ACACIA ALBIDA: ARBOREAL KEYSONE OF SUCCESSFUL AGRO-PASTORAL SYSTEMS IN SUDANO-SAHELIAN AFRICA

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SUMMARY

*Acacia albida* is a leguminous tree (*Mimosoideae* family) found primarily in the drier, cultivated areas of Africa, especially where mixed crop-livestock systems are practiced. In view of its many beneficial qualities, it has traditionally been a protected tree and the promotion of its growth, in mainly millet, cowpeas, and groundnut fields, is actively pursued by farmers living in marginal agricultural zones. Although the importance of this permanent intercrop has long been recognized, growing man and animal population pressures, periodic drought, and the concentration on cash crops are resulting in the demise of this tree. All indicators point to a continued decline in the population of this extremely useful tree and, consequently, dire predictions are being made concerning the livelihood of the sedentary and semi-sedentary farmers and transhumant pastoralists who, over many centuries, have been able to cope successfully with a very inhospitable environment and increase their population levels by the rational use of this essential arboreal component of their agro-sylvopastoral production systems. Massive action is therefore recommended on an urgent basis to arrest this decline and to increase on a vast scale the numbers of this valuable tree as a low-cost means of maintaining high crop yields and, particularly, increasing the productivity of livestock, the principal resource of Sudano-Sahelian Africa.
If one mutilates a branch of an *Acacia albida* without reason, his arm will be cut off, and if one cuts down an *Acacia albida* without authorization, his head will be cut off.

--Dina Djenne, Sultan of Zinder (Niger), ca. 1880 (Gifford, 1964).

**INTRODUCTION AND GENERAL BACKGROUND**

The above quote abundantly reflects the importance attached to the *Acacia albida* tree by many of the settled farmers who inhabit the Sudano-Saharan area of Africa, and the transhumant herders who often rely upon this tree to provide their animals, and the animals that farmers often entrust to them, with essential nutrients during their dry-season sojourn in the area. The rational use of this multipurpose tree over the past several centuries as the keystone element of non-fallow, mixed crop-livestock systems has permitted the human and animal population levels to rise above what could normally be supported by the low natural-resource base of the semi-arid area. For example, in areas with many *A. albida* trees, 30 people and 10 cow-equivalents per square kilometer have been recorded versus about one-fifth this density in neighboring areas in the same ecological zone (19, 43, 47). These high population levels have, ironically, been the major cause of the marked decline of this valuable tree.

In spite of the strong measures taken by traditional and civil authorities to preserve this tree, these growing population pressures (the human population is doubling about every 25 years) make it almost impossible for this tree, and many other useful trees that share the same ecosystem, to regenerate naturally. A prime example of this is that the dense tree stands governed by the Sultans of Zinder have long since been denuded (61).

These pressures also further minimize the chance of this tree surviving the recurrent, unpredictable droughts (it is estimated that 40% of the trees perished during the great Sahelian drought of 1968-1973), which help
characterize all farming and livestock activities in the area as "high-risk" and "low-productive" endeavors (34, 41). Increases in the population have also contributed to the demise of this tree by forcing people to overutilize this tree for firewood and animal fodder.

Another major contributor to the decline of this tree are government policies which have supported a concentration on export crops (e.g., groundnuts in Senegal and cotton in Chad) and prevented individual ownership and management of A. albida trees by declaring them state property. The latter discourages farmers from providing the tree with the protection and care it needs to survive and thrive even when conditions are good, and it allows opportunistic pastoralists, who have no regard for the agronomic aspects of this tree, to mutilate the tree by recklessly chopping off its branches or "bending" them to the ground so that their animals can gain access to the tree's nutritious leaves and pods. Although such practices may ensure the survival of animals during the stressful dry season or in times of life-threatening drought, they often result in the tree's death. These practices, especially the "bending" of branches, also make it more likely that this tree will succumb to the bush fires which often occur in these hot, dry areas as a result of natural causes or, more frequently, from the intentional efforts of herders attempting to improve the quality of pasture grasses. A. albida is known, however, to be one of the more fire- and drought-resistant trees in the African savanna (60).

The emphasis on export crops has brought with it new cultivation practices which rely heavily on imported inputs for the achievement of high yields, and farmers, therefore, concern themselves to a much lesser extent with the maintenance of their more ecologically-balanced production systems such as the permanent intercropping of A. albida trees with traditional annual crops like sorghum, millet, wheat, groundnuts and/or cowpeas. The dangers of replacing
such high yielding, traditional production systems with one that depend heavily on costly, imported inputs of questionable environmental impact are all too evident.

