the cuttings often do not root. They investigated a technique that they claim to be preferable—marcotting. In this technique, also known as air layering, the branch of a mature tree is bark-girdled and the girdled ring is wrapped in a damp medium, inducing rooting. Despite a low rooting success rate (30%) and an even lower survival rate (10%) this is still considered a useful propagation technique (Tchoundjeu et al. 1999). Rooting hormones, more careful handling of the rooted propagules, and initial growth under a non-mist propagator could all significantly increase the survival rate of the propagules.

A further vegetative propagation technique that has been successfully used for *Irvingia* spp. is bud grafting. Okafor (1999) claims that this method, where a bud is grafted from a mature tree onto a seedling, can reduce the fruiting age of the tree to 2–4 years, and also lower the height of the fruit set from 8 meters or more to 1–3 meters. Leakey et al. (2000), however, comment that this technique may not be as successful as propagation by stem cutting because of problems with grafting incompatibilities.

These studies into possible propagation techniques show that *Irvingia* spp. can be propagated by all of the common methods. In Nigeria, workers have detailed standard methods for growing *I. gabonensis* in nurseries (Leakey 1999a). Developing propagation techniques with high success rates and multiplication rates is crucial for the production of superior planting stock for farmers and for the domestication process. IRAD (Institut de la Recherche Agricole pour le Développement) and ICRAF (International Center for Research in Agroforestry) are currently researching improvements of existing propagation methods in Cameroon and Nigeria (Leakey et al. 2000).

Management and harvesting

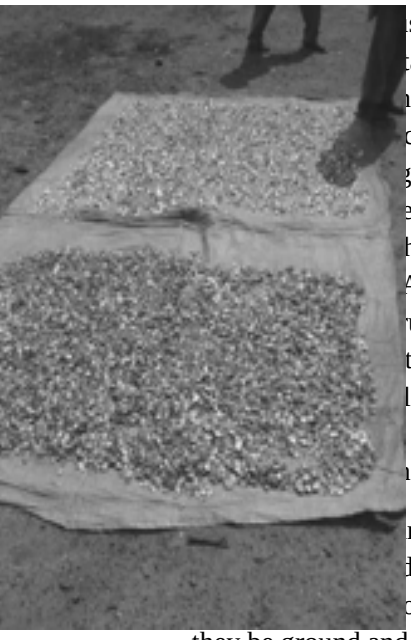
Farmers collect fruits from their own trees as well as wild and semi-wild forest trees. Cultivated trees are pruned and fertilized, and some pest control is carried out (Ayuk et al. 1999). Women usually gather the fruits, except when climbing is necessary (Ndoye et al. 1998). Vabi and Tchamou (1999), however, report that men in the Korup National Park of Cameroon join their wives in collecting bush mango when they are out trapping. Harvesting of fruits is sustainable and non-destructive, although Ndoye et al. (1999) point out that it may have a long-term effect on the tree and could affect the population structure of *Irvingia* spp. Although bark collection causes damage to the tree, the bark is not harvested in large quantities and collection does not significantly affect productivity.

Processing

There are several reported methods for the obtaining the kernels from *Irvingia* fruits. Ejiofor (1994) reports that traditionally the fruits are piled up in heaps and left to ferment before the seeds are extracted. According to Ladipo et al. (1996), either the seeds may be taken out wet from the fermented fruits or the fruit may be sun-dried first. As an alternative to fermentation, the fruits can be split open with a cutlass to reveal the hard seed inside (Ayuk et al. 1999).

Once the seeds have been collected they are dried, either in the sun or over a fire. They are then cracked open and a knife is used to remove the two white cotyledons (kernels). The kernels are dried further to remove all moisture and can then be stored or pro-

Bush Mango drying during processing



se in food (Ejiofor 1994; Joseph
tant that the kernels be fully dry,
g used immediately, because fresh
color and turn moldy. In southwest
go kernels are normally taken fresh
efore drying (Ladipo 1999). In
hree or four women meet to pro-
Ayuk et al. 1999), which are ex-
uits once they have already been
ther drying is necessary (Ladipo
l. (1996) lament that all the meth-
extraction are difficult, hazardous
g.

re ground with a pestle and mortar
l to food (Agbor 1994). Potential
ons of *Irvingia* kernels require that they be ground and that the fat extracted on an industrial scale (Leakey 1999a). Grinding and fat extraction would involve processing machinery. Okolo (1994) describes a pilot plant for the grinding, fat extraction, mixing, cubing and packaging of kernels into ogbono cubes. He estimates that it could produce 20,000 cubes per hour and would require 256 metric tons of bush mango kernels per year.

Storage

The fresh fruits of *I. gabonensis* have a shelf life of less than 2 days if picked when ripe and not more than 10 days if harvested at the mature green stage, due to high respiration rate, moisture loss and microbial attack (Joseph & Aworh 1991, 1992). Poor storage conditions and handling, as well as pest attack, disease and deterioration, contribute to high losses of saleable fruit.

Initially, Joseph and Aworh (1991) tried to lengthen the shelf life of mature green bush mangoes by refrigerating them at 12–15ºC, a common method for delaying ripening. However, this resulted in chilling injuries such as pitting and black spots. Such damage would reduce saleability considerably, making this an unviable option for storage. They then trialed several other post-harvest storage methods, including dipping, wrapping, and waxing the fruit, to see which was the most effective (Joseph and Aworh 1992). They found that the longest shelf life resulted from briefly submerging the fruits in a hot sulfite dip (commonly used in the food industry) and then wrapping them in PVC film. Hot water or other hot chemical dips used in conjunction with waxing or packaging in wrapped boxes were also effective combinations for enhancing shelf life at 22–35ºC and 70–95% relative humidity, normal storage conditions in Africa.

Stored *Irvingia* seeds keep for up to a year (Ndoye et al. 1999), but are susceptible to pests. One major pest is the merchant grain beetle (*Oryzaephilus mercator*), which lays its eggs between the testa and cotyledons of the seed or in cracks in the cotyledons, so that when the larvae hatch they can consume the cotyledons (Dudu et al. 1998b). The testa could be fully removed to reduce the number of preferred oviposition sites, but this may allow other pests to attack. More careful handling of the seeds to prevent cracks will both help to prevent merchant grain beetle infes-

tation and keep the value high, since damage reduces sale price. The beetle has a long life span as well as fast population growth, so it is essential that its presence be detected early to prevent huge losses. Dudu et al. (1998b) suggest that a diethyl ether extract of *I. gabonensis* could be used to attract the beetle, either to detect it or to attract it away from stored oilseeds, including *Irvingia* seeds themselves.

The various products of *Irvingia* kernels have differing length shelf lives. The sauce made from fresh kernels can be kept for 3 or 4 days, while the "dika bread" paste made from crushed, dried kernels can be stored for over a year (Ndoye et al. 1999). The fat extracted from the *I. gabonensis* kernels has been stored for more than a decade with no adverse changes in its properties because it contains natural antioxidants that hinder oxidative decay (Okolo 1994).

Quality control

Irvingia kernels are the most important product of the bush mango tree. As trade increases, quality standardization will become central to setting prices for producers and traders. Ladipo (1999) suggests four quality classes (A–D) for bush mango kernels, based firstly on visual characteristics—including the size and thickness of the kernel, its color and the extent of damage or blemishes—and also on qualities such as oil content, flavor and consistency. All of these qualities affect the kernels' primary use in cooking and determine the value of the kernels to the consumer. Ladipo (1999) notes that the *I. gabonensis* kernels are often mixed with those from *I. wombolu* due to the abundance of *I. gabonensis*, but since they are less desirable than *I. wombolu* kernels they reduce the overall value. Therefore he emphasizes the importance of separating the two species to maintain high market prices.

MARKETS AND TRADING

Introduction

Irvingia trees are a valuable source of income for West and Central African farmers. The fruits are sold, but

Table 1. Mean annual production estimates (in kg/grower or collector) and value of production (in CFA francs/kg) of *Irvingia gabonensis* fruits and seeds in the humid lowlands of Cameroon. Source: Ayuk et al. (1999).

Mean annual production	Division					
	Lekié		Haut Nyong		Mvila	
	Fruits	Seeds	Fruits	Seeds	Fruits	Seeds
Total	112	32	835	27	165	110
Sales	23	15	328	12	90	56
Consumption	54	17	456	15	73	49
Other (e.g., gifts)	35	0	51	0	2	5
Value:						
Start-of-season price	130	705	25	230	135	695
Mid-season price						
End-of-season price	40	300	15	135	45	355
	80	585	10	230	70	325

by far the most important product is the kernels, which fetch a price several times higher than the fruits (Ayuk et al. 1999). The trade in kernels not only benefits the producers financially, but also generates income for traders. *Irvingia* kernel markets extend to local, regional and international levels, and there is even intercontinental export. ICRAF (cited in Ladipo 1999) reported that in 1975 the market for kernel products was worth in the region of US $50 million. This market is still growing.

Production levels and sales price

Fresh fruits of both *I. gabonensis* and *I. wombolu* are marketed locally where they are produced and are traded to non-producing areas. Agbor (1994) found that prices were higher in non-producing areas of Nigeria than in producing areas, as would be expected. In producing areas, *I. gabonensis* fruits were more expensive than *I. wombolu* fruits; however, in non-producing regions this situation was reversed. Agbor (1994) reports that the value of fruits increased immensely between 1986 and 1994. In some northern areas of Nigeria, he notes, prices are astronomical, due not to low fruit production but to the absence of sufficient storage facilities and the high costs of transportation. In the Korup National Park, in Cameroon, difficulties in transporting bush mango fruits to the suburban markets because of nearly impassable roads during the peak season reportedly reduced the prices that producers received (Vabi & Tchamou 1999).

Since *I. wombolu* kernels are preferred for cooking over those of *I. gabonensis*, farmers should earn a higher income from *I. wombolu* trees. According to Ndoye et al. (1998), however, there is presently no distinction between the two species' kernels on the market. This is likely to change as quality controls are introduced (Ladipo 1999). A farmer can expect to earn about US $300 annually through kernel sales from a mature *I. wombolu* tree (Uzo 1980, cited in Okolo 1994).

Despite the high value of the products, however, production is generally at the subsistence level (Agbor 1994). In a study in the south of Cameroon, for example, van Dijk (1999) found that only 20% of the bush mango harvest was sold, yet Malleson (1999) reports that forest spices, including *Irvingia* spp., are the main income generators for women in the Korup Forest of Cameroon. It seems that although farmers only sell a small percentage of their harvest, those sales alone account for a relatively large proportion of their annual income. This low level of marketing of *Irvingia* products is due to a lack of bush mango trees in the area and hence an inadequate supply of produce (Agbor 1994).

The price that producers get for *Irvingia* fruits and kernels depends on the location of the market and fluctuates greatly with seasonal availability. Ayuk et al. (1999) collected data from three divisions in the humid lowlands of Cameroon to gauge the economic value and potential of *I. gabonensis* products, as seen in Table 1.

These figures show the extent of price variation over the season—high prices at the start when availability is low, then reduced prices as the quantity of product increases, and finally a price increase as the products become scarce at the end of the season. Leakey (1999b) also reports that the price of kernels in West Africa varies with the season between £1 (≈US $1.6) and £3 (»US $4.8) per kg. Ndoye et al. (1998) examined the sales value of *Irvingia* spp. in 28 markets in the humid forest zone (HFZ) of Cameroon and found that over 29 weeks, the total value of sales was 34,633,100 CFA francs (» US $70,000). The margins gained by the traders were 30% of the total value of sales. These high market values are repeated in Rio Muni, Equatorial Guinea, where Sunderland and Obama (1999) report that *Irvingia* spp. seeds are sold more widely than any other forest product. Again, sales and prices are greatly influenced by the seasonal availability of bush mango seeds. Sunderland and Obama (1999) state that in June–September, when *Irvingia* products are in season, 100 CFA francs will buy 40 seeds, whereas during September–December,

at the end of the season, the same money will only buy 20 seeds.

Although fresh kernels are highly seasonal, the production of dried kernel cake (*odika*) ensures that bush mango is available all year round. Moss (1995) reports that odika is traded from the Côte d'Ivoire to the Congo. He found that in February 1994, a 100 kg sack of odika was selling at US $76 (US $0.76/kg)

Bush Mango is an important part of food security in Central and West Africa

wholesale in Libreville, Gabon, while in Bitam the retail price was US $1.51 per kg. Yembi (1999) also reports from Libreville that 100 to 5,000 grams of odika can be purchased for 1,000 to 25,000 CFA francs. Agbor's 1994 study in Nigeria, which recorded sale prices for dried and fresh *Irvingia* seeds, discovered that seeds follow the trend of odika, being more expensive in the dry season than in the rainy season. In addition, irrespective of season, dried seeds are more expensive than fresh seeds.

Bush mango is important to the food security of Central and West African people (Ayuk et al. 1999) and unless productivity is increased, there will not be a large enough surplus over the subsistence needs to meet the demand for *Irvingia* products in the markets. Vabi and Tchamou (1999) emphasize this point and state that only when food security is improved will there be a base from which farm income can be increased.

Local and regional markets

The marketing system for *Irvingia* products is described in detail by Agbor (1994). Initially, produce is bought from the producers by country buyers and then sold to wholesale distributors, who, in turn, sell to retailers. There is a demand for *Irvingia* products in urban areas as well as in the country, and much of the trade focuses on moving produce from rural areas into the towns and cities. Where the demand in a country cannot be met, produce is imported from neighboring countries. Products may pass through the hands of several intermediaries before reaching the retail markets, so retail prices are high to accommodate the profit taken by each middleman.

Since this informal marketing system is already in place, increases in production should find no problems with market structure, and it will not be necessary for governments to create a formal system (Moss 1995). It may be beneficial to consumers to reduce the number of intermediaries to a minimum in order to keep prices down, but on the other hand the *Irvingia* trade could support large numbers of wholesale and distribution workers and this may be preferable to lower retail prices.

International markets

The international trade in *Irvingia* kernels has resulted in even higher profit margins for traders (Ndoye et al. 1998). There is a lack of statistics on the volume of international trade, but the trade routes for *Irvingia* spp. are widely known. Cameroon is a major producer, exporting to Gabon and Equatorial Guinea in particular (Ndoye et al. 1998; Sunderland and Obama 1999). Equatorial Guinea in turn supplies kernels to Gabon (Sunderland and Obama 1999; Yembi 1999). Ayuk et al. (1999) report that in West Africa the main exporters are Cameroon, Nigeria and Côte d'Ivoire,

trading to Gabon, Nigeria, Liberia and Sierra Leone. The demand for kernels in southern Nigeria alone is around 80,000 tons per year (Ndoye et al. 1999) and this country serves as both a source and destination for trade.

The export of *Irvingia* products to other continents has already begun. Ladipo (1999) mentions the sale of processed kernels to the United Kingdom and North America, and Tabuna (1999) reports on the trade to Europe. According to Tabuna (1999) there are markets for African NWFPs in France and Belgium which supply African immigrants with bush mango kernels, mainly from Cameroon and Congo. He estimates that there are 100,000 potential consumers in this market. The kernels that are imported are evidently the dried variety, since Tabuna (1999) reports that they are available year-round. This intercontinental trade not only generates higher revenue for producers and traders in Africa, but also creates employment for traders in the destination countries.

Economic potential

Reports in the *Irvingia* trade indicate that *Irvingia* is a very popular product, which is becoming increasingly scarce as productivity fails to keep up with increasing demand. The potential and demand for large-scale production is high, and Agbor (1994) argues that it would have significant positive effects. Firstly, if the volume of trade increases, market efficiency will also increase due to improvements in infrastructure, particularly since governments will be more willing to provide suitable roads, water and storage facilities. Secondly, the economy will be further enhanced by greater demand for labor, packaging plants and other industrial products required in the *Irvingia* trade.

Agbor points out, however, that for large-scale production to occur, farmers will need credit to spend on improvements to existing production methods. This creates a vicious circle: farmers require more funds to increase production, and governments are only likely to help if the volume of trade is greater than it is at present. Thus it is important that the potential of *I. gabonensis* and *I. wombolu* be recognized now and a case made for domestication and improvements to the current trade system, so that the producers can be assisted in raising production to meet demand.

Sunderland and Obama (1999) reiterate that there is high and increasing demand for NWFPs in Central Africa, bush mango included. Ladipo (1999) also describes the market for *Irvingia* kernels as growing steadily. The promotion of *Irvingia* products, particularly new products and those that are under-exploited at the moment, will increase the sale of bush mango even further. Ladipo (1999) even considers that the development of *Irvingia* kernels as a product could be a model case for the development of other African NWFPs.

SUSTAINABILITY ISSUES

Constraints to *Irvingia* spp. promotion

The constraints on the development of *Irvingia* products are applicable to most NWFPs. Firstly, research is crucial to the development of bush mango as a product and for domestication of the species. The problem lies in the fact that tree crops do not clearly fall within the purview of forestry, agronomy or agroforestry bodies (Moss 1995). Unless the confusion over funding for research is resolved, this could hinder the progress of development. Secondly, as Agbor (1994) points out, there are local and imported substitutes for *Irvingia* kernels that are currently cheaper. As long as *Irvingia* can be shown to be a viable competitor on the market in terms of its quality and cost, then larger-scale production is possible. Thirdly, the labor and time involved in harvesting are likely to constrain the number of trees that each farm can maintain. Improved kernel extraction methods would reduce this problem (Van Dijk 1999). Finally, farmers may be unwilling to invest in bush mango trees unless they are guaranteed a price for the produce. Unfortunately, if many farmers began to produce *Irvingia* products on a large scale, then supply

could exceed demand, causing prices to fall. It may be necessary for governments to offer incentives, such as fixed minimum producer prices, to expand current production of *Irvingia* (Agbor 1994).

Suitability of *Irvingia* spp. for agroforestry

Farmer preference surveys conducted by ICRAF have identified *I. gabonensis* as the top indigenous fruit for domestication (Leakey and Newton 1994). In a study of under-exploited tree crops, Moss (1995) also concluded that bush mango was one of two species that presented the best opportunities for development intervention. Leakey (1999b) lists *I. gabonensis* among the "Cinderella" species—trees that are ideal for agroforestry because they are already recognized by local people and found in local markets, and because they are indigenous and therefore well adapted to the region.

Irvingia spp. have positive effects on the soils in which they grow. For example, they reduce soil bulk density and increase levels of organic carbon and exchangeable potassium and magnesium ions (Kang et al. 1994). This makes them very suitable for use as agroforestry trees in a multi-story crop setup. One of the major incentives for selecting *Irvingia* to be developed for agroforestry is that a huge amount of variation exists within the two species that can be exploited for selection of superior breeding specimens. Tchoundjeu et al. (1999) list variations in the fruit (quality, taste and size) as well as in the size of the kernels, the timing of fruit production and the maturation process as important characters with the potential for improvement. Leakey and Newton (1994) also comment on the high likelihood of favorably altering the season and pattern of fruiting and increasing the yield of trees such as *I. gabonensis*.

Farmer knowledge is very important in the selection of trees with potentially suitable genotypes for further breeding. Malleson (1999) and Okafor (1999) both emphasize the need for ethnobotanical information to be used in directing sustainable forest management and agroforestry. Farmers know a great deal about the individual *Irvingia* trees on their land, and this knowledge will greatly aid tree selection. Moss (1995) reports that farmers in Gabon are able to identify which trees bear large fruit, which fruit early and which are consistent in fruiting each year, among other useful characteristics. In summary, both *I. gabonensis* and *I. wombolu* are very favorable for agroforestry and have enormous potential.

Potential due to genetic variation

If *I. gabonensis* and *I. wombolu* are to be improved as agroforestry trees and potentially domesticated, natural variation between trees must be recognized and utilized. Only characters that are determined genetically are of interest, since only these are heritable. Akubor (1996) describes existing bush mango trees as slow-growing and poor-yielding, and Moss (1995) identifies slow maturation as an impediment to the choice of *Irvingia* spp. for planting. Nevertheless, as described in the previous section, *Irvingia* spp. have great potential for improvement due to the extent of natural variation in the species. The amount of variation available has been revealed partly from observations of existing trees and partly from studies of genebank specimens.

Three live genebanks for *I. gabonensis* and *I. wombolu* have been created, containing seeds considered by farmers in Gabon, Cameroon and Nigeria to be from superior trees. These germplasm collections are at Mbalmayo in Cameroon and at Ibadan and Onne in Nigeria (Tchoundjeu et al. 1999). Knowledge of the genetic variation of the bush mango species resulting from studies of these collections will allow genotypic selection of individuals for vegetative propagation, as suggested by Ladipo et al. (1996), to promote the domestication process. Studies of genetic diversity in *I. gabonensis* and *I. wombolu* are possible using seven nuclear cleaved amplified polymorphic sequences (CAPS) that were found by Lowe et al. (1998) and which are suitable for phylogeographic analysis. Leakey et al. (2000) report that Lowe and his co-workers (Lowe et al. 2000) have found the center of genetic diversity for each *Irvingia* species, which for *I.*

gabonensis is around Ebolowa in southern Cameroon and for *I. wombolu* is in southeast Cameroon and western Nigeria.

Desired characteristics of bush mango

According to Leakey (1999a), characteristics that farmers would like to see improved include fruit quality and yield, earlier maturation of the trees, a longer period of fruit availability and reduced tree height. Okafor (1999) lists the desirable characteristics of *I. gabonensis* and *I. wombolu* as fruit size, high fruit yield, good flavor, lack of fibrousness and a shortened time to reproductive maturity.

Table 2. Fruit and kernel ideotype characters for *I. gabonensis*. Source:Leakey et al. (2000).

Fruit Ideotype	Kernel Ideotype
High values for: Flesh depth Fruit weight Good taste Low fibrosity	*High values for:* Kernel weight Shell brittleness Drawability

Leakey (1999b) notes that as well as identifying the traits relevant to farmers, it is also important to consider qualities that are advantageous for specific products in the food industry, or indeed for other applications. It should be noted that farmer's presumptions about attributes are not always correct. Leakey et al. (2000) discovered that, contrary to the predictions of farmers, fruit weight and size do not correlate with kernel weight and size. Hence careful studies of the relationships between different traits are necessary to ensure that the characters that are used for selection will result in superior individuals. Leakey and his team have recommended several qualitative characters for use in the assessment of genetic variation in the fruit and kernels of *I. gabonensis* and have defined these as the "ideotypes" for the production of fresh fruits and kernels.

Leakey et al. (2000) consider that separate "fruit" and "kernel" ideotypes are useful to enable trees to be identified that produce fruits either for consumption or for kernel extraction. Additionally, the kernel ideotype could be subdivided to distinguish kernels that are good for cooking from oil-rich kernels suitable for the production of vegetable oil. In their study, they found that in a small sample of *I. gabonensis* trees from Cameroon, there were individuals that tended towards either the fruit or kernel ideotype. The conclusion is that ideotype selection is possible for this species and would be beneficial to the domestication process (Leakey et al. 2000).

One trait in particular could have a huge impact on the ease of extracting bush mango kernels. Ladipo et al. (1996) report the finding of a tree in northern Gabon that has self-cracking seeds, resulting from unusually early splitting of the tough endocarp, which would normally happen later during germination. The kernels of these seeds can be extracted much more easily than from regular seeds, considerably reducing the labor required for kernel processing (Tchoundjeu et al. 1999). However, these self-cracking seeds have only been documented twice and therefore appear to be rare (Leakey 1999b). Nonetheless, if this trait could be bred into trees for cultivation, it would have enormous benefits for farmers.

CONCLUSIONS AND RECOMMENDATIONS

Species and habitat vulnerability

At present, *I. gabonensis* and *I. wombolu* are widespread in West and Central Africa and would not be considered to be endangered species. Bush mangoes are maintained on tree and field crop farmland (Ayuk et al. 1999), and due to their valuable produce are unlikely to be cleared from this niche. However, the

natural habitat for *Irvingia* spp., humid lowland forest, is being cleared for agricultural land, and its products are often over-exploited. If wild *Irvingia* trees are lost, this will put an even greater strain on the limited produce of cultivated trees. In addition, potentially valuable genotypes could be lost, and an important source of seedlings would be depleted (Ladipo et al. 1996). So, although the bush mango itself is not yet greatly threatened, its habitat needs to be protected to preserve the genetic variation in the two species and to prevent the trees from becoming endangered.

Possible government action

There are several ways in which West and Central African governments can act to promote the development of *Irvingia* production and markets (Agbor 1994):

- Introduce policies for guaranteed minimum producer prices and the purchase of surpluses to provide an incentive for farmers to increase productivity;
- Develop road, water and storage systems to improve the infrastructure for production and trade;
- Fund research into all relevant aspects of *Irvingia*, particularly those that are currently poorly understood;
- Distribute knowledge about *Irvingia* to farmers, with emphasis on the importance of these species;
- Establish *Irvingia* farmers' associations and minor crops marketing boards, as suggested by Ladipo et al. (1996), to increase the promotional possibilities for *Irvingia* products, both in Africa and to other continents.

Gaps in the present knowledge

One little-known major area is the trade of *Irvingia* products. There are few statistics available to quantify the volume and value of trade, locally, regionally or internationally. Clearly, it is important that studies to improve our understanding of the *Irvingia* markets be carried out (Ayuk et al. 1999), particularly so that the marketing potential of new or presently under-exploited products can be quantified.

Some aspects of the biology of *I. gabonensis* and *I. wombolu* have not yet been fully described— for example, the mating systems and other details of the reproductive ecology. The extent of genetic variation both within and between *Irvingia* populations has not been fully assessed, although studies have begun (Leakey et al. 2000). It is critical that the current genetic studies be continued to identify the patterns and potential of genetic variation.

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APPENDIX 1: BOTANICAL DESCRIPTIONS (ADAPTED FROM HARRIS 1996).

Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.

Trait. Bot. Méd. Phan. 2:881 (1884).

Synonyms: *Mangifera gabonensis, Irvingia barteri, I. caerula, I. duparquetii, I. erecta, I. griffoni, I. hookeriana, I. tenuifolia, I. velutina, I. gabonensis var. gabonensis* (Harris 1996, Vivien and Faure 1985).

Tree 10–40 m tall; buttresses to 3 m high; straight and unbranched (in wild trees); crown approximately spherical or taller than wide; foliage dense and dark green. Leaves elliptic; apex tapering or occasionally with a barely discernible acute acumen; base acute to cuneate; length 4.5–8 cm, width 2–4 cm (canopy leaves from mature wild trees); secondary, tertiary and quaternary venation obvious, areolae greater than 1 mm diameter. Inflorescence axillary, laxly branched panicle to 9 cm long. Flowers in fascicles; pedicels to 5 mm long; sepals 1–1.5 mm; petals yellowish white; 3–4 mm long; filaments 4–5 mm long. Fruit ellipsoid to cylindrical, occasionally almost spherical, only slightly laterally compressed; length 4–6.5 cm, width 4.2–6.4 cm, thickness 3.4–6 cm; smooth; green when ripe; mesocarp bright orange, soft and juicy when ripe with a few weak fibers, fibers appressed and curly, or absent on old pyrenes; taste of mesocarp from sweet to slightly bitter with a turpentine flavor but always edible; pyrene single, woody but usually disintegrating after one season on the ground. Seeds 2.5–3.8 cm long, 1.7–2.7 cm wide, 0.8–1.2 cm thick; endosperm visible on fresh material as a white dot 2–3 mm diameter on the inside of the testa opposite the point of attachment of the two cotyledons; this sometimes extends to form a white streak 1–2 mm broad, running parallel to the axis of each cotyledon, on the inside of the testa. Seedlings with purple to red cotyledons, hypocotyl and stipules; first pair of leaves opposite and stem pale green to purple.

Irvingia wombolu **Vermoesen**

Man, Ess. For. Congo Belge: 136 (1923).

Synonyms: *Irvingia gabonensis* var. *excelsa, I. gabonensis* var. *wombolu* (Harris 1996).

Tree to 25 m tall; buttresses to 2 m high; bole often slightly leaning; first branch usually at 7–10 m, foliage regular, not as dense as *I. gabonensis*. Leaves elliptic to obovate, at least some leaves distinctly obovate; apex rounded often with a barely distinct blunt acumen; base obtuse to acute, occasionally very shortly cuneate; length (6.5–)10.5–14(–18) cm, width 4–6(–8.5) cm; often drying blackish or greyish green; secondary, tertiary and quaternary venation obvious, areolae greater than 1 mm diameter. Inflorescence a laxly branched panicle, to 9 cm long, axillary and on older twigs. Flowers crowded together at the end of the inflorescence branches or in fascicles; pedicels to 6 mm long; sepals 1 mm; petals, whitish, 3–4 mm long; filaments 5 mm long; disc bright yellow, diameter 2–3 mm. Fruit ellipsoid, only slightly compressed laterally; length 4.5–5.8 cm; width 4.5–5 cm, thickness 4.3–4.8 cm; green on falling, often turning bright yellow and then black as the mesocarp starts to rot; mesocarp soft and juicy when ripe, fibers more obvious than in *I. gabonensis* but not as numerous nor stiff as those of *I. excelsa*; mesocarp very bitter and completely inedible. Seeds 3.5–5 cm long, 1.7–2.6 cm wide, 8–10 mm thick; endosperm barely visible on fresh material as a white to almost translucent layer less than 0.5 mm thick, covering most of the inside of each half of the testa, in a split-open seed.

APPENDIX 2. LOCAL NAMES

Irvingia species are commonly known as the African mango, dikanut, bush mango or wild mango, which in French (spoken widely in Western and Central Africa) is *mangue sauvage*. There are many local names for *I. gabonensis* and *I. wombolu*, some of which are listed in Table 1 and Table 2. The kernels of these species also have various local names: in Nigeria, they are "ogbono" in Ibo and "apon" in Yoruba (Ladipo *et al.* 1996). Dudu *et al.* (1998a) report that Nigerians distinguish between kernels from *I. gabonensis* and *I. wombolu*, referring to the former as "ugiri" and the latter "ogbono." The paste produced from the kernels in Gabon is termed "dika bread," while in Cameroon it is "etima" (Ndoye *et al.* 1999). Moss (1995) notes that the kernel cake is called "odika" in Northern Gabon. Tabuna (1999) reports use of the name "malombo" for *Irvingia* species kernels traded to Europe.

Table 3. Local names for *Irvingia wombolu*, from Vivien & Faure (1996) and Vivien & Faure (1985) and from herbarium specimen descriptions.

Local Name	Tribe/Country
Ewewe	Bolon, Gabon
Mbolu	Bamindjere
Moboulou	Bibaya Pygmies
Ogwi	Benin
Olili	Turumba
Ossim	Kiaka
Payo	Bibaya Pygmies

Table 4. Local names for *Irvingia gabonensis*, collated from Ake Assi (1991); Vivien & Faure(1996); Vivien & Faure (1985; Ndoye& Tchamou (1994) and Tabuna(1999) and from herbarium specimen descriptions.

Local Name	Tribe/Country
Aadok	Cwondo
Abisibou	Ny
Aiyaiyon	Kiaka
Ando	Mvae
Ando'o	Bulu (or Boulou)
Andok	Bolon, Fang, Gabon
An-Gbere	Temne
Bè	Akyé
Boboi	Mende
Borborou	Abbey, Côte d'Ivoire
Boubwé	Bateke
Bulukutu	Cameroon
Bush mangolo	Bangangte
Bwiba bambale	Dogose
Ebi	Central African Republic
En'doe	Boulou
Eniok	Congo
Kaklou	Baoulé
Kakourou	Gouro
Kplé	Guéré
Mangoron Kurmi	Hausa
Miba	Douala
Mwiba	Bassa
Ndoka	Bassa
Nijaka	Douala
Nouak	Maka
Ntwa	Baka Pygmies
Ogbono	Ibo
Ogui	Benin
Ogwe	Nigeria
Oro	Nigeria
Oroapon	Yoruba
Ororgbije	Yoruba
Péké (or pékié)	Bibaya Pygmies, Maka
Sakossou	Bété
Uyo	Efik
Wiba	Bassa

APPENDIX 3. SEED COMPOSITION

The composition of *Irvingia* species seeds has been well studied, since they are the most valuable product of the tree and have the most industrial potential. Although the two species' seeds differ in their composition, the differences are not always found to be significant and some studies fail to identify which species is being analyzed. This is particularly so for those that were undertaken before *I. wombolu* was recognized as a separate species; in some cases, figures given for *I. gabonensis* are actually for *I. gabonensis* var. *excelsa* (*I. wombolu*). Onyeike *et al.* (1995) report that the crude fat content of *I. gabonensis* seeds is 62.25% ±0.55, proving them to be "very good oil seeds."

Table 5. Approximate composition (%) of fresh kernels of *I. wombolu* (*I. gabonensis* var. *excelsa*). Source: Ejiofor (1987, cited in Ejiofor 1994).

Moisture	Fat	Total carbohydrate	Ash	Crude Protein	Crude fiber	Vitamin C (mg/100g)	Vitamin A (mg/100g)
11.9	51.32	26.02	2.46	7.42	0.86	9.24	0.63

Table 6: Amino acid composition of *Irvingia gabonensis*, values in g/16gN Source: Amubode and Fetuga (1984)

%CP	Trp.	Lys.	His.	Arg.	Asp.	Thr.	Ser.	Glu.	Pro.	Gly.	Ala.	Val.	Met.	Cys.	Ile.	Leu.	Tyr.	Phe.
35.5	1.3	4.9	3.4	10.9	12.1	3.5	3.9	18.8	5.0	5.3	5.3	5.5	1.8	2.4	6.3	7.5	3.8	5.0

(CP = crude protein; Trp. = tryptophan; Lys. = lysine; His. = histidine; Arg. = arginine; Asp. = aspartic acid; Thr. = threonine; Ser. = serine; Glu. = glutamic acid; Pro. = proline; Gly. = glycine; Ala. = alanine; Val. = valine; Met = methionine; Cys. = cystine; Ile. = iso-leucine; Tyr. = tyrosine; Phe. = phenylalanine). Source: Amubode and Fetuga (1984)

Table 7. Lipid composition of *Irvingia gabonensis* seeds, values in mg/g. Source: Omogbai (1990).

Total lipids (mg/g DM)	FA	TG	MGDG	DGDG	SL	PG	PC	PE	PI	DPG	Yield (%)
658 ± 1	8 ± 4	913 ± 3	5 ± 3	10 ± 1	10 ± 2	8 ± 2	25 ± 2	2 ± 1	8 ± 1	10 ± 1	99.2

(FA = unesterified fatty acids; TG = triacylglycerols; MGDG = monogalactosyldiacylglycerol; DGDG = digalactosyldiacylglycerol; SL = sulphoquinovosyldiacylglycerol; PG = phosphatidylglycerol; PC = phosphatidylcholine; PE = phosphatidylethanolamine; PI = phosphatidylinositol; DPG = diphosphatidylglycerol; Yield = sum of weights of individual lipids expressed as a percentage of the weight of the total lipid taken for fractionation).

Table 8: Fatty acid composition (% of total lipids) of the seeds of *Irvingia gabonensis*. Source: Omogbai (1990).

C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:1	Others
1.0	14.6	5.5	8.6	20.5	21.5	21.3	1.3	5.7

Chapter 3
ERU
(*Gnetum Africanum* and *G. Buchholzianum*)

Laurie Clark, Stella Asaha, Nouhou Ndam and Paul Blackmore

INTRODUCTION

Gnetum africanum Welw. and *G. buchholzianum* Engl. are evergreen, leafy vines that grow across the Congo Basin in forest openings, secondary forest, fallow farmlands and, at times, in active mixed-crop farmholdings. Historically, the products of these vines have been consumed primarily by specific ethnic groups, and *Gnetum* was believed to be otherwise little known (Poubom Ngundam 1997). However, in recent times it has become far more visible. Improvements in physical infrastructure and increased movement of people around the nations of Central Africa, together with continuing trade, has raised consumption of *Gnetum* dramatically (Mialoundama 1993). The spread of the use of *Gnetum* in African cuisine echoes demographic movements, and in the sense that people take their culinary habits with them when they migrate, its use serves as a sign of national or ethnic identity (Mialoundama 1993).

Its apparent obscurity may also simply be due to the fact that the research and development community has not been aware of the extent to which people traditionally consumed *Gnetum* in Africa. Chevalier (1951c) points out that the indigenous name "koko" is applied from Bangui to Angola, a distance of 3,000 km. This hardly implies a little-known resource. Rather, it seems that botanists, anthropologists and other researchers have failed until recently to circulate information about the cultural uses of *G. africanum* and *G. buchholzianum* plants across the Central African region.

In many places, the consumption of indigenous vegetables is often seen as a sign of poverty, and they are considered low-status foods. This is not the case in Cameroon, however, where indigenous foods compete very well with introduced crops, and consumption continues to grow (Poubom Ngundam 1997; Gockowski and Ndumbe 1997). Indigenous crops forming the heart of local cuisines are also very popular in Nigeria and Central African Republic (Sunderland 2001; Ndonazi and Ziallo 2000). *Gnetum* is now one of the most commonly consumed plants found growing wild in Central Africa. It plays a significant nutritional and social role across the region and is consumed by people of all social strata (Mialoundama 1993).

TAXONOMY AND ECOLOGY

Taxonomy

Gnetaceae is represented by a single genus, *Gnetum*, that contains 28 species distributed throughout Indomalaysia, Fiji, northern South America and West and Central Africa (Mabberley 1987; Maheshwari and Vasil 1961). *G. africanum* and *G. buchholzianum* are the only two species within the family Gnetaceae that occur in Africa (Hutchinson and Dalziel 1954). Although some species occur as trees and shrubs, the African taxa are lianas (Carlquist and Robinson 1995; Mabberley 1987; Maheshwari and Vasil 1961).

The Gnetaceae constitute one of three genera within the order Gnetales, the other two being the Ephedraceae

and the Welwitschiaceae. The Gnetaceae are of particular interest as, uniquely, they exhibit characteristics of both angiosperms and gymnosperms (Mabberley 1987; Maheshwari and Vasil 1961; Thompson 1916). This is shown by the fact that (1) vessels are present in the secondary wood, and (2) the reproductive organs are surrounded by structures that resemble a perianth (Carlquist and Robinson 1995; Lowe 1984). However, the ovules are not enclosed in an ovary, as is the case with angiosperms. This is particularly emphasized with tropical *Gnetum*; the broad leaves show netlike venation and look very much to be dicotyledonous plants with opposite leaves (Lowe 1984). Within the gymnosperms, *Gnetum* is the only genus with leaves commonly eaten by humans (Schippers 2000).

Life form

G. africanum and *G. buchholzianum* occur as two types of vines (Maheshwari and Vasil 1961): (1) nearly leafless autotrophs that grow rapidly, climbing vertically to reach the upper canopy, and (2) side shoots with fully developed leaves. Mialoundama (1979) found that the two types of vines show distinct growth characteristics in *G. africanum*. The autotrophic form is characterized by the production of side shoots used to climb, long internode distances, leaves that are reduced to scales, and continuous growth. The side shoots growing off the autotrophs form the leaves that are consumed as a vegetable (Schippers 2000). These side shoots have fully developed photosynthetic leaves whose growth proceeds in spurts of about 20 days, followed by a resting period of three months. Each growth spurt is accompanied by the production of a pair of leaves and elongation of the internode (Mialoundama 1980).

Interestingly, removing all the leaves from the side shoot blocks the rhythmic pattern, permitting continuous growth. In contrast, removal of only some of the leaves allows the growth inhibitor to act, resulting in a period of three months' rest between growth spurts (ibid.).

Morphological differences between *G. africanum* and *G. buchholzianum*

The two species of *Gnetum* that occur in Africa are superficially very similar in appearance. However, as shown in Table 1, they can be distinguished by differences in leaf shape and reproductive organs (Shiembo 1997; Hutchinson and Dalziel 1954). In practice, traders of *Gnetum* differentiate between two "types" of *Gnetum*, which, in fact, correspond to the two species. *G. buchholzianum* has a softer, more perishable leaf than *G. africanum*, is perceived to be less palatable and commands a lower trade price (Sunderland 2001).

Table 1: Characteristics distinguishing *G. africanum* and *G. buchholzianum*

G. africanum	Internode of male spike of the same diameter throughout its length, slender in dried (or old) specimens. Staminal column exserted from the mouth of the envelope. Leaves ovate-oblong or elliptic-oblong , more rarely lanceolate, attenuate at base, abruptly acuminate, 10–13 cm long, 3.5–5 cm broad.
G. buchholzianum	Internode of male spike in the fresh condition much thicker at the base than higher up. Staminal column hardly exserted from the mouth of the envelope. Leaves ovate-elliptic or broadly elliptic, rounded or very slightly cuneate at base, abruptly acuminate, 9–14 cm long, 4–7 cm broad.

Adapted from Hutchinson and Dalziel, 1954.

Chromosome count

The haploid number of chromosomes for *G. africanum* is reported to be 12 (Pearson 1912, cited in Maheshwari and Vasil 1961: 123), while Waterkeyn (1959, cited in Maheshwari and Vasil 1961: 123) reports chromosome numbers between 20 and 25. Pearson (ibid.) also found *G. buchholzianum* to have 12 chromosomes.

Reproductive biology and phenology

Gnetum is dioecious (Maheshwari and Vasil 1961) and the flowers occur in whorls in spikelike inflorescences. These whorls are subtended by fleshy collars (Mabberley 1987). Though little studied, the look of the flowers—small greenish-brown, inconspicuous—suggest they may be pollinated by diverse small insects (van Dijk 1994; Putz and Mooney 1991). The pollen from male flowers borne on catkins is transmitted to the female catkins, which ultimately bear the fruit (Shiembo 1997). The catkins of wild and cloned *G. africanum* vines have the same diameter from the base to the top internodes, while those of *G. buchholzianum* taper from the base to the top (Hutchinson and Dalziel 1954).

Very little information is available on the fruiting and flowering periods of the African *Gnetum* species. However, herbarium records show flowering periods in the dry season. Male flower spikes have been found in Nigeria during September, November, December and January, and female in December, February, March, April and June. Boroubou (Boroubou 263, LBV!) collected flowers in October in Gabon, while in Cameroon, collections record flowers in January, April and June (Satabie 44711, YA!; Nkongmeneck 52338, YA!; Thomas 57715, YA!). However, it should be noted that the months corresponding to the dry and rainy seasons vary across the Central African region, so flower and fruit production is correspondingly variable.

Fruits and seeds

Ripe fruit tend to be hard to find, as they are often eaten by birds, bats and rodents before maturity and occur high in the tangled clumps of vines in the forest canopy (Schippers 2000). The fruit of both species is small, oblong, bright red and fleshy, with a single seed or nut inside (Schippers 2000). The seeds are about 1 cm long, first green, then turning red at maturity (Lowe 1984; Maheshwari and Vasil 1961). The endosperm is described as being "brownish" at maturity (Ndam et al. 1997).

Seed dispersal and leaf predation

Shiembo (1997) reports observing birds, squirrels and other rodents eating the fruit as they ripen, reducing the availability of seeds for regeneration. However, Schippers (2000) concludes that it may be necessary for the seeds to pass through the intestines of a bird, fruit bat or other animal before they can readily germinate.

The leaves of *G. africanum* and *G. buchholzianum* are consumed by gorillas in the Nouabali-Ndoki forest of the Republic of Congo (Brazzaville) (Moutsamboté et al. 1994). Schippers notes that in Gabon, the Central African Republic and the Democratic Republic of Congo (Kinshasa), overharvesting is shrinking wild populations of *Gnetum* that also play a role in the diet of other forest dwellers such as chimpanzees and gorillas (Schippers 2000). Hladick and Hladick (1995) report that caterpillars prefer young leaves, like those of *Gnetum*, which are tender and lacking in tannins.

Vegetative regeneration

Nkefor et al. (2000) report production of suckers from *Gnetum* provenances growing in the *Gnetum* genebank of the Limbe Botanic Garden. This suckering can be quite prolific in the wild, suggesting that vegetative regeneration is important (Sunderland 2001, pers. comm.).

