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Title: Use and selection of *Sclerocarya birrea* (marula) in the Bushbuckridge Lowveld, South Africa

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**USE AND SELECTION OF SCLEROCARYA BIRREA (MARULA) IN THE
BUSHBUCKRIDGE LOWVELD, SOUTH AFRICA**

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ABSTRACT

Sclerocarya birrea (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro is a common species throughout the semi-arid, savannas of sub-Saharan Africa. It is locally known as marula. It is a favoured species and is frequently maintained in homestead plots and arable fields in an agroforestry situation. The abundance and popularity of this species has led to a variety of initiatives in several countries to commercialise a number of marula products. It has also been identified by a number of international and national institutes as a key species for domestication and agroforestry promotion. Yet, the sustainability of the resource and user knowledge and practices as relating to possible commercialisation have not been considered. This paper reports on a recent field project dealing with the use of marula products in four rural villages, maintenance and planting of marula in private homesteads and fields (relative to communal lands) and fruit production of this important agroforestry species.

The density of marula stems was measured in homestead plots, arable fields and the surrounding communal rangelands in four villages. Fruit production was assessed by regular counting of fruit fall from marked trees of known size. Within the villages, fruit production was monitored via local community groups supported by the research team. Additional monitoring was conducted on marked trees within local protected areas. Use and value of marula was established by means of a structured interview schedule administered to 36 households per village.

All households used marula for one or more reasons. Typical reasons included consumption of the fresh fruit, brewing of beer, extraction and consumption of the kernels, making of jam, use of bark for medicinal purposes. Many households also sold one or more products within the local village or nearby towns. The majority of households maintained marula trees within their homestead plot and fields. Many nurtured self-seeded recruits, but direct planting was also evident. The proportion of recruits within the population on transformed habitats (homesteads and fields) was less than in surrounding rangelands. Fruit yield from trees within homesteads and fields was higher than trees in protected areas, suggesting some degree of selection and domestication.

KEY WORDS: density, fields, fruit yield, homesteads, marula, use

INTRODUCTION

Rural communities in developing nations make extensive use of wild fruits from the local environment. This may include both indigenous and exotic species. In many instances people transplant or nurture individuals of the most desirable indigenous fruit species within homestead plots and fields in a typical agroforestry situation (Campbell et al., 1991; de Jong, 2001; Grundy et al., 1993; McGregor, 1993). Consumption of the fruits makes an important contribution to local diets and culture, and perhaps income generation from the sale of fruit, thereby having a poverty reduction role, with the value being greatest to poorer households (Leakey & Simons, 1998; Chivaura-Mususa et al., 2000). Whilst not the primary purpose for keeping them in the home environment, fruit trees also offer other goods and services directly used or appreciated by rural households, such as shade, firewood, mulch, and a habitat for other useful species such as birds and edible caterpillars.

Sclerocarya birrea (marula) is a common and widespread fruit-bearing species throughout much of sub-Saharan Africa (Peters, 1988). It is frequently a community dominant and hence is a keystone species in plant and animal community ecology and productivity. It is also widely used by rural populations in most countries wherever it grows (Palmer and Pitman, 1972; Walker, 1989; Shackleton et al., 2000). It has multiple uses, including the fruits that are eaten fresh or fermented to make a beer, the kernels are eaten or the oil extracted, the leaves are browsed by livestock and have medicinal uses, as does the bark. The wood is carved into utilitarian items such as spoons and plates as well as decorative animal figures. Several African cultures have specific beliefs and ceremonies associated with this species (Walker, 1989).

Because of the widespread occurrence and use of *S. birrea* it has frequently been identified as a key species in the development of rural enterprises using the fruit, beer, nuts or oil and therefore as a species for accelerated domestication (Taylor and Moss, 1983; Holtzhausen et al., 1990; Nerd and Mizrahi, 1993; Leakey and Simons, 1998; Leakey, 1999; Leakey & Tomich, 1999). Localised breeding and cultivation initiatives commenced in the 1970s and some continue. Interest in this species was renewed after the development of a highly successful liqueur using extracts from the fruit. This has developed further in southern Africa over the last decade, especially commercialisation initiatives orientated towards befitting the rural poor, including initiatives in Botswana, Malawi, Namibia and South Africa (e.g. Taylor