The cultivation of export crops also provides the farmer with a new source of income which is often invested in the highly valued traditional manner by acquiring more livestock which not only represents the farmer's major asset but also reflects his social and cultural status (See Appendix F for "typical" farm profile). Collectively, the farmers' livestock also represents a principle resource for the 11 countries* in the area (e.g., animal exports provide about 75% of Mali's national revenue (41). This addition of livestock, along with the improved animal health services, watering points, etc. that the revenue generated by cash crops helps provide, further imbalances the traditional production system by overloading it with more animals than it needs to function and it can reasonably support. This overstocking results in further degradation of natural forage sources, especially browse trees like the *A. albida*, which is often one of the only sources of feed available during the latter part of the dry season with adequate nutritional content to satisfy the minimal maintenance requirements of the area's ruminant animals (goats, sheep, primarily zebu-type cattle, and some camels).

If the destruction of browse trees continues unabated at its current rate, it is projected that the Sudano-Sahelian area of Africa will be almost completely denuded of browse shrubs and trees by the year 2030 (41). If such frightening, but entirely plausible, predictions are accurate, it means that a large proportion of the estimated 70 million head of goats, sheep, and cattle in the area, representing the most important resource of the nearly 50 million farmers and herders in the area, risk perishing unless other viable

*Chad, Mali, Upper Volta, Gambia, Niger, Mauritania, Senegal, Sudan, Northern Cameroon, Northern Nigeria, and parts of Ethiopia. (See Appendix B for some basic statistics on the Sudano-Sahelian Parts of these countries).
sources for the protein, vitamins, and minerals provided by browse shrubs and trees are found (18, 36, 65). Given the poverty of the people in the area and their governments (average per capita GNP is $312/year) and the harsh constraints imposed by the inhospitable environment, alternate supplementary feeds can be procured and used only by a few. The introduction of leguminous grasses and other pasture improvements will be of doubtful use as the long dry season will render them just as nearly devoid of nutrients as native grasses which, although adequately nutritious during the early part of the short rainy season, contain 0-3% crude protein during most of the dry season (42). Irrigated forage is, of course, prohibitively expensive and only practical on a very small scale. The use of stored-hay and silage offer only very limited possibilities as tropical grasses are unsuited for such use and the labor required is often lacking. Also, such activities presuppose a settled living style and a stable, permanent land-tenure system, which is far from the case in this area, where population pressures continue to cause tremendous demographic upheaval by forcing farmers to encroach upon traditional pastoral lands, thereby obliging the pastoralists to become sedentarized or to curtail their operations. Although this demographic trend continues to be the source of much conflict, the tendency toward permanent settlement of the area is definitely a growing one.

This increasing "sedentarization" tendency does indicate that one of the most inviting and practical alternatives is the expanded use of the A. albida tree which, besides its important agronomic qualities, is known as a dry-season fodder tree par excellence. It is with this, and the background provided above, in mind that the remainder of this paper will be devoted to examining this interesting tree, particularly focusing on the current and potential benefits it is capable of providing livestock.
CURRENT SITUATION

Range and Habitat of Acacia Albida

The geographical distribution of *A. albida* is shown on Map B of Appendix A. As shown on this map, the range, from sea level up to near 2,000 meters altitude, coincides closely with the semi-arid zones in Africa and, therefore, it also coincides with the major livestock-raising areas of Africa (depicted in Map C). These areas are known to be less susceptible to tsetse fly infestation which severely limits livestock production in the more humid areas of Africa. In this regard, it is important to note that *A. albida* does not provide the kind of arboreal cover that tsetse flies require to survive.

Although some *A. albida* are found in Israel, Syria, and Cyprus, it is considered a tree indigenous to Africa, perhaps having its origin in present-day Tanzania (31, 63). It is believed that the tree spread from this area via the migration of ruminant animals who dispersed *A. albida* seeds by passing most of them (estimated at 60-70%) undamaged through their digestive systems 4-5 days after ingesting them. It is important to note that *A. albida* seeds cannot germinate under natural conditions unless they have passed through the digestive system of these animals (63).

The tree is most prominent in the Sudano-Sahelian part of Africa where it is used to great and similar advantage by such widely separate ethnic groups as the Serere in Senegal, the Hausa in Niger and Northern Nigeria, the Jebel Marra in Sudan, and the Galla and Arussi in the rift valley of Ethiopia (46). The widespread distribution of this tree and the various ethnic groups that exploit its benefits are reflected in the list of the tree's local language names presented in Appendix D.