Mycorrhizal association

Ectomycorrhizae (*Scleroderma sinnamarense*) have been found in association with *Gnetum* plants grown in cultivation (Limbe Botanic Garden 1998; Ingleby 1999). This symbiotic relationship is purported to enhance the ability to take up nutrients from the soil (ibid.).

Geographic distribution

The two African species of *Gnetum* occur throughout Central Africa, including parts of Nigeria, Cameroon, Equatorial Guinea, Gabon, Central African Republic, Republic of Congo, Democratic Republic of Congo, Angola and Mozambique (Lowe 1984; Mialoundama 1993, Chevalier 1951b). Chevalier (1951a) reports the two species growing side by side in the Central African Republic, but says that *G. africanum* is distributed across the Central African region, while *G. buchholzianum* is more limited in its distribution. The latter is found principally in Cameroon, though it also extends into Gabon and the Central African Republic (Markgraf [1930] cited in Maheshwari and Vasil 1961).

Habitat

G. africanum and *G. buchholzianum* occur in humid tropical forests below 1500m elevation (Maheshwari and Vasil 1961). *G. africanum* is common in food crop fields, bush fallow land and degraded forest. It is almost nonexistent in home gardens, although there is growing interest in transplanting natural regenerants into home gardens (Fondoun and Tiki 1999; Ndam et al. 1997; Nkefor et al. 1999). *G. africanum* also grows in the understory of humid forests and in gallery forests (Raponda-Walker and Sillans 1961, Chevalier 1951c), while *G. buchholzianum* is found more often in undisturbed primary forest (Mialoundama 1993; Sunderland 2001).

In Africa, *Gnetum* is shade-tolerant and does not do well in full sunlight (Schippers 2000; Shiembo 1997). However, *G. africanum* may be favored by forest disturbance, a probable explanation for its abundance in degraded forest, bush fallow and crop fields (Fondoun and Tiki 1999; Mialoundama 1993). Both species of *Gnetum* are found in semihumid forest zones in plantain fields, and in the humid forest zone in cassava-based mixed-cropping farm systems, where the plants occur as "weeds" (Poubom Ngundam 1997). Fondoun and Tiki's study (1999) of wild *Gnetum* populations in five provinces of Cameroon found that distribution of *G. africanum* is relatively homogenous in areas where secondary forests predominate, while it is found less frequently than *G. buchholzianum* in primary forest.

USE

Local use as a vegetable

Leafy vegetables play an important nutritional role in household diets, serving as the main accompaniment to the daily starch and providing the majority of the daily intake of iron, vitamin A and vitamin C (Gockowski and Ndumbe 1997). As with other *Gnetum* species, *G. africanum* and *G. buchholzianum* have edible leaves. These evergreen vines provide an important food available year-round to the people of Central Africa. Mialoundama (1993) reports a nutritional analysis of the leaves showing *Gnetum* to be a significant source of protein, essential amino acids and mineral elements. Chemical analysis (Okafor et al. 1994) identifies the leaves specifically as good sources of sodium, potassium, calcium, magnesium and iron. Together with a relatively high fat content (ibid.), the high nutritional value of the leaves makes them a meat substitute in many households (Nkefor et al. 1999; Mialoundama 1993).

The young tender leaves can be eaten fresh as a salad (Okafor 1997; Chevalier 1951c) or, in the Congo, served raw with salted fish (Mialoundama 1993). The young leaves may also be cooked and served with butter, a dish reportedly appreciated by colonial Europeans in what is now the Central African Republic (Chevalier 1951c). The leaves, cut into small slices

resembling grass, are eaten as greens with manioc by the Pygmies and other forest peoples of the Congo Basin (Chevalier 1951c, 1951a). The leaves are converted to a drink in Nigeria (Nkefor et al. 2000).

In the main, however, the leaves are added to sauces and served with a starch. Unlike leaf sauce made with cassava, the sliced leaves of *Gnetum* remain intact and distinct within the sauce (Lowe 1984). The leaves are sliced into strips about 2mm wide (Schippers 2000). Leaves that have been dried are soaked in water before using in cooking (Shiembo 1997). In Cameroon, the leaves are finely chopped, mixed with the leaves of "waterleaf" (*Talinum triangulare*), a widely cultivated exotic plant, and cooked in palm oil. Waterleaf serves to soften the coarse, fibrous leaf strips of *Gnetum*, making a more homogenous sauce. As demand for *Gnetum* grows, it is logical to assume that there will be a corresponding increase in demand for waterleaf (Besong and Sama-Land 1997). "Editan" (*Lasianthera africana*), an understory shrub that grows in secondary and high forest from southern Nigeria to northern Democratic Republic of Congo, is used to adulterate the sauce in Nigeria (Sunderland 2001).

Eru and fufu are often used in combination in traditional Central African cooking

The leaves are often cooked with meat or fish (Moutsambote 1994). A popular recipe in Central Africa is called *chenilles au koko* (caterpillars with koko) (Mialoundama 1993). They are also cooked with palm oil, with the ground seeds of groundnuts (*Arachis hypogaea*) or egusi (*Cucumeropsis mannii*), and with the leaves of cocoyam (*Colocasia esculenta*) (Nkefor et al. 2000). In the Yaoundé region of Cameroon, palm nuts and smoked fish are added to the leaf sauce. In the western regions of Cameroon and in southeast Nigeria, waterleaf, smoked fish or meat is added. In Gabon, smoked fish or crayfish is also added.

These mixtures are invariably served with "water fufu" (made of pounded cassava), garri (pounded and dried cassava fried in palm oil and dried again, then reconstituted in water), boiled plantains, cocoyams, yams and other starchy foods (Poubom Ngundam 1997). In many areas, *Gnetum* dishes are greatly valued as part of the experience of traditional culture, and their presence is required at many traditional occasions (Shiembo 1999; Avomo and Awori 1999; Fondoun and Tiki 1999; Yembi 1999; Ndoye et al. 1998; Liengola 1999).

Medicinal uses

Vergiat (1970, cited in Burkill 1994) reports that in the Central African Republic the leaves of *Gnetum* are eaten for nausea and are used as an antidote against arrow-poison made from *Parquetina nigrescens* (Asclepiadaceae). In Congo-Brazzaville, the chopped leaves serve as a dressing on boils to hasten maturation, and the stem is cut up into small pieces to produce a tisane taken to ease childbirth (Bouquet 1969).

In Cameroon, the leaves are used as an antiseptic on wounds and are believed to enhance blood production (Nkefor et al. 2000). A poultice made from the leaves is used to treat fresh wounds and "whitlow" (an itchy inflammation of the fingers) and is taken as an enema to clear constipation and ease childbirth (ibid.). The

fresh leaves are chewed to neutralize the effects of alcohol (Fondoun and Tiki 1999). Van Dijk (1999) noted that the Bulu use the leaves of *G. buchholzianum* to treat colds.

In Nigeria, *Gnetum* is used to treat hemorrhoids and high blood pressure (Okafor 1997; Schippers 2000). The leaves are also taken to treat enlarged spleen, for sore throat and as a cathartic. Iwu (1993) reports that *G. africanum* leaves are used in Nigeria as a purgative and a tonic, while those of *G. buchholzianum* are used as a potherb and tonic.

Fruit and seed use

In a study of the use of *G. africanum* (Fondoun and Tiki 1999) showed that 100% of respondents in the Littoral Region of Cameroon, and 35% of respondents in the South-West province, collected the seed as well as the leaves. The seed is eaten in what is now the Democratic Republic of Congo (Robyns 1948:11–12, cited in Burkill 1994), and the fruit pulp is eaten in Ubangi (Vergiat 1970a: 83, cited in Burkill 1994).

The stem

The stem is supple and strong, so it is made into traps and nooses for catching game, as well as into straps for portage in the present-day Democratic Republic of Congo (Robyns 1948, cited in Burkill 1994). The stems are also used to tie bundles of harvested leaves (Sunderland 2001).

MARKETS AND BENEFIT SHARING

Marketing and availability

Across the markets of Central Africa, *G. africanum* and *G. buchholzianum* are consistently among the most ubiquitous and consumed of products. They are present year-round and always among the most important NTFP species mentioned (Ndonazi and Ziallo 2000; Sunderland and Obama 1999; Kimpouni 1999; Liengola 1999; Yembi 1999; Ngatoum 2000; Berinyuy et al. 1997; Poubom Ngundam 1997; Besong and Sama-Land 1997; Chevalier 1951c; Sunderland 2001). *Gnetum* leaves are harvested throughout the year (though supplies are often lower in the rainy season because of competing farming activities), so they are available in markets at all times (Tabuna 1999; Moutsambote 1994; Vabi and Tchamou 1999; Besong and Sama-Land 1997; Henkemans 1995; Sunderland 2001). Prices for the leaves vary as a function of the season (harvest and transport is more difficult in the rainy season), price of fuel (transportation within and between countries), and the currency exchange rate between the local and neighboring or export currencies (Ndobe 2000; Henkemans 1995).

Gnetum leaves are hardier than those of many leafy vegetables, and the preferred product is a fresh leaf (Nkefor et al. 2000). Currently, *Gnetum* exhibits a long market chain; there are several steps between harvest and the final consumer, usually across long distances (Besong and Sama-Land 1997). In addition, much of the value is typically captured at the consumption end of the chain, with indigenous harvesters receiving only a small portion of the final sale price (Sunderland 2001).

Production and consumption

Although men, women and children all collect the leaves, this task is primarily performed by women (Henkemans 1995; Mialoundama 1993; Ndoye et al. 1998; Sunderland 2001). The leaves are collected during visits to the forest, either during specific collection trips or opportunistically, in the course of other activities (Henkemans 1995). Actual harvesting of the leaves often entails plucking them from the slender stem and side shoots, which at least allows the individual plant to regenerate. However, there are increasing reports of unsustainable and destructive harvesting through the cutting and removal of the entire plant and/or the felling of the trees the liana is climbing on (Shiembo 1997; Sunderland 2001).

The frequency of collection depends to some extent on demand, which varies with the availability of other green leafy vegetables (Henkemans 1995). For ex-

ample, more harvesting is undertaken during school holidays, when school-age children are available to harvest (Vabi and Tchamou 1999; Henkemans 1995), or when extra income is needed, such as when school fees are due (Vabi and Tchamou 1999). Fondoun and Tiki (1999) found that leaves were harvested between 1 and 4 times/week, while Henkemans (1995) reported an average of 3 times/week for women and up to 7 days per week for unemployed young men. There is less harvesting during the rainy season (Shiembo 1997; Sunderland 2001), because transportation is difficult and there are competing economic activities, particularly the bush mango harvest. Most likely because of the reduction in other activities, as well as improved road conditions, peak harvest occurs during the dry season (Shiembo 1997).

The economic and nutritional roles played by *G. africanum* and *G. buchholzianum* should not be ignored. In a study conducted in the humid forest region of Cameroon, Gockowski and Ndumbe (1997) found that leafy vegetables were served 3–6 times per week in 86% of households surveyed (n=200), and that wild-harvested *Gnetum* leaves were the fifth most commonly prepared leafy vegetable in households surveyed. Daily consumption in Congo was estimated to be 2g per capita, a level deemed to endanger wild *Gnetum* populations, as all leaves are harvested from the wild (Mialoundama 1993). Consumption is estimated to contribute up to 30% of the daily intake of protein in some places in Central Africa (Nkefor 2001).

Once harvested and brought to market, leaves are stored in cool, dark rooms by harvesters and traders in a variety of ways: spread over a plastic sheet or wrapped in plantain (*Musa* spp.) or paw-paw (*Carica papaya*) leaves that have been perforated to permit the passage of air. The leaves can be stored fresh for about a week and are usually traded in this form (Shiembo 1997). The wholesale unit of sale is a "head" (i.e., the small bundles for which a standard price is paid). Often in warehouses the heads are untied, graded and retied before sale.

Fresh leaves are sold whole or finely chopped. The value added from the chopping is considerable: in Congo-Brazzaville, whole leaves sell at 100 Central African francs (CFA) for a packet (about 100 kg), while that same packet, chopped, retails for 300–400 CFA (Kimpouni1999; Mialoundama 1993).

In December 2001, 1 kilogram of sliced *Gnetum* leaves was on sale in the Limbe market of Cameroon for 1,200 CFA. However, the usual units of sale—one bundle of unsliced leaves or one heap of sliced leaves—sold for 800 CFA and 100 CFA, respectively. A bundle weighs roughly one kilogram. A bundle of *Gnetum* is the size of a large handful of leaves (Henkemans 1995). Heaps are roughly 100g, and a family of four might expect to buy three heaps to prepare a meal using the leaves in sauce.

Postharvest losses and transformation

Within Central Africa, most *Gnetum* leaves are sold fresh. However, most *Gnetum* exported from the continent is dried (Shiembo 1997; Sunderland 2001). Drying takes place in the sun (Nkefor et al. 2000), and dried *Gnetum* packaged in air-permeable cellophane bags can be stored for up to 3 months (Sunderland 2001). Tabuna (1999, 2000) reports the sale of fresh, frozen and dried *Gnetum* in European markets.

Potential methods to reduce postharvest losses through product quality include dehydration (the traditional means of preservation), refrigeration or freezing (Numfor 1997). Improvements in processing include waste reduction (disposing of vines and inferior leaves in the forest rather than at the final market destination, where disposal becomes a problem), size reduction (shredding whole leaves, for example) and the addition of packaging (Numfor 1997).

Export markets

Export markets to the African diaspora in Europe (mostly in the former colonial countries of Spain, Portugal, France, Germany, Belgium and Britain) are strong, as is the market from Nigeria to the United

States (Shiembo 1997; Tabuna 1999, 2000; Ladipo 1997). Tabuna (1999) also finds that trade in African NTFPs is spreading to other European nations. Much of the Central African trade in Europe, where *Gnetum* is sold fresh, frozen and dried, comes from Ghana, Nigeria, Cameroon and the Democratic Republic of Congo (ibid.). Exports of *Gnetum* passing through the Nsimalen International Airport in Yaoundé, Cameroon, are increasing (Figure 1).

Trade in the leaves of *G. africanum* and *G. buchholzianum* is also important within and between the countries of the Congo Basin. This includes Gabon, Equatorial Guinea, Congo-Brazzaville, the Democratic Republic of Congo, the south of the Central African Republic, and the humid zones of Nigeria and Cameroon (Ladipo 1997; Shiembo 1997; Sunderland and Obama 1999; Yembi 1999). Interestingly, not all the trade in *Gnetum* leaves is for cash. In the Ngotto forest of Congo (Brazzaville), forest-dwelling Pygmies harvest the leaves of *G. africanum* and *G. buchholzianum* and bring them to villages to trade for manioc flour (Hladick and Hladick 1995).

In Cameroon, the trade in *Gnetum* is most pronounced between the forested zones, where the vines grow, and the drier savanna zones, where they do not (Shiembo 1997). There are two main ports for export trade—Idenau in the South-West Province, where bales of *Gnetum* are transported by sea to Nigeria, and Ambam in the South Province, which trucks bales of *Gnetum* by road south to Gabon and Congo-Brazzaville (Shiembo 1999; Schippers 2000). From the border towns, the bales are broken down into "heads" and shipped to other markets and towns across the country.

Most *Gnetum* from Cameroon, Gabon and the Central African Republic is transported by road to the port of Idenau, then exported to Nigeria (Bokwe and Ngatoum 1994; Sunderland 2001). In addition to the trade reported in the official statistics, it is certain that large quantities of *Gnetum* are transported across the thousands of kilometers of unpoliced borders between Central African nations. Henkemans (1995) reports 100-kg bags being commonly head-portered along bush tracks between Cameroon and Nigeria. Sunderland (pers. comm., 2001) reports that this is common in both the Korup and the Takamanda areas along the western border of Cameroon with Nigeria.

The role of women

Women play a major role in the *Gnetum* trade all along the market chain, from gathering the leaves to brokering, transporting and marketing them (Mialoundama 1993; Ndonazi and Ziallo 2000; Burnley 1999; Shiembo 1999; Vabi and Tchamou 1999; Nkefor et al. 2000; Berinyuy et al. 1997; Mialoundama 1993). *Gnetum* harvest and trade is often the most important economic activity for women involved with NTFPs (Henkemans, 1995; CERUT and AIDEnvironment 1999; Clark 2001), and women dominate the trade in *Gnetum* at all levels (Henkemans, 1995; CERUT and AIDEnvironment 1999; Mialoundama 1993). For young or uneducated women, participation in the *Gnetum* trade often provides their primary income (Henkemans, 1995).

Despite the importance of the *Gnetum* trade to women, its value is leading to an increase in male participation. Ndoye et al. (1998) posit that the 1994 devaluation of the Central African currency to half its previous value is responsible at least in part for the increasing pressure placed on wild-harvested NTFP species such as *Gnetum*. This devaluation may also play a role in the trend for men to become involved in the *Gnetum* trade, often at the expense of women. This is due to a more limited job market, as their decreased buying power forces men to look to nontraditional but lucrative avenues for earning money, such as the *Gnetum* trade.

INSTITUTIONAL ISSUES

Cameroon

In 1994, a survey of important NTFPs was conducted in the South-West Province of Cameroon by mem-

bers of the Ministry of the Environment and Forestry (MINEF) (Bokwe and Ngatoum 1994). The survey, noting that 5,296 tons of *Gnetum* leaves had passed through the ports of Idenau, Tiko, Limbe and Modeka between 1985 and 1994, highlighted to the central government the value of this forest product. By 1996, a permit system for wild-harvested *Gnetum* had been introduced and checkpoints established to control exports (Ngatoum 2000). In 1999, the MINEF created a new subdirectorate for NTFPs, an indication of the increasing recognition of the value of these natural resources.

The Limbe Botanic Garden's Conservation Through Cultivation Programme is establishing a viable genebank of *G. africanum* and *G. buchholzianum*, developing and disseminating effective cultivation techniques (Nkefor et al. 1999). It is hoped that the introduction of *Gnetum* into agricultural cropping systems will reduce the harvesting pressure on wild populations. Sunderland (2001) suggests that the introduction of successful cultivation techniques for high-value NTFPs such as *Gnetum* may also provide an important source of income for community-based rural initiatives.

Some pitfalls remain in cultivating *Gnetum*. A farmer participating in an *Gnetum* cultivation workshop held by Conservation Through Cultivation remarked that there is no use in cultivating eru (*Gnetum*) for sale if, in transporting the product, the farmers have to pay the taxes that are levied on the wild-harvested national resource, or other forms of "informal taxation" (Ngatoum 2000). In the same discussion, the government representative of the Divisional Delegate for Environment and Forestry pointed out that cultivated eru is the business of the Ministry of Agriculture, so it does not require permits to market. At that level, only custom duties would be paid when the product is exported. However, this concern is valid (not least because the officials have no way to determine which *Gnetum* leaves are wild-harvested and which are cultivated) and supports the recommendation that effective systems be put in place to monitor the source of marketed *Gnetum*. Tracking these data is of benefit both to the prospective farmer, who would be taxed differently than the wild harvester, and to the government, allowing it to monitor the natural resource base.

Gabon

All products that are harvested from Gabonese forests are subject to permits and taxation, as defined by the Forestry Administration in Forestry Law 1/82 article 16 (Yembi 1999). Unfortunately, a lack of trained personnel and effective control ensures that the laws are rarely enforced (ibid.; Profizi 1999).

Nigeria

The 1999 Forest Law of Nigeria requires that commercial harvesters taking *Gnetum* from forest reserves have a collection permit, available for a monthly or annual fee (Sunderland 2001). There are no further costs when transporting harvested *Gnetum* through or between states within Nigeria (ibid.). Indigenous people do not need permits to harvest in community forests and have usufruct rights on forest reserves (ibid.).

Equatorial Guinea

Sunderland and Obama (1999) report that few forest-related studies survived the period of transition from colonial to independent rule (in 1968). Indeed, speaking of NTFPs, Fa wrote, "certain products were used by the forest dwelling peoples in Equatorial Guinea, there is little or no recent data on preferred species or their uses" (1991, cited in Sunderland and Obama 1999). Sunderland and Obama go on to point out that most of the NTFPs marketed in Equatorial Guinea are imported from neighboring Cameroon. *Gnetum* is only harvested on the island of Bioko, though it occurs in forests on the mainland as well. According to Sunderland and Tako (2000), the 1997 Appendix to the 1995 Forestry Law of Equatorial Guinea makes reference to sustainable management of commercially exploited NTFPs such as *Prunus africana* and *Piper guineensis*. Although no mention is made of *Gnetum*,

and it is not commercially harvested in Equatorial Guinea on a wide scale, it is possible that if it does become commercially significant it would fall under the same appendix. Sunderland and Tako (2000) report that although the will to ensure the sustainable exploitation of high-value NTFPs exists, it is hindered by a lack of baseline information on their abundance and distribution, as well as lack of knowledge and application of sustainable *in situ* harvesting techniques.

Other central African nations

Several institutions and individuals have worked extensively within Africa on *G. africanum* and *G. buchholzianum*. Unfortunately, in the case of the Democratic Republic of Congo, Angola, Republic of Congo and Central African Republic, civil unrest has hampered communication efforts. It is not known whether such work has continued at the institutions throughout the past several years of unrest, or indeed if the institutions still exist.

TOWARDS A SUSTAINABLE POPULATION OF *G. AFRICANUM* AND *G. BUCHHOLZIANUM*

Factors contributing to the decline of the species

G. africanum and *G. buchholzianum* were formerly plentiful across their ecological ranges, as is evidenced by the importance of their leaves in the diets of indigenous peoples across Central Africa, and the frequency of their consumption. Numerous comments (Shiembo 1997; Poubom Ngundam 1997; Sunderland and Obama 1999) indicate that new concerns about overharvesting stem from the fact that recently *Gnetum* has been difficult to find in the forest. No baseline distribution survey has been carried out to establish population densities across the region. *Gnetum* species are not difficult to cultivate; the principal requirements seem to be a degree of shade and a structure of some sort on which the vine can climb. The principal causes of its decline in the wild include destructive and excessive harvesting practices and the conversion of its habitat to other uses (Shiembo et al. 1996; Shiembo 1999; Ndam et al. 1997; Nkefor et al. 1999; Mialoundama 1993; Bokwe and Ngatoum 1994; Burnley 1999; Fondoun and Tiki 1994; Sunderland 2001). Meanwhile, the strong urban demand for *Gnetum* suggests that consumption of the leaves will continue to increase (Numfor 1997).

Conservation issues

Much of the *Gnetum* leaving Cameroon from Idenau originates in the forests of the Centre, East and South provinces (Shiembo 1999). This reflects the scarcity of *Gnetum* in the heart of its natural range, where the natural populations have been harvested to commercial scarcity in the South-West Province of Cameroon and in Nigeria (Shiembo 1999; Ndam et al. 1997). The urgent need to ensure conservation of these species has been voiced (Bokwe and Ngatoum 1994; Nkonko and de Koeijer 2000), and Fondoun and Tiko (1999) report that the Ministry of the Environment and Forestry of Cameroon in 1995 declared *G. africanum* an "endangered species" (MINEF-PNGE 1995).

As noted earlier, destructive harvesting is a major problem. The vines can survive having their leaves plucked, but more commonly, they are cut down and all biomass removed. In the Takamanda area of Cameroon and southeastern Nigeria, trees are often felled if large vines are growing on them so that the vines can be stripped off (Sunderland, pers. comm., 2001). Introduction of appropriate harvest techniques and guidelines (e.g., prohibition of felling trees for access to *Gnetum*, uprooting the plant, or breaking the stem) would, if enforced, substantially reduce unsustainable exploitation.

Methods of conserving the species *ex situ* and *in situ*

A combination of *ex situ* and *in situ* approaches are recommended to attempt to conserve populations of

G. africanum and *G. buchholzianum* in the wild and establish a sustainable resource base sufficient to meet growing demand for the products (Mialoundama 1993; Schippers and Budd 1997; Wilkie 1999; Sunderland et al. 2002). *In situ* interventions primarily address ecological, management, educational, policy, and land tenure/ enforcement issues (van den Berg et al. 2000; Clark 2001; Gockowski and Ndumbe 1997; Wilkie 1999) with the goal of building ecologically, economically and socially sustainable harvest and management systems. These must be set, of course, within current political and statutory guidelines, which must be adequately applied in the field. Given the current levels of political and social upheaval across central Africa, it seems these aims will only be achieved in the long term.

To complement ongoing *in situ* conservation efforts, a range of *ex situ* interventions are widely recommended for *G. africanum* and *G. buchholzianum* (Schippers and Budd 1997; Wilkie 1999; Shiembo 1997; Mialoundama 1993; Sunderland et al. 2002). These include the development of effective cultivation and domestication techniques and the establishment of viable genebanks. If successful, these steps will establish an alternative secure source of *Gnetum* leaves for farmers and land managers. While not guaranteeing the survival of wild *Gnetum* populations, introducting *Gnetum* into farming systems should reduce harvesting pressures. Development of carefully managed genebanks will ensure that a broad base of genetic material from diverse provenances will be protected and available for intensive improvement and domestication.

The potential for cultivation and domestication

Before setting out to develop markets for products based on wild-sourced species, one should consider the attendant ecological, economic and social implications. An important ecological consideration is the status of the pertinent species in its natural habitat, both locally and across its range. *Gnetum* is relatively abundant across its range, but many populations are locally threatened or extinct (Ndam et al. 1997; Mialoundama, 1993; Nkonko and de Koeijer 2000; Nkefor et al. 1999; Sunderland et al. 2002).

Domestication is one action that may be taken when a wild crop species is threatened. However, domestication programs often involve considerable financial commitment. It takes time to gather the materials and data, then to effect the biological changes in plants, resolve any production issues, and, finally, present improved varieties to farmers. Cultivation programs, on the other hand, can have a much shorter time frame, because they focus on establishing effective methods of propagation, production and harvest rather than on genetic improvement of the crop.

Potential future markets must exist to justify the investment of time, money and technical inputs needed to transfer the natural resource base from wild-sourced to farm-sourced material. From this point of view, *Gnetnum* appears worth the effort. *Gnetum* trade has increased steadily over the past 20 years (Mialoundama 1993; Shiembo 1997; Poubom Ngundam 1997; Ladipo 1997; Numfor 1997). Not only is it rising within African nations and ethnic groups, it is also spreading out from the centers of the African diaspora in Europe and North America to other regions (Tabuna 1999, 2000). Both the volume and value of the trade is increasing; this is a product with a growing consumer base. As the *Gnetum* trade increases and wild-sourced supplies become more difficult and expensive to acquire, farmers are developing a strong interest in incorporating *Gnetum* into their mixed-crop farming systems for both domestic and commercial uses (Fondoun and Tiki 1999; Ndam et al. 1997; Mialoundama 1993; Shiembo 1999; Nkefor 2000; Poubom Ngundam 1997). Taking these ecological, economic and social factors into consideration, it is clear that *G. africanum* and *G. buchholzianum* are excellent candidates for cultivation and domestication programs.

Strategies for the cultivation and domestication of *G. africanum* and *G. buchholzianum*

Seed Germination

The seeds of *Gnetum* species in general mature quite slowly, with most embryo development taking place after the seed has fallen to the soil. At times the seed takes up to 11–12 months for germination (Maheshwari and Vasil 1961). Most trials to germinate seeds under nursery conditions have not been successful, and as a result, seed germination has not been pursued in propagation studies (Okafor 1997; Shiembo 1999; Ndam et al. 1997). Other research appears to have had some success, but it still indicates that germination is very slow and may take a year or more to occur (Shiembo 1997).

Transplantation of wildings

Reports by Fondoun and Tiki (1999), Hladick and Hladick (1995), and Nkefor et al. (2000) demonstrate that farmers have not waited for researchers to introduce *Gnetum* into their farming practices. These studies report farmers transplanting wild *Gnetum* seedlings from the forest and forest clearings, farmers leaving *Gnetum* in farms that have been newly cleared from the forest, and even the collection of seeds for a large plantation (Fondoun and Tiki 1999). Sunderland (2001) reports a long history of *Gnetum* cultivation using wildings in Akwa-Ibom State, Nigeria.

Rooted cuttings

Cuttings from the leafy vines have proved to be the most successful means of vegetative propagation (Alexandre 1993; Shiembo et al. 1996; Ndam et al. 1997; Shiembo 1999; Nkefor et al. 1999; Shiembo 1997; Schippers 2000). Female plants show stronger vine growth than male (Shiembo 1997). In the case of *G. africanum*, this corresponds with a higher production of leaves. *G. buchholzianum*, however, shows no noticeable differences in leaf biomass production between male and female vines (Shiembo 1997).

Rooted cuttings are relatively easy to propagate (Ndam et al. 1997; Shiembo 1997; Shiembo 1999; Schippers 2000; Nkefor et al. 2000). A number of trials have been carried out in the past 10 years, and a basic methodology has emerged (synthesized from Shiembo 1997; Ndam et al. 1997; Nkefor et al. 2000; Schippers 2000):

Vines are selected that have desirable characteristics. Cuttings are taken, with one pair of leaves left per cutting (Shippers, 2000; Nkefor et al. 2000). These are placed in the desired rooting media (as reflected in Table 2); Ndam et al. (1997) recommend a mix of 50% sawdust and 50% sand, while Shiembo (1997) advocates the use of 100% decomposed sawdust in a propagator. Some studies recommend treating the cuttings with indole butyric acid (Alexandre 1993; Shiembo et al. 1996) before setting them in the sawdust rooting medium. Both mist propagators and other types of propagators that are much simpler and cheaper have been tested (Shiembo 1997; Ndam et al. 1997; Nkefor et al. 2000), providing excellent results. Schippers (2000) states that it is most important to keep the cuttings moist and to cover them with a light cloth or gauze net.

Table 2: Results of Trials of Different Rooting Media

Rooting Medium	Days to Rooting of Cuttings			
	0—21	21–28	28–35	
50% sand, 50% decomposed sawdust	*			
100% sand				
100% decomposed sawdust				

*Solid blocks are from Ndam et al. 1997. Striped block is from Shiembo 1997.

Table 3: Production of *Gnetum* cuttings under different light

	Cultivation Media			
Light	**Volcanic soil**	**Compost**	**Poultry manure**	**Palm nut residue**
20% light	150*	250	200	250
50% light (with netting)	900	200	450	600
50% light with tree cover	450	450	300	375

*Each cell represents 50% of leaf biomass (g) of 9 plants, measured after 15 months of cultivation.

The rooted cuttings are then transplanted to cultivation media. Schippers (2000) and Shiembo (1997) recommend forest soil; Ndam et al. (1997) tested four media, as seen in Table 2. Volcanic soil, equivalent to the forest soil recommended by the others, is their recommended medium, producing more leaf biomass under 50% partial shade (provided by netting) than any of the other treatments.

Nkefor et al. (2000) indicate that one cultivated *Gnetum* plant can produce 1.9 kg leaf biomass every 6 months.

The presence of mycorrhizae on the roots of cultivated *Gnetum* plants indicates a symbiotic relationship (Limbe Botanic Garden 1998). Any cultivation program of *Gnetum* might consider inoculation with the specific mycorrhizae to maximize plant vigor and production, although the specific means of inoculation has not been determined (ibid.).

Introduction of *Gnetum* into farming systems

Shiembo (1999) and Nkefor et al. (2000) report the establishment of field trials of rooted *Gnetum* cuttings. Shiembo (1997) introduced rooted cuttings from a variety of provenances to study plots under hardwood timber-tree trials in the Southern Bakundu Forest Reserve in Cameroon. The plants were staked and weeded, then harvested with varying degrees of severity, ranging from the removal of alternate leaves to cutting the vines at ground level. They found considerable variation among provenances, both in survival rates (57.1–78.2%) and production levels. Regrowth of both leaves and vines occurred when leaves were left after harvest; none occurred when all the leaves were harvested, or when the vine was cut at ground level. Mialoundama and Paulet (1986) report that removal of the young leaves found on the principal stem axis of the plant stimulated growth of new leaves.

Nkefor *et al*. (2000), working within the Conservation Through Cultivation Programme (see earlier note) at Limbe Botanic Garden, first established field trials under two conditions: intensive production and the local mixed-crop farming system. Survival and production rates for both methods were monitored, and growth rates were found to be excellent. Pilot farmers were identified in local communities and invited to participate in a workshop, where they were trained in the propagation and cultivation of *Gnetum*. These farmers then established trial farms, each with a communal propagator, testing three methods of cultivation (without staking, using dead-wood stakes and using live-wood staking). Early results showed a 93% survival rate of outplanted cuttings, with more cuttings prepared and rooting in the propagator. Strong interest drew other farmers who came to see the *Gnetum* growing in these pilot farms (Nkefor et al. 2000).

Continued monitoring of established *Gnetum* cuttings (Limbe Botanic Garden 1997) provides further evidence of the importance of providing shade and a climbing structure to cultivate *Gnetum* plants. Plants grown in the shade showed greater vigor and productivity and competed better with weeds than those

grown in direct light (Limbe Botanic Garden 1998). Plants provided with effective climbing structures also competed more effectively with weeds. Weeding was nonetheless shown to be important, because climbing weeds were able to take over the climbing structure as rapidly as the *Gnetum* plants did. However, in greater shade and over time, it is predicted that the *Gnetum* would pull ahead of the climbing weeds (ibid.).

If *Gnetum* is cultivated using a large-scale plantation system, considerable investment will have to be made to provide shade (Schippers 2000). As an alternative, large-scale production could be undertaken as part of a mixed-crop system, where the shady overstory would be provided by other crops, e.g., timber, rubber or fruit plantations.

The amount of shade provided by the overstory crop or canopy should be appropriate for the growth needs of *G. africanum* and *G. buchholzianum* (Gockowski and Ndumbe 1997).

In a study on the use of traditional crops in agroforestry plots, Newman and Wainwright (1997) found that tree spacing played a large role in the amount of light reaching the understory. While the crops in the understory fared best under lower tree densities per hectare than would be ideal for maximum crop production from the trees (oil palm, in their study), the loss in tree crop volume was more than compensated by the value of the understory crop. The high value of *Gnetum* suggests that it may be an economically rational understory crop to introduce into fairly densely planted agroforestry systems. Overstory trees may provide narrow, broad, deep or partial shade as a function of crown shape and density, so selecting the right species will be an important consideration in the production of *Gnetum* as a crop.

There is considerable interest in introducing *Gnetum* into traditional mixed-crop agroforestry systems. In the 1990s, the ECOFAC project in the Ngotto forest of the Central African Republic established several trials of locally valuable species, including *Gnetum*, as part of a mixed-crop agroforestry system (Hladick and Hladick 1995). The Limbe Botanic Garden Conservation Through Cultivation Programme's work to introduce *Gnetum* into farming situations (Nkefor et al. 2000; Sunderland et al. 2002) has met with considerable interest from farmers; from government, even at ministerial levels; and from institutions working in other African nations (Nkefor, pers. comm., 2001).

It is difficult to predict what effect this trend may have on Central Africa's women farmers. The production of most leafy vegetables is often within a mixed-crop system managed by women (Gockowski and Ndumbe 1997). However, a trend noted by Henkemans (1995), Ndoye et al. (1998), and Gockowski and Ndumbe (1997) is that of a move from female-dominated mixed-crop agriculture, primarily for home consumption, to male-dominated monocropping for market sale. The fact that *Gnetum* grows best under shade in mixed farming situations favors its remaining in the domain of women farmers. Nonetheless, its commercial value may attract the involvement of men, shifting the benefits of this important crop away from women (Henkemans 1995).

In a study of leafy vegetable production in Cameroon, Gockowski and Ndumbe (1997) found that the closer a farmer lives to a market town, the greater is the percentage of the farmer's crops that are sold. Leafy vegetables play an increasingly commercial role for people living less than 20 km from a market. The cultivation and introduction of *Gnetum* into these farming systems could lead to greatly reduced market share for women living in remote areas who now rely on the sale of *Gnetum* as a cash crop. On the other hand, cultivation may provide greater income to women living near market towns.

Conserving the species and increasing its use

None of the farmers interviewed by Fondoun and Tiki (1999) in the East and Centre Provinces of Cameroon made any specific effort to protect or conserve *G. africanum*. In contrast, farmers in the Littoral Prov-

ince use several protection methods, including seed collection (30%), planting of seedlings in home gardens (20%) and preventing illegal exploitation, especially by "outsiders" (4%). Seventy-five percent of farmers in the South Province, and 50% in the South-West Province, are managing wild populations (Fondoun and Tiki 1999). Van den Berg et al. (2000) found that applying management techniques to NTFP resources in general was rare and limited to species other than *Gnetum*. Their team observed that as an NTFP resource or habitat became scarcer, the local people tended either to abandon the harvesting of a NTFP in favor of purchasing it, or to harvest it even more intensively for commercial sale. In short, while some farmers show initiative by adopting conservation practices by themselves, more commonly this occurs when there is institutional and technical support for those conservation activities, at least initially (Shiembo et al. 1996).

Differences in the way women and men harvest *Gnetum* may play a role in the decline of wild populations. Henkemans (1995) reports that women tend to be meticulous in their harvest of leaves, carefully picking each leaf, large and small, as well as pulling the vines from the canopy and cutting small trees if necessary. Men, on the other hand, are in more of a hurry and concentrate on picking large leaves, leaving small ones behind. Both men and women cut small trees or vines from the canopy when necessary and climb larger trees to access the vines high up in the canopy.

Non-local people (or "strangers") harvesting in the forest are often observed to have no regard for the regeneration of exploited *Gnetum* plants. *Gnetum* will regenerate, perhaps through the production of suckers, if its roots and at least some of its leaves are left intact (Shiembo 1999; Mialoundama,1980). The importance of leaving leaves to continue photosynthesis and production of new leaves must be emphasized both in the harvest of wild *Gnetum* and as people move to establish cultivated *Gnetum* within mixed agroforestry cropping systems.

Resource tenure is a very important factor in establishing sustainable use of any forest resource. Traditional and statutory law often overlap in this area, especially with respect to high-value crops such as *Gnetum*. Sunderland (2001) reports that most communities in Cross River State, Nigeria, have clear regulations for the harvest of NTFPs from their forests, and that those of *Gnetum* are particularly well defined. Because of this, local people benefit from the harvest and trade of *Gnetum*, while non-local people are generally excluded from harvesting activities (ibid.) Van den Berg et al. (2000) found in southern Cameroon that the intensity of management of NTFP species varies, being largely shaped by customary land tenure arrangements. Allocation of land rights is often given to whoever clears and plants the land (ibid.), with sons inheriting the land and the right to its management and transmission. However, a specific resource—for example, a bush mango (*Irvingia* spp.) tree—may be passed on to either a woman or a man.

Different tiers of ownership and management rights make for a complex tenure situation. Statutory laws guiding the harvest and management of *Gnetum* should harmonize with existing customary practice, and where none exists, should provide a structure for the sustainable management of wild populations.

CONCLUSIONS AND RECOMMENDATIONS

G. africanum and *G. buchholzianum* are both widely consumed and deeply integrated into local cultures from Nigeria to Angola. Past difficulties due to poor communication infrastructures as well as language (French versus English, for the most part) have no doubt contributed to the perception that consumption of *Gnetum* on a wide scale is a recent phenomenon. On the other hand, it is true that improvements in infrastructure, communication, trade and transportation, together with movements of human populations, have contributed to strong new levels of exploitation.

Additionally, civil unrest in much of the region has effectively put a halt to much of the research and work on *Gnetum* being carried out in countries other than Cameroon and Nigeria.

Gnetum leaves have overwhelmingly been harvested from wild plants and populations. Although this was sustainable in the past, under current conditions of human population growth, habitat destruction and increasing demand, the harvest of leaves from wild sources is leading to the destruction of some populations and placing others under serious threat. A few local harvesters and farmers have valued *Gnetum* sufficiently to introduce transplanted wild seedlings into their farming systems, with varying degrees of success. Recent efforts have succeeded in identifying simple, effective means of cultivating *Gnetum* cuttings and establishing them in mixed-crop farms.

Successful introduction of *Gnetum* into farming systems will no doubt lead to a shift in the source of much of the marketed supply of *Gnetum* leaves. This will happen as farmers living close to markets will be able to provide fresher leaves more consistently, and with lower transportation costs, than will harvesters of wild-sourced leaves. It remains to be seen if this leads to a drop in the harvest levels of wild *Gnetum* or merely adds to the total *Gnetum* flow. It is possible that preservation and conservation techniques such as drying and improved storage and packaging will encourage the continued use of leaves from the more remote areas, to be fed into the growing export market to North America and Europe.

The *Gnetum* market chain is dominated by women, and represents an important source of income for them. It is especially valuable to unmarried, young or poor women with little education, because they have few other means by which to support themselves. The introduction of cultivated *Gnetum* leaves into the current marketing structure could have a destabilizing effect. While it is likely that many women will benefit, it is also likely that poorly educated women living in the forest far from marketing centers will be the most vulnerable to the change in the supply chain. Additionally, it is possible that the introduction of *Gnetum*, an economically powerful product, into farming systems will also lead to a shift in the types of systems in which it is grown. Although *Gnetum* grows best in the mixed-crop systems traditionally managed by women, it is possible that increasing commercialization will lead to a shift to monocropping on large-scale plantations, farming systems traditionally managed by men.

In situ conservation of *Gnetum*, as with all NTFPs, is a matter largely of education, policy, resource access and tenure. As the central African nations continue the process of forestry reform initiated in the past 10 years (Brown 2001; Brunner 2001; Clark 2001; Sunderland 2001), NTFPs such as *Gnetum* need to be included in the development of forest management plans. Equally important, support, training and monitoring programs need to be implemented on the ground to ensure implementation of well-thought-out forestry laws.

Conservation and development of *G. africanum* and *G. buchholzianum* will be best achieved through communication and collaboration among the many people and institutions working presently, or in the past, on various aspects of this very important Central African genus. Some recommended actions to achieve this include:

- Developing an integrated regional approach to *ex situ* and *in situ* conservation efforts, including specifically the development of effective propagative techniques, domestication programs, and viable, well-managed genebanks (Schippers and Budd 1997; Ndam et al. 1997; Mialoundama 1993).

- Developing and implementing a vigorous action plan to alert people to the important cultural, nutritional and economic role played by *Gnetum* across Central Africa. This should include structured and creative programs to disseminate sustainable methods of managing and harvesting wild populations as well as suggested methods for cul-

tivating and domesticating of the plants in mixed-crop agroforestry systems.

- Conducting continued research into the biology, physiology and relationships (such as mycorrhizal symbiosis) of *Gnetum* (Mialoundama 1993; Ndam et al. 1997) to establish baseline information about this important natural resource and widely marketed product.

- Encouraging greater communication between the NTFP and indigenous vegetable research and extension communities about *Gnetum* and other "crossover" plants that are of interest to ecologists, conservationists and development and food security workers.

- Formalizing and streamlining the taxation system for *Gnetum* as it moves through the various links of market chains, particularly across national borders, to more efficiently and effectively capture tax revenues as well as to monitor volume, destination and other trade statistics.

- Developing and implementing an effective system to monitor and enforce harvest and trade permits; this must be staffed by trained and motivated field personnel.

- Developing an objective framework of internal and regional monitoring, customs and taxation systems to identify cultivated or sustainably harvested *Gnetum*, as distinct from wild-harvested or unsustainably harvested leaves.

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APPENDIX 1: LOCAL NAMES

There are many names and variations for *G. africanum* and *G. buchholzianum* across the central African region. However, widely applied common names across the region include *afang* in Nigeria; *eru* in Anglophone Cameroon; *koko* in Francophone Cameroon, the Central African Republic, Angola, the Republic of Congo and the Democratic Republic of Congo (DRC); *okoko* in Equatorial Guinea; and *nkumu* in Gabon (Lowe 1984; Ndam et al. 1997; Mialoundama 1993; Chevalier 1951c; Sunderland and Obama 1999; Yembi 1999). A more comprehensive list of vernacular names is presented on the next two pages.