and Moss, 1983; Lombard et al., 2000; Barton, 2001; Maree and Doyer, 2001). Many of these are externally mediated, and the project designs frequently contemplate domestication of the species and planting with superior cultivars already available (at a cost) in South Africa (Leakey, 1999; Holtzhausen, 2001). Yet, a significant proportion of rural households already plant marula trees or nurture seedlings of *S. birrea* that germinate in the grounds of their homesteads or arable fields, and maintain adult trees in an agroforestry situation (Grundy et al., 1993; High and Shackleton, 2000; Shackleton et al., 2000). Others plant seedlings or propagate trees via stem cuttings. The extent of these activities, the productivity of the individual trees, and the effects of selection and planting of more trees to optimise the most desirable traits has not been considered in these commercialisation initiatives. Because of this, the agroforestry potential of *S. birrea* remains appreciated but undeveloped. This was one focus of a recent large multi-institutional research project, in which the objective of one component was to quantify the local use and resource base of *S. birrea* in an area where large scale commercialisation takes place and is accelerating.

STUDY AREA

Four rural villages were selected in the Bushbuckridge lowveld in the Northern Province, South Africa. These were Allandale, Edinburgh, Hokwe and Rolle A, situated towards the centre of the region. The Bushbuckridge region ($\pm 2\ 600\ \text{km}^2$) is characterised by a west to east gradient in topography, climate, and former political boundaries, which have resulted in several distinct landuse zones. Against the Drakensberg escarpment in the west, the mean annual rainfall (MAR) is approximately 1 200 mm, decreasing to 550 mm in the east across a linear distance of 100 km. Mean annual temperature is 22° C, and frost is rare. Except immediately adjacent to the Drakensberg escarpment, the terrain is flat to undulating, being underlain by potassic granites and grandiorite. The most extensive soil types are shallow sandy lithosols, except towards the base of the catena where deeper duplex soils are common. Paralleling the rainfall gradient, two broad vegetation types are evident; Lowveld Sour Bushveld in the wetter west, grading into Lowveld towards the east (Acocks, 1988). The tree stratum is dominated by members of the Combretaceae (*Terminalia sericea*, *Combretum collinum*, *C. hereroense*, *C. zeyheri* and *C. apiculatum*) and Mimosaceae (*Acacia nilotica*, *A. gerrardii*, *A. ataxacantha*, *A. caffra*, *A. sieberana*, *Albizia harveyi*, *Albizia versicolor* and *Dichrostachys cinerea*), although local dominance varies considerably.

The central portion of the Bushbuckridge lowveld is characterised by relatively high-density, underdeveloped rural villages. It formed part of the Lebowa and Gazankulu homelands under the former apartheid dispensation. The human population density in the eastern section is approximately 150 – 200 persons per km². Approximately 60 - 70 % of the potentially economically active population are unemployed. Nearly all households cultivate small areas around the homestead during the rainy season, and 30 - 40 % of households also cultivate demarcated arable fields on the periphery of the village or further afield. Shortage of land prevents more households working an arable plot. The rest of the land is zoned as communal grazing areas. Most households harvest several different kinds of resources from these communal lands, including fruits, thatch grass, fuelwood, mushrooms, reeds and construction wood (Shackleton and Shackleton, 2000). Fuelwood is the primary energy source of over 85 % of households (Banks et al., 1996), although a considerable mix of other fuel sources is used. Approximately one-third of households possess cattle, and the stocking rate is close to ecological carrying capacity (Parsons et al., 1997).

METHODS

Use of *S. birrea* products

At each of the four villages a comprehensive household interview schedule was administered in the local vernacular language to 36 randomly selected households. Each interview lasted between one and two hours and covered aspects of *S. birrea* use, trade, customs, availability, tree planting, as well as a basic socio-economic profile of the household.

Density of *S. birrea* stems

The density of all *S. birrea* trees, irrespective of size, was measured in homestead plots, arable fields, communal grazing lands, and as a comparison, two local protected areas. A proportion of *S. birrea* trees (especially smaller ones, but not solely) are multi-stemmed thereby giving problems as to what comprises a single individual. Consequently, we counted and report upon stems per unit area, as opposed to individual trees. Stem density in homestead plots was done in the same households as the interviews, except for some where

tree measurement was not possible. Thus, the total sample of homestead plots was 99. The height and basal circumference of each tree was recorded, and whether or not it had fruit (or, if no fruit this year, did it sometimes bear fruit), and whether or not the bark showed signs of harvesting for medicinal purposes.