The Sudano-Sahelian habitat of this tree is primarily in the 400-800 mm annual rainfall range, although it is often encountered outside this range.
This rainfall area corresponds roughly to a 400-500 kilometer-wide strip which slopes in a gradual southeast direction across Africa, beginning between 12-16°N latitudes on the west coast of Africa and extending into parts of Ethiopia in Eastern Africa. (See Map A, Appendix A). The northern limit of this vast area (approx. 2,250,000 sq. km) is normally considered the boundary between the strictly pastoral zones and the predominantly agricultural zones in the higher rainfall areas of the south.

This area has a unimodal rainy season lasting less than 3 months (June-August) in the North and almost 5 months (May-September) in the South (the rainfall decreases about 130 mm for each degree of latitude, south to north). Rainfall amounts and distribution are very unpredictable within each year and from one year to the next. The temperature range in the rainy season is roughly 22-35°C, with an average mean range of 27-30°C, and during the dry season the range is 19-40°C, with an average mean range of 27-29°C. The lower and higher temperatures are normally associated with the drier, northern tier of the area. Daily radiation averages from 450 cal cm⁻¹/day in the rainy season to 550 cal cm⁻¹/day in the dry season. The annual evaporation rate is well over 2 meters (or near 3 times precipitation) and the relative humidity is low, rarely exceeding a monthly average of 40% even during the rainy season. Winds are usually gentle to moderate breezes, ranging from 8-20 km/hr, but much stronger winds do occur when the tropical monsoon arrives from the South, commencing the rainy season, and when the desicative Harmattan winds descend from the North during the December to March period. The area where these two air masses meet is called the Inter-Tropical Convergence Zone. The movement, sometimes capricious, of this zone determines the nature and duration of the rainy and dry seasons (39).

The soils of the area are typically sandy, containing over 90% sand and much less than 1% organic matter except in depressions left by ancient
riverbeds, seasonal water courses and in parts of the southern tier where ferruginous soils predominate (2). *A. albida* does prefer, however, deep sandy soils, in low-lying areas where the underground aquifer is 2-10 m deep (17, 23, 24). The natural vegetation is typically African, open-thorn savanna in the North, gradually changing to shrub woodland in the southern part of the area. The major tree and shrub species are *Acacia, Commiphora, Combretum*, and *Terminalia*. The main grass species are *Cenchrus, Aristida*, and *Andropogon gayanus* (42).

**Brief Description of Major Botanical and Agronomic Features**

*Acacia albida* is a leguminous tree of the Mimosoideae family. Recent studies indicate, however, that *A. albida* should be returned to its previous botanical classification, *Faidherbia albida*, under the Ingeae tribe as suggested by Chevalier in 1934 (4, 31, 41, 52). Much of this debate over *A. albida* results from not knowing if *A. Acacia* flowers are self-compatible or if they outcross like other leguminous trees (21, 22, 50). Although perhaps the most studied tree in Africa, little or no genetic work has been done on *A. albida*. The lack of uniform genetic material and the slow growth of the tree (begins producing pods after 7-8 years and its average life-span is estimated at near 80 years) contribute to the reluctance of researchers to undertake genetic studies (19, 58). Most *A. albida* have a common chromosome arrangement of 2N=26, but it has been reported that the amino-acid make up of *A. albida* is different from most of the more than 900 *Acacia* species (16, 63). In any event, there do not exist any named cultivars for *A. albida* and, despite many studies of this tree, the state of knowledge on it is compared to that on corn in the United States in the 1860's (19).

*A. albida* is one of the largest trees that grow in the African savanna, reaching a height of 20-30 meters, a trunk diameter of near 1 meter and a canopy
diameter of 5-10 meters in 10-15 years (12, 19, 44, 57). Its small leaves, sparse, but full branches (see Appendix E for sketch of tree parts), and tall, clean trunk and parasol form make it an excellent shade tree (27, 28). Its small thorns are such that they do not interfere with livestock browsing. The most noteworthy aspect of *A. albida* is that, unlike other tropical deciduous trees, it has the curious habit of shedding its leaves at the onset of the rainy season and remaining leafless (perhaps the only species to do so) until sprouting new leaves and flowers during the dry season. It therefore does not compete with annual crops for light and the loss of its leaves just when annual crops are planted provides a timely, readily decomposable source of organic matter ("nitrogen flush") (8, 11, 37, 38). Botanists do not agree on why *A. albida* has such a "reverse deciduous cycle" and debate continues over whether this is a genetic characteristic, a reaction to water table or soil moisture levels, or in response to changes in atmospheric pressure (19, 33, 40).