Vernacular names for *G. africanum* and *G. buchholzianum*

Name	Language	Country	Source
Áfàng	EFIK	Nigeria	Udofia fide Lowe 1984; Sunderland 2001
Áfâng	IBIBIO	Nigeria	Udofia fide Lowe 1984; Shiembo 1999; Sunderland 2001
Òkazii	IGBO	Nigeria	Lowe 1984; Shiembo 1994; Schippers 2000
Afang	EFIK	Nigeria	Lowe 1984; Shiembo 1999
Ukazi	IGBO	Nigeria	Swarbrick fide Lowe 1984; Sunderland 2001
Eruru	YALA (Ogaja)	Nigeria	Lowe 1984; Sunderland, 2001
Ukasi	IGBO	Nigeria	Shiembo 1999
Okazi	IBO	Nigeria	Okafor 1999
Ikõko	DOUALA	Cameroon	Swarbrick fide Lowe 1984
Mokaka ko	KPE	Cameroon	Maitland fide JMD
Mokako	KPE	Cameroon	Maitland fide Lowe 1984
Ikok	BASSA	Cameroon	
Mokaka ko	BAKWIRI	Cameroon	Hutchinson and Dalziel 1954
Okôk	EWONDO	Cameroon	Shiembo 1997
Kewaa	EWONDO?	Cameroon	
Ambuare	EWONDO?	Cameroon	
Ko'oba	FANG	Cameroon	
Okwa	FANG	Cameroon	
Kogo	BAFIA	Cameroon	
Okok	Yaoundé region	Cameroon	Letouzey fide Lowe 1984
Okok	BOULOU	Cameroon	
Eru	BAYANG	Cameroon	Shiembo 1997
Kogo	BAKOLA	Cameroon	
Eru	Anglophone Cameroon	Cameroon	Schippers 2000; Tchouto et al. 1999; Ndam et al. 1997
Koko	Francophone Cameroon	Cameroon	Schippers 2000; Mialoundama 1993
Okoko	FANG	Equatorial Guinea	Sunderland and Obama 1999
Koko*	SANGO	Central African Republic	Ndonazi and Ziallo 2000; Tabuna 1999; Ndam et al. 1997; Chevalier 1951c
Koko	LISSONGO	Central African Republic	Chevalier 1951c
Gbeiin**	SANGO	Central African Republic	Ndonazi and Ziallo 2000
Okokok		Central African Republic	Schippers 2000

Vernacular names for *G. africanum* and *G. buchholzianum*			
Fumbua		Republic of Congo	Tabuna 1999, 2000
Okok		Republic of Congo	Tabuna 2000
Nduku	BANDA	Near Oubangui	Chevalier 1951c
Ekali	BAKA	Republic of Congo	Moutsambote et al. 1994
Koko	KIKONGO	DRC	
Fumbwa		DRC	Tabuna 1999; Schippers 2000
Fumbua	BALILI	DRC	Chevalier 1951c
Nkumu	AMBAMBA	Gabon	Raponda-Walker and Sillans 1961
Nkumu	MINDUMU	Gabon	Raponda-Walker and Sillans, 1961
Nkumu	FANG	Gabon	Yembi 1999
Makaghe	FANG	Gabon	Raponda-Walker and Sillans, 1961
Kumbu	BADUMA	Gabon	Raponda-Walker and Sillans, 1961
Kumbu	BAWANDJI	Gabon	Raponda-Walker and Sillans, 1961
Kumbu	BANDZABI	Gabon	Raponda-Walker and Sillans, 1961
Kumbu	MASANGU	Gabon	Raponda-Walker and Sillans, 1961
Mfumbu	LOANGO	Gabon	Raponda-Walker and Sillans, 1961
Okokok		Gabon	Schippers 2000
Bokôo		Gabon	Chevalier 1951c
Koko		Angola	Chevalier 1951c
N'coco		Angola	Chevalier 1951c (quoting from Catal. Welw. Plants, Vol. II, Part 1, p. 257).

** Gnetum africanum ** Gnetum buchholzianum*

Chapter 4
NJANSANG
(*Ricinodendron Heudelotii* subsp. *Africanum*)[1]

Kristina Plenderleith

INTRODUCTION

Ricinodendron heudelotii (Baill.) Heckel subsp. *africanum* (Muell. Arg.) J. Léonard is a fast-growing late secondary forest tree found in the Guinean-Congolean humid forests of West and Central Africa. It is valued for its distinctively flavored seeds, commonly called "njansang," which are dried and ground and used as a flavoring and thickening agent in food. The seeds are exported within the region as well as to European cities with significant West African populations. In addition to its value as a condiment, the tree has many medicinal uses, some of which are highly localized. In addition, it is grown by farmers for soil improvement, forage, shade, poles and light woodwork. It is mainly found in secondary forest and on the fringes of settlements, but in the future, management of the species on farms may eventually become necessary as existing forest diminishes and agriculture spreads with population growth.

R. heudelotii subsp. *africanum* has been planted on the compound farms (kitchen gardens) of Nigeria and on plantations as a fast-growing shade tree. Research is being carried out on vegetative propagation of the species to make it more productive and reduce the length of time it takes for a sapling to begin fruiting.

The material gathered together in this paper relies heavily on work carried out by CARPE, ICRAF, the Tropenbos program in Southern Cameroon, and the Mount Cameroon Project, Limbe. As such, it is not representative of knowledge and use of the species throughout its area of geographical distribution. It also relies on material gathered from Anglophone and Francophone countries and published in Europe. This study should therefore not be considered as definitive, but rather as a starting point for increasing the state of knowledge of the uses and importance of *R. heudelotii* subsp. *africanum* in Africa, its place in the local economy, and its potential for commercialization.

TAXONOMY AND ECOLOGY

Taxonomy

Ricinodendron (Euphorbiaceae) is represented by two species: *R. heudelotii* in West and Central Africa and *R. rautanenii* Schinz in southern Africa. *R. heudelotii* is further divided into two subspecies: *R. heudelotii* subsp. *africanum* and *R. heudelotii* subsp. *heudelotii* (Léonard 1961). As shown in Table 1, these latter taxa are not only distinguished through morphological differences, but they also occupy different geographical ranges (see below). A detailed botanical description of *R. heudelotii* subsp. *africanum* can be found in Appendix 1.

[1] Editor's note: Despite being somewhat cumbersome, the correct taxonomic name for njansang, *R. heudelotii* subsp. *Africanum*, is applied throughout this paper, rather than the more commonly, and incorrectly, used *R. heudelotii*.

Table 1. Morphological differences between the subspecies of *R. heudelotii* (modified from Léonard 1961)

	R. heudelotii	
	subsp. *heudelotii*	**subsp. *Africanum***
Petiole	Without glands at the top on the upper surface, or occasionally with 1–2 glands. The base has (1)2–4(6) large glands, or, exceptionally, there are no glands. There are 3 or 5 stipules.	Generally with (1)2 large glands at the top on the upper surface, or fairly often without glands. The base lacking glands, or, exceptionally, with 1(4) gland(s). Generally 5 stipules, rarely 3–4, fairly often (6)7.
Flower	Female flowers with 3 locules and 3 styles.	Female flowers with 2 locules, very rarely 3, and 2 or, very rarely, 3 styles.
Fruit	3 locules, 3-lobed, 1.5–2 cm long and 2.4–3.4 cm in diameter, when dried. Sometimes 2-lobed or without lobes resulting from the abortion of 1 or 2 seeds.	2 locules, 2-lobed, 1.3–2.5 cm in length and breadth, and 2.4–3.5 cm in width when dried, sometimes unlobed resulting from abortion of a seed, and very rarely 3-celled.

Distribution

As mentioned above, the distribution of the two subspecies of *R. heudelotii* is quite distinct. *R. heudelotii* subsp. *heudelotii* extends from Guinea-Bissau to Ghana only, while *R. heudelotii* subsp. *africanum* is distributed through Nigeria, Cameroon, Equatorial Guinea, Republic of Congo (Brazzaville), Angola, Central African Republic, Sudan, Democratic Republic of

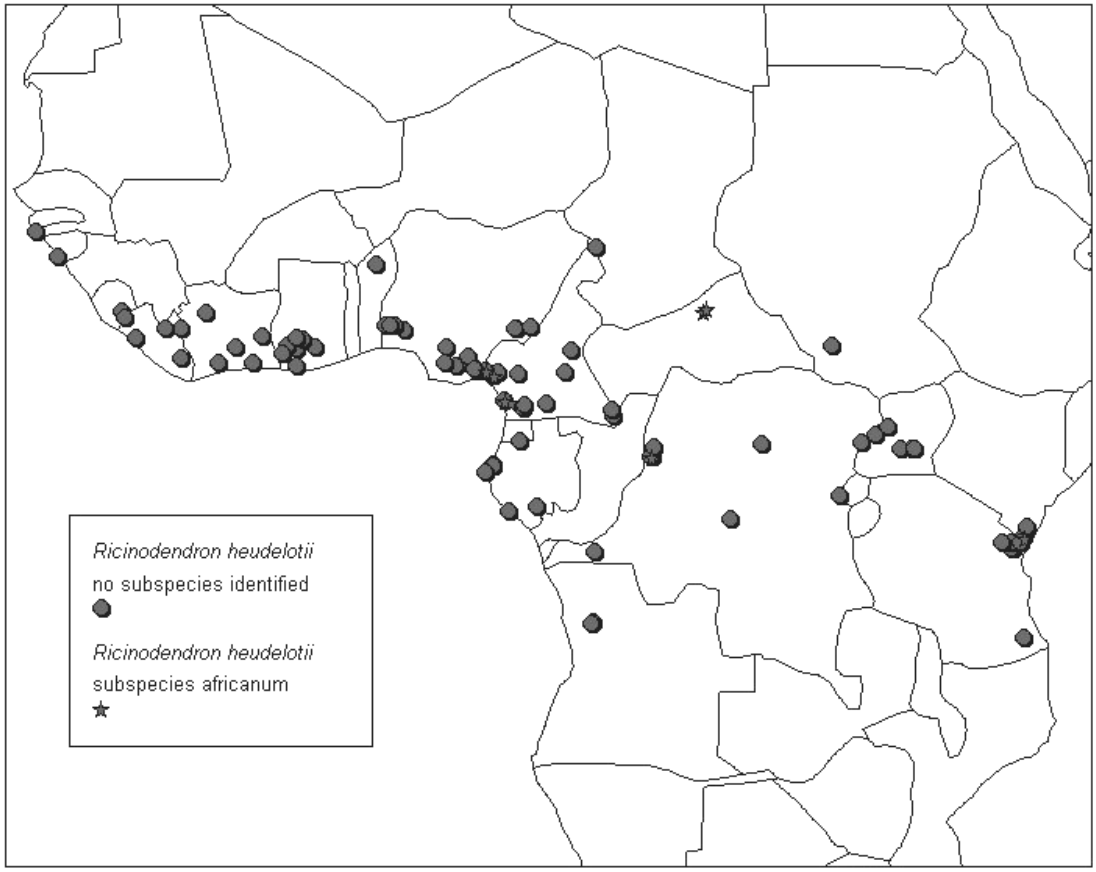

Figure 1. Distribution of R. heudelotii subsp. africanum *from collection locations of herbarium specimens from Kew, Meise, Missouri, Oxford and Wageningen*

Congo, Uganda, Tanzania and Mozambique (Léonard 1961). It is this latter taxon, and its use in Central Africa, that is the focus of this paper.

Habitat and population

R. heudelotii subsp. *africanum* is a light-demanding species occurring most frequently in fringing, deciduous and secondary forests (Taylor 1960; Burkill 1994). It is common throughout the semidry wooded-savanna zone of Central Africa. The species is often retained when land is cleared and is common on abandoned farmland (Chudnoff 1984). Dalziel described it as a "quick-growing tree, shooting readily from the stump and coming up freely in old farms. Trees growing spontaneously from seed are often preserved in the neighbourhood of villages in the forest" (1948:159).

The species is able to grow in hot, humid climates with as much as 2,800 mm rainfall/year, and can also withstand drought. It will survive well in soils with a pH as high as 7.7. Indeed, it can thrive across a range of soil, moisture and drainage conditions if not subject to heavy competition for light (Anigbogu 1996). In open-light spaces, it will bear fruit in the 7th to 10th year (Dalziel 1948).

In the South Province of Cameroon, an average density of 2.1 stems/ha. was observed in secondary forest, with a maximum density of 4.1 stems/ha (van Dijk 1999). In the Mbalmayo Forest Reserve, also in Cameroon, a higher density of 5 individuals/ha was recorded (Musoko *et al.* 1994). Van der Linden (1994) measured the following relative densities of *R. heudelotii* subsp. *africanum* in the Dja Fauna Reserve, East Cameroon:

- Altitude 3,000 m, dbh >10 cm, 0.7 stems/ha; dbh >70 cm, 0.3 stems/ha.
- Altitude 2,850 m, dbh >10 cm, 1 stem/ha; dbh >70 cm, 0.3 stems/ha.
- Altitude 1,650 m, dbh >10 cm, 2.4 stems/ha; dbh >70 cm, 0.5 stems/ha.

Dispersal and regeneration

The fruits are produced in large quantities, and most of them remain dormant for about 6 months. They are reported to be dispersed by bats, hornbills and rodents (Taylor 1960). However, human harvesting of fruits of species such as *R. heudelotii* from the forest may be affecting the species' population structure. Sunderland and Tchouto (1999) found evidence that overgathering of fruits, given the length of time needed for the seed to reach germination point, is having an impact on natural regeneration rates.

After the pulp has rotted, the stony endocarp may lie for more than 2 years if it does not germinate or get carried away by rodents (Shiembo 1994). Katende et al. (1995) suggest that seed could be collected from the forest ground after the seed capsules have broken open and scattered the seeds (Katende et al. 1995). This is the only suggestion in the literature examined that the endocarp opens spontaneously and explosively rather than rotting away.

In the forest, there is mass germination under the parent female tree when regrowth is cleared at the start of the rainy season. The seedlings are then attacked by psyllids or smothered by regrowth, but seeds that are carried away from the parent tree will germinate (Shiembo 1994).

Mycorrhizae

R. heudelotii subsp. *africanum* growing in semi-evergreen forest in Tanzania was examined for mycorrhizal associations (Högberg 1982). The species was found to be endomycorrhizal (Redhead 1968; de Alwis and Abeynayake 1980; Högberg 1982), the most common type of association found in the tropics.

Table 2. Flowering and fruiting times for *R. heudelotii* subsp. *africanum* as recorded in the literature observation of herbarium specimens

Country	Flowering	Fruiting	Source
Nigeria	January and July	August, September–October	Kennedy 1936:78
Nigeria	March and September		Lawton and Lawton 1971:189
Nigeria	January		64
Nigeria	April		Chapman, J.D. 5330
Nigeria		June	Gentry, A. and G. Pilz 32657
Nigeria		August	Chapman, H.M. 165
Nigeria and Cameroon	March–May	May–October	Keay et al. 1960:257; Thikakul 1985:305
Cameroon		August–November	Fereday et al. 1997:19, fig.2
Cameroon		August–December	Sunderland and Tchouto 1999:18, table 5.
Cameroon	February		Thomas, D. 3059
Cameroon	March		Thomas, D. 3269
Cameroon		May	Thomas, D. 3477
Cameroon		May	Mildhaer 9266
Cameroon		June	Leeuwenberg, A.J.M. 5970
Central African Republic	March		Harris, D.J. and J.M. Fay 317
Central African Republic		November	Fay, J.M. and D. Harris 8682
Equatorial Guinea	April		Tessmann, G. 357
Gabon		November	Louis, A.M., F.J. Breteler et al. 818
Dem. Republic of Congo	March		Louis, J. 8308
Angola		March	Dechamps, R.-F. Murta et M. Da Silva 1529 28.196
Uganda	March		Harris, C.M. 634
Uganda	November		Dummer, R.A. 4444
Uganda		October	Dawe, M.J. 637
Kenya		March	Faden, R.B. and A.J. 74/312
Tanzania	January		Greenway, P.J. 4843

MANAGEMENT AND USES OF *R. HEUDELOTII* SUBSP. *AFRICANUM*

Wood and timber

The wood of *R. heudelotii* subsp. *africanum* is white and light, often compared with balsa (Uganda Protectorate Forest Department 1934; Fouarge and Gérard 1964; Chudnoff 1984). It is suitable for fishnet floats and life belts, toys and models, soundproofing, heatproofing, electrical insulation, and reducing vibration as in wrappings, paddings or fillings (Dalziel 1948; Burkill 1994). It also can be used for crude joinery such as boxes and crates or as plywood core stock (Dalziel 1948; Burkill 1994; Laird et al. 1997), but it is seldom used for general construction (Shiembo 1994). The wood is also used for carvings and musical instruments (Dechamps 1970; Burkill 1994).

Wood ash

The ash is used in Guinea to prepare a vegetable salt for soap making and indigo dyeing (Burkill 1994; ICRAF 1999); the Mende in Sierra Leone use it as a source of potash in soap making (Burkill 1994:131), as do the Ghanaians (Abbiw 1990:228). In Ghana (Abbiw 1990) and the Democratic Republic of Congo (Latham 1999), the wood ash is used as a cooking salt.

The seeds

The hard, stonelike seeds of *R. heudelotii* subsp. *africanum* have a multiplicity of uses and are processed in various ways once the outer fruit has been removed. The seeds are used in Sierra Leone in rattles for bundu dances (Burkill 1994), and in Cameroon they are used as rattlers inside dried gourds to produce musical sounds (Shiembo 1994). The seeds are used in Nigeria by the Igbo as playing pieces in "okwe" (also the Igbo name for the tree), and in Cameroon for "songo," both of which are games similar to checkers (Burkill 1994; Mapongmetsem and Tchiegang 1996; ICRAF 1999).

The seeds and husks can be processed to obtain oil. In 1907 and 1908 samples of *R. africanum* seeds were received at the Imperial Institute in London, where they were tested for their oil content (Imperial Institute 1907). The kernels, which were white and soft and could not be freed easily from their shells, accounted for 29%, and the shells for 71%, by weight, of the whole seeds. The yield of oil was 47% on the kernels and 14% on the entire nuts (including the shells). It was light yellow, with a pleasant taste resembling that of groundnut oil, and dried to a film in a few hours (Imperial Institute 1908). More contemporary studies show similar results. As part of their ethnobotanical survey in southern Cameroon, Fondoun et al. (1999) extracted the oil from the kernels of *R. heudelotii* subsp. *africanum*. The total oil content found in their analysis varied from 49.25% to 63.18%. Similar oil content has been reported by Tchiegang et al. (in press, quoted in Fondoun et al. 1999). It has

Njansang wood and wood ash are used in a variety of ways, including fishing, musical instruments and soap making

been suggested that the high fat and oil content of the seeds of *R. heudelotii* subsp. *africanum* indicates their suitability for commercial production of cooking oil and margarine as well as soaps and pharmaceutical preparations (Okafor and Lamb 1992; Mapongmetsem and Tchiegang 1996; Latham 1999).

Throughout its range, the main use of the seeds of *R. heudelotii* subsp. *africanum* is as a condiment for cooking. Crushed njangsang has a spicy/peppery taste and acts as a thickening agent (Fereday et al. 1997; Sunderland and Tchouto 1999). The ground seeds are used to thicken and flavor pepe soup, fish stews and other dishes. They are also cooked with fish, chicken and vegetables or eaten plain (Amadi, 1993; Mapongmetsem and Tchiegang 1996; Brocklesby and Ambrose-Oji 1997; Laird et al. 1997; Ndoye et al. 1998). In addition, the kernels may be roasted, made into a paste and used for making a sauce similar to peanut sauce (Ake Assi 1991; Fondoun et al. 1999; ICRAF 1999).

Obtaining seeds from the fruits of *R. heudelotii* subsp. *africanum* is extremely labor-intensive. The large green kidney-shaped fruits drop toward the end of the rainy season and are collected into piles under the tree, usually by the women and children of the village. The piles signify ownership of the fruits, as well as allowing the pulp to rot to reveal the yellow nuts. It takes about 3–4 weeks for the fruit to decompose, then the fleshy parts are removed and the nuts are given a long boiling to crack them. Finally, the kernels are dried in the sun or in an oven. Removal of the nuts from the fruit is done by women and children over a period of 6 weeks to 2 months. It takes approximately 2 days' processing to fill a 10-liter basket. The dried kernels can be kept for several years and may be sold throughout the year in urban markets (Gautier-Béguin 1992; Vivien and Faure 1996; Fereday et al. 1997; Ntamag 1997; Sunderland and Tchouto 1999). The kernels are easily damaged in cracking the nut, but this is avoided by boiling the nuts before cracking them (Dalziel 1948).

Medicinal uses

R. heudelotii subsp. *africanum* has widespread medicinal uses. The bark appears to be the most efficacious and most frequently used part of the tree for medicine. Bark extract of *R. heudelotii* subsp. *africanum* is used to treat coughs and as an antidote to poison (Kimbu et al. 1991; Burkill 1994). The roots and root bark are mixed with bush pepper and salt in Nigeria for use as a laxative (Burkill 1994). In the Mount Cameroon region (Laird et al. 1997), an infusion of the bark or root bark is taken to treat diarrhea.

In the Congo region, a bark decoction is used in lotions and baths to strengthen children with rickets and premature babies. It is also used to treat rheumatism (Burkill 1994). In Gabon and Congo, a bark decoction is used to treat anemia and blennorrhea, and a stem bark decoction is used to wash and cicatrize sores (Burkill 1994). A bark decoction may be used in lotions and baths to relieve the swelling of edema (Burkill 1994), and elephantiasis is treated by local application of pounded and warmed bark (Dalziel 1948; Abbiw,1990; Fakankun and Loto 1990; Burkill 1994; Laird et al. 1997).

Treatments made from *Ricinodendron* bark are widely used for sexual and fertility problems, as well as to ease the pain associated with menstruation or childbirth. In Nigeria, a bark infusion is used by pregnant women to relieve labor pains and prevent miscarriage (Fakankun and Loto 1990). The bark is also used as a cure for gonorrhea (Fakankun and Loto 1990).

Wome (1984) reports use of *R. heudelotii* subsp. *africanum* to treat leprosy in Kisangani, Haut-Zaïre (the present-day Democratic Republic of Congo). The treatment involves an infusion made from the trunk bark of the species, used as a local/topical bath to disinfect and heal the skin (Wome 1984).

In Cameroon, the leaves are used in baths, vapor baths or medicinal drinks to treat fever (Mapongmetsem and Tchiegang 1996; Laird et al. 1997) and are mashed and applied to fungal ailments and abscesses

(Mapongmetsem and Tchiegang 1996). In the Mount Cameroon region, the seeds are used in soups to stimulate the appetite of invalids and build their strength, and also in a mixture with palm oil to treat stomach discomfort and "bad bile" (Laird et al. 1997:62).

In the Congo, the bark and leaves are pulped and "applied to fungal infections and to maturate abscesses, furuncles and buboes" and the expressed sap is applied to the eye for filaria and ophthalmias (Burkill 1994).

Propagation and cultivation

Germination of *R. heudelotii* subsp. *africanum* seed is fairly slow, with only a 40% success rate that decreases rapidly with time (Vivien and Faure 1996). Although Katende et al. (1995) recommend soaking the seed to hasten germination, Shiembo (1994) found that germination was unpredictable and that other pretreatments, such as scarification, partial burning under a thin layer of grass, or cycles of soaking and drying, were ineffective in promoting even and early germination (Shiembo 1994).

The most effective means of improving *R. heudelotii* subsp. *africanum* for on-farm use is by vegetative propagation, which can rapidly overcome the limitations to improvement imposed by long generation times, irregular fruiting/flowering and outbreeding. Propagation trials of the species have been carried out at the Institute of Terrestrial Ecology, Edinburgh (Leakey et al. 1992). *R. heudelotii* subsp. *africanum* often appears to compete for domestication with *Irvingia gabonensis* (see Ainge and Brown, this volume), a focus of current ICRAF research for which many high-yielding and improved cultivars are available.

Experiments on vegetative propagation of *R. heudelotii* subsp. *africanum* were also undertaken in Cameroon (Shiembo 1994; Leakey and Newton 1994) to determine appropriate treatments for mass production of clonal planting stock. In particular, the trials assessed the effect of variation in the propagation medium, auxin concentration and leaf area on the rooting of leafy stem cuttings. Rooting percentages of over 80% were achieved in all three experiments; the highest rooting percentages were achieved in sawdust. None of the leafless cuttings rooted. It is suggested that optimum leaf area for propagation of *R. heudelotii subsp. africanum* is >80 cm^2. The main cause of cutting mortality in these experiments was stem rotting following leaf abscission (Shiembo et al. 1997).

Experiments were also designed to test the suitability of a low-technology nonmist system for propagating this species. Using improved low-technology, high-humidity polyethylene propagators, it was found that by day 21 rooting was best done without mist (75%, compared to 50% under mist) (Leakey et al. 1990:255). Shiembo (1994) also reports that in experiments to find the optimal rooting method for *R. heudelotii* subsp. *africanum* stock plants, rooting declined with increasing pollard height—the highest success rate was obtained at 1.5 m.

Without doubt, farmers in the Central African region would benefit from the breeding programs described above because of the market potential for the seeds as well as the species' multiple uses. There is evidence that market supplies of njangsang are shrinking due to the reduction of forests and increasing demand for the condiment (Perez et al. 1999), and Perez et al. suggest that this demand could be met if *R. heudelotii* subsp. *africanum* were cultivated (ibid.). Katende et al. (1995) recommend that the tree could be planted either in pure stands, intercropped with cash crops such as coffee, cocoa or banana, or as individual shade and avenue trees.

Currently, the actual level of integration of *R. heudelotii* subsp. *africanum* into farming systems varies somewhat across its range. Shiembo (1994) reported that farmers in Cameroon seldom plant the species because planting stocks are not readily obtainable, as the seeds are difficult to germinate. In spite of these drawbacks, *R. heudelotii* subsp. *africanum* has potential for increased use by farmers

in agroforestry systems. Sunderland and Tchouto (1999) believe that prospects for domestication or incorporation into agroforestry systems are "good." They rate the species a "high-value resource" which would benefit more from better management, such as retaining individuals on farmland, than from domestication. Surveys carried out by ICRAF and its partners to find farmers' preferences for multipurpose trees ranked *R. heudelotii* subsp. *africanum* third among species considered useful for domestication in the West African humid lowlands (Leakey and Tomich 1999). It was also ranked the fourth most-valued multipurpose tree species (MPTS) in a survey by ICRAF/IITA/OSU that screened over 100 MPTS at their Ibadan, Onne (Nigeria) and Mbalmayo (Cameroon) sites (Adeola 1995).

Improvements in reproduction and in attributes useful to farmers are needed to facilitate increased on-farm use of *R. heudelotii* subsp. *africanum*. For example, farmers taking part in the ICRAF MPTS surveys said the attributes required to make the species more acceptable were precocity, reduced tree height, increased biomass, larger seeds and larger fruit with a longer shelf life (Adeola 1995; Mollet et al. 1995).

MARKETS AND TRADING

Local trade

The variable incomes from the marketing of many NTFPs and agricultural products reflect their seasonal nature. Prices are low at harvesting and tend to increase as supplies diminish. The harvest is sold through the home and village markets. For example, in villages surveyed in the north and northeast of the Korup Project Area in South West Cameroon, November to January is a boom period. That is when cocoa, coffee, oranges, bush pepper, njansang and smoked bush mango are harvested and sold (Vabi and Tchamou 1999).

Wherever *R. heudelotii* subsp. *africanum* fruits are harvested and processed, these activities are almost exclusively the domain of women (Ntamag 1997; Vabi and Tchamou 1999). In the Mokoko River Forest Reserve, Cameroon, even though njansang is regarded as one of the more valuable NTFPs available, it is an "open access" resource; hence, njansang fruits are more commonly exploited by local women (Sunderland and Tchouto 1999). Throughout Cameroon, *R. heudelotii* subsp. *africanum* is generally sold between October and November, with the peak period for harvesting being August–October (Vabi and Tchamou 1999). However, well-dried kernels will keep for up to two years, enabling them to be stored and sold throughout the year in urban markets (Vivien and Faure 1996; Laird et al. 1997).

Mapongmetsem and Tchiegang (1996) found that *R. heudelotii* subsp. *africanum* seeds are important in both local and regional markets, with 1 kg (averaging 250 nuts) selling for US $1.30–1.50 (1996 prices). An extrapolation from additional market surveys in Cameroon suggests that trade in 4 indigenous fruits (*R. heudelotii* subsp. *africanum*, *Irvingia gabonensis* and *I. wombolu*, *Dacryodes edulis* and *Cola* spp.) from the humid forest zone over the 6-month period January–July 1995 was valued at US $1.2m (Leakey and Tomich 1999). Of this, the share for *R. heudelotii* subsp. *africanum* was US $460,200 (ibid.).

The market value of *R. heudelotii* subsp. *africanum* not only varies with the season, but with availability and demand. Ndoye et al. (1998) found a clear difference in the percentage net marketing margin of the species, with the value in markets in the Littoral province of Cameroon being about double that in the Centre province. This reflects the source of supply. *R. heudelotii* subsp. *africanum* is readily available in the Centre-South provinces, but is relatively scarce in the Littoral province. In addition, demand is high in the Littoral province because fish is an important staple there, and *Ricinodendron* is a popular condiment for use with fish (ibid.).

In Cameroon, markets for *R. heudelotii* subsp. *africanum* are concentrated in the vicinity of large urban centers. Wholesale traders buy from local markets and villages and sell to larger urban centers and for export (Laird et al. 1997). Wholesalers help to stabilize prices, at the same time earning a considerable premium by storing the more durable processed products such as cola, bush mango and njangsang. The premiums earned more than compensate for storage costs and losses due to insect damage (Fereday et al. 1997). Wholesalers also perform arbitrage, moving product from areas where supplies are high and prices are low, to areas where there is demand but not as much supply (Fereday et al. 1997).

Njansang is widely trade in Central and West Africa

Wider trade patterns

R. heudelotii subsp. *africanum* seeds, and to a lesser extent the bark and roots, are widely traded within West and Central Africa, both within countries and across borders. It is estimated that exports from markets studied in Cameroon to neighboring countries in 1996 amounted to at least US $980,000 (Pérez et al. 1999).

There is also trade in NTFPs between Cameroon and some large European cities such as Paris and Brussels where there are large numbers of immigrants from West and Central Africa (Tabuna 1999). The trade in African NTFPs is known to employ several hundred persons in France and Belgium. In Paris, a survey listed *R. heudelotii* subsp. *africanum* among the NTFPs most frequently imported into France, although the volume and monetary value of the trade is difficult to quantify (Tabuna 1999). The markets are diverse because national origins tend to influence customers' purchases. For example, *R. heudelotii* subsp. *africanum* is bought predominantly by people from Cameroon (ibid.).

INSTITUTIONAL ISSUES

National land use laws may present an opportunity to conserve NTFPs by offering long-term security to users of the land. For example, the 1994 Cameroon Land Tenure Act (Articles 14, 16 and 17) created opportunities for indigenous people to defend land rights and privileges (Ntamag 1997). Within the categories of forest land established in the legislation, "national forests" are areas of nonpermanent forest that are not state, council or private forests, and forest products remain the property of the state, unless they are subject to management agreements, as in community forests. "Community forests" are formed from forested land within "national forests" and are likely to be under relatively intense exploitation already (Ambrose 1994). Community forest land may cover as much as 50–60% of all national forest territory, but it has little legal protection (see also Sunderland and Tchouto 1999).

Clearing forest land and planting cash crops, such as cocoa or coffee, grants de facto possession of the land for 30 years, although whether this includes clearing land and planting trees around forest margins or fallow land is not clear. Awarding people long-term control over their land gives them an interest in retaining valuable NTFP resources, such as *R. heudelotii* subsp. *africanum*, because their horizons are longer

and the benefits of long-term earnings from trees are seen as accruing to them (Sunderland and Tchouto 1999). However, Ambrose (1994) reported that even though such usufruct rights to forest land in Cameroon exist under state and national forest land classifications, legal title cannot be obtained for "virgin" forest. Furthermore, Fereday et al. (1997) point out that there is a potential for conflict under Cameroon law, because the existing forest resource classification means that harvesting NWTPs for commerce could be interpreted as illegal.

R. heudelotii subsp. *africanum* is not on the World Conservation Monitoring Center's list of endangered species in West Africa, even though it is reported that individual trees in the forest are not as common as they once were (Laird et al. 1997).

CONCLUSIONS AND RECOMMENDATIONS

Although *R. heudelotii* subsp. *africanum* is a useful multipurpose tree, it has been incorporated into agricultural systems in parts of its range, but not in others. Breeding programs to realize farmers' requirements for high-value NTFPs would benefit from greater understanding of the species concerned and the importance of habitat to the growth of superior trees, as well as the socioeconomic acceptability of increased production through cultivation.

In addition to improvements to the species' performance, there is a need to make processing the fruits an easier exercise. At present extracting and drying the seeds is a time-consuming task undertaken by women, and the prices they receive when they sell their produce to traders, or in local markets, are unlikely to reflect the true value of the labor involved. Cooperative ventures may be a means to improve this situation. For example, production and marketing cooperatives for such forest produce as *R. heudelotii* subsp. *africanum* have been formed, giving women a stronger bargaining position and helping them to obtain better prices for their produce (Arrey 1999).

The most intractable issue relating to NTFPs such as *R. heudelotii* subsp. *africanun* is that of tenure and usufruct rights. For such species, both formal legislation and customary rights may inhibit development of sizable markets. The formal legislation limits control over land use, very often by retaining land ownership in government hands. Thus, even if a farmer is renting his land he has little incentive to invest in long-term resources such as trees. Customary rights may support sustainability by limiting the use of a resource, but this limitation also acts as a brake on increasing revenues.

More research is needed on *R. heudelotii* subsp. *africanum*, especially concerning ways to increase its productivity. Suggested topics for further study include:

- Improving planting stock for farmers, either by improving seed germination or by further work on vegetative propagation and clonal reproduction
- Assessing provenance using local farmers to find superior trees from which improved stock could be bred
- Dispersal and regeneration of the species: Is overcollection of fruits lessening regeneration of natural/wild populations?
- Extending fruit production to meet potential market demand, through community-based cultivation programs
- Improving locally based methods of seed extraction and processing
- Improving market access for farmers
- Establishing locally based cooperatives that could share processing and distribution.

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APPENDIX 1: BOTANICAL DESCRIPTION OF *RICINODENDRON HEUDELOTII* (FROM ICRAF 1999)

***Ricinodendron heudelotii* (Euphorbiaceae)**

Ricinodendron heudelotii is a fast-growing tree, reaching up to 50 m in height and 2.7 m in girth; bole straight with short buttress; bark grey, smooth at first, becoming scaly with aging; slash dark red, densely mottled with scattered pits and orange stone-cell granules. Leaves alternate, digitately 3–5 foliate; leaflets sessile or subsessile, glandular, denticulate, often white-felted on the underside at first with stellate pubescent hairs, becoming glabrous; obovate to obovate-elliptic; apex long-acuminate; base cuneate; stipules large, foliaceous, persistent, deeply toothed. Inflorescence yellow tomentose; male panicles up to 41 cm long; female panicles shorter and stouter; male flowers with 5 sepals, a 5-lobed corolla tube and 10 stamens; female flowers with stellate tomentose ovary and 2 styles, slender and bipartite. Fruit indehiscent, 2–3 lobed, 2 celled, with a thick, hard shell and a smell of overripe apples; contains 2–3 red-brown-black seeds, rounded, flat, over 1 cm across. Two varieties are recognized: *Ricinodendron heudelotii* var. *heudelotii* in Ghana and westwards, and *R. heudelotii* var. *africanum* in Nigeria and eastwards.

APPENDIX 2: BOTANICAL DESCRIPTION OF *RICINODENDRON HEUDELOTII* (BAILL.) HECKEL SUBSP. *AFRICANUM* (MODIFIED FROM KEAY 1989)

***Ricinodendron heudelotii* (Baill.) Heckel subsp. *africanum* (Muell. Arg.)**

J. Léonard *Bull. Jard. Bot. Brux*. 31:398 (1961)

Synonym: *R. africanum* Muell. Arg.

Tree to 50 m high and 2.5 m in girth. Deciduous. Bole usually straight, sometimes with short buttresses. Bark smooth at first, becoming rough and scaly, brownish; slash reddish and very granular. Branches widely spreading and crooked when old, markedly whorled and more or less horizontal in young trees. Leaves with 3–5 leaflets on a stalk up to 20 cm long with large, persistent, toothed stipules at the base; the leaflets 6–24 cm long by 2.5–11 cm broad, the lateral leaflets often smaller; pointed elliptic, stalkless, long-acuminate, gradually cuneate at base, the margins slightly toothed, with teeth ending in a small, black gland; mid-rib and lateral nerves prominent. Flowers usually in terminal panicles. Male panicles loosely branched up to 30 cm long; buds about 2 mm across, on short flower stalks, densely covered in a yellowish felt; female panicles stouter and shorter, ovary densely stellate hairy. Fruits at first stellate, hairy, 2.5 cm or more across, containing 2 or, occasionally, 3 seeds. Wood white, very soft.

APPENDIX 3. VERNACULAR NAMES

Vernacular name	Language/Country	Source
African nut tree, African wood, African wood-oil nut tree, cork wood	English	ICRAF 1999
African wood oil nut tree		Adjanohoun et al. 1991
Akin	Baule (Côte d'Ivoire)	Burkill 1994
Akpi	Ngban, Abe, Akan-Asante, Akye, Baule (Côte d'Ivoire)	Gautier-Béguin 1992; Burkill 1994
Akporo	Baule (Côte d'Ivoire)	Burkill 1994
Akwi	Akye, Anyi (Côte d'Ivoire)	Burkill 1994
Alokpo	Ghana	Burkill 1994
Andjo cos yogos	Tanda (Guinea Bissau)	Malaisse and Claes, 1995
Anwarma		Fouarge and Gérard 1964
Api	Anyi, Brong, Kulango (Côte d'Ivoire)	Burkill 1994
Asoma	Anyi, Nzema (Ghana)	Burkill 1994
Awama, awoma, owama	Akan-Asante, Fante (Ghana)	Burkill 1994
Bofeko	Democratic Republic of Congo	Fouarge and Gérard 1964; Chudnoff 1984
Bo-gboho	Kissi (Guinea)	Burkill 1994
Bonjasanga	Kundu (Cameroon)	Burkill 1994
Bonjaosao	Duala (Cameroon)	Burkill 1994
Bõn kuõforo	Manding-Mandinka (Senegal)	Burkill 1994
Boroï	Toma (Guinea)	Burkill 1994
Bosisang	Lundu (Cameroon)	Burkill 1994
Bu kenkare, bu makureg, bu makurèn	Diola (Senegal)	Burkill 1994

Vernacular name	Language/Country	Source
Haipi	Kulango (Côte d'Ivoire)	Burkill 1994
Hakpiwaka	Anyi (Ghana)	Burkill 1994
Hobo hapi	Abe (Côte d'Ivoire)	Burkill 1994
Irinmado	Nigeria	Fakankun and Loto 1990
Irranguila	Zambia	herbarium
Isain	Akye (Côte d'Ivoire)	Burkill 1994
Isange	Koosi (Cameroon)	Burkill 1994
Issanguila	Gabon	Klaine 1895
Ka-kino, ka-sigboro	Temne (Sierra Leone)	Burkill 1994
Karro-tu	Guere (Liberia)	Burkill 1994
Karatu	Kru-Grebo (Côte d'Ivoire)	Burkill 1994
Katotu	"Kru" (Côte d'Ivoire)	Burkill 1994
Kô, koo	Mano (Guinea); Mano (Liberia); Gagu, Guere, Kweni (Côte d'Ivoire)	Burkill 1994
Ko	Dan (Liberia)	Burkill 1994
Kohué, kotué, ko-ué	Kru-Grebo, Guere (Côte d'Ivoire)	Burkill 1994
Koor	Ktu-Basa (Liberia)	Burkill 1994
Kpedi	Vhe (Ghana)	Burkill 1994
Kpo	Kissi (Sierra Leone)	Burkill 1994
Kua	Guere (Côte d'Ivoire)	Burkill 1994
Kingela	Kicongo (Bas Congo)	Latham, pers. comm 1999
Kishongo	Uganda	Chudnoff 1984
Kisongo	Kuamba	Forest 1958
Matondoo	Tanzania	Zimmerman 1917
Mbob, nbob	Adyukru, "Kru" (Côte d'Ivoire)	Burkill 1994
Mille[1]	Ngban (Côte d'Ivoire)	Gautier-Béguin 1992
Mlindi	Kishamba (Tanzania)	Herbarium
Muawa	Swahili	ICRAF 1999
Mughele	Bapounou (Gabon)	Yembi 1999
Mulela	Democratic Republic of Congo	Pieters 1977
Munguella	Angola	Gossweiler 1908; Fouarge and Gérard 1964; Chudnoff 1984
Musodo	Lunyoro (Uganda)	Forest 1934, 1958
Ngwama, ngwani	Nzema (Ghana)	Burkill 1994
Njansang, njangsang	Kundu (Cameroon)	van Dijk 1999; Vabi and Tchamou 1999; Malleson 1999; Sunderland and Tchouto 1999; Burkill 1994
Nsasana	Efik (Nigeria)	Burkill 1994
Nwuama	Anufo (Ghana)	Burkill 1994
Ode, odede	Igala (Nigeria)	Burkill 1994

[1] The author does not know the meaning of this name.