Thirty arable fields were randomly selected per village, with a total sample size of 120. The number and size of each tree per arable field was determined. In terms of trees growing within the fence of the field, only every second tree was counted to ensure there was no double counting if adjacent fields were enumerated. Stem dimensions and fruiting were measured as above.

The communal grazing land around each village were sample via means of four transects radiating out from the village to account for possible differences in stem density with decreasing levels of disturbance or harvesting (Shackleton et al., 1994). Each transect consisted of four 1 ha plots placed 300 to 500 m apart, resulting in 16 plots per village. At Rolle the communal lands were so fragmented by infrastructure, houses and fields that only three transects were possible. Thus, the total sample size for the four villages was 60 plots.

To provide a benchmark, the density of stems in two protected was determined. In each protected area 25 plots of 0.2 ha were randomly sampled, providing 50 plots in total. A smaller plot size was used because of the greater overall density of trees and shrubs making sampling slower and more difficult to locate small stems than in the communal grazing lands.

Fruit yield per tree

Fruit yield per adult female tree was determined within homestead plots, a few fields, and the protected areas. The trees monitored at Wits Rural Facility were the same as those monitored by Shackleton (in press) in 1993, plus ten additional ones. It was not possible to monitor fruit yield in the communal lands since there was no tenure over specific trees, and thus harvesting of fruits from specific trees was difficult to monitor or control. Fruit yield was determined by permanently marking a sample of trees, and then counting fruit fall at each tree on a regular basis throughout the fruiting season. In terms of trees in villages, the monitoring was done at selected households by volunteers with support from the research team, after initial training. Researchers then met with each volunteer group on a weekly basis. The process went well

except at Rolle, were compliance with guidelines and attendance at meetings was poor. In terms of protected areas, monitoring was done by the research team with assistance from locally hired participants. Fruit yield was not determined at Edinburgh village because of strong localised storm in late December that blew off much of the immature fruit, uprooted trees and damaged buildings. Thus, trees were marked at Madile village instead. Up to twenty fruits were randomly selected from each tree and fresh mass determined.

Most *S. birrea* products are derived from the fruit, and hence density of adult female trees is of greater significance than total tree density. This requires definition of what is an adult tree (i.e. potentially could bear fruit), and what is female. In this study we defined a female tree as one that had fruit during the season of the study, or if no fruit was apparent, the tree was reported by local respondents to sometimes bear fruit, or had evidence of old kernels beneath the tree. The basal circumference of the fifth smallest tree with fruit was 45 cm. We used this size as an indication of when a tree could be reproductively mature (male or female) and hence an adult. Stems smaller than 45 cm circumference were thus regarded as juveniles.

Differences between sites were examined via ANOVA after testing for normality. The number of fruits per tree was log transformed, and tree basal area or canopy volume attributes were square root transformed. For significant ANOVA results, subsequent pair-wise comparisons were via the Least Significant Difference. To detect differences between landuse (villages and protected areas) a T-test was used.

RESULTS

Use of *S. birrea*

There was widespread use of *S. birrea* parts and products in each of the four villages, particularly firewood, fruit, and kernels (Table 1). There was only limited use of fruit for fresh juice, or of wood for carvings or household utensils. There were no differences between the four villages. Kernels were used largely to eat, or to sell.

INSERT TABLE 1

Stem density

The density of *S. birrea* stems varied depending on landuse, being greatest in the protected areas, and least in the agricultural fields (Table 2). But consideration of only adult or female stems, presents a different picture. A greater proportion of the population were adults in the larger human modified environments, namely homestead plots and agricultural fields. This indicates reduced recruitment in these two environments, but a high proportion of potentially useful trees. Examination of the absolute density of female trees, indicated no difference between homestead plots and wild populations in protected areas, with both sites having approximately 4.5 adult females per hectare. Relative to this figure, there was an approximately 40 - 50 % reduction in the density of adult female trees in fields and the surrounding communal grazing lands.