The possible adverse effects of a dense planting (average in farmers' fields is 10-20 trees/ha.) of *A. albida* on the water table is a major concern. It has been speculated that a dense stand of trees could not survive without a plentiful supply of underground water and that such stands would reduce the availability of moisture to annual crops. It is for this and other reasons that there is some debate over whether or not the trees should be planted individually in farmers' fields, in separate contour bands or in windbreak formations (6, 11, 35). *A. albida* has proven to be a very useful tree in schemes designed to combat desert encroachment, to control water and wind erosion, to stabilize sand dunes, and to restore fertility to unproductive lands (1, 7, 30, 44, 59).

*A. albida* has a fast-growing (2-5 m/year) taproot which grows straight down for over a meter before branching out, reaching up to 30 meters; therefore,
there is not any competition with annual crops for surface-soil nutrients and water, and it does not interfere with cultivation (9, 27). The OM and N levels in upper layers of soil are 2-5 times higher under the leaf-fall area (100-300 m²) of a mature tree than on open ground, resulting in about a 50% increase in the CEC (9, 10). It has been calculated that the annual leaf-fall from 50 trees/ha is equivalent to applying 50 MT of manure (42).

Millet yields 2-2.5 times higher than those obtained on unfertilized areas not covered by A. albida are regularly achieved. Millet grown under A. albida contains 3-4 times more protein (9). It is also interesting to note that millet takes up organic nitrogen in preference to nitrogen provided by chemical fertilizer (10). Other experiments on the nutrients returned to soil with a population of 16 trees/ha covering 24% of the ground have been evaluated in kg/ha/year as follows: Ca--120; Mg--25; K--13; N--75; P--12; and S--20 (14). These figures represent sharp increases over the nutrient content of soils of open fields.

It has also been reported that microbiological activity is 2-5 times higher under tree canopy with an average C/N ratio of near 16 (37, 38). This increase in activity is largely due to higher soil moisture and relative humidity caused by the "microclimate" created under the tree, including an appreciable reduction in maximum average temperatures during the hottest and driest part of the year (January-May) when A. albida has its full foliage (14). Also, photosynthesis has been reported to be 4-5 times higher and evapotranspiration 50-70% lower under the tree canopy (42).

It is surmised that the rich soils under A. albida are due in part to its ability to fix N, but scientists are not sure just how it fixes N. Pot experiments show A. albida readily nodulates, but nodules are rarely observed in the field. It is thought that high soil temperatures do not allow A. albida rhizobia to survive in the field (19, 20, 32). Also, few Azotobacter bacteria are found, but Bacillus Circulan bacteria are plentiful under A. albida and
they can fix nitrogen (37). Jung (1970) suggested that A. albida is taking N from the water table instead of producing it through symbiotic fixation; however, this is considered highly unlikely (19).

Salient Aspects with Regard to Livestock

It is difficult to single out any one component of the very complex, integrated A. albida system as being the most important, and the practically indivisible symbiotic relationship, involving the tree, man and his animals and crops, requires that no one aspect of the system be manipulated without considering the impact upon the other components and the total attractiveness of the system. Nonetheless, the important, but increasingly unstable, role animals play in the functioning of the system and their value to man indicates that this component requires special attention.

As indicated above, the leaves, pods, and seeds of the area's browse shrubs and trees constitute a vital portion of the ruminant diet (over 75% of the 7-10,000 shrubs and trees in Africa are browsed), providing essential vitamins, minerals, and protein which cannot be obtained from grass forage alone and without which grass forage cannot be fully utilized (64). The intake of browse is especially critical during the latter several months (January-May) of the dry season when it can represent up to 30-45% of the animals' total feed intake (42). Given that in those areas where A. albida grows, it often provides the only available "green" intake during this dry period, it is evident that this tree's inverse growing cycle makes it "just what the doctor ordered".

The "unique" shade provided by A. albida during the hottest part of the year provides protection to animals (and man) from excessive solar radiation and thereby helps to improve the feed intake by reducing the energy expended in thermal regulation. Also, by staying near the A. albida "fodder-park" areas the animals expend less energy ranging long distances in their very selective
search for suitable forage (as compared with the rainy season, animals must
often increase by up to 50% the distance covered during this "hungry season")
(48). The grouping of animals under or near these trees also results in the
depositing of manure in fixed locations which facilitates its collection for use
on other fields, as a fuel or a building material. This manure also helps
provide the animals more nutritious grasses which have a longer growing season
beneath the tree and/or some crop residues which are an important part of their
post-harvest (October-December) diet. The reduction in animal roving also makes
it easier to protect new trees and maintain draft and dairy animals (19, 27, 37,
41, 63). Taken altogether these factors tend to result in a desirable consolida-
tion of usually fragmented, small-scale land-holdings. This strengthening of
mixed farming does occur, however, at the expense of the pastoralists who can no
longer count on exchanging animal products for the food staples they need.