Vernacular name	Language/Country	Source
Bukombola	Kitembo (Democratic Republic of Congo)	Troupin, 1957
Corkwood	English	Forest 1958; ICRAF, 1999
Djansang		Tabuna 1999
Egobo	Central African Republic	herbarium
Eho, ého	Abe (Côte d'Ivoire)	Fouarge and Gérard 1964; Burkill 1994
Eke	Urhobo (Nigeria)	Keay et al. 1960; Keay 1989; Burkill 1994
Ekku	Yoruba (Nigeria)	Burkill 1994
Ekobo	Central African Republic	herbarium
Ekpedi	Adangme-Krobo (Ghana)	Burkill 1994
Engwanle	Nzema (Ghana)	Burkill 1994
Epi	Akan-Asante (Ghana)	Burkill 1994
Epo	Edo (Nigeria)	Burkill 1994
Epui, epuwi	Anyi, Anufo (Ghana)	Burkill 1994
Erimado, erín madò	Democratic Republic of Congo; Yoruba (Nigeria)	Pieters 1977; ICRAF 1999; herbarium; Chudnoff 1984; Fouarge and Gérard 1964
Erinmado, erinmadu	Yoruba, Edo (Nigeria)	Keay et al. 1960; Keay 1989; Burkill 1994
Esangasanga	Kpe (Cameroon)	Burkill 1994
Esesang	Fang (Equatorial Guinea)	Sunderland and Obama 1999
Essandaille, esseng ndaye	Adyukru (Côte d'Ivoire)	Burkill 1994
Essesang, essessang	Fang (Equatorial Guinea); Gabon; Cameroon; Democratic Republic of Congo	Fouarge and Gérard 1964; Chudnoff 1984; Sunderland and Obama 1999; Yembi 1999; Pieters 1977
Ewama, enwany(e), nwuama	Anufo (Ghana)	Burkill 1994
Ezan	Cameroon	Bates 1921
Ezezang, ezang	Cameroon	Anigbogu 1996
Flekpo	Ghana	Burkill 1994
Gbo	Kissi (Sierra Leone)	Burkill 1994
Gboe	Kono (Sierra Leone)	Burkill 1994
Gbore	Koranko (Sierra Leone)	Burkill 1994
Gbolei, gbolo, gboloi, gbolei, kpolei, kpolo	Mende (Sierra Leone); Mende (Liberia)	Burkill 1994
Gbolo	Kpelle (Guinea)	Burkill 1994
Gboloba-bulu	Manding-Maninka (Guinea)	Burkill 1994
Gboloye	Toma (Guinea)	Burkill 1994
Gbuho-ba	Dioula (Côte dIvoire)	Ambe 1997
Gbwoye	Kono (Sierra Leone)	Burkill 1994
Goodi	Dan (Côte d'Ivoire)	Burkill 1994
Gporo	Toma (Guinea)	Burkill 1994
Groundnut tree	English (Cameroon)	Anigbogu 1996
Groundnut tree	Nigeria	Okafor and Lamb 1992
Hacbiuagpi, haipi	Anyi (Côte d'Ivoire)	Burkill 1994

Vernacular name	Language/Country	Source
Okao koodo	Ghana	Burkill 1994
Okengbo	Ijaw, Ijo-Izon (Nigeria)	Keay et al. 1960; Keay 1989; Burkill 1994
Okhuen, okhuen-nebo, okhuen-n'fua, okhuen-seva	Bini, Benin, Edo (Nigeria)	Smith 1931; Keay et al. 1960; Chudnoff 1984; Keay 1989; Burkill 1994
Okponum	Abua (Nigeria)	Burkill 1994
Okue	Itsekiri (Nigeria)	Keay et al. 1960; Keay 1989; Burkill 1994
Okwar	Mbe (Nigeria)	Burkill 1994
Okwe	Ibo (eastern Nigeria); Igbo (Nigeria)	Keay et al. 1960; Anigbogu, 1996; Keay 1989; Burkill 1994
Olóbò igbó	Yoruba (Nigeria)	Burkill 1994
Omodan, omodon, oromodon	Yoruba (Nigeria)	Adjanohoun et al. 1991; Burkill 1994
Omwama, onwama	Twi (Ghana)	Burnett 1926; Burkill 1994
Ovovo	Ijo-Izon (Nigeria)	Burkill 1994
Plo	Kono (Guinea)	Burkill 1994
Poposi	Abure (Côte d'Ivoire)	Burkill 1994
Popossi, popossi ya, propossi	Kyama (Côte d'Ivoire)	Burkill 1994
Poto poto, putu putu, putu putu funfun	Yoruba (Nigeria)	Burkill 1994
Sanga-sanga	Democratic Republic of Congo	Fouarge and Gérard 1964; Pieters 1977
Sesamga	Angola	Dawe 1921
Sosahu	Nzema (Côte d'Ivoire)	Burkill 1994
Tonta	Susu, Sosso (Guinea)	Burkill 1994; Malaisse and Claes 1995
Tsain	Akye (Côte d'Ivoire)	Burkill 1994
Tondoro	Tanzania	herbarium
Uama, wamba	Akan-Asante (Côte d'Ivoire); Ahanta, Wasa (Ghana)	Burkill 1994
Wama, wamba, wamma	Wasa (Ghana)	Vigne 1926, 1927; Chudnoff, 1984; Burkill, 1994; Abbiw, 1990
Wawankurmi, wawan kurmi	Hausa, Bassa (Nigeria)	Chapman 1974; Keay et al. 1960; Burkill 1994
Wawanputu kurmi	Hausa (Nigeria)	Keay 1989
Wawan kormi	Hausa (Nigeria)	herbarium
Webango	Democratic Republic of Congo	Pieters 1977
Wongasanga, wonjasanga, wonjangasanga	Kpe (Cameroon)	Burkill 1994

Appendix 4: Recorded distribution of *Ricinodendron heudelotii*, subsp. *heudelotii* and subsp. *africanum* (taken from literature sources).			
Species	***Country***	***Distribution***	***Source***
Ricinodendron heudelotii (Baill.) Pierre ex Pax, FWTA, ed.2, 1:393, fig.137. Synonym: *R. africanum* Muell. Arg. FWTA ed.1, 1:294	Benin	Sapoba, *Mitchell* FHI 2614	Keay et al., 1960:257
Ricinodendron heudelotii (Baill.) Pierre ex Heckel., Ann. Inst. Col. Marseille, V.2, p.40 (1898) pp. ~subsp. *heudelotii*	Guinea-Bissau; Equatorial Guinea; Sierra Leone; Liberia; Côte d'Ivoire; Ghana	Portuguese Guinea (Fulacunda, S. João, Mato de Poncom); Guinea (Fouta Djallon); Sierra Leone (Bagroo River); Liberia (Dukwia R.); Côte d'Ivoire (Dabou, Danané, 60 km N. of Sassandra); Ghana (Sikamang, Kumasi).	Léonard, 1961
Ricinodendron heudelotii (Baill.) Pierre ex Heckel., Ann. Inst. Col. Marseille, V.2, p.40 (1898) pp. ~subsp. africanum	Nigeria; Malabo (Equatorial Guinea); Cameroon; Equatorial Guinea; Congo; Cabinda; Angola; Central African Republic; Sudan; Democratic Republic of Congo; Uganda; Tanzania; Mozambique (?)	Nigeria (Calabar River Division; Ishagama-Ibadan); Fernando Po; Cameroon (Babua; Duala; Bipinde); Spanish Guinea (Nkolentangam); Gabon (Libreville); Congo Republic (Congo); Cabinda (Chiluango); Angola (Loanda–Cazengo, Luanda–Ambriz); Central African Republic (Boukoko); Sudan (Bendere–Zande District); Congo (Eala, Yangambi); Uganda (Semliki Forest); Tanganyika (Korogwe, Eastern Usambaras, Tanga District [1 location?]); Mozambique (ex bibliogr.).	Léonard, 1961
R. heudelotii (Baill.) Pierre ex Heckel subsp. *heudelotii*	Guinea-Bissau to Ghana	Portuguese Guinea to Ghana	Léonard, 1965:635
R. heudelotii (Baill.) Pierre ex Heckel subsp. *africanum* (Müll. Arg.) J. Léonard		Guinea-Congo region	Léonard, 1965:630-631
Ricinodendron Müller d'Argovie: *R. heudelotii*, subsp. *africanum*		Nigeria to Angola and from Uganda to Mozambique.	Normand and Paquis, 1976:67
Ricinodendron Müller d'Argovie: *R. heudelotii*, subsp. *heudelotii*		Western part of the Guineo-Congolese forests	Normand and Paquis, 1976:67

Species	*Country*	*Distribution*	*Source*
Ricinodendron heudelotii (Baill.) Pierre ex Heckel subsp. *africanum* (Müll. Arg.) J. Léonard.	Democratic Republic of Congo	Mayumbe, Bas-Zaïre, central forests of Zaïre, Bas-Shaba, Kasai, Ubangi-Uele.	Pieters, 1977:213
Ricinodendron heudelotii (Baill.) Pierre ex Pax, FWTA 1:393. Euphorbiaceae		Guinea Bissau to Angola and Tanzania; (Guineo-Congolian wide)	Hall and Swaine, 1981:275
Ricinodendron heudelotii		West tropical Africa from Guinea to Angola and eastward to Uganda	Chudnoff, 1984:2
Ricinodendron heudelotii (Baill.) Heckel, subsp. *africanum* (Müll. Arg.) J. Léonard, 1961; FWTA, ed.2, 1:393, fig. 137		Southern Nigeria eastwards to Sudan, Uganda, Tanzania, Angola and Mozambique	Keay, 1989:152
Ricinodendron heudelotii (Baill.), subsp. *heudelotii*		Guinea-Bissau to Ghana only	Keay, 1989:152
Ricinodendron heudelotii (Baill.) Pierre. ssp. *heudelotii*		Ghana and westwards	Burkill, 1994:131
Ricinodendron heudelotii (Baill.) Pierre. ssp. *africanum*		Nigeria and eastwards	Burkill, 1994:131
Ricinodendron heudelotii	Cameroon	Mbalmayo Forest Reserve (lat. 3°31`N; long. 11°30`E	Musoko et al., 19
Ricinodendron heudelotii		Tropical Africa from Guinea to Angola and in east Africa. Stations: Kaka (III), Linté (IX), Matomb (IV), Nguila (IX–X), Yangafok.	Vivien and Faure
Ricinodendron heudelotii		Senegal to Cameroon and Bioko, across to Zaïre (DRC) and Tanzania and Angola. Mount Cameroon region in lower forest areas, such as Mabeta-Moliwe and along the West Coast to Idenau.	Laird et al., 1997
Ricinodendron heudelotii	Cameroon	Southern Bakundu Forest Reserve, Southwest Province,	Shiembo et al., 19

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Chapter 5
KOLA NUTS
(*Cola Acuminata* and *Cola Nitida*)

Emmanuel Tachie-Obeng and Nick Brown

INTRODUCTION

Cola acuminata (P. Beauv.) Schott & Endl. and *Cola nitida* (Vent.) Schott & Endl. are two of the most economically important members of the genus (Lovejoy 1980). These moderately sized evergreen trees occur naturally from Sierra Leone east to Benin, and from Nigeria south to Angola. Both species are also widely cultivated across West and Central Africa. Valued primarily for the stimulants contained in the bitter-tasting nuts, known conventionally as "kola nuts," *Cola nitida* and *C. acuminata* figure largely in historical and modern trade and play an important cultural role throughout Central Africa. The nuts are also used as an ingredient in the popular soft drink Coca-Cola, while the alkaloids are used in pharmaceutical products and the stem and twig wood is used for chew sticks. Currently, however, most of the demand comes from West and Central Africa.

Long cultivated, the species are in little or no danger of overexploitation. However, wild populations and the genetic diversity they represent are threatened by increased clearing of wild forest for farms, by fires, and by uncertain resource tenure across much of the range of the two species.

This chapter summarizes the state of knowledge for *Cola nitida* and *C. acuminata*. Recommendations for future socioeconomic, institutional and research interventions are also discussed.

TAXONOMY AND ECOLOGY

The genus Cola

The genus *Cola*, in the family Sterculiaceae, comprises about 125 species (Keay 1989). The species of *Cola* are evergreen, and most *Cola* trees are small or moderate-sized, although a few grow up to 25 meters in height. The genus is found exclusively in tropical lowland and montane forest in continental Africa. The greatest number of species in any regional flora is the 42 (plus nine poorly known species) found in tropical West Africa (Cheek 2002). A number of the species are widely cultivated in tropical regions, in Africa especially, for their edible nuts (cotyledons), which are high in caffeine content and are chewed as a stimulant. The most commonly used and cultivated of these species are *C. verticillata* (Thonn.) Stapf ex A. Chev., *C. anomala* K. Schum., *C. acuminata* and *C. nitida*, with the last two possessing the greatest economic importance (Lovejoy 1980). These two species are the true "kola nuts," and this term is synonymous with both taxa (Dalziel 1937). Throughout this chapter, the term "kola nuts," or more simply "kola," refers to both species.

The seed of *C. nitida* consists of two cotyledons, and the seeds readily split into two, while *C. acuminata* has from 3 to as many as 6 cotyledons, with the seed splitting into a corresponding number of pieces (Irvine 1956; Keay 1989; Russell 1955). This characteristic is a good means of distinguishing between the species. Table 1 (below) summarizes additional morpho-

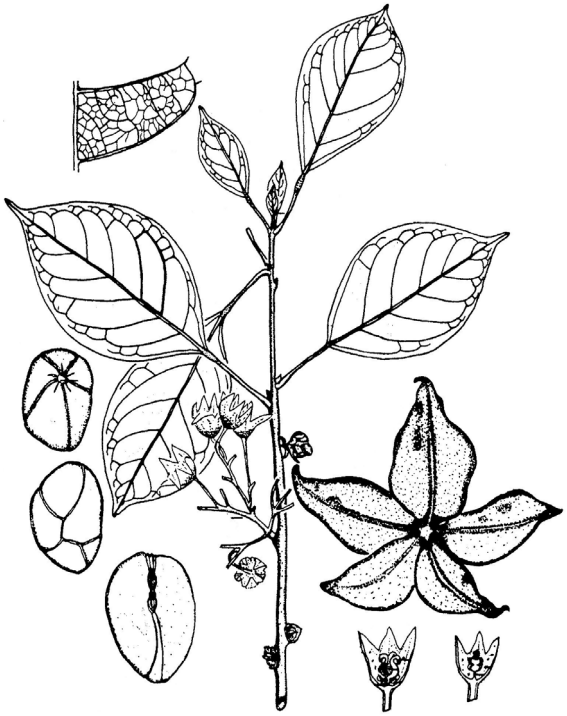

Figure 1. Cola acuminata *(reproduced with permission from Nkongmeneck 1985)*

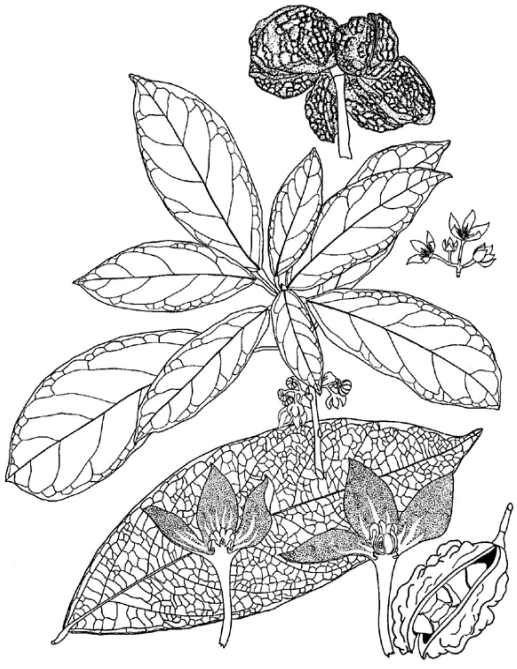

Figure 2. Cola nitidia *(reproduced with permission from Nkongmeneck 1985)*

Table 1. Key morphological differences between *C. nitida* and *C. acuminata*

Tree parts	*Cola nitida*	*Cola acuminata*
Leaves	Leaves abruptly acuminate, flat, with nerves prominent	Leaves broadly acuminate, curved and twisted
Fruits	Fruits curved, with prominent keel extended to form a curved beak, rugose or tuberculate, green, smooth to the touch	Fruits straight or slightly curved, not rugose or tuberculate, russet, rough to the touch
Seeds	Seeds with 2 cotyledons	Seeds with 3 or more cotyledons (up to 6)
Germination	The 2 cotyledons remain closed, and the plumule arises outside them	The cotyledons spread open and the plumule arises between them

logical differences between the two. More detailed botanical descriptions are provided in Appendix 1.

Taxonomic history of *Cola* species

Despite being a very important commodity for centuries, *Cola* was not described until 1805, when Palisot de Beauvois published a preliminary account of botanical specimens that he had collected during a visit to parts of what is now Nigeria (Russell 1955). Among the species he described was the local kola tree, named by him as *Sterculia acuminata*. In the same year, Ventenat described a species he was sent from a botanical garden in Mauritius as *Sterculia nitida* (Russell 1955). Both species subsequently became part of the genus *Cola* when Schott and Endlicher first described it in 1832.

The taxonomy of *Cola* was in a state of "indescribable confusion" by the beginning of the 20th century as a result of a profusion of new species, named on the basis of very meager evidence (Russell 1955:213). Some level of clarity was restored with the taxonomic account of the French botanists Chevalier and Perrot (1911). Their new classification created the subgenus Eucola, which contained five species of *Cola*: *C. nitida*, *C. acuminata*, *C. verticillata*, *C. ballayi* Cornu ex Heckel and *C. sphaerocarpa*. The last three species are not known to be cultivated, but their seeds are sometimes used to adulterate the produce of the commercial species when the latter are scarce. These three species are more commonly referred to as "false kolas" (Russell 1955) and are not addressed further in this chapter. It is clear that the taxonomy of this genus is still unresolved, but a new monograph on the topic is currently under preparation at the Royal Botanic Gardens in Kew, London (Cheek 2002).

ECOLOGY AND DISTRIBUTION

Distribution

The natural distributions of *C. nitida* and *C. acuminata* are are difficult to discern. Both species have a very long history of trade and cultivation both on- and off-farm, and their widespread distribution in West Africa reflects this. It is likely that many herbarium collections contain material from planted trees.

Opeke (1992) proposed that the natural distribution of *C. nitida* (see Figure 3) was along the west coast of Africa from Sierra Leone to the Republic of Benin, with a center of origin in the forest areas of Côte d'Ivoire and Ghana. Warburg (1902) and Chevalier and Perrott (1911, cited in Opeke 1992) stated that the cultivation of *C. nitida* was carried eastward through Nigeria toward Cameroon and the Congo around 1900, and spread westward as far as Senegal. Hawthorne (1995) suggested that the much rarer species *C. verticillata* is often mistaken for *C. nitida* in

Figure 3. Distribution map of C. nitida *(taken from collection locations of 130 herbarium specimens from the Meise, Wageningen, Kew and Missouri herbaria)*

Figure 4. Distribution map of C. acuminata *(taken from collection locations of 83 herbarium specimens from the Meise, Wageningen, Kew and Missouri herbaria)*

Ghana and that this may have added to confusion over the natural distribution of this species.

Cola acuminata (see Figure 4) was originally distributed from Nigeria to northern Angola and is cultivated elsewhere (Keay 1989). In particular, *C. acuminata* has been widely planted through Senegal, Guinea, Liberia, Côte d'Ivoire and Ghana toward the western part of Nigeria (Voelcker 1935). It has also long been in cultivation on the islands of Fernando Po (Bioko), Principe, and São Tomé (Opeke 1992; Fereday et al. 1997).

West Africans took the seed with them when they traveled outside Africa, even in the days of the slave trade (Russell 1955). As a result, both *C. acuminata* and *C. nitida* have been extensively cultivated in tropical South and Central America and the West Indies. They have also spread eastward to Mauritius and Malaysia (FAO 1982; Purseglove 1968; Russell 1955). Seeds of both species were distributed from the UK's Royal Botanic Gardens at Kew as well, for planting commercial plantations in Calcutta, Singapore, Sri Lanka, Java, the West Indies and the United States (Moloney 1887).

Despite the botanical differences between *C. acuminata* and *C. nitida*, it is widely speculated that there are morphological intermediates between the two taxa, particularly where they occur in the same localities, usually though the process of cultivation (Russell 1955). This hybridization has implications for both the taxonomy and the economic aspects of the two species and needs to be investigated further.

Climatic requirements

Cola species occur predominantly in the tropical lowland forests of West and Central Africa, but also extend to the drier forests of East Africa. A number of species have also been cultivated in the transitional zones where the forest gives way to the savanna (Opeke 1992). Briefly, the genus requires a warm humid climate with a mean annual temperature of 23–28°C, and with well-marked wet and dry seasons. It is capable of withstanding 3 or more months of dry season (Keay et al. 1960). The preferred annual rainfall for *Cola* species is ca. 1700 mm. However, further inland, toward the moist deciduous forest and the savannah regions where the dry season extends up to 7 months or more, *C. acuminata* and *C. nitida* can grow with an annual rainfall of ca. 1200 mm (Russell 1955).

Hawthorne (1995) examined the ecological profiles of Ghanaian forest trees using data collected from over three thousand sample plots distributed systematically throughout Ghana's forest reserves. *C. nitida* was found to be most abundant where annual rainfall exceeded 1750 mm, but was present in natural forests that had between 1500 and 1750 mm.

Soil and topographic requirements

Both *C. acuminata* and *C. nitida* appear to tolerate a wider range of soil types than many other tropical tree crops, but the soil must be well-drained and fertile (Opeke 1992). In Ghana *C. nitida* was most abundant along rivers or where slopes exceeded 15° (Hawthorne 1995). This species was least abundant on rocky soils.

Light requirements

C. nitida is described as being a shade-bearing, medium-sized, understory tree (Hawthorne 1995). In this study the crown exposure (*sensu* Dawkins 1958) of trees in Ghanaian natural forest varied little with diameter class and was consistently lower than an all-species average for natural forest.

Seedlings of both species are vulnerable to desiccation and are unable to establish without shade (Opeke 1992). Once established, seedlings that are transplanted into cleared areas often become stunted and heavily branched. They may also be more prone to pest and fungal attack. Although seedlings will survive in the forest understory, the greatest survival and growth occurs in large forest gaps or in line plantings. Pro-

vided that they have sufficient moisture, the adult trees grow well in full sunlight (ibid).

Phenology

Russell (1955) records a profusion of flowers on most trees of *C. nitida* in July and August and sporadic bursts of flowers thereafter. According to Voelcker (1935), flowering of *C. nitida* takes place sporadically throughout the year unless drought occurs.

The main flowering flush commences in the middle of the wet season between July and August, though the trees sometimes flower between May and January as well (Keay et al. 1960). Flowering gives rise to the crop, which is harvested 4 or 5 months later. Analysis of 108 herbarium specimens of *C. nitida* showed that flowers had been collected through most of the year across this species' range. Few flowering specimens were collected in March or April, however.

In Nigeria, *C. acuminata* flowers abundantly in the dry season from December to February, and to a lesser extent in August and September. The fruits are harvested from April to June (Russell 1955). However, climatic variations throughout West and Central Africa mean that this timing is somewhat staggered.

USES

Kola nuts are widely cultivated in West Africa because they contain two alkaloids, caffeine and theobromine. These are powerful stimulants that counteract fatigue, suppress thirst and hunger, and are believed to enhance intellectual activity (Dalziel 1937; Sundstrom 1966; Nickalls 1986; Abbiw 1990; Burkill 2000). Due to their unique bitter taste, kola nuts are effective for refreshing the mouth, and they are also used as a source of alkaloids in pharmaceutical preparations (Opeke 1992). The nuts have considerable potential for development of new pharmaceuticals and foods (Fereday et al. 1997).

Large quantities of the nuts are exported to Europe and North America, where they are used chiefly for flavoring cola drinks such as Coca-Cola, which are refreshing or stimulating substitutes for tea or coffee (Irvine 1956).[1] Beverages such as kola wine, kola cocoa and kola chocolate, a type of chocolate containing cocoa and kola powder in cocoa butterfat (Opeke 1992), were once tried in Britain, along with one interesting-sounding concoction called "Burroughs and Wellcome's Forced March Tabloid." But all these were short-lived (Tindall 1998).

Composition of kola nuts

Kola nuts (of both species) typically comprise sugars and starch, phenols, water, crude protein, cellulose, fat, tannins and ash in varying proportions (Purseglove 1968). As noted above, the seed is also rich in caffeine and theobromine (ibid.).

Moloney (1887) compared the nutritive constituent of kola nuts to other species used as stimulants, such as cocoa (*Theobroma cacao* L.) and coffee (*Coffea* spp.). He stated that kola nuts contain more caffeine than coffee, an appreciable quantity of theobromine and a great deal of glucose. In addition, kola nuts have three times as much starch as cocoa, but relatively little fat. Oladokun (1989) found no significant difference in inorganic nutrient content between nuts from *C. nitida* and *C. acuminata*. However, *C. nitida* was found to have a much higher concentration of free sugars, lipids and proteins.

Most fruits are rich in polyphenolic compounds, which play an important role in determining color and flavor. Chromatogram analysis of kola nuts has indicated the presence of phenolic constituents in greater quantities than those typical of many fruits. Many polyphenolic compounds are highly reactive with human body constituents and have an impact on metabolic processes. Analyses by Odebode (1996) showed that *C. nitida* and *C. acuminata* differed markedly in total phenol, and that differences also existed between different color variants (Table 2). The total phenol content is greater in *C. nitida* than in *C. acuminata*. In *C. nitida,* the

Table 2: Total phenolics in two *Cola* species (mg/l00g fresh weight). Source: Odebode (1996)

Color	*Cola nitida*	*Cola acuminata*
White	4.45	3.37
Pink	6.12	4.17
Red	9.09	—

quantity of total phenol in red nuts is up to three times that of white and pink nuts; but in *C. acuminata*, the difference is not significant. This investigation supports the general view that *C. nitida* is more astringent than *C. acuminata*, as astringency is related to the phenolic content of the fruits (Odebode 1996).

Mouth and gastro-intestinal cancers are prevalent in areas where the chewing of kola nuts is common practice. Studies such as that by Morton (1992) have suggested that kola nuts are carcinogenic to humans because of their very high tannin content. However, Atawodi et al. (1995) suggest that other carcinogenic compounds may be present or derived in the mouth or stomach from kola nuts. They analyzed both *C. acuminata* and *C. nitida* for their primary and secondary amine content and assessed them for their relative methylating potential. Seeds of both species contained high quantities of both primary and secondary amines**.** Methylating activity was significantly higher in kola nuts (170–490 mg/kg) than has ever been reported for a fresh plant product. The authors urge that the possible role of these compounds in causing cancer be explored in countries where kola nuts are widely chewed as stimulants.

Ibu et al. (1986) reported that both species of *Cola* induced significant increases in gastric acid secretion. They advise sufferers from peptic ulcers to avoid eating kola nuts.

Sociocultural values and uses of kola nuts

Chewing of kola nuts is a widespread habit in sub-Saharan Africa, especially in northern Nigeria and Sudan. Kola chewing plays a social role like that of tea and coffee drinking or cigarette smoking in Western countries (Purseglove 1968; Rosengarten 1984; Russell 1955). *C. acuminata* is widely used ceremonially and socially by the people of West and Central Africa. At a birth, a kola tree may be planted for the newborn child, who remains the lifelong owner of the tree. A kola tree is also often planted at the head of a grave as part of local death rites (Tindall 1998).

Russell (1955) described cultural uses of kola in what was then known as the Yorubaland of western Nigeria. He reported that the seed is normally kept in the house, and an offering of kola forms part of the greeting to an honored guest. The older the kola, the more highly it is regarded, and white and pink nuts are kept for particularly favored guests. The gift of kola, and especially the splitting and sharing of kola nuts between two or more people, signifies a special bond of friendship. Similarly, sharing kola nuts is a necessary prerequisite to business dealings, which involve a strict etiquette in presenting, dividing and eating the fruits. Proposals of marriage may be made by a young man's presentation of kola nuts to the prospective bride's father, and her acceptance or refusal may be conveyed by a reciprocal gift of nuts, with the meaning depending upon the nuts' quality and color. Kola nuts presented by the bride's family signify fertility, productivity, prosperity, contentment and desire for the union (Johnson and Johnson 1976; Sundstrom 1966). Similar patterns are reported among other ethnic groups.

Kola figures prominently in religion and magic. It is used in divination and to learn the mind or intent of a god for healing illness or infertility. In some areas, it is

a component of an oath-taking process. Possession and use of kola nuts may be a symbol of wealth and prestige (Hauenstein 1974; Lovejoy 1980).

Uses of other plant parts

Traditionally, the leaves, twigs, flowers, fruit follicles and bark of both *C. nitida* and *C. acuminata* were used to prepare a tonic as a remedy for dysentery, coughs, diarrhea, vomiting (Ayensu 1978) and chest complaints (Irvine 1961). The twigs of both *C. acuminata* and *C. nitida* are used as chewing sticks to clean the teeth and gums (Lewis and Elvin-Lewis 1985). Extracts of *C. nitida* bark have been tested on various pathogenic bacteria (*Staphylococcus aureus*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, beta-hemolytic streptococci, *Escherichia coli* and *Neisseria gonorrheae*) (Ebana et al. 1991). All the extracts showed inhibitory activity against these organisms. Benie et al. (1987) report that stem bark extracts of *C. nitida* inhibited the release of luteinizing hormone (LH) from rat pituitary cells and may therefore regulate gonadotropin release. This has potential to be used as a natural fertility regulator.

The pods of *C. nitida* have been found to have high levels of crude protein and relatively low crude fiber content. In West Africa crushed pods have been fed to poultry as a replacement for maize. No significant reduction in bird performance (measured in terms of egg production) was detected when up to 600 g kg^{-1} of maize was replaced by kola pod (Olubamiwa et al. 2000). This means that poultry can be adequately fed in areas where cereal crops are largely for human consumption.

MANAGEMENT

Propagation

Kola is commonly propagated from seed, but seeds show notoriously slow and uneven germination. Much research has focused on identifying factors that influence germination rates and in developing methods for accelerating the process. There are conflicting results of investigations into the influence of seed size on germination rates. Clay (1964) and Eijnatten (1969) suggested that nut size does not effect germination rate, but Ibikunle (1975) and Oladokun (1985) found that percentage germination and speed of germination of *C. acuminata* increased with increasing nut size and number of cotyledons. Germination is hypogeous, which means that cotyledons are likely to act as storage organs. Greater size and numbers of cotyledons will provide more resources for early growth.

One possible explanation for these very different results may be differences in the freshness of the nuts used for experimentation. Ibikunle & Mackenzie (1974) established that the cotyledons of fresh kola nuts are very firmly held together and this provides a significant mechanical impediment to seed germination. It has been shown that stored nuts typically show higher germination rates than fresh nuts (Eijnatten 1969) and this may be because the adhesion between cotyledons weakens as nuts age. A traditional method used to enhance germination is to cut the tips from the cotyledons. Ibikunle & Mackenzie (1974) obtained higher rates of germination when the cotyledons were forced apart. They also recommended soaking seeds for 24 hours in water at 30°C.

Opeke (1992) recommended a pre-germination treatment in which kola seeds are stored in a damp mixture of sand and topsoil at 32–34°C, as this gave a higher and more rapid germination rate. Germinated seeds are then sown in pots or in nursery beds at a depth of 7–10 cm. Opeke (1992) maintained that nuts planted horizontally result in a higher proportion of seedlings with straight roots. However, Ibikunle (1975) found that nuts sown with the radicle facing upwards germinated at higher than those sown in other positions.

Nursery propagation costs more in material and labor than sowing directly in the field, but where valuable seed is being used, the additional cost is justified (Russell 1955). Germination is slow, but under favorable conditions, *C. nitida* germinates within 80 days

and *C. acuminata* within 60 days. Newly established seedlings are intolerant of water stress and will only survive under the protection of light shade (Opeke 1992). However, over-watering should be avoided, since the seedlings are prone to various fungal and other pathogenic infections (Oludemokun 1979; Opeke 1992). Soil sterilization is important in nurseries.

Propagation by cuttings is preferred as a means of multiplying the more popular white-seeded strain of *C. nitida*. Vegetative reproduction is a relatively straightforward way to multiply, test, select and use the wide range of genetic diversity present in the *Cola* species. This is the most promising method for producing highly productive clones that could be used locally and for industrial purposes (Tchoundjeu et al. 1999). A detailed protocol for taking and rooting cuttings is given in Opeke (1992).

Whether *Cola* species are raised sexually or vegetatively, the time for transplanting the young seedlings is ideally during the rainy season, when enough moisture and nutrients are available for plant growth. Little attention is needed once the tree is established, yet more information, such as advice on pruning, fertilizer application and other cultural practices, would be desirable (Ekanade and Egbe 1991; Fereday et al. 1997).

Initial growth is slow, with the young plants reaching only 3 meters in 4 years, during which time they should be kept clear of weeds (Opeke 1992). Flowers may occur in the 5th year, but it is not usually until the 7th year that any fruit is seen, and this is scanty. By the 11th year, a fair crop should be obtained, and production begins to peak after 12 years. Full production is normally reached about the 20th year, and trees may continue to bear fruit until they are 70 to 100 years old (Russell 1955). Productivity mainly depends on environmental factors and may be depressed by problems such as excessive drought or changes in weather patterns that alter the period of flowering and fruiting of the species.

Management of kola on- and off-farm

Among the various non-timber forest products (NTFPs) in West and Central Africa, *C. nitida* and *C. acuminata* are among the most widely used because they contribute greatly to the social, economic and cultural life of the people. Okafor (1980) believed *C. acuminata* to be one of the most commonly cultivated indigenous plants in southern Nigeria and central Ghana. However, scientific research on domestication of kola species is still in its infancy (Tchoundjeu et al. 1999). This is probably because in the past, cultivation of kola has been largely passive rather than active. Useful trees such as kola were not cut when forest was cleared and natural regeneration occurred when land was left fallow.

Individuals of *C. acuminata* and *C. nitida* are commonly encountered in secondary forest. An inventory of all trees >10 cm trunk diameter growing on 34 one-hectare sample plots in the south of Cameroon found *C. acuminata* and *C. nitida* to reach their maximum density (4.1 stems ha^{-1}) in secondary logged forest (van Dijk 1999). Many of these trees arise from natural regeneration, having been protected during bush clearance in and around compound farms or in relatively nearby outlying farms. In most cases, the impetus for off-farm protection is farmer-driven, with no outside pressure (such as from government institutions or market traders) encouraging preservation or domestication (Fereday et al. 1997).

The extent of kola cultivation within forest or farm systems therefore reflects the local importance of kola nuts in providing food and revenue and, particularly, in the social life and religious customs of the local people living along the forest fringes (Okafor 1980; Russell 1955). However, individual farmers may not see protecting kola seedlings on farmland as particularly beneficial, because most kola trees, either in forest or on farmlands, are considered an open-access resource. While many farmers view growing kola trees on farmland as a means of assuring regular supply, others find their insecure tenure a disincentive. Resource managers should therefore consider the ques-

tion of tenure, because it is very difficult to manage an open-access resource sustainably and equitably.

Kola as an agroforestry tree crop

Traditional farming techniques in West and Central Africa favor frequent interplanting of food crops and other tree crops like cocoa with *Cola* spp. The advantages are that the young kola trees provide light overhead shade, while the annual crops provide the farmer with some form of cash income until the juvenile kola becomes productive. One disadvantage is that during the establishment phase, young kola trees are growing without shade, leading to stunting and high incidence of disease.

Kola is often grown interplanted with other tree crops, especially cocoa and coffee. In southern Nigeria during the 1980's, an average of 55% of kola farms in Ogun State were intercropped with cocoa alone, while 16% were intercropped with both cocoa and robusta coffee (*Coffea canephora* L.). Only 29% of the kola farms were under monoculture (Oladokun and Egbe 1990). A comparison of yields in cocoa/kola intercropped plots in southwestern Nigeria over a period of 10 years demonstrated superior results from intercropping: approximately 1.75 ha of monoculture were required to produce the same crop yield (kg/ha) as 1.0 ha of a mixed culture (Oladokun and Egbe 1990). Dublin (1965) also observed that kola interplanted with robusta coffee grew and yielded well in the Central African Republic.

For many farmers, higher productivity is not the only reason to intercrop cocoa and kola trees. Labor inputs, for weed control and other maintenance activities, are invariably shared by the crops. Kola is known to fruit erratically, and an intercrop of cocoa can provide an important insurance against kola crop failure. Juvenile kola trees can provide the light shade necessary for productive cocoa cultivation. Oladokun and Egbe (1990) observed that the copper sulphate used to control *Phytophthora palmivora*, the fungus that causes black pod disease in cocoa, also benefited kola trees, which have a high copper requirement.

A concern about such intercropping has been that it might deplete the surface soil's stored fertility while causing the crops to compete excessively for light and moisture (Russell 1955). However, appropriate planting patterns can ensure sustained soil fertility and higher productivity. Using the proper combination of tree crops is vital (Ekanade 1989; Ekanade et al. 1991). Planting kola with tree crops like cocoa or coffee, or food crops such as plantain, helps to maintain soil fertility as well as providing immediate and diversified economic benefits (food and/or income) for the farmer.

Woodlots have also been tried in agroforestry systems with kola. Farmers planting kola trees in forest zones usually provide overhead shade by retaining some forest trees. This practice is very important for the local farmers' livelihood because the shade trees also serve as sources of firewood, other wild fruits and building materials. Farmers may therefore prefer interplanting timber-yielding species rather than an agricultural crop for income generation. Current research on interplanting kola trees with timber-yielding trees and/or woodlots such as *Gmelina arborea* and *Tectona grandis* proved the practice to be high-yielding and efficient (Ojeniyi and Oweto 1986; Ojeniyi and Agbede 1980). Interplanting kola trees with scattered shade trees such as *Albizia*, *Erythrina* or *Inga* species also provides overhead shade and helps to create an appropriate microclimate for soil conservation, as well as supplying firewood (ibid.).

Unlike other tree crops such as cocoa and coffee, *C. acuminata* and *C. nitida* coppice well when the trunk of a mature tree is cut (Opeke 1992). Coppicing could therefore be a means of replacing a dying, overgrown or diseased tree with young material from the old rootstock. When used in combination with replanting of new stock, this is a useful method for respacing a closely planted stand to produce a new orchard from the coppiced outgrowth while selectively removing crowded trees. Experience has shown that the optimum height for coppicing individual kola trees is 120 cm (Opeke 1992). Coppicing at this height produces abundant regrowth that branches out very rapidly. This

regrowth should be thinned to two or three shoots to ensure healthy regrowth and strong junction. Mostly, the shoots develop from suborbicular outgrowths on the stump. These outgrowths form a sort of cushion or swelling, with many buds at the apex.

It is usually advisable to coppice at the beginning of the rainy season. Though the amount of rainfall does not influence the number of cushions formed, a humid environment enables the young shoots to develop, letting the leaves harden before the dry season sets in. According to Opeke (1992), growth from shoots is rapid, and production may resume in the second or the third year after coppicing.

Planting arrangement

For both *C. acuminata* and *C. nitida*, Dublin (1965) suggested a spacing of between 5 m x 5 m and 8 m x 8 m for commercial groves in monoculture plantations. However, for agroforestry combinations with other tree crops, different planting patterns may be needed to ensure optimum yield. To date, no standards in spatial arrangement for interplanting kola with other tree or food crops have been developed.

Intercropping and soil fertility status

Mixed cropping of kola with cocoa and timber species has proved to maintain and enhance soils far better than monocultures do (Ekanade et al. 1991; Oladokun and Egbe 1990). It makes various soil properties and macronutrients available for plant use, including pH, organic matter, phosphorus, calcium, magnesium, potassium, zinc and copper. This practice is of particular importance for the development of agroforestry systems appropriate to low-income farmers, as it does not involve application of chemical fertilizers.

Ekanade and Egbe (1990) indicated that interplanting cocoa and kola may enhance soil fertility, since the mixture of their litter releases crucial nutrients to the topsoil. This is possible because cocoa and kola do not continue to bear fruits throughout the year, so nutrients withdrawn during the harvesting period are replenished during the off-season through the rapid decomposition of litter (Ekanade 1987).

However, not all soils may be suitable for mixed cropping. For instance, kola is far hardier and tolerates a wider range of soil environments than cocoa, which requires more fertile soil. Therefore, soil maps or site analysis is necessary for intercropping to ensure sustainable crop yield.

Cola nitida and *C. acuminata* fruit at different times of the year. Unless a farmer has trees of both species or has intercropped with cocoa or coffee, income from the nuts is highly seasonal. Most farmers therefore prefer cultivating a mixture of annual crops along with their kola trees so the benefits are spread more evenly throughout the year.

HARVESTING

Kola nuts are harvested several times a year, either by collecting the fallen fruits or by slicing them off with a curved knife blade attached to the tip of a long pole. Farmers usually climb the tree with this harvesting tool and scramble among the branches, cutting all the fruits they can see approaching maturity. This practice is repeated monthly during the fruiting season from September to January. The greatest production is usually from October to December for cultivated species in Nigeria, with a shorter harvest period in March and April (Fereday et al. 1997; Keay 1989; Russell 1955).

As noted earlier, a careful farmer cuts the fruit from the tree before the follicle splits open to ensure that fruits are protected from pest attack (Opeke 1992). The approach of maturity can be predicted by a change in color from deep green to light brown. At the beginning of the harvest period, undergrowth beneath the kola trees is cleared to reduce the risk of infestation by the larvae of the kola weevil, *Ceratitis colae*, and infection by the fungus *Botryodiplodia theobromae* (Opeke 1992; Russell 1955).

In most of West and Central Africa, women and children who live in forest-fringe communities gather and extract kola nuts. In western Nigeria, kola nut harvest and sale are important sources of income for women traders. Ndoye et al. (1997) reported that in Cameroon, about 94% of those who gather and sell kola are women. Sales from the nuts, therefore, supplement the household income of many of the region's forest dwellers and comprise 5–35% of households' cash revenue in western Cameroon (Champaud 1983).

In the past, the harvesting practices of kola have been sustainable, with little risk to the remaining population (Peters 1994). However, commercial harvesting of the fruits can affect not only species regeneration, but also the genetic composition and quality of the resource, particularly if "inferior" fruits and seeds are left to regenerate (FAO 1995). Due to inadequate information on the management of wild resources for optimal productivity and population dynamics, it is difficult to determine a sustainable level of harvest for wild kola populations. In the future, the sustainable harvest of kola nuts will depend on the size-class distribution of the tree population, differences in exploitation intensities, and the careful selection of fruits and seedlings left to regenerate for the future.

Stakeholders should be encouraged in the domestication of kola species and their incorporation into suitable agroforestry systems. These could contribute both to preserving biological diversity and improving the lot of local communities through income generation and equitable distribution of benefits.

Postharvest treatment

Harvested fruits are usually piled on the ground under the trees. The large green pods are cracked open and the nuts are carried back to villages, where the thin outer skin is removed to reveal the nuts. To facilitate removal of the testa, the nuts are either soaked in water or heaped into a large basket where they are left to ferment for about five days. The nuts are then rinsed in water and the softened testa wiped off.

The cleaned nuts are transferred to baskets, often enormous and unlined, kept there for three or four days, and stirred frequently. Defective nuts are picked out during this stage. A great deal of natural "sweating" of the fruits occurs at this point in the process (known as curing), gently reducing the water content of the seeds. The seeds are then graded and may be stored to wait for a favorable market. They are wrapped in green leaves and deposited on the ground or in a cool corner of a hut and checked regularly for weevil damage (Russell 1955). Fresh wrapping leaves are applied to keep them moist. The leaves used are of various species including *Mitragyna stipulosa*, but some marantaceous plants are preferred, particularly *Marantochloa* sp. and *Thaumatococcus daniellii*, whose large leaves show resistance to rotting.

The quality of the nuts depends greatly on the care with which the harvesting, cleaning, and curing were carried out. Under the best conditions, the seed may be stored for many months without any decline in quality (Masefield 1949). Kola nuts can be also be stored for up to two years if kept dry, usually in baskets or old fertilizer bags (Fereday et al. 1997). However, fresh nuts are much preferred by consumers, and optimum storage conditions therefore reflect a trade-off between preventing nuts from drying out and inhibiting the growth of fungi. Oludemokun and McDonald (1976) reported that storing the nuts at a low temperature (10°C) and low humidity discouraged fungal growth, but nuts hardened and changed color. They found that storing kola nuts at a temperature of 20°C and relative humidity of 75–100% gave the optimum conditions for reducing fungal growth without desiccating the nuts.

Quality of products

Unlike many other NTFPs, kola nuts are often graded. Retailers inspect the nuts and set aside any showing insect damage; the remaining nuts are then graded according to color and size. The most careful and repeated examination is for weevil infestation (Opeke 1992; Russell, 1955). The quality of the product is

very important for setting market price. During harvest, the farmer makes sure to prevent the collection of immature fruits, as the nuts they yield become thin and shrunken after drying. Postharvest attack from insect pests can also seriously affect market acceptability. Apart from weevil damage, environmental factors such as high humidity and temperature can affect the rate at which the quality of the nuts declines (Oludemokun and McDonald 1976), rendering them prone to fungal attack, particularly by *Botryodiplodia theobromae*. Mechanical damage to the nuts, a danger especially during the extraction of nuts with machetes, also reduces quality significantly (Ladipo 1997).

In most cases, appropriate variations in prices reward farmers' efforts to ensure good flavor during the curing process and storage. However, customers' preferences depend on more than flavor, responding to color, size, level of adulteration, and keeping quality as well (Ladipo 1997). Usually, white nuts are preferred to pink or purple in both traditional and commercial markets.