INSERT TABLE 2

Fruit yield per tree

The average number of fruits per tree varied between trees and sites. Trees within the villages had significantly more fruits (>17 000 per tree) than those in the protected areas (<3 500 per tree) ($T = 12.5$; $p < 0.005$). There were also differences between the four villages, with the mean number of fruit per tree at Rolle being almost three times that of the other villages (Table 3). In light of the data collection problems at Rolle, this needs to be treated with caution. Omitting Rolle from the analysis, still resulted in significant differences between landuses and between sites already reflected in Table 3.

INSERT TABLE 3

Although the trees in the villages were significantly larger than in the protected areas (height: $T = 8.36$; $p < 0.001$, circumference: $T = 7.63$; $p < 0.001$), this difference was not solely accountable for the greater number of fruits per tree. Yield (in terms of number of fruits) was significantly higher in the villages than the protected areas on a per unit basal area ($T = 9.8$;

P<0.001) or canopy volume (T = 6.4; p <0.001) basis. Thus, a cubic metre of canopy produced more fruits in the villages, than in the protected areas. This applied even if the data from Rolle village were excluded (Table 4).

INSERT TABLE 4

Paralleling the differences in number of fruit per tree at the different villages and landuses, so too were the significant differences in the mean mass of individual fruits between individual trees at specific sites, and also between sites. In particular, fruits from trees at Hokwe were heavier than individual fruits at the other three villages ($F_{5, 2621} = 91.3$; $p < 0.001$) (Table 5). In comparing fruit size on trees in the villages relative to the protected areas, they were approximately 20 % larger on the village trees (T = 15.2; $p < 0.001$), except at Madile, where they were of a comparable mass. The mean mass of a single fruit across all village trees was 24.9 ± 0.19 g, where it was 20.9 ± 0.18 g for the protected area trees.

INSERT TABLE 5

Tree planting and care

The higher density of adult female trees in homestead plots is a result of active planting of new trees, as well as passive protection and nurturing of self-seeded recruits (Table 6). Just less than one-third of respondents planted *S. birrea* in their yards, whereas approximately half the respondents nurtured new seedlings that they found growing in suitable positions in the home yard. When planting, most people used a *S. birrea* seed that was harvested from trees in the wild or from neighbours' trees. Many also used either a truncheon harvested from a tree with desirable traits, or transplanted a seedling they had observed growing in the wild or elsewhere in the village.

INSERT TABLE 6

DISCUSSION

Agroforestry needs to build upon existing practices of small-scale farmers and rural households (Kristjanson *et al.* 2002), as do commercialisation initiatives based on non-timber forest products such as *S. birrea* (Leakey & Tomich, 1999). In doing it needs to appreciate the knowledge, understanding and practices that local communities have around key resources and for this to be incorporated into project design and implementation (Cardoso *et al.*, 2001). Thus, a preliminary research phase involving resource users is required.

Preliminary analysis of the data from this project show that *S. birrea* products are widely used by rural households in the Bushbuckridge region, supporting findings for this and other fruit species elsewhere (Campbell, 1987; Cunningham, 1988; Grundy *et al.*, 1993). Over three-quarters of households use *S. birrea* trees for firewood, fruit and kernels. This region supplies *S. birrea* fruit and kernels to a number of externally mediated commercialisation initiatives, and growing small-scale household-level commercialisation, especially of beer (S. Shackleton, unpublished data). Thus, there is the potential for conflict given the high local demand for *S. birrea* products. Indeed, 36.5 % of the interviewed households with adult female *S. birrea* trees in their yards or fields indicated that theft of fruit from their trees was a growing phenomenon, and was unheard of until only a few years ago. Conflict is also apparent at an institutional level, with some local headmen barring villagers under their jurisdiction from participating in commercialisation activities using *S. birrea* or *S. birrea* products. The chopping of *S. birrea* trees for firewood adds to the pressure on local resources and raises the possibility for conflict. Chopping of *S. birrea* trees is reasonably common, although many households would not admit to it, since traditional norms prohibit the felling of fruit trees. However, these norms are eroding in much of the communal management areas of South and southern Africa. In most instances it is the male *S. birrea* trees that are felled, or if female trees, they are ones with undesirable fruit. The cutting of male trees is actively encouraged by government extension officers, with little regard to the other agroforestry related benefits large male trees offer to the environment as whole, enhancement of agricultural production near the tree, nor the need for males to pollinate the female trees. A similar situation was reported in Zimbabwe with agricultural extension officers urging small-scale farmers to fell all indigenous trees within the fields and homestead plots (Campbell *et al.*, 1991; Chivaura-Mususa *et al.*, 2000).

The local appreciation of *S. birrea* as a key species is also evident in the proportion of households that have *S. birrea* trees in their homesteads and/or fields, 78.9 % and 58.2 %, respectively. Moreover, the density of adult female trees in the intensively human-modified area around the house is no different from that in local protected areas. Conversely, there was some reduction in the density of female *S. birrea* trees in fields and the surrounding communal lands. With increasing risk of theft of fruit, it is possible that people will channel most investment in *S. birrea* into the homestead plot, rather than the fields which are more distant and therefore harder to police. These results are comparable to those from unpublished data from Mozambique and KwaZulu-Natal Province in South Africa which also show that densities of *S. birrea* were not reduced, and in many areas were greater, in anthropogenic landscapes than adjacent rangelands (A.B. Cunningham (WWF/People and Plants Initiative), Sept 2001, pers. communication). Many respondents stated that they would now plant more trees at home because of the commercial opportunities offered by Mhala Development Centre for raw fruit and kernels.

Over half the households reported nurturing self seeded trees to increase the likelihood of survival to maturity. Almost one third of the households indicated that they have actively planted *S. birrea* trees around their home, or in their fields. New plantings are also nurtured to maturity. Nurturing may take the form of watering the new plant, protecting it from browsers or being trampled by animals or humans, and clearing of weeds or climbers that may impair growth. Fertilisation was not mentioned. Using a seed from a female tree with desirable traits was the most common mechanism of direct planting. Traits considered desirable included productivity of the tree, and the size, hardness, juiciness, taste, and smell, of the fruit. Different types of fruit are used for different purposes.

Given the amount of care and attention afforded *S. birrea* it was of little surprise to see that trees in the villages produced more fruit relative to their size than trees in protected areas. It may also be related to reduced plant competition for trees in homesteads as opposed to ones in the wild. This conclusion was unaffected by omitting the data from Rolle village, where it is possible the results were erroneous. Additionally, the mean fruit size was also significantly greater from trees in villages than the local protected areas. Both these traits suggest some level of domestication and selection of *S. birrea* by residents in the Bushbuckridge region (Leakey & Tomich, 1999). This conclusion could be further supported through assessment of the proportion of trees with the desirable traits within the village and protected area

populations. Whilst sample trees from neither population were randomly selected, there is little reason to doubt the results. The patterns were consistent across all the villages and both protected areas. Local residents volunteered to help monitor fruit production without tree size of any other attribute being a criterion for participation.

The combination of heavier fruit mass and greater number of fruits per tree, means that trees within the villages have a significantly greater mass of fruit than trees in protected areas. Shackleton (in press) recently reported a mean fruit production in the 1993/94 season of 37 ± 7.8 kg per tree from 64 trees from three protected areas in the same region, casting doubts on anecdotal reports of more than a ton of fruit per tree. Within this new study, however, there were many trees within the villages that produced over one ton of fruit. The mean mass per tree was greater than one ton at both Allandale and Rolle. In comparison, the mean mass of fruit per tree at the two protected areas was one or two orders of magnitude lower; 73 and 56 kg at Andover Nature Reserve and Wits Rural Facility, respectively. Thus, modelling of resource supply at specific localities or regions must account for the differential production of trees in human-modified environments relative to the wild populations.

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REFERENCES

- Acocks JPH (1988) Veldtypes of South Africa. *Mem Bot Surv S Afr* 57: 1-146
- Banks DI, Griffin N, Shackleton CM, Shackleton SE & Mavrandonis J (1996) Wood supply and demand around two rural settlements in a semi-arid savanna, South Africa. *Biomass & Bioenergy* 11: 319-331
- Barton S (2001) Overview of marula-based small business and industry. In: Anon. Marula workshop: report and abstracts. pp 25-27. University of Pretoria, Pretoria