SELECTION FOR GREATER PRODUCTIVITY

The average annual production of kola nuts, from both *C. acuminata* and *C. nitida*, has been estimated to be about 300 seeds per tree (FAO 1982). Commercial kola nut farms typically have low productivity. Russell (1955) pointed out that a striking feature of kola plantations in western Nigeria was the great variation in productivity among individual trees on the same farm. Purseglove (1968) recorded nut production from 246 trees over 4 years in Nigeria with the following results: 46 trees gave no nuts at all; 79% of all the trees gave mean annual yields of 0–300 nuts, while the remaining 21% produced 72% of the total yield of the plot. The average was 210 nuts per annum, while the 10 best trees averaged 1,415 nuts, peaking at 2,209 nuts per annum. The size of the nuts varied from 16.9 to 40 nuts per lb of fresh seed after removal of the testa, with an average of about 27.7 nuts/lb. These results suggest that there is considerable potential for producing improved varieties from these individual high-yielding trees.

Similarly, Sanwo (1998) examined individual tree performances in Nigeria. Annual pod and nut yields per tree exhibited substantial scope for success in selection. Approximately 7.3% of the selected trees gave nut yields that were over 250% of the Nigerian recorded annual yield. Both high- and low-yielding trees exhibited considerable annual variation in productivity. One tree naturally combined annual consistency in yield and high-yield traits. It would appear that although the two traits are distinct and appear independently controlled, they could be combined via breeding. The number of nuts per pod was less variable.

PESTS AND DISEASES

Daramola (1974) and Opeke (1992) catalogued many of the known pests and diseases of kola. This section summarizes information on those that have been recorded to have a major impact on the survival, growth or productivity of kola.

Fruit and seeds

Kola nuts are vulnerable to various fungal diseases; in fact, the fungus *Botryodiplodia theobromae* has been found to be the most common single species of pathogen associated with kola (Oludemokun 1979). It has been identified infesting the follicles, which develop a black rot that subsequently affects the nuts. Rusty brown spots develop on the nuts, which later turn black and become hard and dry. The tissue may fall out, leaving small pits in the surface. *Botryodiplodia theobromae* can also attack other parts of the kola tree.

Botryodiplodia is far from the only culprit, however. The traditional method of storing kola nuts, wrapped in fresh leaves leaves and stored in baskets at a high

temperature and high humidity, provokes development of various parasitic fungi, especially wet rots caused by *Fusarium* and *Penicillium* species (Oludemokun 1979; Opeke 1992). The extent of loss in storage assessed in northern Nigeria was estimated to be as high as 30% (Oludemokun 1979).

Interestingly, Olunloyo (1979) found that the rate of development of fungi actively growing on nuts of *C. nitida* depended more on the ambient relative humidity than on the nuts' moisture content. The principal postharvest pathogens were found to be *Botryodiplodia theobromae* and *Fusarium* spp. Milton solution (1% sodium hypochlorite) was slightly fungicidal at 0.5 and 0.75% concentrations, and highly so at 0.95 and 1% concentrations, depending on exposure period. Postharvest rot was substantially reduced (particularly in nuts stored in baskets lined with polyethylene sheeting or banana leaves) when the nuts were soaked in 1% Milton solution for 30 minutes before storage (Olunloyo 1979).

Agbeniyi (1999) also tested the efficacy of Milton solution and wood ash in controlling storage rot of kola nuts (*C. nitida* only). The effects of the treatments on microbial contamination caused principally by *Botryodiplodia theobromae* and *Fusarium pallidoroseum* were investigated. Both the Milton solution and the wood ash treatments (at a rate of 3 g dry powder per g of kola nuts) caused a significant reduction in the percentage of nuts damaged by storage rot. This suggests that wood ash could be a cheap alternative preservative for the control of storage rot.

The kola weevil *Balanogastris kolae* Desbr. is among the most common of the many insect pests to attack kola nuts on the tree and when stored. Eradication of kola weevils is very important during harvesting and storage. Field losses have been estimated up to 50–70% (Opeke 1992). A careful farmer ensures regular and thorough harvesting of fruits before they reach the point of splitting and also avoids breaking kola pods, which damages the seeds and leaves them open to weevil infection. Eggs are laid into the nuts, or on other parts of the fruits, and the adult weevil emerges within a month. *Balanogastris kolae* have an average life span of 53 days, compared with 20 days for *Sophrorhinus insperatus* Faust, another important kola weevil. Weevils will breed throughout the year under favorable (high-humidity) conditions (Opeke 1992).

Both *C. nitida* and *C. acuminata* seeds are vulnerable to attack from the curculionid kola weevil, *Sophrorhinus gbanjaensis* D & T. The oviposition and development of larvae on nuts of *C. nitida*, *C. acuminata* and the wild species *C. verticillata* were studied by Daramola (1980). Significantly higher numbers of eggs were laid in nuts of *C. nitida* and *C. verticillata* than in those of *C. acuminata* when mated females were caged with 35 nuts of each species separately for 35 days. Moreover, when nuts of the three species were offered together, mated females preferred *Cola nitida* and *C. verticillata* to *C. acuminata* as oviposition sites.

An assessment of the effect of weevil infestation on the caffeine content of red and white cultivars of *C. nitida* was carried out in Nigeria (Lale & Okunade 2000). Results showed significant decreases in the amount of caffeine with increasing levels of infestation, especially in the red cultivar. Mean reductions in caffeine content ranged from 8.8% to 62.6% in the red cultivar and from 18.8% to 25% in the white cultivar.

Burrowing by the larvae of the kola fruitfly, *Ceratitis colae* Silvestri, is reported to cause significant damage to kola nuts and to provide entry points for kola weevils (Opeke 1992). A full morphological description of this species is given in Carroll et al. (2002 onwards).

Leaves and twigs

Opeke (1992) reported an unidentified fungal disease (possible *Pestalotia* or *Glomerella* species) to cause brown patches, dieback and death of leaves on kola trees around Ibadan, Nigeria. *Phomopsis* species have been observed to cause tip dieback diseases of kola. *Guignardia citricarpa* is associated with yellow or

orange discoloration of leaves, while *Botryodiplodia theobromae* causes a twig blight and a brown-colored blight of leaves (Adebayo 1975). The diseased twigs die and turn black, with leaves remaining attached. *Glomerella cingulata* causes greenish spots with a moldy appearance on kola leaves (Oludemokun 1979).

The stem-boring longhorn beetles *Phosphorus virescens* and *P. gabonator* have been found to cause serious losses in kola plantations in both Ghana and Nigeria (anon. 1917; Opeke 1992).

The ant species *Crematogaster buchneri* is known to attack the flowers, leaves, young branches and pods of *C. nitida* in Nigeria. The ants scrape off the epidermis, so that affected leaves fall and the pods become shriveled (Eguagie 1973).

Roots

In nurseries, seedlings are often infected with fungal diseases. Most common among these are *Botryodiplodia theobromae* and *Fusarium* species that cause the roots of the infected seedling to rot and turn their leaves brown. Aldrex T pesticides containing 25% aldrin and 50% thiram have been reported to reduce the incidence of fungal infection in nurseries (Adebayo 1975; Oludemokun 1979).

In the field, infected roots often cause yellowing of leaves before eventually killing the plant. *Rigidoporus lignosus*, *Fomes lignosus* and *F. noxius* commonly cause this type of problem in both *C. nitida* and *C. acuminata* in Nigeria and Sierra Leone (Adebayo 1975; Opeke 1992). Adebayo (1975) reports that root collar inspection was found to be a more reliable method of detection than foliage inspection.

MARKET TRENDS AND DEVELOPMENT

The trade in kola nuts

Kola nuts are traded in three forms (Opeke 1992): unprocessed nuts in their pods, unskinned nuts that have been extracted from the pods, and fully processed nuts. Nuts that have been extracted from their pods command a much higher price. *Cola nitida* is the main commercial species traded globally, whereas *C. acuminata* is of local trading importance, notably among the Yoruba tribes in West Africa. Fresh nuts are exported only to countries in or near West Africa. Only dried nuts are exported beyond that general region.

In southern parts of West Africa, the most commonly consumed species is *C. acuminata*, while *C. nitida* is preferred in northern parts. Entrepreneurs involved in harvesting/gathering and selling kola nuts in the humid forest of the subregion can be categorized into:

- farmers, who harvest or gather products for sale;
- assemblers/retailers, who buy from village markets or directly door-to-door from farmers, and sort and package them in large baskets or units of a bag; and
- wholesalers, who conduct their transactions in bags and export to neighboring countries, Europe or America.

Domestic markets

Most farmers sell all their kola nuts immediately after harvest, primarily due to a lack of efficient storage facilities and transport. The price is usually determined by the farmer's effort to maintain a high-quality product.

As discussed earlier, the quality of the nuts depends greatly on the methods used to extract the nuts from

the pod, and to cure, clean and store them (Masefield 1949; McIlroy 1963). There is a well-established protocol applied in marketing kola nuts. For instance, in the trans-savannah trade within West Africa, nuts are sorted according to color and size, and each class commands its own prices according to quality (Russell 1955). As with most NTFPs in West and Central Africa, marketing of kola nuts is typically informal and is usually conducted through oral agreements.

In general, many farmers view kola marketing as a secondary but significant activity carried out to supplement income earned from farming activities, especially during the farming off-season. For example, a recent Tropenbos survey of the collection of kola nuts by family households of the Bipindi-Akom II region in the South province of Cameroon recognized that income from kola nut sales is very important, and also that nuts are sold in great quantities (van Dijk 1999). Laird et al. (1997) emphasize that the income from NTFPs in some rural households in the South-West province of Cameroon was even higher than from coffee, with kola nuts contributing between 5% and 37% of household cash revenue.

Local markets

In west and central Africa, most of the retailers selling kola (apart from farmers and local traders) are Hausa people from Nigeria, who scramble for new market sources in the subregion in response to increases in demand. Most of these kola nut traders have higher gross profit margins than retailers of local origin and are more likely to depend solely on kola sales for their livelihood. In Nigeria, kola retailers are distributed along the railway line linking Lagos and the Kassa Marire market in Kano in the north. A feature of most villages in parts of Yoruba country is a group of huts outside the village, occupied by Hausa traders from the north who are engaged in buying kola nuts from the farmers, packing them and sending them to their country of residence.

During the main harvesting season, many traders, especially the Hausa buyers from northern Nigeria, tour villages and towns buying stocks of kola nuts. They usually hire a storeroom where they keep their produce. Their major marketing problems are high transport costs (which consume about half the value of the purchase) and storage losses (about 10%). Their main sales focus is the local markets in the humid forest zones of Cameroon, Ghana, Sierra Leone and other nearby countries, including the Central African Republic (CAR), Equatorial Guinea and Gabon (Ndoye et al. 1997). Most retailers/farmers offer their products in smaller units such as cups and bowls and, as noted earlier, sell only by oral agreement.

Kola nuts are an integral part of West African culture and trade

The international trade in kola nuts

Large quantities of kola nuts have been traded for centuries both among the countries of West and Central Africa and between them and the rest of sub-Saharan Africa. Until the establishment of kola nut plantations in South and Central America, the West Indies, Sri Lanka and what was then Malaya, there was considerable export from West and Central Africa to the rest of the world, though exports to Western Europe were very small. To take just one example, exports from

Lagos to Brazil were valued at £2,949 in 1878 and £3,560 in 1882 (Moloney 1887). Exports declined once kola plantations were established elsewhere in the early twentieth century. However, the vast majority of kola nuts produced continued to be used within the African continent, particularly in sub-Saharan Africa (McIlroy 1963). FAO (1982) estimated that, of a total production of kola nuts from West and Central Africa of 180,000 tons (of which 120,000 tons were produced by Nigeria alone), only 60,000 tons were exported, including nuts exported to Europe and North America for flavoring cola drinks and for use in the manufacture of pharmaceuticals. Oyedade (1973) stated that a few hundred tons annually were exported for these purposes. In short, off-continent exports appear to absorb only a minor part of the African production (Rosengarten 1984).

Intra-African trade in kola nuts also has a long and significant history. Hausa kola nut traders have followed fixed caravan routes through West Africa for many centuries to Timbuktu, Sokoto, Kano and elsewhere (Lovejoy 1980). Purseglove (1968) reported that extensive trade in kola nuts still continued along ancient trading routes to Burkina Faso from Ghana and Sierra Leone.

C. acuminata is particularly valued by the people of northern Nigeria and Sudan, who are the main buyers (Lovejoy 1980). Of this species, Nigeria's annual production alone is estimated at 100,000 tons (Tindall 1998). In Cameroon, Nkongmeneck (1985) estimated the quantity of *C. acuminata* kola nuts in trade to be 24,400 tons, most of which is exported to Kano in northern Nigeria. In contrast, *C. nitida* kola nuts have long served as an important crop for Ghana, Sierra Leone, Northern Nigeria, Burkina Faso, Côte d'Ivoire and Sudan in the trans-Saharan trade.

Large quantities of kola nuts are shipped from Sierra Leone and Ghana to Lagos; they are then conveyed by rail linking Lagos and Kano. The railway carries 50,000–60,000 tons of kola nuts annually to the markets of the northern Nigeria (Lovejoy 1980). Exports of kola nuts from Ghana were estimated at 6 million tons in 1988 and 7,482,602 tons in 1989, with a value of US $1,031,952 and US $1,476,135, respectively (Laird et al. 1997).

In Cameroon, Nkongmeneck (1985) reports that approximately 22,500 tons of kola nuts were produced in 1981 (of which 20,400 tons entered commerce). In 1980 alone, an estimated 1,100 tons (worth approximately 182.6 million FCFA) were exported to Nigeria and Chad. Nkongmeneck adds that there are many gaps in government data, so these figures are, at best, only indicative. He adds that the price of kola nuts for the export market appears to be lower than for those sold in internal markets. He postulates that this is because of poor internal market organization and problems associated with kola nut conservation (Nkongmeneck 1985).

SUSTAINABLE EXPLOITATION OF KOLA SPECIES

Land and resource tenure

Kola species are widely cultivated on farmlands. However, vast quantities of wild kola also occur in state forests, communal forest estates and open access areas. Land tenure problems and issues over rights of access to wild resources are major issues for sustainable management throughout West and Central Africa (Ambrose-Oji 1997; Jeanrenaud 1991).

Land tenure systems and the rights of land ownership determine to a large extent the scope of tree cultivation, management options and sustainability (FD/IIED 1994). For example, Fereday et al. (1997) observed that land rights in Cameroon are complex and discourage the management of slow-growing tree crops. Many farmers rent their land, and only traditional landowners have permanent farms. It is not logical for a tenant farmer to plant or protect trees on rented land, unless the land is leased for a long period, because the trees will become the property of the landowner once the tenancy expires. Insecurity over land tenure natu-

rally reduces tenants' planning horizons, and hence most farmers plant crops that can generate quick returns. Even where farmers have secure access to land, few may be prepared to take a sufficiently long-term view, especially for products that seem to occur naturally in abundance in the forest.

Control over wild resources may be even more complex, especially where there are conflicts between traditional patterns of rights and modern land-management systems. There is a danger that wild resources may become "open-access" and vulnerable to overexploitation. In order to prevent this type of problem, a number of policies have been instituted in Ghana to regulate exploitation of non-timber forest resources to ensure sustainable use and conserve their genetic diversity. The following regulations apply to wild kola trees (Ministry of Lands and Forestry 1996):

- The government manages and regulates exploitation of "kola products" in both states and communal forest estates in interest of the community.
- The local communities and private individuals may exercise their rights of ownership of their forest/tree establishments based on the governing land tenure system of the state.
- Commercial exploitation may proceed with procurement of a written permit and equivalent royalties paid to the state.
- The resources are assigned in accordance with the master plan of the regional forestry development.
- Use of "kola resources" is restricted in areas declared as ecologically fragile.

There is little information yet available on whether these types of policies are successful in regulating the exploitation of wild resources.

Cultural beliefs

Some of the cultural beliefs in the subregion also pose a problem to sustainable management. Chevalier and Perrot (1911) recorded that, in some parts of Guinea-Conakry where *C. nitida* is native, it is held to be most inauspicious to plant a seed of the species, since the person doing so will "assuredly die as soon as the seedling comes into flower." However, this belief has not accompanied *C. nitida* into other regions, as the farmers seemingly cultivate kola trees without any ill effects!

In Nigeria, most farmers regularly slash the trunks of their kola trees with cutlasses to enhance kola production. Though wounding the bark of the tree has been shown experimentally to result in a significant short-term increase in yield of mature fruits, it is also believed to have a long-term detrimental effect on the tree's production (Russell 1955).

Shifting cultivation

Shifting cultivation has always been a major problem in protecting coppiced and regenerated kola species throughout West and Central Africa. Very often cultivation of farmland involves clearing, slashing and burning forests together with all their valuable tree species. This is more common with tenant farmers, who place little value on retaining trees because as renters they do not have long-term control over the land. Though some farmers may retain kola species for seasonal subsistence, most of the trees are destroyed because they are believed to cast too much shade on annual crops. FAO (1995) reported that the practice of shifting cultivation accounts for 60% of forest losses in this region each year.

CONCLUSION

Opportunities for sustainable management

There is considerable potential for further development of kola species as a commercial crop under sustainable management. The traditional cultivation, harvesting and processing of kola is widely practiced in West and Central Africa. Although prone to a number of pests and diseases, both *C. nitida* and *C. acuminata* have been shown to tolerate a wide range of environmental conditions. The crop is easily cultivated, and these species appear to be more resistant to pest and disease attack than other plantation crops of the region. Kola species are suitable for agroforestry combinations with both agricultural crops and timber-yielding tree species/woodlots. Kola nuts have high market value, and there is considerable potential for expanding markets outside of Africa.

Recommendations

The following recommendations are based on the findings of this review:

- A selective breeding program of *C. nitida* and *C. acuminata* is needed. This will require provenance trials and establishment of seed orchards to supply improved stock to farmers.
- The international market must be expanded to encourage exports and boost the incomes of kola farmers. This may require development of new processing technologies and dissemination of information on potential food and medicinal products that can be manufactured using kola nuts.
- More research is needed into the pests and diseases of kola and how they may be effectively controlled.
- More research should be initiated on the optimum densities and configurations of kola intercrops for suitable agroforestry systems.
- Quality control measures need to be developed to enable farmers to produce a crop of consistent quality for export and to ensure that high-quality products are able to attract premium prices. This will give farmers an incentive for planting improved stock.
- Appropriate storage methods should be introduced to ensure that kola nuts are available throughout the year and do not deteriorate in storage. This will ensure that producers are able to store their crop so as to command better prices and sustained income.
- Individual countries may need to review their legislation governing land tenure to encourage a longer-term view of production among farmers in which slow-growing tree crops such as kola will once again be valued—and to ensure sustainable management of these wild resources.

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APPENDIX 1.

***Cola nitida* (Vent.) Schott and Endl.**

Schott and Endl. *Meletem. Bot.:* 33 (1832)

Sterculia grandiflora Vent. *Jard. Malmaison*: t. 91 (1805)

Vernacular names

Botanical description (modified from Keay 1989)

Tree commonly 8–12 m high, but sometimes attaining 24 m; bole unbranched for a few meters, buttresses narrow extending up the bole for 1 m in old trees. Bark grey with longitudinal fissures. Branchlets glabrous or nearly so. Foliage dense and not confined to the tips of the branches. Leaves simple, 9–32 cm long, 3.5–13 cm broad, broadly oblong or elliptic, sometimes elliptic-oblanceolate, obtuse or rounded at base, abruptly and shortly acuminate at apex; glabrous or nearly so, leathery, dark green; lateral nerves 7–10, the lowest arising close to the base and running parallel to the margin; stalk 1–10 cm long, swollen at the top. Flowers in rather irregularly branched axillary inflorescences shorter than the leaves; calyx with spreading lobes, joined for about a third of their length and often forming an open cup, up to 5 cm in diameter (male flowers up to only ca. 2 cm); typically white or cream with a small dark red marking inside at the base and extending up the veins, or wholly white, or white without and maroon within; anthers borne in 2 whorls at the base of the calyx. Fruits composed of up to 5 carpels borne on a short hanging stalk, the carpels usually in a recurved position, green and shiny, smooth to the touch, but knobbly with large warts and a pronounced keel that extends into a short curved beak, up to 14 cm long and 7.5 cm broad; seeds up to 10, covered with a white skin, usually with only 2 cotyledons (rarely 3).

Notes

Chevalier and Perrot (1911) recognized four subspecies within *C. nitida*. In their treatment, the main difference among these subspecies lies in the color of the seed. However, Russell (1955) believed that the criteria used by Chevalier and Perrot to differentiate subspecies within *C. nitida* were too slight to justify their formation. Two distinctive kinds of *C. nitida* were therefore described merely as "white flowered" and "red flowered." Chamney (1927, cited in Voelcker 1935), in *Distribution of white and pink seeds of kola nuts plants in Ghana*, concluded that cotyledon color is a function of age. However, Voelcker (1935) summarized his findings from his experiments at Ibadan, Nigeria:

- The color of the cotyledon of *C. nitida* may be red, white or intermediate shades of pink. Red is the most common; white is rare in Nigeria.
- The color of the nuts may vary from follicle to follicle, from tree to tree and, on the same tree, from year to year.
- The color has been shown to be determined by the genetic constitution of the tree on which the flowers are borne and of the tree that yields the fertilizing pollen.
- Trees grown from white nuts produce only white nuts when the flowers are self-fertilized.
- Trees grown from white nuts produce red, pink or white flowers when the flowers are fertilized with pollen from trees grown from red nuts.
- Crossing flowers from trees grown from red nuts with white pollen give red and white fruits.

***Cola acuminata* (P. Beauv.) Schott and Endl.**

Schott and Endl. *Meletem. Bot.:* 33 (1832)

Sterculia acuminata P. Beauv. *Fl. Oware* I 41 t. 24 (1805)

Cola pseudoacuminata Engl. *Planzenw. Afr*. III, II: 465 (1921)

Botanical description (modified from Keay 1989)

Tree up to 18 m high in forest, usually 6–9 m high in cultivation, bole commonly branching low, branches markedly ascending and rather slender. Bark dark green or grey; slash pale brown. Branchlets glabrous or nearly so. Foliage sparse and confined to the tips of the branches. Leaves simple, 7–22 cm long, 2–8 cm broad, sometimes larger oblanceolate to narrowly oblong or elliptic, sometime narrowly obovate, obtuse at base, gradually long-acuminate at apex, the tip often twisted downward, glabrous or nearly so, leathery, dark green, lateral nerves 7–10, the lowest arising close to the base and running parallel to the margin; stalk 1–6 cm long, swollen at the top. Flowers in rather irregularly branched axillary inflorescences shorter than the leaves; calyx with spreading lobes, joined for about half their length and often forming an open cup, up to 2.5 cm in diameter, white or cream with red coloration inside near the base and along the veins; anthers borne in 2 whorls at the top of a short stalk. Fruits composed of up to 5 carpels borne at right angles to the stalk, or slightly downward; carpels russet or olive-brown, rough to the touch but not knobbly, up to 20 cm long and 6 cm broad, narrowed to a straight apex; seeds up to 14, covered with a white skin, usually with 3–5 cotyledons (rarely 2 or 6).

Country	Vernacular name	Language ethnic group	Reference
	kola nut, bitter kola nut	English	Abbiw 1990; Iwu 1993; Burkill 2000
	kola, kolatier (colatier) (tree)	French	Burkill 2000
	coleira	Portuguese	Exell, 1944; Burkill 2000
	guru, woro	Arabic	Iwu 1993
	gbanja cola, goro cola, labozhi (labuje) kola	Trade	Russel, 1955; Burkill 2000
Benin	vi	Gbe	Burkill 2000
Côte d'Ivoire	na	Abe	Burkill 2000
	mbuessé	Abure	Burkill 2000
	alu, halu	Adyukru	Burkill 2000
	uessé	Akan-Asanti	Burkill 2000
	komonbélo	Akye	Burkill 2000
	uèsè	Ando	Burkill 2000
	ehuessé	Anyi	Burkill 2000
	uessè	Baule	Burkill 2000
	gurèsu	Kru	Burkill 2000
	hurè, urè	Grebo	Burkill 2000
	yêtu	Guere	Burkill 2000
	goli	Kweni	Burkill 2000
	apo	Kyama	Burkill 2000
	go	Manding	Burkill 2000
	balinka	Maninka	Burkill 2000
Cameroon	abu, goro	Bulu, Fang	van Dijk 1999
	talà	Bamiléké	Nkongmeneck 1985
	ataras	Moungo	Nkongmeneck 1985
	bobe, dibe	Bafok, Kundu	Burkill 2000
	ebe	Koosi	Burkill 2000
	mabanga	Kpe	Burkill 2000
	mbanga	Wovea	Burkill 2000

Country	Vernacular name	Language ethnic group	Reference
Gabon	*Red-seeded variety:*		Raponda-Walker & Sillans 1961
	ombéné	Mpongwe, Galoa, Nkomi, Orungu	Hallé 1961; Raponda-Walker & Sillans, 1961
	ngwang, éy'abèl	Fang	Hallé 1961; Raponda-Walker & Sillans 1961
	ngwanghè	Béséki	Raponda-Walker & Sillans 1961
	ngwanghè, ndama-nzambé, pul'abélyè	Bakèlè	Raponda-Walker & Sillans 1961
	mumbimu	Éshira, Bavarama	Raponda-Walker & Sillans 1961
	mumbini	Bavungu, Bapunu	Hallé 1961; Raponda-Walker & Sillans 1961
	mbini	Loango	Raponda-Walker & Sillans 1961
	obéï	Simba, Apindji, Mitsogo	Raponda-Walker & Sillans 1961
	obèdu	Bavové	Raponda-Walker & Sillans 1961
	bodèdu	Benga	Raponda-Walker & Sillans 1961
	ébèï	Masungu	Raponda-Walker & Sillans 1961
	obiri	Mindumu	Raponda-Walker & Sillans 1961
	mubiru	Bavili	Raponda-Walker & Sillans 1961
	mubidu	Baduma	Raponda-Walker & Sillans 1961
	mubeda	Banzabi	Raponda-Walker & Sillans 1961
	waé	Ivéa	Raponda-Walker & Sillans 1961
	idjali-dja-subi	Ngowé	Raponda-Walker & Sillans 1961

Country	Vernacular name	Language ethnic group	Reference
Gabon (cont)	*White-seeded variety:*		
	obanga	Mpongwè, Galoa, Nkomi, Orungu, Ivéa, Mitsogo	Raponda-Walker & Sillans 1961
	abèl, mfèmabèl	Fang	Hallé 1961; Raponda-Walker & Sillans 1961
	débélé	Bakèlè	Raponda-Walker & Sillans 1961
	dibé	Béséki	Raponda-Walker & Sillans 1961
	bobanga	Benga	Raponda-Walker & Sillans 1961
	mobanga	Bavové	Raponda-Walker & Sillans 1961
	mubanga	Bavili, Masangu	Raponda-Walker & Sillans 1961
	mbanghi	Mindumu	Raponda-Walker & Sillans 1961
	mondjalè	Apindji	Raponda-Walker & Sillans 1961
	mundjèli	Banzabi	Raponda-Walker & Sillans 1961
	idjali-dja-vèma	Ngowé	Raponda-Walker & Sillans 1961
	mwali	Éshira, Bavarama, Bavungu, Bapunu	Hallé 1961; Raponda-Walker & Sillans 1961
	mugatsu	Balumbu	Raponda-Walker & Sillans 1961
	nkasu	Loango	Raponda-Walker & Sillans 1961
	obanga	Mitsogo	Hallé 1961; Raponda-Walker & Sillans 1961
Gambia	goro	Fula	Burkill 2000
	kuruo	Manding	Burkill 2000
	goro	Wolof	Burkill 2000

Country	Vernacular name	Language ethnic group	Reference
Ghana	bise pa (red kola), bisehene (white kola)	Akan	Burkill 2000
	bese, bise	Asante, Twi, Wasa	Burkill 2000
	bawsi	Fante	Iwu 1993; Burkill 2000
	ehuesi	Anyi	Burkill 2000
	bisi	Gbe	Burkill 2000
	evi	Vhe	Burkill 2000
	gwe	Grusi	Burkill 2000
	erhesele	Nzema	Burkill 2000
Guinea-Bissau	uncurame	Balanta	Burkill 2000
	cola	Crioulo	Burkill 2000
	gòró	Fula	Burkill 2000
	cúrô	Manding	Burkill 2000
Guinea	goro	Fula	Burkill 2000
	tuguléuru	Kono	Burkill 2000
	tugule	Kpelle	Burkill 2000
	ture	Toma	Burkill 2000
Liberia	tohn-we-eh	Kru	Burkill 2000
	go	Mano	Burkill 2000
Mali	goro, guru, oro, uru, woro	Maninka, Manding	Burkill 2000
Nigeria	goro	Hausa	Keay 1989; Iwu 1993
	oji	Igbo	Iwu 1993; Burkill 2000
	obi-gbanja	Yoruba	Keay 1989; Iwu 1993
	chigban'bi	Nupe	Keay 1989
	evbe gabari	Edo	Burkill 2000
	goro	Fula	Burkill 2000
	gwolo	Gwari	Burkill 2000
	enme	Idoma	Burkill 2000
	óbì	Igala	Burkill 2000

Country	Vernacular name	Language ethnic group	Reference
Nigeria (cont)	dábóú	Ijo-Izon	Burkill 2000
	egin-ibo	Isekiri	Burkill 2000
	atara	Nupe	Burkill 2000
	alie a uke	Tiv	Burkill 2000
	evbe	Urhobo	Burkill 2000
Senegal	bakuru	Banyun	Burkill 2000
	kaguru	Diola	Burkill 2000
	goro	Fula, Tukulor	Burkill 2000
	oro	Manding	Burkill 2000
	kurukuo	Mandinka	Burkill 2000
	guro	Maninka, Wolof	Burkill 2000
Sierra Leone	kone	Bulom	Burkill 2000
	ngoro	Fula	Burkill 2000
	golo	Gola	Burkill 2000
	kolo	Kissi	Burkill 2000
	wolo	Kono	Burkill 2000
	worili	Koranko	Burkill 2000
	kola	Krio	Burkill 2000
	tugi	Limba	Burkill 2000
	kumande	Loko	Burkill 2000
	wuru	Manding	Burkill 2000
	kui	Mende	Burkill 2000
	ka-bim	Temne	Burkill 2000
	tole	Vai	Burkill 2000
	kola-na	Yalunka	Burkill 2000

Country	Vernacular name	Language / ethnic group	Reference
	kola (cola), true, or commercial cola	English	Burkill 2000
	coleira	Portuguese	Burkill 2000
	juro	Arabic	Burkill 2000
	abata kola	Trade	Russell 1955; Burkill 2000
	commercial cola nut tree	Trade	Abbiw 1990
Burkina Faso	gwòlì	Gurma	Burkill 2000
Cameroon	abu	Bulu	van Dijk 1999
	lebele	Babyeli	van Dijk 1999
	abeu	Beti	Nkongmeneck 1985
	abel	Fang	Nkongmeneck 1985
	ligo, lügo	Bibaya	Nkongmeneck 1985
	l'ebenou, l'ambanou	Yambassa	Nkongmeneck 1985
	libel	Bassa	Nkongmeneck 1985
	dibe, dobe	Bafok	Burkill 2000
	bòbàngà	Duala	Burkill 2000
	ebe	Koosi	Burkill 2000
	bobe, dibe	Kundu	Burkill 2000
	mabanga	Kpe, Wovea	Burkill 2000
Côte d'Ivoire	na	Abe	Burkill 2000
	mbuessé	Abure	Burkill 2000
	alu	Adyukru	Burkill 2000
	lu	Akye	Burkill 2000
	ehussé	Anyi	Burkill 2000
	yétu, ge	Kru	Burkill 2000
	gurésu	Bete	Burkill 2000
	wé, ué, huré, uré	Grebo	Burkill 2000
	ihié	Guere	Burkill 2000
	guéré	Neyo	Burkill 2000
	apo, hapo	Kyama	Burkill 2000
	go	Manding	Burkill 2000

Country	Vernacular name	Language / ethnic group	Reference
Benin	vi	Gbe	Burkill 2000
Democratic Republic of Congo	ngongoka	Nonde	Liengola 1999
	libelu	Topoke	Liengola 1999
	gbongbolia	Swahili	Liengola 1999
Equatorial Guinea	abe-cola	Fang	Sunderland & Obama 1999
Gabon	cola mâle, cola du Gabon	French	Raponda-Walker & Sillans, 1961
	faux-colatier	French	Hallé 1961
	abel	Fang	Hallé 1961
	monalé	Bapounou	Hallé 1961
Ghana	bisé toro	Akan	Burkill 2000
	bese, bese kyem	Akan-Asanti	Burkill 2000
	bawsi	Fanti	Iwu 1993; Burkill 2000
	bese	Twi	Burkill 2000
	awasi	Aowin	Burkill 2000
	awasi	Sehwi	Burkill 2000
	guli	Dagbani	Burkill 2000
	bisi-pa	Gbe	Burkill 2000
	godoti	Vhe	Burkill 2000
	gwe	Grusi	Burkill 2000
	kàpúshè díbì	Guang	Burkill 2000
	guru	Hausa	Burkill 2000
	esele, eresele	Nzema	Iwu 1993; Burkill 2000
Liberia	doe-fiah	Kru-Basa	Burkill 2000
	go	Mana	Burkill 2000
Nigeria	íbóng	Efik, Ibibio	Keay 1989; Iwu 1993; Burkill 2000
	oji-awusa	Igbo	Iwu 1993
	obi-abata	Yoruba	Keay 1989; Iwu 1993
	ajaura	Hausa	Keay 1989; Burkill 2000
	górò	Borim	Burkill 2000
	ereado	Edo	Burkill 2000

Country	Vernacular name	Language / ethnic group	Reference
Nigeria (cont)	fataki	Fula	Burkill 2000
	gwolo	Gwari	Burkill 2000
	óbì igala	Igala	Burkill 2000
	dábóú	Ijo-Izon	Burkill 2000
	egin-obo	Isekiri	Burkill 2000
	gòrò	Kanuri	Burkill 2000
	afata	Nupe	Burkill 2000
	alie a uke	Tiv	Burkill 2000
	evbe	Urhobo	Burkill 2000
Sierra Leone	kol-le	Bulom	Burkill, 2000
	kolo	Kissi	Burkill 2000
	wolo, wuru	Kono	Burkill 2000
	wureko	Koranko	Burkill 2000
	kola	Krio	Burkill 2000
	tugwi, tutugi	Limba	Burkill 2000
	togo	Loko	Burkill 2000
	kui	Mende	Burkill 2000
	kolai	Susu	Burkill 2000
	a-kola	Temne	Burkill 2000
Togo	guōōi	Gurma	Burkill 2000
	Bisi	Gbe	Burkill 2000
United States	bichy tree, bissy nut tree	African-American vernacular	Grimé 1979
West Indies	gooranut, cocu	Creole	Hedrick 1972; Grimé 1979

Chapter 6
YOHIMBE
(*Pausinystalia johimbe*)

Terry C.H. Sunderland, Anthony B. Cunningham, Zacharie Tchoundjeu, Marie-Laure Ngo-Mpeck and Sarah A. Laird

INTRODUCTION

Pausinystalia johimbe (K. Schum) Pierre ex Bielle is a tree native to coastal forests of Central Africa, with a range extending from southeast Nigeria to Gabon (Vivien and Faure 1985) and possibly to the Democratic Republic of Congo (Stoffelen et al. 1996). It is a late-secondary tree species of tropical forest that does not attain a large diameter. The bark of *P. johimbe* has long been used in traditional health care and cultural systems for its aphrodisiac properties. Indeed, the efficacy of the bark in treating organic male impotence has led to the development of a worldwide market for yohimbe-based products. These products involve both pharmaceutical channels and the less-regulated herbal medicine markets. Cameroon supplies the majority of the raw bark entering the commercial trade, and recent increases in harvest levels have led to concerns about the future sustainability of this exploitation (Sunderland et al. 1997b; Sunderland et al. 1999; Sunderland et al. 2000). Although *P. yohimbe* is not currently listed as threatened (Oldfield et al. 1998), it is likely that current levels and methods of exploitation will result in considerable local scarcity, if not long-term endangerment, of the species.

This chapter summarizes the current state of knowledge for *P. johimbe*, building on the information provided in the initial CARPE/FAO proceedings (Sunderland et al. 1999). Recommendations for future socioeconomic, institutional and research interventions are discussed as well.

TAXONOMY AND ECOLOGY

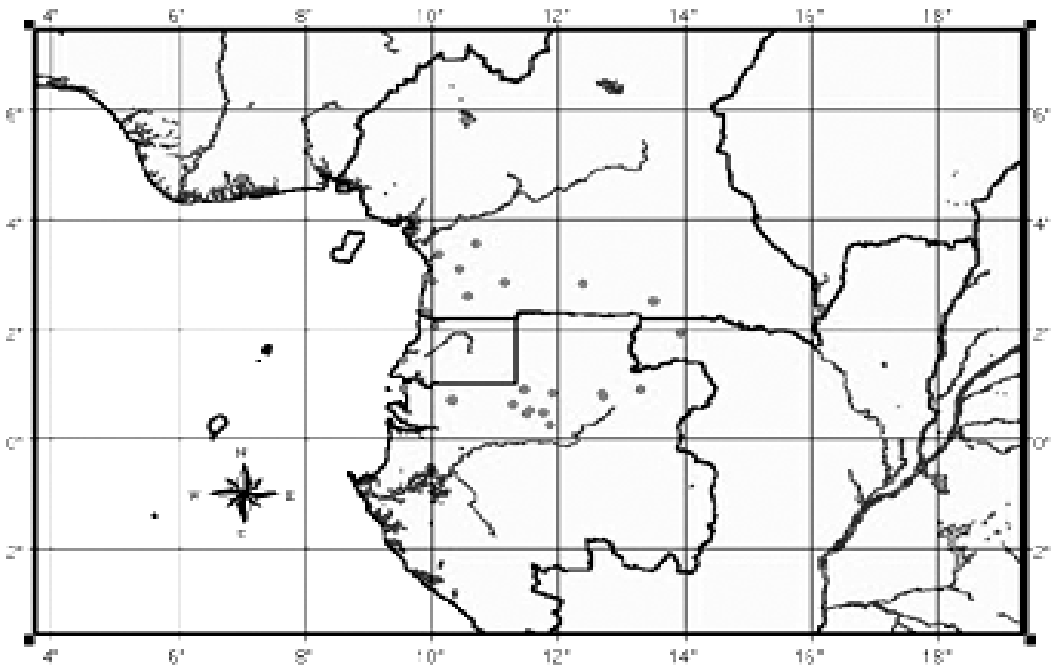
Taxonomy

Pausinystalia is in the family Rubiaceae. Within this large family, the genus is included in the tribe Coptosapeltaea, along with *Corynanthe*, *Crossopteryx*, *Hallea*, *Hymenodictyon*, *Mitragyna* and *Uncaria*. These genera, and indeed the tribe, are characterized by the presence of a distinct spherical, club-shaped or linear appendage on the corolla lobes (Stoffelen et al. 1996). Within the Coptosapelteae, *Pausinystalia* is most closely related to *Corynanthe*, and both genera possess stipules with interlocking vernation, a type of ptyxis not previously reported in the Rubiaceae (ibid.). However, *Pausinystalia* differs from *Corynanthe* in having a type of corolla that is unusual in the Rubiaceae: it is differentiated into a shortly cylindrical base with an apical bladder, resembling a wine glass (ibid.). The genus *Pausinystalia* comprises five species, with *P. lane-poolei* further represented by two subspecies (ibid.). *P. johimbe* is unique within the genus in that it has near-sessile, obovate leaves 15–25 cm long, often in whorls of 3, with distinctive cordate leaf bases (see Appendix 1).

Habitat and distribution

As noted above, *P. johimbe* is native to coastal forests of Central Africa from southeast Nigeria (Keay 1989) to Gabon (Vivien and Faure 1985). Two voucher specimens are also reported to have been collected from the Democratic Republic of Congo (Stoffelen et al. 1996), which suggests that the species might extend to the Lower Congo. However, the lack of accu-

Figure 1. Distribution of *P. johimbe*.



rate locality information for these collections does not confirm the presence of *P. johimbe* in Democratic Republic of Congo, and further vouchers will be needed to determine full distribution of the species (ibid.).

P. johimbe is predominantly found within the forest type classified by Letouzey (1985) as Atlantic Biafran evergreen forest with Caesalpiniaceae. This is an extensive forest formation dominating the coastal regions of southeast Nigeria, Cameroon, Equatorial Guinea, Gabon and Congo-Brazzaville. A notable disjunction in the distribution of *P. johimbe* occurs in the lowland forest areas around Mount Cameroon, an active volcano with significant areas of basaltic soil.

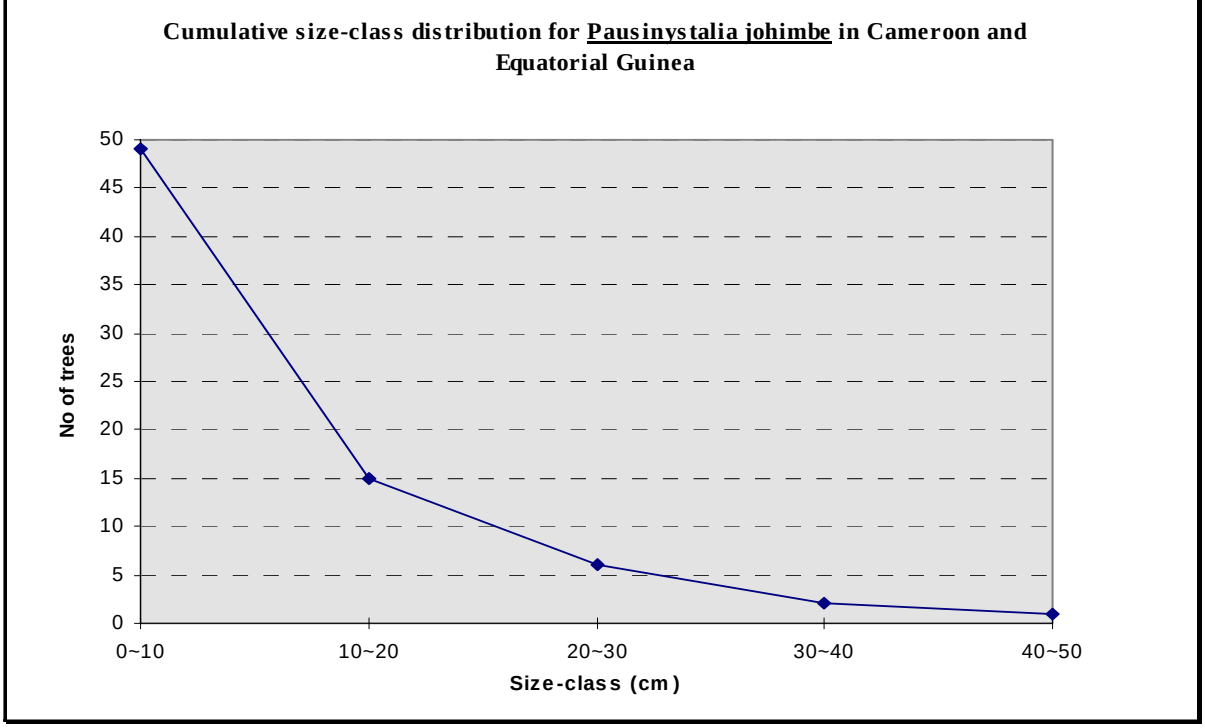
P. johimbe is predominantly encountered in closed-canopy forest and does not reach a great diameter, the recorded maximum being ca. 50 cm diameter at breast height (dbh). Hence the presence of many lower size-class individuals (Sunderland et al. 1997b). This seems to be a natural feature of the genus, by contrast with other genera, where prevalent slenderness is thought to reflect overexploitation of the larger size-class individuals. Enumeration of a 1 ha permanent sample plot, in the Campo Faunal Reserve, Cameroon, recorded 16 individual *P. johimbe* trees (>1 cm dbh) with a mean dbh of 10.8 cm, highlighting the lack of large-diameter individuals (Sunderland et al. 1997a).

Even in areas where harvesting does not take place, *P. johimbe* occurs at relatively low densities. Transect data in Campo Faunal Reserve, Cameroon, and Ntole Forest Reserve and Angoma in Equatorial Guinea, for example, showed a mean of 15 trees >1 cm dbh /ha and only 10 trees >10 cm dbh /ha (Sunderland et al. 1997b).

Conservation status

Due to its restricted distribution and habitat loss throughout its range, two species of the genus *Pausinystalia* are listed in the IUCN's World List of Threatened Trees (Oldfield et al. 1998). *Pausinystalia*

Figure 2. Size-class distribution of *P. johimbe* from Cameroon and EquatorialGuinea.



lane-poolei subsp. *lane-poolei* (Hutch.) Hutch. ex Lane-Poole is classed as "vulnerable," and *P. brachythyrsum* (K. Schum.) W. Brandt is listed as "extinct." Although this latter taxon is known only from the type specimen (the specimen in the herbarium collection from which a species is first described) and has not been recollected since Zenker's original specimen from Bipindi, in southern Cameroon, it is not clear whether it is indeed extinct or is merely highly restricted in its distribution and, hence, extremely rare (Stoffelen et al. 1996).

As noted earlier, *P. johimbe* is currently not included in any listing of threatened species. However, if exploitation continues at its current rate, it may soon be necessary to reassess its conservation status.

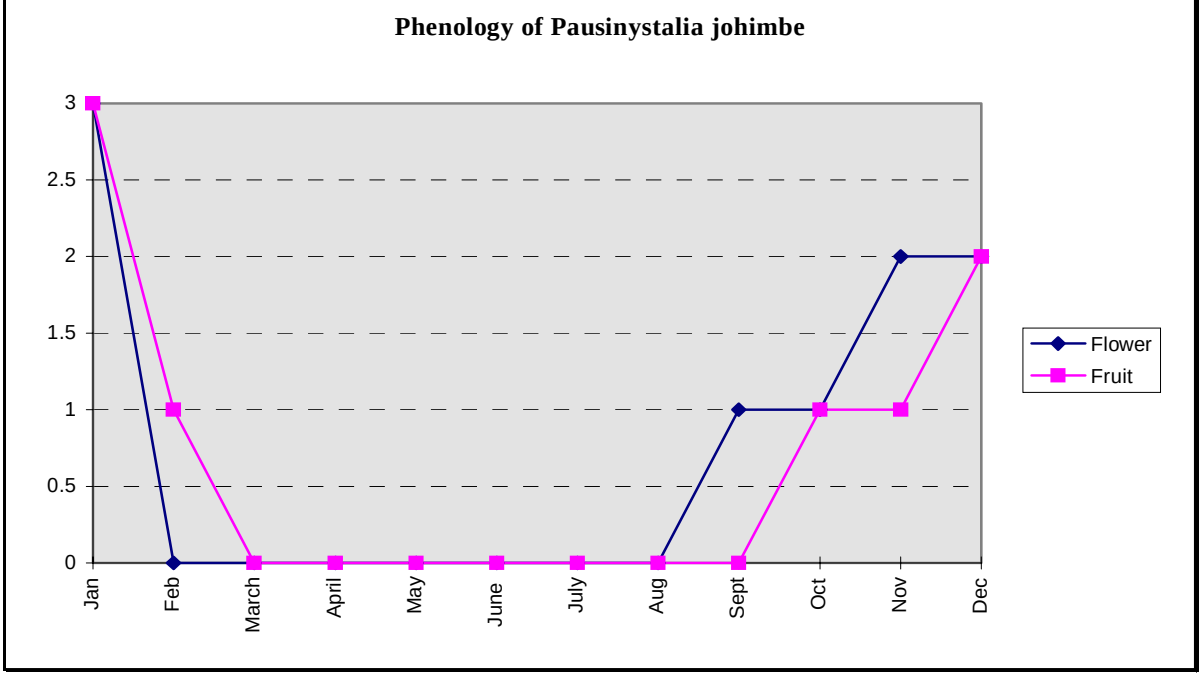
Phenology

Based on analysis of herbarium specimens and confirmed by field observations, the phenology of *P. johimbe* centers on the production of flowers from August to February, with corresponding seed production from September to March. There seems to be little variation in phenological events throughout the range of the species. There is no evidence to suggest that flowering and fruiting are periodic events, and relatively large quantities of seed are produced each year.

Reproductive biology

Although it seems probable that *P. johimbe* is insect-pollinated (see next paragraph), little is known about its breeding systems. Self-incompatibility is likely, however. For example, a study of breeding systems of neotropical forest Rubiaceae showed that 13 of 14 species were self-incompatible (Bawa and Beach

Figure 3. Phenological variation within *P. johimbe* flower and fruit production.



1983). Inclusion of the stigma and anthers means that protandry (the maturation of the anthers before the ovules to ensure cross-pollination) cannot be as prevalent in *Pausinystalia* as it is in *Corynanthe*, and it is not yet obvious what floral morphological mechanism encourages cross-pollination (Stoffelen et al. 1996).

Pollination

Stoffelen et al. (1996) postulate that the flowers of the genus *Pausinystalia* are insect-pollinated. Although there are no field observations to support this, the diversification of the corolla tube of *Pausinystalia*, and the fact that it is highly distinct from the closely related *Corynanthe*, suggests that these profound differences in the flower morphology of the two genera likely correlate with different insect pollinators. Chutwuogo (no. 4666, herb. K!) states that the flowers of *P. johimbe* "smell like rubber."

Seed morphology and dispersal

The fruit of *P. johimbe* is a bilocular elongated capsule, up to 1.0 cm long and 0.5 cm wide. It is crowned by a persistent calyx and separates from the tip to base in 4 distinct valves. The seeds have a bipolar wing that is narrow at the endosperm-bearing part, triangular at the apex and two-forked at the base (Stoffelen et al. 1996). The seeds are almost certainly orthodox and conform to the morphological and ecological requirements for orthodox seed as postulated by Whitmore (1990).

Because of their lightness and winged nature, the seeds of *P. johimbe* are wind-dispersed and can travel long distances, even in the mildest of breezes. Wind dispersal is frequent among species that are relatively tall within their respective habitats, such as trees and canopy lianas in forests, or tall herbs in fields. *P. johimbe*, a canopy tree, can reach a much greater height

than most Rubiaceae, which are usually understory trees and shrubs. Nevertheless, this wind-dispersal mechanism may have important implications for the timing of tree felling and resultant canopy gap formation. In their study of seed dispersal at the edge of moist tropical forest in Queensland, Australia, for example, Willson and Croome (1989) found that the presence of small trees and shrubs often decreases deposition of wind-dispersed seeds in the soil. If this is the case with *P. johimbe*, then there would be a relatively narrow window of opportunity for successful seed deposition after tree fall and canopy gap formation.

If seed deposition is successful, then seeds lie dormant in the soil seed bank until there is minor to moderate disturbance of the forest canopy and light penetrates to the forest floor (Sunderland et al. 1997b). It is better, however, if the canopy is not disturbed for long, because *P. johimbe* seedling survival in full sunlight—i.e., forest gaps—is poor.

Regeneration and recruitment

There is little information on the regeneration ecology of *P. johimbe* in unexploited populations. However, it has been observed that juvenile trees rarely, if ever, appear under parent trees, but rather some distance from the parent trees. In studies in Equatorial Guinea and Cameroon by Sunderland et al. (1997b), the closest distance between a juvenile tree and a parent tree was found to be 25 m. As a result, in heavily exploited populations recruitment would be expected to come either from seeds in the soil seed bank or from wind-dispersed seeds blowing into the gaps created by felling.

P. johimbe is felled for bark exploitation mainly during the rainy season (May–September), before it flowers (August–February) or fruits (September–March). Most seeds become mature and disperse between November and January, so the chances of seed dispersal from mature seeds shed during felling is considerably reduced. As a result, the seeds that "rain" into gaps created by felled *P. johimbe* are not from this species, but from other (competing) species.

USE

Ethnobotany and local use

Throughout its range, the bark of *P. johimbe* is used extensively by local people. Its many recorded uses vary, but its primary use is as an aphrodisiac and as a treatment for male impotence (Small and Adams 1922; Greenish 1929; Ainslie 1937; Dalziel 1937; Raponda-Walker and Sillans 1961; Motte 1980; Farnsworth 1984; Oliver-Beyer 1986; Tyler 1993). However, a decoction of the bark is also used as a local anesthetic (Greenish 1929; Oliver-Beyer 1986), a mild stimulant to prevent drowsiness (Raponda-Walker and Sillans 1961; Obama, pers. comm., 1997), a hallucinogen (Tyler 1993), a treatment for angina (*Lawrence Review of Natural Products* 1990), a hypertensive (Oliver-Beyer,1986; *Lawrence Review of Natural Products* 1990), a general tonic (Ainslie 1937), a treatment for intestinal worms (van Dijk 1999), a performance enhancer for athletes, and to increase the clarity of singers' voices of during long cultural festivals (Motte 1980). Less common, the bark is sometimes used in Gabon as a fish poison and to increase the resilience of hunting dogs (Raponda-Walker and Sillans 1961).

Other nonmedicinal values include using the inner bark as straps for hunting panniers and the young poles for construction purposes (Bivina, pers. comm, 1997; Okala, pers. comm., 1997). *P. johimbe* is also a preferred fuelwood species. Due to their flexibility, young saplings of both species are also widely used as snare-trap mechanisms (Okala, pers. comm., 1997).

Commercial use

In common with widespread local use, *P. johimbe* bark and bark extracts have been used for over 70 years in North America and Europe as an aphrodisiac and to treat male impotence (Ernst 1999; Riley 1994). The best studied of the active ingredients in the bark is the alkaloid yohimbine (17 alpha-hydroxy-yohimban-16 alpha-carboxylic acid methyl ester), although other alkaloids, including ajmaline, alloyohimbine,

pseudoyohimbine, corynantheine, and alpha- and beta-yohimbine, also occur in smaller amounts (Betz et al. 1995). Clinically, yohimbine affects the autonomic nervous system and helps with male erection by increasing blood flow to the penis (Foster 1999).

These effects are summarized by Tyler (1993:327), who reports that "the drug dilates the blood vessels of the skin and mucous membranes and thereby lowers blood pressure. Its alleged aphrodisiac properties are attributed not only to this enlargement of blood vessels in the sexual organs but to increased reflex excitability in the sacral (lower) region of the spinal cord."

Mann (1992:101) puts it much more concisely: *P. johimbe* acts "by increasing blood supply to the erectile tissues of the genitalia and also provides a central enhancement of the reflexes involved in the control of ejaculation."

Yohimbine-related products have also been widely used as a veterinary medicine to promote sexual proclivity among stud animals (Small and Adams 1922; Henry 1939), and early in the 20th century the *Pharmaceutical Journal* often carried recommendations for dosing stallions and boars for this purpose (anon. 1922). Yohimbe products are also used to reverse the effects of ketamine and xylazine drugs used to immobilize a wide range of animals, including Bengal tigers (Seal et al. 1987), budgerigars (Heaton and Brauth 1992), coyotes (Kreeger and Seal 1986) and white-tailed deer (Kreeger et al. 1987).

In addition, yohimbine-based products are increasingly being marketed as dietary supplements to enhance athletic performance (Betz et al. 1995) and to encourage weight loss (Fillmore et al. 1999). In the United Kingdom, yohimbine-containing drugs have become fashionable as "herbal highs," as reported in the British press (Castle 1997).

SUSTAINABILITY ISSUES

Current modes of bark exploitation

All harvested bark of *P. johimbe* is currently taken from wild populations. This exploitation takes place almost exclusively in the lowland forests of Cameroon, although there is interest in exploiting the bark in Equatorial Guinea and Gabon as well. In Cameroon, much of the exploitation of *P. johimbe* is related to timber prospecting, with individual stems of the species being identified during the inventories preceding logging. After timber is felled, the *P. johimbe* trees are felled and stripped, often by logging company employees themselves or by local forest dwellers. This bark is then sold at the roadside directly to contractors who trade it.

These contractors are registered local businesses that have licenses to exploit medicinal plants. These licenses are issued, on application, by the Forestry Department (see below). Unfortunately, the Forestry Department assigns exploitation quotas to contractors without adequate reference to baseline studies on stocking rates or sustainable yields, if indeed this information is available. As we will see below, it is unlikely that the current rate of *P. johimbe* bark harvest is sustainable. The problems of exploitation are exacerbated by harvesting carried out by unlicensed cutters, rather than by permit holders, who effectively act as middlemen; low levels of enforcement of forestry laws; and minor penalties for infringements when "free riders" are caught. The inherent economic pressure for unsustainable bark harvesting perpetuates this problem.

P. johimbe bark exploitation is a seasonal activity because the yohimbine levels are highest during the rainy season in May to September (Paris and Letouzey 1960). Contractors travel into the areas where *P. johimbe* is known to occur, paying villagers or logging company employees directly to exploit the bark. They then return 2–3 weeks later with suitable payment and vehicles to transport the bark.

The bark is often collected from the main stem only (except when it is harvested by Pygmy exploiters—see below) and not the branches. This is surprising, given that yohimbine occurs in not only both the branches and young stems, but also in the leaves (Paris and Letouzey 1960). To increase output, and to avoid climbing the trees during the bark-stripping process,

Improper felling of trees can have a damaging effect on the sustainability of Yohimbe *production*

the trees are often felled. Plantecam, formerly a key supplier of *P. johimbe* bark to Europe, admitted that during exploitation, "98% of the trees exploited are probably felled" (Nkuinkeu, pers. comm., 1997). A number of informants interviewed by Sunderland et al. (1997b) stated that *P. johimbe* individuals can be harvested when they reach an estimated 10 cm dbh. Although all of the respondents in the Sunderland et al. (1997b) studies suggested that it was easier and more ergonomic to harvest from larger-diameter trees, these individuals are not as commonly encountered, hence the felling of greater numbers of small-diameter trees.

Although felling is a common means of bark harvesting, some bark is also stripped from standing trees. Harvesting a small amount of bark from standing *P. johimbe* trees results in the development of enough callus tissue to protect the tree. Unfortunately, removal of large quantities of bark leads to an attack on the sapwood by an as yet unidentified stem borer. This borer penetrates the unprotected stem in numbers sufficient to kill the individual tree. This is why many harvesters prefer to fell the tree, as "the tree would die anyway" (Sunderland et al. 1997b). BaKola (Pygmy) harvesters, who are commonly employed to harvest *P. johimbe* along the Edea to Campo road, not only fell the trees but crosscut them into portable pieces. The bark is removed from all of the cut logs, including the branches, carried to the roadside and sold. The stripped logs are then used for fuelwood.

In summary, commercial harvesting, which selects trees >10 cm dbh, has three major damaging effects:

- It cuts into an already low population of adult trees.
- It removes individuals in the intermediate (10–30 cm dbh) size classes, some of which are growing rapidly (rather than being shade-suppressed). This reduces future yields of bark and seed.

Confusion between *P. johimbe* and *P. macroceras*

Despite the fact that the species are quite distinct and relatively easy to differentiate, both in the field and from the raw bark, considerable adulteration of *P. johimbe* bark with *P. macroceras* bark commonly occurs at the source, a common complaint of buyers of "*P. johimbe*" bark. It is estimated that *P. macroceras* bark represents around 60% of the *Pausinystalia* bark collected in Cameroon (Nkuinkeu, pers. comm., 1997). This implies an unnecessary impact on *P. macroceras* populations as well as a lower-quality product from the outset; *P. johimbe* bark contains about 6% total alkaloids, 10–15% of which are yohimbine,

whereas bark from *P. macroceras* contains only 0.02–0.32% indole alkaloids (Betz et al. 1995).

Appendix 1 provides details of the botanical and bark characteristics that differentiate the species.

POTENTIAL FOR DOMESTICATION

Introduction

Decisions about starting a domestication program for any forest product face dilemmas: on the one hand, demand may drop, and there may be no viable market when the species reaches maturity. On the other hand, a lack of action, coupled with continued overexploitation, may further endanger the wild populations of species. In the case of *P. johimbe*, the biological urgency is clear and, as discussed below, the market seems secure enough in the short to medium term to warrant a domestication program. If there is no long-term market, the species can be used for other purposes, such as fuelwood. The tree serves other valuable functions as well. The bark contains red tannins that can be used as a dye, and the young poles can used for construction (Sunderland et al. 1997b; Salim et al. 1998). Moreover, *P. johimbe* timber is a yellow semihardwood, of medium density and pleasing appearance. Despite its small diameter, it could provide a suitable substitute for *Khaya ivorensis* (mahogany) (Raponda-Walker and Sillans 1961; Vivien and Faure 1985). Hence the International Council for Research on Agroforestry (ICRAF) has begun a research program to investigate the potential for domestication of *P. johimbe* and its possible inclusion in agroforestry systems. Initial experiments to determine optimum means of cultivation have concentrated on seed multiplication and vegetative propagation (Tchoundjeu et al. 1999).

Seed multiplication

Seed multiplication may not be the most promising path to domestication: both the architecture and the ecology of *P. johimbe* are major handicaps for the collection of large quantities of viable seed. The bole has a monopodial growth habit, is mainly straight and cylindrical and is clear of branches for about 70–80 % of the total tree height of 20–35 meters (Thirakul 1985; Vivien and Faure 1985). Because individual trees of *P. johimbe* are relatively small in diameter and very tall, collecting seeds using standard climbing techniques is difficult, if not impossible. In addition, at maturity, the fruiting capsules open and wind action disperses the winged seeds at a considerable distance from the mother tree. This makes seed collection very difficult, because the fruits cannot be easily collected from tall trees, nor can the mature tiny seeds be gathered from the forest floor.

Despite these constraints, the first experimental nursery germination of *P. johimbe* seed was undertaken in the ICRAF nursery in Yaoundé, Cameroon, in 1998. Seed was harvested from trees felled by bark collectors near Campo in the South Province. Over 300 seeds (50 per experimental unit, replicated 6 times) were sown in sand set under a non-mist propagator, as described by Leakey et al. (1990). Four weeks after the experiment was initiated, less than 10% of all seeds had germinated. Adding forest soil collected from under mature *P. johimbe* trees to the propagation medium improved the germination rate, and 75% of the seeds had germinated by 6 weeks after sowing, suggesting a strong mycorrhizal symbiosis. However, within two months after potting the seedlings in polyethylene bags, at least 90 % of the seedlings had dried up and died. None of the remaining plants kept under shade reached 30 cm of growth height after 1 year. Despite the relatively encouraging germination rate, the low survival rate of plants after containerization, together with the difficulties of seed collection, pose significant disincentives to farmers interested in cultivating this tree species through seed multiplication (Tchoundjeu et al. 1999).

Vegetative propagation

Because of the constraints on seed multiplication described above, vegetative propagation has been investigated as an alternative source of planting material for farmers. Not only does this allow for clonal selection, but vegetative methods permit propagation to take place throughout the year. The ability of *P. johimbe* to coppice after being felled allows the removal of vigorous leafy stem cuttings, which are rooted using nonmist propagators (Leakey and Longman 1988; Leakey et al. 1990). Recent ICRAF experiments along these lines clearly indicate that it is highly feasible to multiply *P. johimbe* by rooting this juvenile vegetative material (Tchoundjeu et al., 1999).

Indeed, initial indications are that the use of vegetative propagation techniques to cultivate *P. johimbe* is an important step toward an appropriate local strategy to conserve the species (ibid.). Preliminary attempts to cultivate *P. johimbe* using vegetative propagation are underway in some pilot villages in southern Cameroon, where land and resource tenure are secure, and many seedlings have been planted in existing farming systems. The results so far are promising and indicate that *P. johimbe* will readily grow in association with annual food crops. The food crops provide immediate financial returns, while long-term benefits should be provided through the harvest and sale of *P. johimbe* bark, as long as local and international markets remain buoyant.

MARKET AND TRADE ISSUES

The trade in *P. johimbe* bark

Outside of Africa, interest in the use of *P. johimbe* bark as an aphrodisiac was first recorded in Germany circa 1900 (Oliver-Beyer 1986). The significant growth in the herbal medicine market that came about in the 1970s sparked a corresponding interest in yohimbe-based products (Foster 1999). Before the launch of Viagra, these products were the medicine of choice for impotency for millions of men around the world. The market for products treating erectile dysfunction is substantial; it is estimated that 50% of men between the ages of 40 and 70 suffer from this affliction in some degree (Tyler 1999).

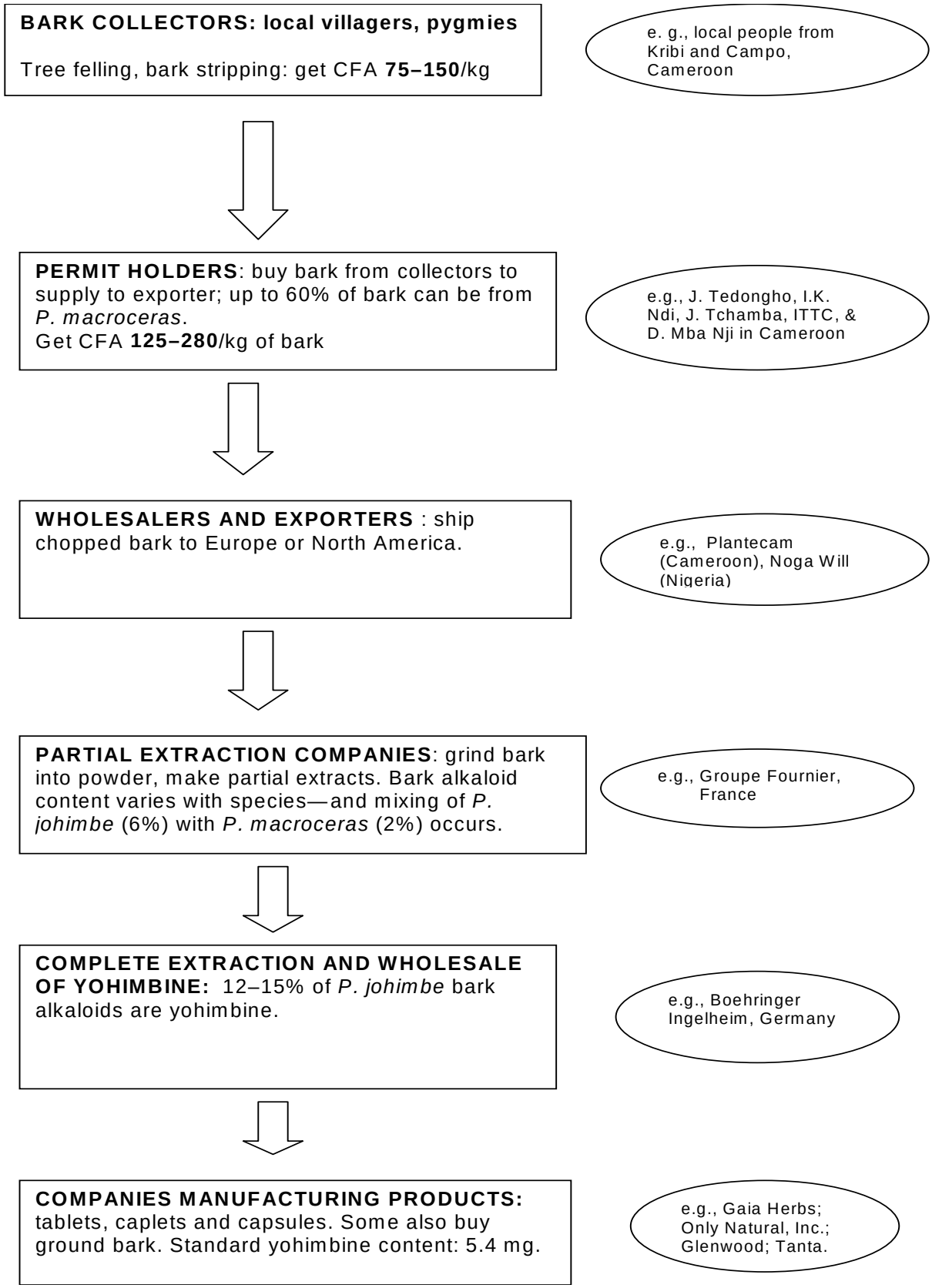
Despite the paucity of reliable information, it is known that almost all *P. johimbe* bark entering commercial trade originates from Cameroon (Sunderland et al. 1997b). In 1997–98, a year of peak production, 715 tons were exported, worth 382,728,320 CFA (approximately US $600,000) (MINEFI 1999). A number of companies are involved in trade in *P. johimbe* bark from Cameroon. The Cameroon-based Plantecam, a subsidiary of Groupe Fournier in France, was a major exporter, but the company stopped operating its Cameroon subsidiary in 2000. Currently, the main exporters of *P. johimbe* bark from Cameroon are Ets. I. K. Ndi and Brothers, Afrimed SARL, and Agrodenree SA. Additionally, there are numerous small exporters.

Expanding markets for Yohimbe *have raised concerns about the future sustainability of production.*

Commercial interest in sustainable supplies

In a sample of U.S. and European supply and marketing companies interviewed as part of this study, most had little interest in the sources of their raw *P. johimbe*

Figure 4. Trade route of yohimbe bark.



bark, as long as it meets quality control specifications. None of the companies had any real idea of how yohimbe bark is sourced, or from where. Many companies thought *P. johimbe* bark originates in Africa, but were not certain exactly where in Africa. Almost all of the companies interviewed purchase material from the last in a long chain of intermediaries and most could not elaborate on the nature of this chain, since they deal only with their contact, located in the United States or, more commonly, in Europe. Some, like Pure World Botanicals, buy only unprocessed bark to ensure quality control in processing, but most buy extracts or ground and dried bark. In the United States, one company, HerbPharm, actually markets a yohimbe extract as "Custom Wildcrafted … especially for us in their native habitat in Cameroon, Africa." What this means in practice is unclear, since there is no known certification or even field assessment of *P. johimbe* raw material sources in Cameroon.

Another company, Gaia Herbs, requires suppliers to sign a "Wildcrafter's Agreement" which is intended to provide herbalists and botanists with strict guidelines as they gather wild harvested herbs for the company. While this is an extremely responsible and progressive step for a botanical medicine company, it is highly unlikely that a number of terms within the agreement have been met for *P. johimbe*, although the company claims its suppliers of bark adhere to the agreement. What these cases do demonstrate, however, is a growing response on the part of industry to increased consumer concerns about sources of raw materials. In many cases, this is motivated by health concerns, with organic material preferred, but in some cases concerns have been raised about the sustainability of supplies, and these are likely to increase in the near future.

INSTITUTIONAL ISSUES

Legislation controlling harvest

In Cameroon, where the majority of *P. johimbe* bark for commercial sale is harvested, the large-scale exploitation of NTFPs requires a *permis d'exploitation* from the Ministry of Environment and Forestry (MINEF). This permit stipulates the quantities to be exploited and collected within a specified geographic area, with criteria set by the Department of Forestry; however, baseline and monitoring data for estimating potential sustainable yield are woefully incomplete for most resources covered by this permit system. The length of the exploitation permit does not usually exceed one year, except by special arrangement. For example, Plantecam formally possessed permits for *Prunus africana* exploitation issued for a period of up to three years' duration (Cunningham and Mbenkum 1993).

Exploitation permits also apply to special products, which include medicinal species or those of particular interest. Even if special products are found on lands belonging to private individuals, they remain the property of the state, except where the rights to these products have been acquired from the state by the individual concerned.

There is no specific regulation of the harvest of NTFPs in Equatorial Guinea, aside from *Prunus africana* (Sunderland and Tako 2000). The same lack of control of the harvest of NTFPs also exists in Gabon (Profizi 1999).

Legislation controlling yohimbe-based products

The largest market for yohimbe-based products is the United States. Under U.S. law, *P. johimbe* bark is regulated as a dietary supplement. However, while yohimbine hydrochloride is approved by the U.S. Food and Drug Administration (FDA) as a pharmaceutical drug

for impotence, it is also included on the FDA's Unsafe List (see Health and Safety below). These are two distinct markets, with different regulatory environments.

EFFICACY OF YOHIMBE-BASED PRODUCTS

In 1995, the U.S. FDA sponsored a study of 26 over-the-counter yohimbe products and found only trace amounts of yohimbine in the products tested, ranging from 0.1 to 489 ppm. This is probably not concentrated enough to have much effect, and is much less than the average yohimbine content of yohimbe bark (7,089 ppm). As one article reported, "There is almost a 100% chance that the yohimbe product you purchase over the counter will be worthless" (Milman 1999).

HEALTH AND SAFETY

Unfortunately, *P. johimbe* products have been linked to serious health problems, and steps have been taken in the United States, in particular, to better regulate these products. Included on the FDA's "Unsafe List," yohimbe can cause anxiety and sleeplessness and may react dangerously with tyramine-containing foods such as liver, cheese and red wine as well as cold remedies and certain diet aids (Tyler 1993). The 1997 FDA safety rules for ephedra-containing products included advising against the use of ephedra products mixed with caffeine or yohimbe (FDA Stops Short …, 1997). Health Canada and the Health Protection Branch of the U.S. federal government banned the sale of yohimbe, along with dozens of other botanical products, due to safety concerns (Lake 1998). Germany's Commission E monograph does not recommend use of yohimbe-based products for impotence, citing mixed clinical evidence and the potential for adverse side effects, such as tremors, sleeplessness, high blood pressure and rapid heartbeat (Tyler 1999).

As a result, although the media spotlight on Viagra helped to create interest in botanical impotence drugs, concerns associated with the safety of yohimbe-based products have had a dampening effect on its widespread acceptance. And although yohimbine is the only botanical sex aid to be listed in the *Physicians' Desk Reference*, and has been scientifically proven to improve sexual function, its side effects are considered as serious as those associated with Viagra, if not more so. People with hypertension, prostate problems or heart disease—in effect, those most likely to consume it—are warned against using yohimbe-based products (Tyler 1999). Ginkgo biloba, garlic (*Allium sativa*), ginseng (*Eleutherococcus senticosus* and *Panax ginseng*), oatstraw (*Avena sativa*), muira puama (*Ptychopetalum olacoides*), damiana (*Turnera diffusa*) and other botanicals tend to be promoted in the botanical medicine literature for widespread use instead of *P. johimbe*. However, to many specialists, the species appears to be holding its own (Haynes 1998; Natural Way 1998). In short, yohimbine is considered to be a useful medicine, but one to be taken cautiously and under the advice of a specialist, not consumed through the widespread self-medicating botanicals market.

CONCLUSIONS AND RECOMMENDATIONS

Potential for yohimbe bark certification

A process already selected by many companies and compatible with consumers' interest in organic certified material is ecological and social certification. This process ensures that sustainably sourced material, whether wildcrafted or cultivated, is also socially responsible in that local communities receive adequate benefits and compensation. Certification is a market-based tool used to promote certain types of corporate

behavior through consumer choice. The issues involved in certifying NTFPs are explored in an upcoming manual (Shanley et al., 2002); a summary of some of the findings on the pros and cons of pursuing this option for yohimbe are discussed below.

Demand for yohimbe is significant and, despite product safety concerns, is projected to grow in the coming years. However, yohimbe products supply two significantly different markets: pharmaceutical and botanical medicine. The former is not a likely candidate for certified raw material, with the exception of raw material certified for quality and active constituents. The botanical medicine industry is a more likely candidate for certified raw material, and, as discussed above, some products already carry claims of sustainability. Given health concerns associated with yohimbe products in the botanical medicine industry, however, an ecological and social certifier should collaborate with groups that also certify quality and active constituents. The availability of substitute products that may also be certifiable should also be kept in mind as an additional factor influencing future demand for *P. johimbe*.

P. johimbe bark is currently collected from 100% wild sources, and collection often takes place in remote areas. Assessing the chain of custody (tracking bark from its source to the end user) could prove extremely challenging in this case. Moreover, the ecology of *P. johimbe* is poorly understood, and a great deal of work would be required to develop adequate sustainable management plans as the basis for certification. Sustainable systems of wild harvest have not been developed to date, and there is little understanding of the long-term impact of current harvesting practices on populations. However, research is underway to domesticate the species and thereby supplement wild supplies of raw material. Ecological studies on wild populations will yield data critical to the development of sustainable sources of supply.

Existing trade networks and collection, processing and commercialization activities do not appear to significantly benefit those living near wild sources of *P. johimbe*. For example, wild harvesters earned less than half of the price paid at the gates of the processing company (Plantecam) within Cameroon before its closure, and prices paid for raw materials supplied by Plantecam were, in turn, a fraction of the final product's sale price (Sunderland et al. 1997a). However, Plantecam at least guaranteed a minimum price for the raw bark. Currently the harvest and export of *P. johimbe* bark is controlled by a number of smaller companies, and the minimum price per kilogram of bark is reported to vary considerably. In this regard, certification would need to avoid encouraging existing inequity built into the collection and trade system and should seek to promote greater benefits for local communities. In addition, *P. johimbe*'s role in the timber commodity system should be addressed. The bark is often harvested by employees of logging companies following the felling of timber in a given area; certification might be conducted in conjunction with timber certification.

Without question, issues involving the chain of custody, sustainable management and social effects would prove challenging for anyone attempting to certify *P. johimbe*. However, the product's relatively high market value, consistent international demand and relatively good potential for sustainable management argue for consideration of this approach.

Value-adding through processing in the region

Current beneficiaries of the exploitation of *P. johimbe* are, in the main, outside the source countries. To encourage a more equitable distribution of the benefits of the industry, it is recommended that a greater proportion of the original processing, such as bark maceration or even the extraction of yohimbine, be undertaken in the country of origin. This would help to realize more revenue, which could possibly be reinvested in the formal forestry sector of the country involved.

Improving the permit system

It is clear that the current permit procedure for exploitation of *P. johimbe* bark is inadequate throughout its range, but particularly in Cameroon, where exploitation is concentrated. Permits need to be set on a quota system that is both realistic (i.e., based on potential sustainable yield levels, once such models are developed) and enforceable.

Possible CITES legislation?

It is possible that in the immediate future, there may be significant scarcity and shortages of *P. johimbe* bark. In this regard**,** the exploitation of *P. johimbe* bark has much in common with that of *Prunus africana,* which is currently listed on CITES Appendix 2 (CITES 1994). This status means that countries of export have to issue export permits, and countries of import have to check these permits on entry. The scientific authority of an export country advises its management authority on the sustainability of a consignment and, ideally, the export permit would be based on sound inventory and management information. This should ultimately mean that the bark imported to a consumer country is harvested from a "sustainable" source.

Given current rates of exploitation of *P. johimbe* and the need to regulate its trade, the product might well be a suitable candidate for inclusion in CITES legislation, particularly in the countries currently exporting *P. johimbe* bark that are signatories to CITES. However, in Cameroon, there is currently no scientific authority for plants, nor is there the baseline information needed to determine levels of sustainability.

Essential further research

To determine a suitable sustainable management regime for *P. johimbe*, further research on this species is recommended. This includes:

- Experimental field pollination research studies to learn more about *P. johimbe's* breeding systems and establish whether it is self-incompatible.
- Further research on seed dormancy, the length of time seeds persist in the soil seed bank, seed germination requirements and seedling survival rates.
- Research on the timing of maximum seed shedding. It is possible that it would be better for selection felling to take place during March–April (at the end of the fruiting season) rather than May–September (after seed has been shed and before the remaining trees flower), so that canopy gaps are opened at a time when the *P. johimbe* "seed rain" occurs.

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APPENDIX I: IDENTIFICATION GUIDE TO *P. JOHIMBE* AND *P. MACROCERAS*

The majority of bark harvesters distinguish *Pausinystalia johimbe* and *P. macroceras* through slash characteristics. Yohimbine becomes yellow-orange-brown on exposure to light. *P. johimbe* is said to oxidize red-brown very slowly, with *P. macroceras* oxidizing rapidly (Vivien and Faure 1985). However, this characteristic is not reliable; in fact, the two species are almost impossible to tell apart this way. The confusion between the species in the field is not helped by the fact that the bark and bole characteristics of both species are also similar. In addition, the two species appear to be highly allopatric, meaning that direct morphological comparison is often impossible. However, the leaves of both species are highly distinctive, with *P. johimbe* having sessile, obovate leaves 15–25 cm long, often in whorls of 3 with distinctive cordate leaf bases, while *P. macroceras* has petiolate, ovoid leaves 6–15 cm long.

More subtle differences between the two species include the fact that the bark of *P. johimbe* is extremely bitter to the taste and easy to peel, while *P. macroceras* bark is less bitter and is extremely difficult to peel, often needing beating first to loosen the cambial layer from the sapwood.

***Pausinystalia johimbe* (K. Schum.) Pierre ex Bielle**

Vernacular names (from Sunderland et al. 1997a):

adjadjo (Baka), avom (Bakola), batock (Bassa), achek, akel (Bulu), nloa (Nlogdhiga-pygmy), nloune gyo, nloune adjap, nloune ewame (Ngoumbe), nikiba (Bini), idagbon (Yoruba), crocodile (Bulu vern.), yohimbe (vern.), démarreur (French vern.).

Description (adapted from Stoffelen et al. 1996):

Trees 9–30 m tall; vegetative and generative ramification ternate, rarely decussate. Leaves with petioles up to 0.5 cm long; blades 24–47 x 10–17.5 cm, glabrous, obovate, cuneate or rounded, sometimes angustate or cordate at the base, acumen less than 0.5cm long; 13–18 pairs of prominant secondary nerves and reticulate intersecondary nerves; domatia, if present, glabrous intermediate between crypt- and pit-type. Inflorescences terminal or axillary, 10–21(–30) cm long and 9–15 cm wide; stipules at the base persistent. Flowers (4–)5-merous. Calyx outside densely hairy, inside with many long hairs. Corolla lobes each with a linear appendage 8–20(–25) mm long; bladder 1.4–2.4 x 1.8–2.6 mm, inside hairy and outside glabrous; basal cylindrical portion 0.4–0.8 mm long and 0.4–0.5 mm in diameter. Anthers 0.7–1.6 mm long. Style and stigma 1.6–1.8 mm long. Ovary strongly hairy, 1.2–1.6 x 1.1–1.5 mm. Capsule almost 100% septicidal and somewhat loculicidal, 1–1.5 x 0.6 cm. Seeds 8–12 x 1.8–2.5 mm.

Bark description (adapted from Small and Adams 1922):

Bark usually occurs in channeled pieces, 4–10 mm thick, with a varying tinge of red in the grey-brown or brown outer and inner surfaces. The outer surface is longitudinally furrowed and bears numerous narrow, transverse cracks at fairly regular intervals of 1–2 cm. The cork is not firmly adherent, the bark peeling easily. The fracture is splintery, the fractured surface being soft and velvety. Older bark may be up to 15–20 mm thick, dark on the inner cut surfaces, with a scaly outer bark showing few or no transverse cracks. Young bark may be 2–3 mm thick with narrow, shallow inconspicuous transverse cracks. In transverse section under the microscope, the outer zone of the phloem shows a characteristic beaded appearance due to the alternation of sclerenchymatous fibers with parenchymatous cells, the fibers being mostly isolated and not in groups of 2 or 3.

P. johimbe

Aubreville 107; a. habit x ¾ (½); b. flower cluster x 5; c. flower x 7 ½; Letouzey 11762; fruit on stem x 1; e. fruit x 2 ½; f. seed x 2 ½.

***Pausinystalia macroceras* (K. Schum.) Pierre**

Vernacular names (from Sunderland et al. 1997a):

Caiman (Bulu vern.), false yohimbe (vern.). *P. macroceras* is also often given same vernacular names as *P. johimbe,* as many forest peoples do not distinguish between the two.

Description (adapted from Stoffelen et al. 1996):

Trees 14–40 m tall. Vegetative and generative ramification decussate. Leaves with petioles (0.3–) 0.7–2 cm long; blades 7–47 x 3–17.5 cm, obovate of elliptical, angustate, cuneate or rounded; acumen 0.5–2 cm long; 8–11 pairs of prominant secondary nerves and reticulate intersecondary nerves; hairy or glabrous domatia belonging to crypt-type or intermediate between crypt- and pit-type. Inflorescences axillary, 9–15 x 5–14 cm; stipules at the base caducous. Flowers (4–)5–6-merous. Calyx outside somewhat hairy, rarely glabrous, inside densely hairy. Corolla with small hairy inside and outside glabrous lobes, each apically provided with a linear appendage (5–)6–12.5 mm long; bladder 1.5–1.8 x 1.4–2 mm, inside hairy and outside

Figure 5. Botanical illustration of P. johimbe *(drawn by Lucy T. Smith)*

Figure 6. Botanical illustration of P. macroceras *(drawn by Lucy T Smith).*

glabrous; basal cylindrical portion (0.5–)0.7–1 mm long and 0.3–0.5 mm diameter. Anthers 0.6–1.1 mm long. Ovary 0.7–1.6 mm long, 0.7–1.5(–1.6) mm broad, hairy or glabrous. Style and stigma 1–2.2 mm long. Capsule almost 100% septicidal and somewhat loculicidal 1.1–2 x 0.5–0.7 cm. Seeds 5–14 x 1–2 mm.

Bark description (adapted from Small and Adams 1922):

Bark 4–15 mm thick, outside bark light or dark brown surface, often with longitudinal furrows and ridges with few or curved transverse cracks. Cork thin, adhering closely, making it difficult to peel. Inner bark, dark or reddish brown, ridged and wrinkled. Fracture short, fibrous and sometimes splintery on the inside, surfaces soft and velvety.

P. macroceras

Hart 126: a. habit x ¾; b. flower cluster x 5; c. flower x 7 ½; Thomas et al. 5210; d. fruit on stem x 1 ½; e. fruit x 2 ¼; f. seed x 2 ¼.

Chapter 7
MOABI
(*Baillonella toxisperma*)

Kristina Plenderleith and Nick Brown

INTRODUCTION

Baillonella toxisperma Pierre is a large lowland rainforest species that is found only in an area stretching from southeastern Nigeria to the Democratic Republic of Congo. It is a valuable timber tree that is also prized for the distinctive oil obtained from its fruits by local people, who also use other parts of the tree for medicines. As a result of large-scale timber extraction, the species is in danger of disappearing from its natural range. The resource-use conflict between logging the tree and extracting the oil from its fruits clearly links the conservation of *B. toxisperma* with larger forest conservation issues. Its continued existence and accessibility are also tied to the issue of perpetuating traditional lifestyles, because of its importance in the local economy (both barter and cash) of forest peoples. The challenge for research will be finding ways to protect the future of the species in the face of urgent and conflicting demands for access to its benefits.

TAXONOMY AND ECOLOGY

Taxonomy

Baillonella toxisperma Pierre is a monospecific member of the Sapotaceae, occurring only in the humid tropical forests of West Central Africa. *Baillonella* was described as a distinct genus by Pierre from a single sample of seeds sent from Gabon (Pierre 1890). However, Engler (1904) included the newly described *Baillonella* in the genus *Mimusops*, as *Mimusops djave*. Although the name *Mimusops djave* is still commonly used in Nigeria, *Baillonella toxisperma* is generally regarded as a distinct taxon due to differences in the testae, which are flaky, dull and tough in *Mimusops* and hard, shiny and thick in *Baillonella* (Dalziel 1948; Ahonkhai 1988; Keay 1989). The flowers of *B. toxisperma* also differ from those of *Mimusops* in having undivided appendages to the corolla (White 1964). Throughout most of its range, the most widely applied name for the tree and its timber is "moabi." A full botanical description is provided in Appendix 2.