- Campbell BM (1987) The use of wild fruits in Zimbabwe. *Econ Bot* 41: 375-385
- Campbell BM, Clarke JM & Gumbo DJ (1991) Traditional agroforestry practices in Zimbabwe. *Agrofor Sys* 14: 99-111
- Cardoso IM, Guijt I, Franco FS, Carvalho AF & Ferreira Neto PS (2001) Continual learning for agroforestry system design: university, NGO and farmer partnership in Minas Gerais, Brazil. *Agric Sys* 69: 235-257
- Chivaura-Mususa C, Campbell B & Kenyon W (2000) The value of mature trees in arable fields in the small-holder sector, Zimbabwe. *Ecol Econ* 33: 395-400
- Cunningham AB (1988) Collection of wild plant foods in Theme Thonga society: a guide to Iron Age gathering activities. *Ann Natal Mus* 29: 433-446
- De Jong W (2001) Tree and forest management in the floodplains of the Peruvian Amazon. *For Ecol Mgmt* 150: 125-134
- Grundy IM, Campbell BM, Balebereho S, Cunliffe R, Tafangenyasha C, Fergusson R & Parry D (1993). Availability and use of trees in Mutanda Resettlement area, Zimbabwe. *For Ecol Mgmt* 56: 243-266
- High C & Shackleton CM (2000) The comparative value of wild and domestic plants in home gardens of a South African rural village. *Agrofor Sys* 48: 141- 156
- Holtzhausen C (2001) Enobling the African marula. In: Anon. Marula workshop: report and abstracts. pp 20-22. University of Pretoria, Pretoria
- Holtzhausen LC, Swart E & van Rensburg R (1990). Propagation of the marula (*Sclerocarya birrea* subsp. *caffra*). *Acta Hort* 275: 323 - 334
- Kristjanson P, Place F, Franzel S & Thornton PK (2002) Assessing research impact on poverty: the importance of farmers' perceptions. *Agric Sys* 72: 73-92.
- Leakey RRB (1999) Potential for novel food products from agroforestry trees: a review. *Food Chem* 66: 1-14
- Leakey RRB & Simons AJ (1998) The domestication and commercialisation of indigenous trees in agroforestry for the alleviation of poverty. *Agrofor Sys* 38: 165 - 176
- Leakey RRB & Tomich TP (1999) Domestication of tropical trees: from biology to economics and policy. In: Buck LE, Lassoie JP & Fernandes ECM (Eds.) *Agroforestry in sustainable agricultural systems*. Pp 319-338. CRC Press/Lewis Publishers, New York
- Lombard C, Allanic B & Shilote B (2000) Potential for the development of marula products in the Bushbuckridge area. DANCED/DWAF, Nelspruit. 67 pp.
- Maree D & Doyer T (2001) The critical aspects of the supply chain for marula yoghurt. In: Anon. Marula workshop: report and abstracts. pp 32-35. University of Pretoria, Pretoria

- McGregor J (1993) Woodland pattern and structure in a peasant farming area of Zimbabwe: ecological determinants and present land use. *For Ecol & Mgmt* 63: 97-133
- Nerd A & Mizrahi Y (1993) Domestication and introduction of marula (*Sclerocarya birrea* subsp. *caffra*) as a new crop for the Negev desert of Israel. In: Janick, J. & Simon, J.E. (Eds.). *New crops*. Pp. 496 - 499. Wiley, New York.
- Palmer E & Pitman N (1972) *Trees of Southern Africa. Volume 2*. Struik, Cape Town.
- Parsons DA, Shackleton CM & Scholes RJ (1997) Changes in herbaceous layer condition under contrasting land use systems in the semi-arid lowveld, South Africa. *J Arid Env* 37: 319-329
- Peters CR (1988) Notes on the distribution and relative abundance of *Sclerocarya birrea* (A.Rich.) Hochst. (Anacardiaceae). *Monogr Syst Bot Miss Bot Gard* 25: 403-410
- Shackleton CM (In press) Growth and fruit production of *Sclerocarya birrea* in the South African lowveld. *Agrofor Sys*
- Shackleton CM & Shackleton SE (2000) Direct use values of savanna resources harvested from communal savannas in the Bushbuckridge lowveld, South Africa. *J Trop For Prod* 6: 21-40
- Shackleton CM, Griffin N, Banks DI, Mavrandonis J & Shackleton SE (1994) Community structure and species composition along a disturbance gradient in a communally managed South African savanna. *Vegetatio* 115: 157-168
- Shackleton CM, Dzerefos CM, Shackleton SE & Mathabela FR (2000) The use and trade in indigenous edible fruits in the Bushbuckridge savanna region, South Africa. *Ecol Food Nutr* 39: 225 - 245
- Taylor FW & Moss H (1983) The potential for the commercial utilisation of veld products in Botswana. I. The resource and its commercialisation. *Veld products Research*, Gaborone.
- Walker N (1989) "King of foods. Marula economics in the matabos. *Afr Wildl* 43: 281-285