Distribution

B. toxisperma's distribution is limited to the lowland rainforests of West and Central Africa, ranging from southeastern Nigeria and Cameroon to Gabon, Cabinda (Angola) and the Democratic Republic of Congo (White 1964; Vivien and Faure 1985; Keay 1989). (See figure 1.) Schneemann (1995) believes that it is most abundant in Nigeria, Cameroon and Gabon, and is found to a "lesser extent" in Congo, Angola and Equatorial Guinea. The species is not regarded as gregarious; it is described as being local in distribution, generally scattered or, very rarely, in groups of several trees (Centre Technique Forestier Tropical, n.d.; Kennedy 1936).

Habitat

B. toxisperma is described as a tree of the lowland rainforests (Chudnoff 1984; Dalziel 1948; White 1964) or, more specifically, of the wetter parts of the rainforest (Nielsen 1965). According to Schneemann (1995), there is very little information on the ecological requirements of *B. toxisperma*, or its ecological niche; from his studies, however, he thought it was limited to the densest parts of forests. This view has been contradicted somewhat by Sunderland and

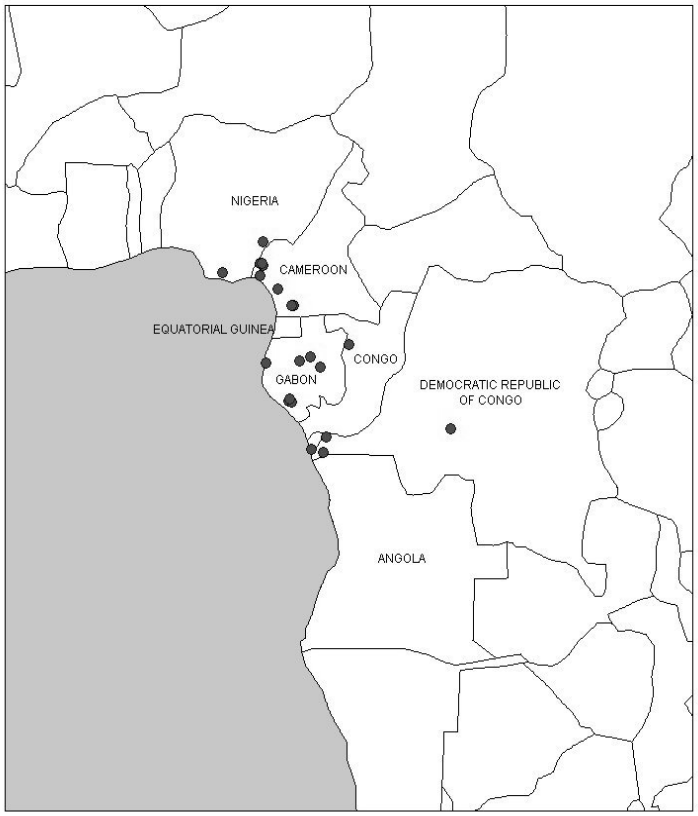

Figure 1. Distribution of Baillonella toxisperma *(plotted from the locations where specimens in the herbaria of Kew, Meise, Missouri, Oxford and Wageningen were collected)*

Tchouto (1999), who have found it to be a mid- to late-secondary species that is often predominant in farm bush and late-secondary forest, and it has been described as occurring "occasionally in cocoa plantations" (Ntamag 1997). Schneemann (1995) claimed that villagers around Mbang, in East Cameroon, planted moabi as shade trees in cocoa plantations between the years 1930 and 1950, and Hédin (1928) commented on the deliberate planting of moabi in Cameroon in the 1920s.

Baillonella toxisperma occurs at relatively low densities. Van Dijk (1999) found this to be a common feature of marketable NTFP species. A large majority of these species did not achieve densities greater than 5 stems/ha (for stems with a dbh greater than 10 cm) in any part of the Bipindi-Akom II region in Cameroon. Some species, such *as B. toxisperma* and another high-value oleaginous seed-bearing tree, *Poga oleosa*, could be classified as being rare, with less than 1 tree greater than 10 cm dbh per hectare (van Dijk 1999). In an inventory of marketable trees in two coupes in southern Cameroon, Nef (1997) found fewer than 0.01 *B. toxisperma* trees/ha. Schneemann (1995) estimated the density of *B. toxisperma* to be between 0.01 stems/ha and 0.08 stems/ha in the Mbang subdistrict, East Cameroon.

Archaeologists in West Africa are finding that the tree acts as a marker for past settlements, presumably because of its usefulness and value to past residents of the forests. The tree's distinctive shape and size make it relatively easy to pick out in the canopy from the air (R. Moss, pers. comm., 2000).

Phenology

Baillonella toxisperma is deciduous and produces flowers after the leaves have dropped. Although there may be one or two flowerings in a year, fruiting may not be an annual event. Schneemann (1995) suggested that flowering and fruiting follow a cycle of 1 or 2 productions every 3 years, with abundant production during 1 in 3 years. Many accounts are based on data from one or a few seasons and/or relate to a very limited geographical area, so the available information is patchy. See table 1 (next page).

In Cameroon, Debroux et al. (1998) said that flowering, if it takes place, occurs between February and April, when the main dry season moves into the minor wet season. Subsequent fruiting is massive and usually occurs between June and August, just before the main wet season. There are, however, exceptions that detract from the apparent regularity of the cycle, such as the fruiting of a few stems at the height of the

dry season in 1997. They add that according to Schneeman (1994), abundant fruiting happens about once in every 3 seasons. This observation has been proved during the last 5 years, and this pattern would be halfway between the episodic and periodic types discussed by Hecketsweiler (1992). A phenologic inversion is noted according to the study sites: in the east of Cameroon (Schneeman 1994), to Lopé (White, pers. comm), to Mayombe (Pangou 1989). This phenologic inversion probably corresponds to the inversion of seasons on either side of the equator (Debroux et al. 1998).

Dispersal

Although several different animals are known to consume the fruit of *Baillonella toxisperma*, there is no certainty about their role in dispersing and germinating the seed. White and Abernethy (1997) believe that *B. toxisperma* depends on forest elephants for seed dispersal, as these animals consume the whole fruit and excrete the whole seed in their dung. Other animals known to eat the fruit, but not necessarily without damaging or discarding the seeds, are wild pigs, porcupines (WCMC Tree Conservation Database 1999), forest duikers (Kennedy 1936) and gorillas. Schneemann (1995) suggests that gorillas eat only the pulp of the fruit, while animals such as wild pigs and porcupines eat the seeds (thereby damaging them and decreasing seed availability), and that elephants play an important role in dissemination by depositing the entire seeds away from the parent tree in their excrement. Schneemann also points out that people affect the tree's reproductive potential by gathering seeds for oil extraction and by logging trees for timber.

MANAGEMENT AND USES

Timber

Ahonkhai and Nwokoro (1987) classed moabi as a "strong and heavy" wood. The wood is fine-textured, with straight grain that is very homogeneous (Centre Technique Forestier Tropical 1957). The heartwood is rated as very durable and resistant to termites and is reportedly rarely attacked by marine borers (Chudnoff

Table 1. Flowering and fruiting times of *Baillonella toxisperma* taken from the literature

Country	Flowering	Fruiting	Source
Oban, Nigeria		July	Kennedy 1936
Nigeria			
Cameroon	February–April	June–August	Debroux et al. 1998
Cameroon	April (Yokadouma)	September (Douala)	Hédin 1928
Cameroon		June–July	Thikakul 1985
South Cameroon		July–August	Ntamag 1997
Mokoko River Forest Reserve, Cameroon		March–May	Sunderland and Tchouto 1999
Gabon	September–October		Heitz 1943

1984). This resistance may be due to the silica content of the timber, to toxic substances in the wood or to a combination of both. On the one hand, descriptions of the general characteristics of moabi wood refer to saponins in the dust affecting the mucous membranes (Bertin and Meniaud 1949; Centre Technique Forestier Tropical n.d.; Chudnoff 1984) that may contribute to its resistance to attack. On the other hand, the wood also generally has a fairly high silica content (Centre Technique Forestier Tropical n.d.). In investigations in France and Belgium of four tropical timber species, *Entandrophragma angolense*, *Virola* spp., *Baillonella toxisperma* and *Afzelia bipindensis*, *B. toxisperma* was found to be the most durable of the four. It had the highest percentage of silica, representing more than half the weight of the ashes, with a silica percentage about 100 times greater than that of *Entandophragma* (Ninin 1969). Its cellulose and lignin percentages are normal.

The wood is suitable for furniture making, cabinetwork, decorative flooring, decorative veneers, joinery, and store fittings (Chudnoff 1984; Laird et al. 1997). Because it is fine-grained, it is ideal for sculpture, engraving and turnery (Bertin and Meniaud 1949). It is also said by some to be suitable for exterior carpentry and heavy woodworking (Centre Technique 1957). However, Bertin and Meniaud (1949) maintain that the wood is sensitive to moisture variation and, as such, should only be used for interior joinery, cabinet work and large panels (preferably in the form of veneers). The timber is also weak on impact, so it should not be used for structures subject to movement (ibid.).

Many timber trees have wood with similar appearance and properties. Knowledge of these similarities is of potential interest to conservationists, because slow-growing and endangered species with a high timber value such as *B. toxisperma* could be replaced in the market by other species that do not have NWFP value and/or are more widespread and replaceable. For example, moabi is often confused with douka (*Tieghemella africana*) and makoré (*Dumoria heckelii* (Sapotaceae) (Centre Technique Forestier Tropical 1957) and is not unlike *Manilkara* species in appearance, except that it is rather lighter in weight (Brown 1977).

Nonwood uses

Baillonella toxisperma is valuable to local communities as a multipurpose forest tree. People collect its fruits, bark or other parts for use as food, medicines, etc. (Adeola 1995; Vivien and Faure 1996). In a survey carried out in Cameroon, 570 farmers were asked to list 15–25 multipurpose trees, ranking them in order of priority perceived by them. Seventy-seven per cent of respondents mentioned *B. toxisperma*, giving it a rank-order value of 6.0. The uses mentioned were timber, medicine, firewood and oil (Adeola 1995).

Medicinal

The tree's seeds, seed oil, bark (Schneemann 1995) and latex are, or have been, all used for medicinal treatment. For example, in the Mount Cameroon region of Cameroon, a decoction made from the bark (by drying in the sun or boiling) is used to prepare a woman for childbirth (Laird et al. 1997). The bark is also used to treat infertility and other gynecological problems (ibid.). In the same region, seed oil is used for mixing local plant medicines; often it is heated first. It is rubbed on skin inflammations and on joints for rheumatic pains. In the South West province of Cameroon, a bark decoction is used as a mouthwash to reduce pain and as an enema for groin abscesses. Seed oil is rubbed on abscesses, and the baked seeds are ground with *Aframomum* species and rubbed on swellings behind the ears (ibid.).

In Gabon, leaves of *Rauvolfia vomitoria* are cooked with djave nut butter (*B. toxisperma*) and applied as an ointment to inflammations, dislocated joints and limbs affected by rheumatism (Burkill 1985). Also in Gabon, it was recorded that local people used the latex for dressing wounds (Heitz 1943). In Gabon and Equatorial Guinea, the Fang use the oil from the seeds to treat rheumatism (Moss 1995; Sunderland & Tchouto 1999).

Ritual

In Cameroon, the seeds are used in the manufacture of foot-rattles used in traditional dances and celebrations (Sunderland and Tchouto 1999). In 1948, Dalziel reported that the seeds were also used as an ordeal poison in some parts of Cameroon, and that the bark is used in native medicine to ensure strength (Dalziel 1948). In the subdistrict of Mbang, Cameroon, the Baka are said to use a part of the bark to become invisible for elephant hunting (Schneemann 1995).

Fruit and seed

The fruits of *B. toxisperma* are harvested when they have fallen, and although it is reported that 15–20 kg of nuts may be found at the base of each mature individual, the harvest varies greatly from year to year (Hédin 1928). The fruits can be eaten fresh, or they can be processed to produce a high-value, viscous oil. This very expensive oil is exclusively processed by women, predominantly for household consumption. The oil is so prized and so scarce that it is rarely sold in markets; local communities prefer to keep what they can collect for their own use, though it is traded throughout the Central African region when there is a surplus (Laird 1999; Ntamag 1997; Sunderland & Tchouto 1999). One of its advantages is that it provides an "easily stored and transported commodity" (Moss 1994). The oil, described as similar to shea butter (Keay 1989), is said to be preferred above all other oils in communities where it is available (Agom and Ogar 1994; Hédin 1928; Laird et al. 1997; Moss 1994; Sunderland & Tchouto 1999).

Extracting the oil is a rather laborious process. After the nuts are thoroughly dried, the shells are removed for use as fuel and the kernels are finely ground (Dalziel 1948). Either the paste is put into a pot with boiling water so that the fat that surfaces can be recovered (Hédin 1928) or it is moistened frequently with boiling water and manipulated into lumps or balls until the fat appears (Dalziel 1948). The extraction may also be done mechanically, with the smoothly ground mass being put in a press (Dalziel 1948).

In Gabon, Moss (1994) observed that the traditional method for extracting oil from the inedible pulp involves a process of manual grinding, heating and expulsion of the oil through sacking. This method is very time-consuming, and extraction rates appear to be low. *B. toxisperma* oil is prepared only in small volumes by older women accustomed to this task since childhood. The difficulties involved in processing were repeatedly cited by villagers as the key reason for the decline in the production of *B. toxisperma* oil.

After the oil has been expressed from the seeds, an oily residue is left that has been described by various authors as being poisonous to fowls and animals in general; it has been found to contain saponin (Keay 1989; Offem 1990). It could be used as a worm-killer on lawns or as a fertilizer. Local people know the toxicity of the seed, for they take care that the residue is not consumed by domestic animals. The final residue contains a considerable amount of oil and is used to light fires (like the fiber of palm nuts), or is thrown in streams or pools to stupefy fish, the effect being probably due to the saponin (Dalziel 1948:358). Neuwinger (1994) concluded that the effect of these saponins on the fish may be due to a pathological increase of permeability in the gill epithelial cells. The essential electrolytes dissolved in plasma—e.g., potassium ions—go into the surrounding water, and this irreversible leakage of ions stuns and often kills the fish.

Offem (1990) analyzed seeds from *Mimusops djave (B. toxisperma*) for nutritional, toxic and other components, including fat, protein, ash, fiber and minerals. He found that whole seeds contain about 613 g crude fat/kg, while defatted seeds contain 219.6 g crude protein/kg, corresponding to 85 g/kg whole seeds. The silica-free ash and crude fiber contents were 73.8 g/kg and 34.6 g/kg of the defatted seed meal, respectively. A methanol extract of the defatted seeds produced 100% mortality within 72 hours of feeding to chicks. Aflatoxin B_1 was detected at 3 mg/100g of dried and defatted seed and G_1 in only trace amounts, plus low levels of lead and cyanide, but these were too low to account for the chick deaths. The

methanol extract was purified and analyzed, and found to contain two compounds with the spectral characteristics of saponins.

MARKETS AND BENEFIT SHARING

Timber

As one of the prized tropical timbers exported from West Africa, *B. toxisperma* has been considerably overexploited. By volume, it was the 10th most important commercial timber species exported from Cameroon in 1997: 27,944 m^3 were exported in January–September 1997 (SGS Cameroun, S.A. 1997, quoted in Laird 1999). From 1990 to 1993, *B. toxisperma* constituted 2.6–3.7% of the total volume of logs (all species) exported from Cameroon (Schneemann 1995).

Nef (1997) reports the stumpage value of moabi to a concessionaire in Cameroon to have an export price of CFA 91,653/m^3; stumpage value/m^3 CFA 77,653; stumpage value/ha CFA 2,718; and stumpage value/tree CFA 784,295.

Laird et al. (1997) described the timber value as "mercurial." Between 1990 and 1993, the export price in Cameroon for *B. toxisperma* logs averaged CFA 62,500 (US $250) /$m^3$ (f.o.b. Douala). This export value was 20–34 million French francs, 3.4–3.5% of the total export value for logs of all species (Schneemann 1995). Also in Cameroon, Nef (1997) quoted the following figures from the Dutch logging company GWZ: 1993–94 log export sales for *B. toxisperma*: 172 logs (1287 m^3), total value CFA 118 million**,** were 2.78 % of total export value, with a price/m^3 of CFA 91,653.

In 1987, 55,884 m^3 of moabi timber were exported from Gabon at an average price of CFA 60,000 /m^3 (US $91/$m^3$), and 59,891$m^3$ were exported in 1989 (Wilks 1990, quoted in Moss 1994).

Oil

There are many reports that people prefer the flavor of the oil obtained from *B. toxisperma* seeds where they have access to it (Agom and Ogar 1994; Amadi 1993; Laird et al. 1997; Nef 1997). Okafor and Lamb (1992) suggest that it is a species whose fruits, with their high fat and oil content, would be suitable for commercial production of cooking oil and margarine and for use in soap manufacture and pharmaceutical preparations.

In addition to local preference for the oil, the seeds of *B. toxisperma* were historically imported by Europe, where there was a market for the fats and oils. As Hédin reported in 1928:

> The lack of fats from which certain of our industries suffer has led us to import from our colonies all the fats and oils that can be economically exploited. It is important to re-examine the seeds of *Baillonella toxisperma* Pierre (1890) which has already been part of a by no means negligible trade with England and Germany. . . . In the time of our predecessors Hamburg regularly purchased the *Baillonella* nut harvest; production was greater or smaller according to the year. In 1907 it was 15 t.: in 1908 183 t. representing a value of 20,000 marks. In 1911 exports reached a value of 32,000 M. It is still the Hamburg market that offers an outlet for shelled njabi nuts. So, in the region of Yabasse in 1920, 14 t. were exported, in 1921 28 t. But transport presented difficulties: the seeds in bags arrived broken and partly pulverised. There is no doubt that industry would be more interested in the fat itself (p. 854).

The nuts were also formerly exported from Portuguese Equatorial Africa to Germany, possibly along with those of *Mimusops pierreana*, which yield a similar product (Dalziel 1948).

The trade in the unprocessed seeds ceased, and now consumption of the fats is documented as being limited to the West and Central African regions, where the species is endemic. As noted above, current re-

search into use of NTFPs indicates that the markets are very restricted due to limited availability of the oil. In his recent study of NTFPs available in Paris, Tabuna (1999) did not record the oil as being sold in the Paris markets, despite the fact that the source countries for these NTFPs were those of the Congo Basin, and the clientele in Paris were primarily African or Caribbean in origin.

The oil is high-priced, which indicates its value and scarcity. In Nigeria, *B. toxisperma* has very high NTFP value. In 1994 the oil was selling at N 30/beer bottle (70 cl.) and was used like any other vegetable oil. An average-size tree is able to produce 170 bottles of oil per season (i.e., annually). A single tree would thus have been worth about N 5,100 a year (Agom and Ogar 1994). In Northern Gabon, very little of the oil is marketed and prices are variable. However, in 1994 most of the *B. toxisperma* oil that went on the market sold for at least CFA 3,000 (US $3.3)/liter, compared with CFA 995 (US $0.75)/liter for peanut oil. Oil sold as medicine in 5 cl. bottles fetched as much as CFA 20,000 (US $15.1)/liter (Moss 1994). In East Cameroon, demand for *B. toxisperma* oil exceeds availability. Prices in 1995 varied from CFA 400 (US $1.6)/liter in far-off production areas (e.g., Lomié) to CFA 2,000 or 3,000 (US $8 or $12) in Douala and Yaoundé. Extrapolation of inventory results showed that in 1992 Baka and Bantu women in the subdistrict of Mbang would have extracted approximately 6,200 liters of oil, with a local value of CFA 4.6 million (approximately US $18,400). They would have sold 2,100 liters of oil for CFA 1.6 million (US $49,600) (Schneemann 1995).

Comparison of NTFP value and timber value of *B. toxisperma*

Until recently, the species' value to local communities was its availability for repeated harvesting of the seeds. Today, however, the timber value of a tree to a local community may outweigh its NTFP value, at least over the short term. For example, Nigerian communities which own forest that is exploited are given a royalty of 50% of the permit money that loggers pay to the Forestry Department (Agom & Ogar 1994: 11). The value of this to the community per tree extracted was about N 1,125 for first-grade trees in the early 1990s. *B. toxisperma* is classified as Group A, a high-value species (Schneemann 1995), so the timber value to a community of logging the species may far exceed its value as a backup resource at any one point in time.

Schneemann (1995), however, compared the economic benefits to the "manager" of a moabi tree of extracting the oils and selling them periodically, to those of logging a single mature tree at its peak economic value. He found that the tree's timber value, once every 140 years, was about CFA 462,500 (approx. US $1,850). The value of its oil, estimated at a rate of 135–165 liters of oil from one tree every 3 years, would be CFA 300,000 (approx. US $1,200). With a discount rate of 10%, the value of the tree's oil production 4.5 years after year x would be CFA 455,000 (approx. US $1,820); after 7.5 years, the total revenues would be CFA 602,000 (US $2,408), discounted to year x.

Schneemann (1995) concluded that, comparing the two scenarios after 4.5 years, the benefits of oil extraction are almost equal to those of the timber revenue of a tree with a diameter of 100 cm. Moreover, after 7.5 years, the discounted oil revenues do largely exceed the timber revenues, so the economic value of NWFP gathering could be promoted as providing greater long-term benefits to a community, compared to a tree's timber value (Schneemann 1995).

INSTITUTIONAL ISSUES

The survival of *B. toxisperma* in its natural habitat is affected by a country's logging laws, conservation legislation (national and international laws) and customary laws and rights. Investment in and strength of infrastructure are critical accessories to these laws and rights—to ensure their implementation, to provide opportunities within the species' natural range for its *in situ* conservation, and to enable research

into managed plantings in suitable, accessible locations.

B. toxisperma is a particularly vulnerable species because of its slow rate of regeneration and lateness to fruit, coupled with its high timber value as a diminishing resource in an increasingly demanding market. The IUCN Red List lists the species as "vulnerable," i.e., facing a very high risk of extinction in the wild in the immediate future (Oldfield et al. 1998). The species has been declared by the World Conservation Monitoring Centre to be vulnerable in Cameroon, uncertain in Gabon and Nigeria and not threatened in Congo. A draft CITES proposal in 1991 expressed concern about illegal trading in *B. toxisperma* in some countries.

While there may be forms of legal protection in place that could help *B. toxisperma*'s conservation, weak government and infrastructure failings militate against this. It is well documented that the oil is a valued resource to local communities in Central Africa. However, it seems likely that as the species becomes increasingly rare, initiatives to protect it will weaken as it is replaced in local diets by other oils that are cheaper and easier to find and as knowledge about preparing and using it is lost. Therefore, the sooner effective forms of protection are devised for the species, the greater the odds that the indigenous peoples of the region will continue to use and value it.

Protection needs to be directed toward balancing the value of its timber to countries in the region and local needs, including those of forest biodiversity. As early as 1928, Hédin wrote of the strength of logging companies in influencing government policy in Cameroon when the ban on felling *B. toxisperma* in logging coupes was altered, permitting the felling of trees not used by local people. This is still the case where commercial pressures influence governments against the interests of local communities or override their practices.

Cameroon

The clash between local use rights and logging pressures on *B. toxisperma* is most visible in various reports on studies carried out in Cameroon (Ambrose 1994; Schneemann 1995; Horta 1997; Ntamag 1997; Sunderland & Tchouto 1999). As Schneemann notes (1995):

> The people living in South and East Cameroon have a tradition of communal ownership of land and forest resources. For example, for *B. toxisperma*, the man who discovers the tree obtains the right to use it during his life, together with his family. The discoverer consolidates his right by marking the tree and by cleaning the area surrounding the tree. The tree is heritable and becomes a family's property. Ownership was established many decades ago by the Bantu, who were the first to settle in villages. Nowadays, the Baka complain that the Bantu have "taken" all the *B. toxisperma* and *Irvingia* spp. trees near the villages, and that they (the Baka) have to penetrate far into the forest to collect fruits and nuts from "free" trees. Although this concerns customary right, the state is the legal owner of all natural resources, including forest resources.

According to Schneemann, logging started around 1900 at the coast of Cameroon and expanded toward the East province between 1950 and 1960. Since 1971–72, *B. toxisperma* has been exploited in the East province, in particular in the districts Kadey and Haut-Nyong. To assure forest regeneration, the forestry department has determined a certain "minimum diameter of exploitation" (DME) for each timber species. It is forbidden to log *B. toxisperma* trees with a diameter of less than 100 cm, though this rule is not always respected. Logging companies qualify *B. toxisperma* trees as suitable for logging if they: (1) have a diameter of at least 100 cm; (2) are not situated near a ravine and (3) have a straight and healthy stem (Schneemann 1995).

Up to 1981, logging companies were obliged to assist local communities by building infrastructure such as classrooms, health centers, etc. Since 1981, the companies no longer have direct obligations to the population because they pay a "communal tax" in Yaoundé that is meant to finance local infrastructure building.

Now local communities are only informed about the arrival of a logging company, its license, etc. Though local communities have often expressed the desire that logging companies would not log the *B. toxisperma* trees they use for oil extraction, logging companies and government have given no guarantee that they will conserve those trees (Schneemann 1995).

In their survey of timber and NTFPs in the Mokoko River Forest Reserve in the South West Province of Cameroon, Sunderland and Tchouto (1999) found that even where a company has an agreement with a local community, there is no certainty that it will be honored. The recovery of timber by Cameroon Development Corporation (CDC) during its expansion has led to the felling of a number of taxa of some importance to local people, the worst example being *B. toxisperma*. Protests by villagers have led to negotiations with CDC to retain some valuable NTFP species on plantation land. At the time of writing, no agreement had been reached on this. However, it is important to note that this issue does not affect the Mokoko Reserve itself, and is an issue on CDC land only (Sunderland & Tchouto 1999).

Nigeria

It has already been mentioned that in Nigeria, communities that own forests exploited for timber are paid royalties from the money earned by the government. Specifically, they receive 50% of the permit money paid to the Forestry Department, which in the early 1990s came to about N1,125 for first-grade trees (Agom and Ogar 1994).

Equatorial Guinea

In Equatorial Guinea, forestry is a major contributor to the country's GDP, yet only about 1% of the earnings from forestry taxes are channeled back into forest administration. A large discrepancy can be noted between forest policy, legislation and the actual situation in the forest (van Breugel & Parren 1997). The 1997 forestry law (Ley No. 1/1997) set the maximum size of logging concessions at 50,000 ha effective harvestable area (concessions in mountainous areas, for example, could be larger), valid for 15 years. However, good timber quality in the coastal zone, where most logging activity has been concentrated, is declining, while the number of enterprises is increasing and all potential land has been handed out. As van Breugel and Parren note, "This surface includes other land use types apart from forest lands. Of the present concessions, about 960,000 ha are exploited or have been exploited, while at the same time logging takes place in community forests (*reservas de poblados*) and on private land." There is an interdiction on felling fruit trees useful for human consumption (van Breugel & Parren 1997) that could be used to protect taxa such as *B. toxisperma* if supervision and management of forests were effective.

TOWARD A SUSTAINABLE POPULATION OF *B. TOXISPERMA*

Contributory factors to the species' decline

The factors that make *B. toxisperma* a vulnerable species are:

- habit (slow growth and large size, late maturity, irregular fruiting, low density);
- restricted range and distribution;
- loss of habitat resulting from forest clearance and changing land uses;
- high timber value;
- political weakness of forest peoples who collect and process the fruits; and
- growing preference for more easily accessed and cheaper sources of oil (since processing is slow and laborious).

As a slow-growing, long-lived species with a replacement time of more than half a century (Vivien & Faure 1996; Schneemann 1995), *B. toxisperma* is disappear-

ing from the more accessible parts of its habitat. It grows within a limited region of tropical Africa that is under global pressure from the world timber industry: forests are rapidly being logged, and primary forests area giving way to more transitory forms of vegetation cover, secondary forest or agriculture. As logging encroaches further and further inland from more easily accessible forests, the species is losing its habitat for regeneration and is not replacing itself. Because of its poor regeneration and the extent of its exploitation, which occurs without (sufficient) restrictions, the species will probably disappear from a large part of its original area of distribution.

There are conflicting interests in the region that need to be resolved, placing traditional forest-based lifestyles at odds with opportunities for Central African countries to earn high timber revenues. These conflicts are becoming more acute as other tropical timber–producing countries introduce export controls, or their forests are logged out and the industry seeks alternative timber sources. The principal conflict of interest affecting *in situ* conservation of *B. toxisperma* is between local communities and logging companies. Communities that until recently had been dependent on NTFPs to supplement their dietary and other needs have found that their access to and use of the forests is being curtailed by the encroachment of loggers, who not only remove valued trees but also ignore customary ownership and rights to forest products. Changes in social structure that occur when forests are cleared and replaced by agriculture also undermine these rights, along with traditional knowledge and use of NTFPs.

B. toxisperma is not the only species at risk: logging operations have a serious effect on local communities' use of many NTFPs, particularly where both commercial and local values are high. The extent to which these values correspond often determines the level of community-based opposition that may arise (Nef 1997). *B. toxisperma* is, however, an excellent example of this conflict of interests. Its density/ha is low; it is commercially valued for its fine timber; and the oil from the fruits, traditionally valuable to local communities, is in increasingly scarce supply (Laird 1999). Extraction of *B. toxisperma* affects peoples such as the Baka and Bantu in East Cameroon for whom the fruits have been their only source of edible oil. They sold or exchanged surpluses not needed for their own consumption, and loss of the trees, as noted above, has resulted in conflicts between them and the logging companies (Schneemann 1995).

Agom and Ogar (1994) surveyed a concession area of 170 km^2 in the Afi River Forest Reserve, Cross River State, Nigeria, to estimate the impact of logging on the forest and on the communities situated there. The concession area was next to a village, Abo Ogbabante, and the villagers used the forest regularly for collecting NTFPs. However, some of these products were being destroyed by logging, notably *B. toxisperma*. This species constituted 37.8% of the total extracted by the loggers.

The impact of logging on communities was also witnessed by Ntamag (1997) during her research into the collection of NTFPs in Nyangong, Cameroon. The local people complained that particular trees they depended on for very highly valued NTFPs, such as *B. toxisperma*, were being logged out (Ntamag 1997). In addition, Sunderland and Tchouto (1999) have written of the conflict in the Mokoko River Forest Reserve between the Cameroon Development Corporation and local people.

It is not only commercial logging companies that are exploiting the timber resource. In the roadside settlements of the Korup Forest, Cameroon, where poorer groups sell NTFPs, their access to forest resources is diminishing as forest is converted to farmland. The elites have adopted new farming methods that entail clearing large areas of land to make way for the cultivation of yams, cassava and other crops. These methods are not only used to earn cash from farm sales, but also to generate income from the timber trees, including *B. toxisperma*, that are felled during clearing (Malleson 1999).

Other factors contributing to the decline in use of *B. toxisperma* oil are a more general reflection of social change. The availability and consumption of native fruits are declining as the trees become rarer (Okafor & Lamb 1992). For example, one consequence of the declining availability of oil from *B. toxisperma* is that

A slow-growing species, B. toxisperma *is disappearing from the more accessible parts of its habitat.*

people turn to more easily obtained products, such as palm oil, and the taste and quality of the traditional oil is, in time, forgotten. Moreover, Chikudze (1995) found that as cultivated foods become more affordable, the need to collect forest foods declines. As a consequence, the more field crops are harvested and sold, the less reliance there is on NTFPs. Cultivated foods often have a significant price advantage over foods that require collection from the forest and laborious processing. As introduced fruits gain a market foothold, greater attention is given to researching, developing and marketing them.

Another contributing factor to the decline in NTFP use is that communities have no control over these trees because their customary rights over either the land or the trees themselves are ineffectual (Ambrose 1994; Horta 1997). Sunderland and Tchouto (1999) have examined the impact on conservation that results from lack of land tenure and long-term security. They found that where people had long-term control over their land and the species growing there, and as they became more aware of the market value of certain products beyond the subsistence level, farmers were retaining valuable NTFP resources, such as *B. toxisperma*, on their lands.

Means of conserving the species *ex situ* as well as *in situ*

It has been shown that dispersal, germination and early growth are uncertain processes in *B. toxisperma* (White and Abernethy 1997; Schneemann 1995; Sunderland & Tchouto 1999; Debroux et al. 1998). This is due to seed predation (including removal by humans); the short period during which the seeds retain viability; the species' possible dependence on a single dispersal agent (the forest elephant); seedling damage and allelopathy; and the species' low density (van Dijk 1997).

B. toxisperma is not currently in cultivation on any large scale (Sunderland & Tchoutou, 1999). However, germination tests have been carried out with optimistic results. A comparative study was made of *B. toxisperma* and *Autranella congolensis* in the Dja Wildlife Reserve, Cameroon, which tested germination and development of seeds under nursery conditions (Debroux et al., 1998). The study found that *B. toxisperma* has a short latent germination period, that the germination rate is very high, and that seedlings grow quickly.

Despite this rapid germination in the nursery, the later stages of growth are slower. There is also evidence of heavy mortality in the early stages of growth. In the Afi Reserve in southern Nigeria, Kennedy (1936) reported that natural regeneration was good, but dur-

ing the second year when seedlings were about 4 ft. high, the majority of promising saplings died back.

However, using such traditional horticultural techniques as vegetative propagation and clonal selection (Leakey & Maghembe n.d.), early growth can be accelerated by bypassing the dispersal and germination stage, and farmers can have access to saplings rather than searching for wildings. Trials on vegetative propagation of *B. toxisperma* have been carried out at the Institute of Terrestrial Ecology, Edinburgh (Leakey et al. 1992). In addition to enabling material to be selected and multiplied from superior genotypes, and the conservation of genetic variety, vegetative propagation for fruit trees can achieve early fruiting and fruit set in slow-maturing species by using mature adult budwood (Okafor & Lamb 1992).

The literature shows that *B. toxisperma* has been planted in the past, and has been left as a shade tree when land was cleared for plantations (Sunderland & Tchouto 1999; Ntamag 1997; Schneemann 1995; Hédin 1928). Okafor and Lamb (1992) have written that programs to incorporate forest fruit trees into traditional agricultural systems have been tried in Nigeria and included *B. toxisperma* in their list of recommended species. In Gabon, *B. toxisperma* is one of 6 species of wild fruit trees being researched by the Ministère des Eaux et Forêts and the Institut de Recherche Agronomique et Forestière (IRAF) for their potential for reforestation to augment timber production. IRAF is also investigating the biology of wild fruit trees because of their importance to the local population (Bourobou-Bourobou 1999). Trials are also being carried out of mixed plantings of large trees such as *B. toxisperma* with faster-growing medium-sized trees such as *Irvingia gabonensis* and plants with rapid growth such as *Macaranga* species (Bourobou-Bourobou 1999, citing Hladik & Miquel 1984).

In conclusion: conserving the species and increasing its use

A number of factors would help conservation and promotion of *B. toxisperma*, including:

- development of smaller, earlier-fruiting trees;
- *in situ* conservation (forbidding logging in protected areas, and elsewhere when trees are below a specified size or age);
- alternative sources of germplasm (*ex situ* conservation in nurseries);
- improved or more secure access to and use of trees for NWFP harvesters;
- improved oil-processing techniques; and
- enlarged markets and promotion of the oil as a quality product.

Lawson (1992) has recommended coordinating breeding programs through national germplasm collections. Lawson recommends breeding native hardwood trees through a regional hardwoods improvement program using a range of timber and multipurpose species such as *B. toxisperma*, *Garcinia kola* and *Prunus africana*. Such programs could provide stock for planting in and near villages and farms. Local people who still use *B. toxisperma* products would be able to indicate superior trees from which to obtain planting stock because they would know the characteristics of mature trees from which products were gathered.

Since the quality and quantity of fruits decline when a tree is old (Hédin 1928), people with rights over trees could sell the tree for timber when it is considered to be past its prime fruit-bearing age. Such small-scale production of timber could be marketed through specialist outlets promoting sustainable wood use and production at premium prices.

The problems of processing oil-producing fruits like *B. toxisperma* were addressed by Amadi (1993) in Cameroon and Moss (1994) in Gabon. Amadi (1993) recommended launching studies on the potential to

facilitate mechanical processing of NTFPs such as *B. toxisperma*, where traditional methods of oil extraction from the seed kernels are lengthy and laborious. Moss (1994) found that because the traditional processing method was so laborious, *B. toxisperma* fruits often went uncollected despite high oil prices. However, this process, which involves pounding, heating and pressing, could easily be mechanized using improvised, locally made equipment, and if the kernels collected a good price, villagers would be encouraged to resume gathering, even from trees deep in the forest. Moss recommended that a pilot buying and processing scheme should be initiated, with the aim of setting up individual entrepreneurs, or perhaps village groups, to buy and process the seeds themselves.

Programs for enlarging markets for the oil and familiarizing people with its flavor and utility could be promoted, and alternative uses could be developed for the oil. Leakey and Newton (1994) recommend investigating *B. toxisperma*'s potential for commercial production of cooking oil and margarine, manufacture of soaps, pharmaceutical preparations, etc.

Schneemann (1995) made recommendations for conserving *B. toxisperma*, balancing its use for oil and timber in such a way that sufficient regeneration is guaranteed. He suggests:

- conserving good-quality "mother trees";
- increasing the minimum diameter of exploitation;
- restricting logging of trees used by local communities;
- thoroughly analyzing national forest inventories to determine sustainable exploitation levels;
- researching the influence of seed gathering on the regeneration of *B. toxisperma*;
- improving controls on logging operations;
- investigating the possibilities for planting *B. toxisperma*; and

Suggestions for further areas of study of *Baillonella toxisperma*

} *The tree is not currently suitable for agroforestry because of its slow growth rate and size. A possible option is a plantation approach. Moabi has been planted as a shade tree.*

} *The seeds are recalcitrant and fruiting irregular. This limits seed supply for planting, because seeds quickly lose their viability. Investigation into vegetative and clonal propagation of the species is needed to speed up the reproductive process.*

} *There is very little information on the ecological requirements of* B. toxisperma, *or of its ecological niche. Is it limited to only the densest parts of the forests, or is it a mid- to late-secondary species that survives in farm bush and late-secondary forest?*

} *If elephants are the main dispersers of the seeds, is* B. toxisperma *wholly dependent on forest elephants for dispersal? To increase understanding of the species' ecological niche, further studies need to be made on seed dispersal and regeneration and on whether the limiting factor on the species' range is linked to the range of the forest elephant in the Congo Basin.*

} *Investigation into the role of predation, disease/parasitism and allelopathy in seedling survival in the forest may also help in overcoming high sapling mortality.*

} *Would widespread education programs on the uses and potential of such NTFPs as* B. toxisperma *create sufficient popular pressure to influence forest policy and law enforcement?*

} *There is a possibility of a moratorium, led by IUCN and Greenpeace, on harvesting* B. toxisperma *for timber in Cameroon. The likely effectiveness of this policy should be assessed by analyzing similar strategies used elsewhere in the humid tropics for high-value timber species (e.g.,* Diospyros ebenum *and* Swietenia macrophylla*).*

- investigating the potential of new applications for *B. toxisperma* oil (e.g., for cosmetics).

Strategies suggested by Okafor and Lamb (1992) for promoting diversity and conservation included investing in intravarietal diversity, using phenological and geographical variation, to extend fruiting periods. They also recommended encouraging people to cultivate local forest species in their farming systems, as well as developing commercial products, e.g., from the oil. Forest reserves, strict natural reserves and protected fetish groves should be used as reservoirs of the species.

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APPENDIX 1: VERNACULAR NAMES FOR *BAILLONELLA TOXISPERMA*

Local or common name	*Locality*	*Source*
adjab	Balundu, Duala, etc. (West Cameroon)	Dalziel 1948
adjap	Fang (Equatorial Guinea); south Cameroon; Yaoundé, Boulu (south Cameroon); Boulou/Ewondo (Centre) (Cameroon)	Sunderland, 1998; Sunderland and Obama, 1999; Berti, 1982; Nef, 1997; Hédin, 1928; Schneemann, 1994
adjap, ayap	Cameroon, Equatorial Guinea	Centre Technique n.d.
adza	Gabon	Chudnoff 1984; Centre Technique n.d.
adzap	Yaoundé (Cameroon)	Aubréville, 1964:49
African pearwood (timber)		Brown 1977
aghanokpe, aganokwe	Benin (South Nigeria)	Dalziel 1948
bojie	Boki (Nigeria)	Dalziel 1948; Keay 1989
dimpampi	Congo	Chudnoff 1984
djabi	Douala (Cameroon)	Aubréville, 1964
djabo	Bakola Pygmies (South, Cameroon)	Schneemann 1994
djap	Bassa (Littoral-Centre, Cameroon)	Schneemann 1994
djave (seeds), moabi (wood)	West Africa	Mabberley 1990
djave, ndjabe, njave (fruit)	Gabon	Dalziel 1948
ebondo	Kota (Congo–Brazzaville)	Champluvier, 1995
efam	Efik (South Nigeria)	Dalziel 1948
emi-igbó (shea of the forest)	Yoruba (South Nigeria)	Dalziel, 1948
gyabo	Bakola (south Cameroon)	Nef 1997
karité	South and East Cameroon	Schneemann 1995
mabè	Baka Pygmies (Est) (Cameroon)	Schneemann, 1994
makoré	Nigeria	Ahonkhai 1988
maniki (fruit)	Cameroon	Engler 1904
mimusops	Gabon	Moss 1994
moabi	Bapunu (Gabon); Baka (Cameroon/Gabon)	Centre Technique 1957; Horta 1997

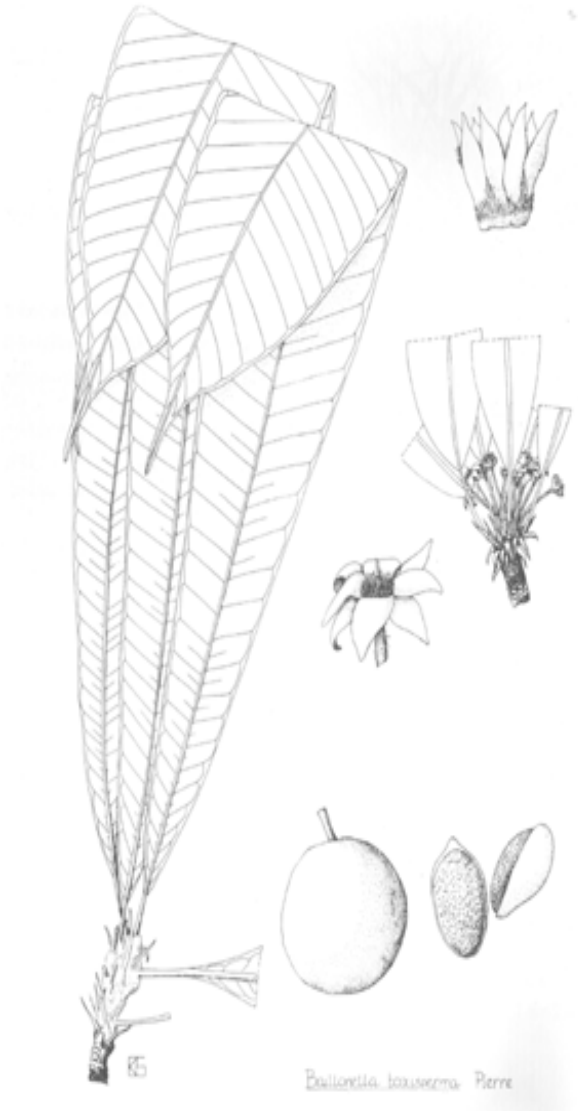
Local or common name	*Locality*	*Source*
moabi (wood)	Gabon, Cameroon, Congo, Zaire, Angola	Engler 1904; Fouquet 1984; Laird 1999; Centre Technique n.d.
mwabi	Congo, Zaire, Angola	Centre Technique n.d.; Normand and Paquis 1976
ngiari	Mayouka (Cameroon)	Aubréville, 1964
n'jabi	Douala (Cameroon)	Centre Technique 1957
n'jave (tree)	Gabon	Engler 1904
niabi	Gabon	Centre Technique n.d.
njab	Balundu, Duala, etc. (West Cameroon)	Dalziel 1948
njabe, njabé	Cameroon	Malleson 1999; Sunderland and Tchouto 1999
njabi	Balundu, Duala, etc. (South Cameroon) (Nigeria)	Dalziel 1948; Chudnoff 1984; Schneemann 1994:3
numgu (tree)	Cameroon	Engler 1904
nungu	South Cameroon	Dalziel 1948
nyam	Efik (South Nigeria)	Dalziel 1948 (also Kennedy 1936)
oaat	Itung (South Nigeria)	Dalziel 1948
oabé	Gabon	Centre Technique n.d.
ode	Ogoja/Okoja (South Nigeria)	Dalziel 1948; Keay 1989
odjoh	Kozimé (Haut-Nyong, Cameroon)	Schneemann 1994
ofor	Kiaka (Nigeria)	Keay 1989
ofri	Ogoja/Okoja (South Nigeria)	Dalziel 1948; Keay 1989
ojo	Boki (South Nigeria)	Dalziel, 1948
oko	Ibo, Ow, etc. (South Nigeria)	Dalziel 1948
oko uku	Igbo (Nigeria)	Keay 1989
orere (tree)	Gabon	Dalziel 1948
oreré (fruit)		Engler 1904
oréré, orèrè	N'Komi, Gabon	Centre Technique 1957, n.d.
osat	Itung (Nigeria)	Keay 1989
osso	Mézimé/Bangantou (Mbang, Cameroon)	Schneemann 1994:3
oyabi	Mboko (Congo–Brazzaville)	Champluvier, 1995
shellnut	Nigeria?	Okafor and Lamb 1992
ube, uku	On (Bonny, South Nigeria)	Dalziel 1948

APPENDIX 2: BOTANICAL DESCRIPTION

Baillonella toxisperma *(Sapotaceae)*

Synonym: *Mimusops djave*, used in Nigeria (Keay 1989: 390)

Tree up to 48 m high with an umbrella-shaped crown that closely resembles *Terminalia ivorensis*. Bole straight, cylindrical, unbranched for up to 27 m, with slight basal swelling but scarcely buttressed, with a girth of up to 9 m. Bark dark brown, deeply fissured. Slash: outer bark thick, dark brown; inner bark red or red-streaked with white, exuding a thick white latex. Leaves up to 21 cm long by 9 cm broad, clustered at the ends of very stout twigs, oblanceolate, very slightly acuminate at the apex, later nerves in about 25 widely spaced pairs, very prominent beneath, forming loops just within the margin, lower surface with minute hairs on the nerves. Flowers clustered among the leaves, stalks about 2.5 cm long, pubescent, sepals 1 cm long, pubescent, not persistent in the fruit. Fruits pale grey-green, more or less globose, about 9 cm long, containing 1 or 2 seeds in a yellowish pulp, slightly acid and edible when ripe. The seed is more or less ellipsoid, abut 5 cm long by 3 cm wide, and has a thin testa and a large scar covering nearly the whole of one face of the seed. Wood: the sapwood is white and the heartwood is rich red or light reddish-brown, often figured, termite-proof, heavy and durable (Keay 1989:392).



Chapter 8
IBOGA
(*Tabernanthe iboga*)

Tonye Mahop, Alex Uden, Stella Asaha, Nouhou Ndam and Terry Sunderland

INTRODUCTION

Tabernanthe iboga Baillon is an understory shrub distributed throughout the lowland tropical forests of the Congo Basin. The plant, particularly the root cortex, contains a number of alkaloids, of which ibogaine, a psychoactive indole alkaloid, is attracting the most interest (Popik and Skolnick 1999). Taken in small doses, ibogaine is a stimulant used to sustain activity during arduous tasks. In much larger doses, it is hallucinogenic, and as such is used by members of the Bwiti religious tradition of Gabon, Equatorial Guinea and southern Cameroon (Fernandez 1982). The species thus plays a significant cultural role in the lives of many people within and on the fringes of the forests of Central Africa. Ibogaine has long been known to Western science, but has only recently come under increased scrutiny for its potential to interrupt drug addiction and its applications in psychotherapy (Popik and Skolnick 1999).

Although there are no official data concerning harvesting rates or trade, *T. iboga* is reportedly in high demand in certain West African countries, and the sustainability of current exploitation rates has recently been questioned (Wilkie 1999). If clinical trials studying ibogaine's effectiveness and safety in treating drug addiction are successful, and no synthetic substitute for ibogaine is developed, demand for the raw material should rise further.

TAXONOMY AND ECOLOGY

Taxonomy

The genus *Tabernanthe* is a member of the family of Apocynaceae. The Apocynaceae is a large, widespread family, particularly concentrated in the tropics, and is characterized by the presence of copious exudate. There are eight species of *Tabernanthe*, all of which occur in the lowland tropical forests of Africa. *T. iboga* is probably the most widely distributed of the species within the genus and is also the most interesting in terms of use, despite the fact that ibogaine is also present in *Tabernanthe manii* and, in small quantities, in *Tabernaemontana crassa*. (*Tabernaemontana* is a closely related genus.)

Distribution

T. iboga is occurs in the lowland tropical forests of the Congo Basin and is distributed from southern Cameroon to northern Angola (Neuwinger 1996). A forest understory species, *T. iboga* is most commonly found in riverine forest and other areas of seasonally inundated forest, but it also occurs in closed-canopy forest and farmbush (Raponda-Walker and Sillans 1961).

Indigenous classification

Two varieties of iboga are sometimes distinguished within indigenous classification systems. For example, the Myéné of Gabon call plants with lengthened fruits (like a small cocoa pod) "iboga nome," and those with

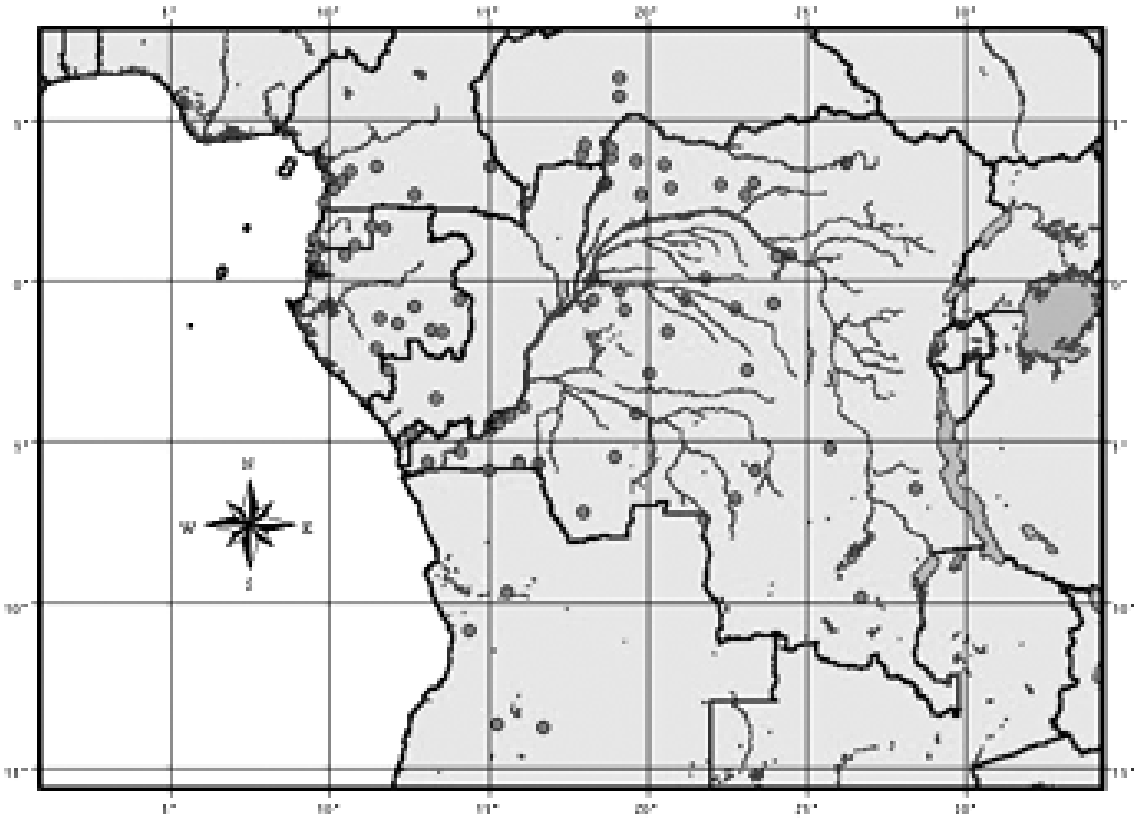


Figure 1. Distribution of T. iboga

globular fruits (similar to a lime) "iboga ny' anto" (Raponda-Walker and Sillans 1961). See Appendix 2 for a full list of indigenous names.

Phenology

Preliminary analysis of herbarium records indicates that flowering and fruiting of *T. iboga* occurs for much of the year, with peaks of phenological activity during the dry season (see Figure 2).

Pollination and seed dispersal

The pollination and breeding systems of *T. iboga* are not well documented and require further study. Similarly, there is little recorded information on seed dispersal. Many informants interviewed by Mahop et al. (2000) reported that rodents, pigs, buffalo, elephants and gorillas all eat the fruit and roots of *T. iboga*, and it is likely that these animals help in dispersing seeds.

TRADITIONAL AND COMMERCIAL USES

Harvesting

The root bark is the most valued and used part of the plant, as it contains the highest concentration of ibogaine. In *T. iboga*, the plant root thickens to a swollen mass 2–10 cm in diameter just below the ground, with individual roots 50–80 cm in length branching out in all directions from this mass. The fresh roots are yellowish-brown in color, turning gray when dried (Neuwinger 1996). Harvesters in Gabon, Equatorial Guinea and the South Province of Cameroon dig around the base of a shrub, exposing the roots, from which the bark is peeled. The soil is then replaced to enable the plant to continue growing. This technique makes it possible to harvest *T. iboga* shrubs in rota-

tion, and, hence, relatively sustainably, although it is not known to what extent this harvesting method impedes plant growth (Mahop et al. 2000).

Occasionally, more destructive harvesting methods are used in which the plant is completely uprooted and the entire root mass stripped. Recent field surveys by Mahop et al. (2000) encountered plants that had been harvested this way. The desire to maximize harvesting rates comes from the fact that *T. iboga* products are widely traded in some areas and represent a comparatively lucrative activity for many forest dwellers within *T. iboga*'s range.

Traditional use

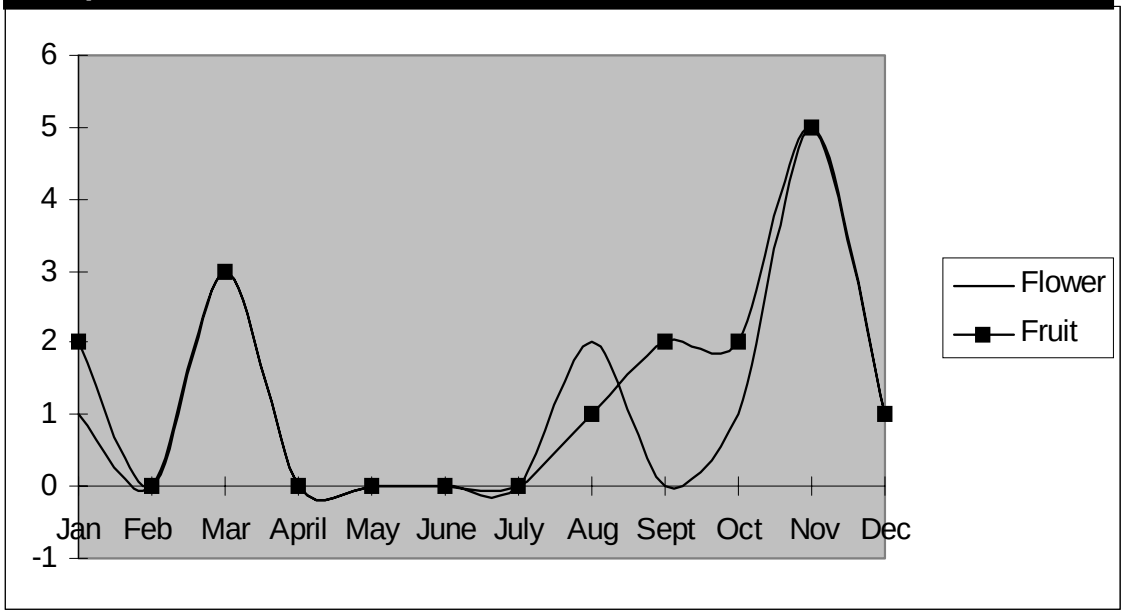
T. iboga is often used in low doses by those involved in strenuous activities, such as hunters and fishermen. Its action as a neurostimulant reduces fatigue and allows an individual to sustain more laborious tasks than would otherwise be possible (Neuwinger 1996; Barabe 1982; Goutarel 1993). Such individuals often reported that iboga is preferred to other stimulants such as coffee and cola nuts (Mahop et al. 2000). Its effectiveness as a stimulant may be one reason the German colonial authorities of Cameroon tolerated its use by their African labor force while building the railway network (Fernandez 1982).

Medicinal uses

The majority of traditional medicine practitioners interviewed by Mahop et al. (2000) in the South Province of Cameroon used *T. iboga* to treat a wide range of ailments. Bark from the stem and roots is administered alone or mixed with other ingredients from forest species such as *Garcinia kola* or *Annickia chlorantha*, depending on the ailment being targeted.

The healers reported its effectiveness in treating fever, stomachache, liver disorders and mental illness, as well as addiction to *mbanga* (*Cannabis sativa*) and *afofo* (a local alcoholic drink made from distilled palm wine). Decoctions of the root and leaves are used to treat diarrhea, physical and intellectual asthenia, and nervous depression. It is also administered to babies to enhance their immune system. Certain healers have even suggested that it might be effective as a treatment for AIDS (Mahop et al. 2000), demonstrating

Figure 2. Phenology of *T. iboga* based on examination of herbarium specimens from the Limbe, Yaounde, Bata and Libreville herbaria



their faith in the multifaceted curative properties of the species.

Some traditional healers of the Bwiti spiritual tradition use *T. iboga* more as a diagnostic aid than for direct treatment for disease. Either the healer himself or the patient will take a dose of iboga to communicate with the ancestors. While in this state, they are told which plants will treat the illness in question (ibid.). Women suffering from infertility and impotent men are also given insights into the underlying cause of their affliction while under the influence of *T. iboga* (ibid.).

Spiritual use: the Bwiti tradition

The use of *T. iboga* in Gabonese religious ceremonies has been recorded from an early date. In 1885, Father Henri Neu wrote:

> Most Europeans [living in Gabon] have heard about this plant, used in fetishistic ceremonies. The natives use an infusion of iboga root scrapings as a potent philter that enables one to discover hidden things and to tell the future. The one who drinks it falls into a deep sleep during which he is obsessed by uninterrupted dreams which, until the time that he awakens, he takes to be actual events. (quoted in Gouterel 1993)

Bwiti is thought to have arisen among the Mitsogho when they reached present-day Gabon. It is a syncretic blend of ancestor worship with various cultural elements assimilated during the Mitsogho migrations. The use of *T. iboga* is vital for initiation into Bwiti because it gives an individual direct experience in and understanding of the tradition. The Mitsogho believe that they gained knowledge of iboga from the Pygmies of the equatorial rainforest (Goutarel 1993; Burne 2000; Fernandez 1982), who, in turn, attribute its discovery to wart hogs, which seem to have a predilection for the roots (Barabe 1982, Raponda-Walker and Sillans 1961). The Bwiti practiced by the Fang along the coastal areas of Gabon has further integrated aspects of Christianity into its practice. The Fang have also accepted female initiates, unlike the Mitsogho, whose initiates remain exclusively male (Barabe 1982; Goutarel 1993).

The congregation of the *mbandja* (the Bwiti church) has a hierarchical order. Only those formally initiated can fully understand the tradition. Once initiated, a person is known as a *banzi* (angel) or *ndzi eboka* (eater of iboga), the first step in a hierarchy that culminates with the father of the mbandja, who has the authority to initiate people into the tradition.

The Bwiti tradition is one way Iboga *is used in Central African spiritual life.*

The Mitsogho initiation

During the initiation ceremony, a prospective banzi must consume a large quantity of iboga root bark, either cut into scrapings, ground into a powder, or soaked in water and drunk as an infusion (Fernandez 1982). The iboga is consumed in order to "break open the head," to induce a waking dream in which the initiate is contacted by ancestors and gains firsthand experience of Bwiti.

Before the ritual starts, the banzi is assigned a "mother," an experienced male initiate whose role is to supervise the quantity of iboga ingested by the initiate according to the latter's physiological reactions. The "mother" does this by continually checking the pulse, listening

to the heartbeat, touching the body to assess the temperature and pricking the skin to evaluate sensitivity (Goutarel 1993). The quantity of *T. iboga* ingested by the banzi varies; one to three small baskets may be consumed over an 8–24 hour period, representing an ingestion of 300–1000 grams of *T. iboga*. This contains about 15–50 grams of ibogaine, as much as 40–60 times the threshold dose (the dose which creates noticeable effects) (Fernandez 1972).

During the consumption of iboga, the candidate's head is struck three times with a hammer to free his spirit, and the tongue is pricked to give the candidate the power to relate to coming visions. Before the onset of these visions, the candidate is taken to a river. A model canoe made from leaves is floated downstream toward the west, symbolizing the death of the old self. The candidate must then swim upstream through a diamond-shaped wooden frame, symbolizing the female sexual organs, in a symbolic rebirth (Goutarel 1993).

The initiate is then led back to the mbandja. If he is starting to feel the influence of the iboga, he may have to be physically supported by members of the congregation to manage this short walk. The drug frequently provokes violent and repeated vomiting, "followed by motor inco-ordination, strong agitation, tremor, laughter and crying, partial anaesthesia with intermittent hypothermia and hyperthermia and panting that may go as far as choking" (Goutarel 1993:233).

The initiate is seated on the left side of the mbandja, which represents womanhood, darkness and death. The visions begin roughly 10 hours after ingesting the drug; although there are variations in the type of visions experienced, they tend to follow a similar pattern (Fernandez 1982). What follows is a description of the "standard vision" given by Goutarel (1993). The visions are divided into four stages.

The first stage consists of hazy, disordered visions, the legitimacy of which is often questioned by the banzi.

During the second stage, the banzi often sees visions of threatening animals (this stage is associated with evil spirits, and a few candidates do not progress beyond this stage).

After this, the initiate becomes calm and is carried by the wind to a village (the village of the Bwiti) stretching to infinity. During the journey, voices of the ancestors are heard telling the candidate he is on the right path. They also give the candidate an initiatory name.

The final stage of the visions is often referred to as the normative stage, when the candidate sees superior beings such as Nzamba-Kana and Disumba, the mother and father of mankind, and Ngondi and Minanga, the moon and the stars. After encountering these beings, the initiate is carried back to earth by the wind.

When the visions recede, the elders welcome the initiate and may question him about his experience. If the elders do not believe the initiate had a sufficient revelation, they may not accept him, although this is rare. More commonly, the initiate answers satisfactorily and is seated at the right hand of the temple, the side of men and life, to symbolize his successful initiation (Barabe 1982).

The fact that many candidates have eagerly sought knowledge of the experiences of previous initiates may explain the homogeneous nature of many of the visions. Even if visions differ in content, they seem to have similar themes. In his analysis of 21 descriptions of iboga visions, Fernandez found the common themes to be contact with the dead, visionary journeys in the company of relatives (often by flying or floating), experiences with greater powers, and physical reactions (such as a feeling of nausea or sensations relating to flying, etc.) (Fernandez 1982).

The imagery in the visions also depends on the cultural context. The Fang, who have assimilated elements of Christianity, experience visions of Christ, the Virgin Mary and Lucifer, although their role and

the dialogue is very similar to that of the supreme beings of the Mitsogho visions (Goutarel 1993).

Such high doses of iboga are only taken once or twice in a banzi's life. Repeated use is forbidden by many of the Bwiti sects; they believe that it would interfere with the work of the ancestors. Members continue to use iboga throughout their life, but at much lower doses. During the course of a night's ceremony, less than 20 grams of powdered iboga bark will normally be ingested; this amount is insufficient to produce visions but enables the individual to remain active and to engage in the strenuous ritual dancing which takes place throughout the night. Those who take small doses also report that they can hear the strings of the cult harp (played during ceremonies) with greater clarity, and that the notes become the voice of Nyingwam Mebege, the female principle of the universe (Fernandez 1972).

Taking large doses of *T. iboga* roots is not without risk; initiates occasionally die during the ordeal. Such deaths have led to a number of charges of murder and manslaughter being leveled against Bwiti churches. As a result of these risks, certain precautionary practices surround the initiation. Before taking a large dose of *T. iboga*, the Mitsogho often take smaller doses to test for any adverse reactions. The leader of the church may also take *T. iboga* to ask the ancestors if an initiation is going to be successful (Fernandez 1982).

Use in Western medicine

In 1901, Dybowsky and Landrin successfully isolated a crystallized alkaloid from the iboga root, which they named ibogaine (De Rienzo and Beal 1997). An issue of *The Chemist and Druggist* from 1907 includes a description of this drug. It reports that as an anesthetic, ibogaine does not measure up to cocaine or storvaine, but rates it as a good stimulant of the central nervous system and as a muscular, nerve and heart tonic. It is also recommended for nervous depression caused by infectious disease or malnutrition (Landrin 1907).

Research and interest in iboga stagnated until the end of the 1930s, when Raymond-Hamet began his 22-year study of the drug. It was also at this time that a pharmaceutical preparation named Lambarene appeared on the market in France: based on dried root extracts of *T. manii*, it contained about 8 mg of ibogaine per tablet (Popik and Skolnick 1999). It was sold as a stimulant for those suffering from fatigue due to ill health or for healthy adults undertaking strenuous activities. It attracted the attention of postwar endurance athletes but disappeared from the market in 1966 when the sale of ibogaine was prohibited, and it has been on the International Olympic Committee's list of banned substances since 1989 (Goutarel 1993).

The present wave of interest in ibogaine has developed within the spheres of addiction treatment and psychotherapy. Its potential ability to treat chemical dependence was first noticed in the underground drug scene of 1960s America. Although there are differing accounts of the exact events, it appears that a drug user named Howard Lotsof was offered ibogaine by a chemist friend while living in New Jersey. Not wanting to take it himself, Lotsof gave it to a friend who later reported its therapeutic potential. This prompted Lotsof to carry out further investigations, during which he gave single doses of ibogaine to 20 people, 7 of whom were cocaine and heroin users (including Lotsof himself), over an 8-month period. Five of these 7 addicts quit using heroin or cocaine for 6 months or more after their experience with ibogaine (De Rienzo and Beal 1997).

In subsequent years, Lotsof's involvement with ibogaine declined as the American government began a crackdown on psychedelics (ibogaine was banned along with LSD and psilocybin in the early 1970s) (Popik and Skolnick 1999). However, 20 years later, he resumed his quest to promote ibogaine as a mainstream antiaddiction medication. This led him to form the company NDA International, which obtained a number of patents for use of ibogaine in treating addiction and carried out several studies to assess the

drug's potential. Lotsof conducted these studies in Holland with Jan Bastiaans, a psychotherapist, and in the early 1990s treated 30 addict volunteers (Sandberg 2001).

In a review of these and other treatments administered in informal settings between 1962 and 1993, Dr. Kenneth Alper concluded that, although the study lacked clinical research methodology, there was some evidence for the efficacy of ibogaine in treating acute opioid withdrawal (Alper et al. 1999). Seventy-six percent of the patients reviewed were free of withdrawal signs after 24 hours of treatment and did not try to obtain drugs during 72 hours of observation. An additional 12 percent were free from withdrawal signs, yet chose to resume drug use. Dr. Alper did raise concerns over safety issues and questioned the economic competitiveness of treating patients with ibogaine in a conventional medical setting compared to other treatment methods (Alper et al. 1999).

In 1991, the U.S. National Institute for Drug Abuse (NIDA) began evaluating the safety of ibogaine. It was partly encouraged by the case studies reported from informal treatment and a number of studies conducted on animals (Sandberg 2001), a necessary precursor to sanctioning clinical trials with human subjects.

Although Dahir proved the low toxicity of ibogaine in 1971 (Dahir 1971, cited in Goutarel 1993), it was not until new neuroscience techniques were developed that data were obtained pointing toward the actual mechanisms through which ibogaine acted in the treatment of addicts. Using microdialysis, it was found that acute administration of amphetamine, cocaine, morphine, nicotine and ethanol (known addictive drugs) increases the extracellular dopamine (DA) levels in the nucleus accumbens, "the brain's pleasure centre," and to a lesser extent in the stratium (Di Chiara and Imperato 1988, cited in Goutarel 1993). Maisonneuve et al. (1991) then showed that ibogaine prevents the morphine-induced stimulation of mesolimbic and striatal dopamine.

Glick et al. (1991) used ibogaine to treat rats which were self-administering morphine. In some rats, there was a decrease in morphine intake for weeks after a single ibogaine dose. Others showed persistent decreases only after 2–3 weekly injections, suggesting that multiple doses may be more effective in some cases. Glick et al. (1992) also studied the effects of ibogaine treatment on acute symptoms of morphine withdrawal in rats, finding that it significantly reduced the usual symptoms of "wet-dog shakes," grooming, teeth chattering and diarrhea. Cappendijk et al. (1994) came to the same conclusion in a similar study of the effects of ibogaine on withdrawal syndrome in rats.

Mann (1992) noticed that the pharmacology of ibogaine resembles that of the tricyclic antidepressant amitriptyline. Nonetheless, there is some confusion about its mode of action; it probably produces a generalized disruption in the uptake of the neurotransmitters noradrenaline and serotonin into neurons. This probably increases the availability of seratonin and noradrenaline in the central nervous system (ibid.).

As a result of these preliminary studies, the U.S. Food and Drug Administration (FDA) gave permission in 1993 for clinical trials with ibogaine to commence, to be undertaken by Dr. Deborah Mash of the University of Miami's School of Medicine on behalf of NDA International. The work has been hindered, however, by a number of factors concerning the safety of ibogaine treatment.

Molliver and O'Hearn (cited in De Rienzo and Beal 1997) demonstrated that high doses of ibogaine can cause damage to the cells of the cerebellum, the part of the brain that controls balance and coordination. However, Mash's team conducted neurological and psychiatric evaluations on drug dependents who had received ibogaine treatment in the Netherlands and Panama (at a treatment center set up by Howard Lotsof in 1994) and found that the neurobehavioral effects of high-dose treatment were reversible (Mash et al. n.d.). Furthermore, when the University of Miami team studied the effects of multiple doses of ibogaine on

primate subjects, their data failed to show signs of cell death or other signs of neuronal toxicity (ibid.). The team also had the opportunity to conduct an autopsy on a brain of woman who died after receiving treatment with ibogaine (for the third time) in Panama. The autopsy did not show ibogaine to be a contributing factor to her death; rather, the cause was a small bowel infarction (De Rienzo and Beal 1997). Microscopic inspection of the brain showed no significant signs of pathology in any of the brain's regions, including the cerebellum (Mash et al. n.d.).

In FDA-approved clinical trials, 6 male patient volunteers receiving doses of 10–29 mg/kg experienced mild tremors and transient ataxia with an "overwhelming visual resurgence of repressed memories" (Mash et al. n.d.). However, these symptoms subsided almost entirely 24 hours after the dose, and while some patients had mild insomnia for several days post-ibogaine, neuropsychological profiles showed no apparent evidence of clinical impairment (ibid.).

However, although the death that occurred after treatment in Panama was not related to ibogaine, it was not the first fatality to occur after ibogaine treatment. In 1993, the Dutch project came to an end when a young woman died after being treated with ibogaine in a hotel room (Birmingham 1998). Forensic pathological examination revealed no definitive conclusion regarding the possible cause of death (Alper et al. 1999), although it was suspected that she might have used opioids surreptitiously after taking ibogaine (Sandberg 2001). The closure of the Dutch project was the reason Lotsof set up a program in Panama.

Chris Sanders of the Ibogaine Project, a UK group raising awareness for ibogaine treatment, is among those who believe that the deaths linked to ibogaine have been caused when addicts return to drug use after treatment. Ibogaine "resets" the function of the brain relating to drug use, so addicts cannot endure the doses they were accustomed to, and they risk overdosing when they resume their habit (Thompson 2001). This is consistent with the fact that one heroin addict who was part of an informal investigation of ibogaine in Amsterdam reported experiencing more intense heroin highs after treatment (Sheppard 1994).

In March 1995, NIDA decided to greatly reduce its involvement with ibogaine studies. The reasons given were the death in Holland and the fact that ibogaine was only shown to keep people off drugs for a period of months rather than indefinitely. Others report that NIDA was discouraged by the lack of enthusiasm from pharmaceutical companies (Sandberg 2001), creating little economic incentive to develop the drug.

The pharmaceutical companies' reticence may be due to a number of reasons. Perhaps the most important is that no one has successfully redesigned the ibogaine molecule, making improvements that would allow it to be patented (*Hudson Valley Business Journal* 1996, quoted in Allan 1996). In addition, developing addiction pharmocotherapy is not a high priority for many drug development companies. This is reflected in the fact that in the United States, only US $65 million per year is spent on developing drugs in this field, when the average cost of putting a new drug on the market is US $200–$600 million (Glick, quoted in Burne 2000). Added to these economic factors is the fact that ibogaine is often viewed from a political rather than medical perspective (Grund, quoted in Geerte 1998). Geerte (1998) believes the Dutch government's reluctance to support the drug is due to increased pressure from the European Community to change its progressive drug policy, and he thinks that most countries are playing a waiting game, each hoping for the other to start testing and marketing the drug.

With the withdrawal of support from NIDA, Dr. Mash, funded by private individuals, set up a private clinic called "Healing Visions" to offer ibogaine treatment on the island of St. Kitts, claiming that this was the only way she could continue her studies (Birmingham 1998). At Healing Visions, she charges in excess of US $10,000 for a full pretreatment medical screening and a personalized rehabilitation program. Over 70 people have been treated at the clinic (Burne 2000). At a 1999 ibogaine conference in New York the cases of

30 Healing Visions patients were presented, 25 of whom had no withdrawal symptoms or further cravings after 24 hours. Although Mash admits that ibogaine does not work for all addicts, she claims that treatment with it succeeds far better than other methods such as methadone (Mash, quoted in Burne 2000). In addition, methadone is itself an addictive drug, requiring prolonged use, and is reputedly responsible for 200 deaths a year in Britain alone (ibid.).

Even the latest phase of studies in Panama and St. Kitts has not been without incident, however. In April 1997, Mash and Lotsof became involved in a protracted legal battle concerning a patent on noribogaine, an ibogaine metabolite that Mash claimed to have discovered (Birmingham 1998). Ibogaine is cleared rapidly from the blood, in about 24 hours, so the extended loss of cravings and lack of withdrawal syndrome in treated individuals is likely to be due to noribogaine, which remains in the system a lot longer (Mash et al. 2000). Mash accused Lotsof of fraud when the latter covertly took out a patent on noribogaine. Four months later, Lotsof countersued, accusing Mash of violating her contract to perform the phase 1 studies and of infringing on his company's intellectual property rights for her own monetary gain by founding Healing Visions in St. Kitts (Birmingham 1998).

Perhaps due to the fragmentary nature of previous studies, the exact mechanisms through which ibogaine interrupts drug addiction are still unclear. Although ibogaine's effect on dopamine and seratonin levels is likely to be a key factor, it is believed to have a more diverse effect on the brain (Mash 1995). Also, addiction cannot be explained purely in terms of a physiological dependence on dopamine but has a psychological basis as well. It is believed that the hallucinogenic experience caused by ibogaine overwhelms a person emotionally and psychologically so that old, destructive behavior patterns are broken (Emanon, quoted in Burne 2000). Addicts also frequently report that they are given insights into the underlying cause of their addiction through their ibogaine experience (Sandberg 2001).

Whatever the reasons, it is now generally accepted that ibogaine is not the one-stop cure it was once believed to be. However, by removing drug cravings and withdrawal symptoms, ibogaine gives an addict time to seek counseling to consolidate any gains (Burne 2000). This constitutes a significant difference from other forms of drug treatment, which have attempted either to block the effects of drugs or to find a similar substitute such as methadone.

In terms of the dangers involved in taking ibogaine, it is unclear what has caused the ibogaine-related deaths because none have occurred in a clinical setting. However, taking too much of the drug, vomiting excessively, using stepped doses (increasing the amount of ibogaine taken during a treatment session if the original dose is not believed to have been sufficient), being excessively thin, or suffering from liver or heart problems have all been acknowledged as dangers (Sandberg 2001).

The first death to be recorded in a coroner's report as attributable to ibogaine took place in the UK when a 40-year-old heroin addict infected with hepatitis C died 40 hours after taking 6 grams of a *T. iboga* preparation. The inquest at Westminster Coroners Court ruled that the cause of death was a fatal reaction to *T. iboga*. The fact that the patient had suffered considerable liver damage as a result of hepatitis C was recorded as a secondary cause (Sandberg 2001). Before this death, ibogaine was classed as an unlicensed, experimental drug in the UK, making it legal to possess the drug, but making distribution a possible offense. However, the coroner involved in the case recommended that the status of ibogaine be reviewed, making it illegal to possess the plant or any of its products (ibid.).

Currently, ibogaine is a restricted substance in the United States, Belgium, Switzerland and Sweden. Treatment under medical supervision is available in a number of countries, including Panama and St. Kitts, northern Italy and Mexico. It is also thought that in-

formal treatment is occurring worldwide in the absence of medically trained personnel (www.ibogaine.co.uk).

Ibogaine in psychotherapy

Claudio Naranjo first investigated possible uses for ibogaine in psychotherapy, presenting his preliminary work at a conference on psychedelic substances at the University of California in 1966 (Naranjo 1974). Since then, its use has been adopted by a number of psychiatrists, mainly in South America. Ibogaine's application in psychotherapy stems from the fact that it places patients in a different state from other hallucinogenics such as LSD (although it is similar to harmaline, an alkaloid obtained from the South American plant *Peganum harmala*) (Naranjo 1974). It produces a dreamlike state without loss of consciousness, formal or illusionary thought deterioration, or depersonalization, and without inducing episodes of psychotic behavior. Therefore, it enhances fantasies but does not interfere with the ego (Goutarel 1993).

Furthermore, the content of visions induced by drugs such as mescaline or LSD are of "aesthetic sensations" and a general feeling of disassociation, which Naranjo (1974) has termed "man-the-god" or "man-the-devil." Conversely, ibogaine visions stress "man-the-animal" by bringing out the instinctual side of the psyche. Prominent visions include animals, sexual themes and destruction. There is also a propensity for those taking ibogaine to become preoccupied with childhood reminiscences and fantasies (Naranjo 1974). Another advantage of ibogaine is that, compared with other drugs, the subjects are better able to manipulate their visions either by themselves or through the psychotherapist allowing them to "re-wind" a vision, explore alternative scenarios, etc. (Goutarel 1993).

The therapist Sarah Emanon (a pseudonym used by Allan 1996) believes that, unlike hypnosis, ibogaine makes patients "physiologically and chemically open." This means that memories are not simply accessed at the cellular or chemical imprinting level, as in hypnosis, but are reexperienced physiologically, so that the person also experiences the chemical correlates of the memory. In this way the body chemistry may be reset in a way that prevents the repetition of patterned behavior. Emanon claims that people who have undergone treatment with ibogaine may, months later, calmly handle a situation which previously would have been traumatic for them without consciously realizing until afterward that it was a result of their therapy (Emanon, quoted in Allan 1996).

TRADE

There are few official statistics concerning exploitation rates or trade volumes of *T. iboga*. Within the areas covered by this study, its sale was most widespread in Gabon, where it is often sold in the traditional pharmacies and markets of Libreville, Oyem and Bitam (Mahop et al. 2000). The price for a 1-liter bottle of iboga powder is 15,000F CFA (US $19.5), and for 0.05L, 1000F CFA (US $1.3) (ibid.).

Much of the trade occurs between Bwiti members and traditional healers in Central Africa, although it is also exported to Western countries (Nnoh pers. comm., cited in Mahop et al. 2000). The combination of a thriving market for *T. iboga* products and the destructive harvesting techniques used have created concerns about the future security of wild stocks (Mahop et al. 2000). However, in the absence of accurate figures pertaining to levels of exploitation and regeneration, this remains conjectural.

PROPAGATION AND DOMESTICATION

In areas where *T. iboga* is in high demand, people report a shortage of the plant (Mahop et al. 2000). If further developments occur in modern use of the plant (i.e., wider use in treatment for drug addiction), demand will rise, making it necessary to consider large-scale domestication. At present, some practitioners of traditional medicine and Bwiti members plant the spe-

cies around their houses or churches, but few scientific domestication and propagation trials have been conducted with *T. iboga* in Central Africa (ibid.).

Studies in propagation and cultivation that have been implemented or are planned include preliminary studies on the cultivation of the species by GERPIC (Groupe d'Etudes et de Recherches sur la Promotion d'Iboga Culturelle**)** and trials at the Limbe Botanic Garden, Cameroon, as part of the garden's Conservation Through Cultivation program. Plantecam, based at Mutengene in Cameroon, established a nursery of *T. iboga* seedlings for prospective pharmaceutical purposes, but the company folded in 2000.

LEGISLATION AND INSTITUTIONAL ISSUES

Cameroon

Only one NTFP, *Prunus africana*, is directly covered by forestry legislation in Cameroon, under the control of the Ministry of Environment and Forestry (MINEF). Recently, however, a sub-directorate in charge of NTFPs was created within MINEF to define and control implementation of rules and regulations governing the exploitation of these products. Despite considerable international interest, *T. iboga* may not be a priority for inclusion in forest management plans because its harvest and sale is currently relatively localized. However, should clinical trials of *T. iboga* for treatment of narcotic dependence show positive results, there will be considerable interest and almost certainly overexploitation of the species in the future.

Gabon

As in Cameroon, there are no official guidelines regulating the exploitation of *T. iboga* in Gabon, even though it is more widely known and used there (Mahop et al., 2000). GERPIC, the organization formed and run by Bwiti initiates, has drafted a proposal to implement regulations governing the harvest of the plant that has been submitted to the Prime Minister's Office (ibid.). A decision has yet to be made whether these regulations will be included in the country's forestry code.

Equatorial Guinea

In Equatorial Guinea, only the harvest of *Prunus africana* and *Piper guineensis* is currently regulated by the Forestry Law (Sunderland and Tako 2000; Stenmanns 2001).

"The West"

In much of Europe (excluding Belgium, Switzerland and Sweden, where ibogaine is a restricted substance), ibogaine "remains in a legal nowhere-land" (www.ibogaine.co.uk). In many countries, such as the UK, it is classed as an unlicensed experimental drug. This means that it is legal to possess the drug, but it may be an offense to distribute it. However, as previously mentioned, due to the death of a man in London linked to ibogaine, its legal status in the UK is being reviewed (Sandberg 2001). In the United States, it is illegal to possess *T. iboga* plants and dried roots, but not the seeds (www.ibogaine.org).

Ibogaine treatment under medical supervision is available at Dr. Mash's Healing Visions clinic in St. Kitts in the West Indies and in a hospital in Panama, both of which are licensed by the government. Other countries where treatment is being offered include Italy, France, Cameroon and Pakistan, although none of this treatment is government licensed (www.ibogaine.co.uk).

CONCLUSION

It is difficult to make predictions about the future sustainability of *T. iboga* based on the current literature, due to the paucity of botanical and ecological knowledge. Anecdotal data concerning destructive harvesting techniques and plant scarcity, along with the absence of state legislation governing its collec-

tion, suggest that current rates of use may be unsustainable. Yet, before any definitive statements are made, much more work needs to be undertaken, including:

- detailed surveys of wild stocks and informal cultivation;
- assessment of the impact of root bark harvesting on the growth of plants;
- domestic and international market surveys to ascertain the magnitude of trade in *T. iboga* products;
- studies of the plant's phenology, pollination, breeding systems and seed dispersal; and
- formal domestication trials to evaluate the practicality of relieving pressure on wild stocks through cultivation.

This work is necessary because *T. iboga* has the potential to contribute to conservation and development throughout its range, as well as benefiting external stakeholders. This potential will be greatly increased if ibogaine becomes a mainstream treatment for drug addiction, although it is unlikely that this will happen in the immediate future. Despite the growing interest in ibogaine, concerns over its safety, economic and political constraints, and legal disputes over intellectual property rights all hinder its development. However, demand may still increase from private clinics and individuals offering informal treatment. If ibogaine is managed sustainably, such demand could offer a valuable source of cash income for forest dwellers, either from cultivation or from harvesting of wild plants, in preference to more destructive forest activities such as logging and commercial hunting.

Sustainable management of *T. iboga* is justified for more than merely economic reasons. Unlike many other NTFPs, *T. iboga* forms the very core of a cultural tradition and shapes the way that people perceive and interact with their environment. Initiation into Bwiti is said to give members an identification with and mastery over the forest. Indeed, Bwiti is often referred to as a religion of the forest, "*nyiba ye afan*" (Fernandez 1982). Fernandez (1982) sees *T. iboga* as a force that has maintained the Fang peoples' association with the forest in the face of external pressures to leave their villages in favor of the commercial world of towns and cities—pressures that go back to the colonial period.

The fact that there are local institutions such as GERPIC that are working towards sustainable management of *T. iboga* is encouraging and consonant with modern participatory conservation paradigms. These institutions could be used as a basis for a multidisciplinary research initiative to promote further understanding of this important plant and ensure its future availability.

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APPENDIX 1. BOTANICAL DESCRIPTION OF *T. IBOGA* (ADAPTED FROM NEUWINGER 1996)

Baillon (1889) in *Bull. Mens. Soc. Linn. de Paris* 1: 783

Shrub or small tree, 1–5 m high with copious latex when cut. Petiole short, 0.2 cm; leaves in opposing pairs, elliptic, ovate or obovate, acuminate at apex, long-acuminate or cuneate at base, 8–13(–21) x 2.5–4.5(–7) cm, with 9–11 pairs of lateral nerves, looping to join neighboring nerves, tertiary nerves almost right-angled to the lateral nerves. Flowers small, axillary, in groups of 5–12 on slender peduncles, yellowish-white to pinkish-white; corolla 0.6 cm long, hypocrateriform with 5 rounded twisted lobes, each 0.3 cm long; calyx deeply divided into 5 parts, acuminate. Fruit fleshy, berrylike, smooth or slightly warty, yellow or yellow-orange, usually in pairs on long peduncles, ending in a straight or slightly curved apex, 2.5–5 x 1.2–1.5 cm; mesocarp white, pulpy; seeds brown, with a wafflelike surface, 4–6 x 3–4 mm, ca. 20–30 seeds in each fruit.

APPENDIX 2. VERNACULAR NAMES FOR *T. IBOGA* (ADAPTED FROM NEUWINGER 1996; MAHOP ET AL. 2000)

Country	Tribe	Vernacular Name
	Gbaya	Gbana
Central African Republic	Aka	Mbondo
	Sango	Mbenge
Congo	Vili, Yoombe	Liboko
	Bakwele	Meboa
Cameroon	Fang	Iboga
Equatorial Guinea	Fang	Eboka
		Elongated pointed fruits
	Mitsogho	Nyoka
	Fang	Sese
	Eshira	Mungondu
Gabon	Myéné	Iboga nome
		Ovoid fruits
	Mitsogho	Mbasoka
	Fang	Minkolongo
	Eshira	Difuma
	Myéné	Iboga ny' anto
	Mongo tribes	Inkomi
		Elahu
		Pandu
Democratic Republic of Congo		Ikuke
	Ngala	Bugensongo
	Turumbu	Inaolo a ikakusa
	Tshiluba	Inado a ebengabanga

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