Table 1: Proportion of households in four villages making use of *S. birrea*

	Allandale	Edinburgh	Hokwe	Rolle	Mean
Firewood	94.3	97.2	94.4	94.4	95.1
Fruit	94.3	94.4	94.4	91.7	93.7
Kernels	94.3	83.3	86.1	86.1	87.4
Beer	74.3	72.2	75.0	75.0	74.1
Jam	60.0	36.1	55.6	55.6	51.7
Medicine	37.1	44.4	41.7	33.3	39.2
Juice	28.6	8.3	13.9	8.3	14.7
Carvings/wooden utensils	14.3	2.8	11.1	25.0	13.3

Table 2: Density of *S. birrea* under different landuses

	Homestead yards	Fields	Communal grazing lands	Protected areas
Density (stems/ha)	10.8 ± 1.3	5.7 ± 0.5	57.9 ± 6.1	102.1 ± 10.2
% adults (> 45 cm circumf.)	72.7 ± 3.6	73.9 ± 2.9	13.8 ± 2.1	13.1 ± 5.9
% of adults that were female	58.1 ± 4.3	42.3 ± 3.0	43.5 ± 4.1	33.6 ± 5.9
Female density (trees/ha)	4.5 ± 0.7	2.0 ± 0.2	2.6 ± 0.4	4.5 ± 0.8

Table 3: Mean number of fruits per tree (\pm SE)

Village/protected area	Fruit mass	N	Significance
Allandale	44 200 \pm 9 270	24	A
Hokwe	26 502 \pm 3 961	18	A B
Madile	17 742 \pm 3 251	23	B
Rolle	115 399 \pm 17 608	21	C
Andover	3 475 + 675	30	D
WRF	2 728 \pm 842	32	D
Total	30 773 \pm 4 265	148	($F_{5,146} = 43.5$; $p < 0.001$)

Table 4: Mean number of fruits (\pm SE) per cubic metre canopy volume

Village/protected area	Fruit cubic metre of canopy volume	N	Significance
Allandale	59.6 \pm 9.9	24	A
Hokwe	35.9 \pm 5.3	18	A
Madile	34.2 \pm 5.8	23	A
Rolle	127.0 \pm 25.2	21	B
Andover	9.2 \pm 1.7	30	C
WRF	14.0 \pm 3.6	32	C
Total	42.3 \pm 4.1	148	($F_{5, 146} = 22.5$; $p < 0.001$)

Table 5: Mean mass of individual fruits (\pm SE)

Village/protected area	Fruit mass (g)	N	Significance
Allandale	24.7 \pm 0.32	443	A
Hokwe	28.9 \pm 0.35	340	B
Madile	21.6 \pm 0.34	360	C
Rolle	24.8 \pm 0.46	320	A
Andover	21.0 \pm 0.24	588	C D
WRF	20.7 \pm 0.24	576	D
Total	23.6 \pm 0.14	2627	($F_{5, 2621} = 91.3; p < 0.001$)

Table 6. Proportion of households propagating new *S. birrea* trees

	Allandale	Edinburgh	Hokwe	Rolle	Total
% nurturing self seeded recruits	45.7	50.0	55.5	52.8	51.0
% planting new trees	37.1	22.2	27.8	33.3	30.1
Of those planting,					
Proportion using: - seed	42.9	50.0	50.0	33.3	44.1
- truncheons	28.6	25.0	30.0	16.7	25.1
- transplants	28.6	25.0	20.0	50.0	30.9
Proportion of households with at least one <i>S. birrea</i> tree in the homestead plot	68.6	77.8	86.1	82.9	78.9
Proportion of households with fields that have at least one <i>S. birrea</i> tree in the field	42.1	71.4	64.7	54.5	58.2