In practice, there is no doubt about the salutary effects that the con-
sumption of A. albida pods and leaves has on ruminants. Often times the large
A. albida pods are marketed at relatively high prices or stored (they can be
stored with ease for up to three years with almost no decrease in their nutri-
tional value) as a special feed for weakened or sick animals, who recover
rapidly after consuming the highly palatable pods, for milk cows and for fat-
tening prestige animals (5, 42, 62). Farmers in Senegal state that dry A.
albida pods and leaves are an excellent feed and that all their animals (except
horses) can be fed as much as they can consume without any ill effects (19).
Standard chemical analyses show a high crude protein content for the pods and
leaves, 15-20% and 10-15% respectively, and adequate levels of vitamin A,
phosphorus, and calcium (13, 19, 29, 42). Le Houerou (1980b) believes the pods
can be used like a concentrate. (A nutritional composition table of A. albida browse
parts is presented in Appendix C.). C. Charreau (cited in Felker, 1978)
believes this high feeding value of A. albida pods and their storability are more important factors than the contribution of A. albida to either soil fertility or the more nutritious pasture grasses (which cannot be stored) that grow beneath the tree. Penning Devries et al. (1982) believe, however, that leaves and pods are, in general, of secondary importance compared to the feeding value of the grasses growing beneath leguminous trees in the Sahelian zone.

Recent progress in the analytical procedures used to determine the true digestibility of browse forages has tended, however, to confuse judgment about the feeding value of A. albida pods. It has now been concluded that standard procedures cannot be accurately used to analyze the value of feeds such as A. albida pods because their high tannin content markedly inhibits the digestion of protein (42, 45, 49, 55, 56). J. Reed (1983) reports that dry A. albida leaves collected in Kenya have a high condensed tannin content of 18% of dry matter. M. Diagável (1981) demonstrated, in perhaps the first feeding trial using A. albida, that with West African wethers the protein digestive coefficient of dry leaves is extremely low (approx. 13.8%, which would, on the average, yield a crude protein content of less than 2%). This latter finding really puts the farmer's age-old practices and knowledge at odds with scientific findings. In brief, how can the voracious intake by ruminants of a feed with such a low protein digestive coefficient have such a large salutary effect on the performance of these animals?

It is only recently that animal nutritionalists have concluded that they are really "in the dark", when it comes to analyzing the feeding values of such browse species as the A. albida (42). Yet, leaders in this field, like the renowned French animal scientist, Dr. G. Boudet, continue to claim, for instance, that A. albida pods have a feeding value equivalent to 77% of an equal weight of barley. This high value was derived from the widely used international forage unit concept which uses alfalfa hay as a "benchmark feed" (6,
...G. Wickens (1969) makes a similarly dubious claim that five mature *A. albida* trees produce the same amount of digestible protein as one acre of groundnuts with a yield of 300 kgs.

It was in recognition of this confusion regarding the value of browse in Africa and the need to pay much greater attention to this essential portion of the diet of ruminants in Africa that prompted the holding of an international conference on this subject in April 1980 at the International Livestock Center for Africa (ILCA) in Addis Ababa. The collection of papers presented at this conference were assembled in a seminal document (ILCA, 1980) which will hopefully serve to redirect part of the substantial resources committed to the research of grass forages to the study of browse which, in comparison, has been grossly neglected (54).

**Other Uses and Additional Points of Interest**

*A. albida* wood is useful for firewood, making charcoal, minor construction, artisanal purposes, etc. Also, different parts of the tree are used as ingredients in many medicinal remedies. In some areas the tree is the object of spiritual beliefs and animistic ceremonies due to its importance and the way it "works against the will of God" via its reverse leaf-growing cycle (64). *A. albida* seeds are also consumed by humans in time of famine (13, 19).

It is worth noting that *A. albida* and other leguminous trees have evolved to dominate the arid and semi-arid ecosystems. Perhaps the capability of tree-legumes to deal with common soil N deficiencies while resisting drought has something to do with this (20). Given that these deficiencies may be more of a limiting factor on plant productivity than a lack of water, it is likely that tree-legumes like *A. albida* play an indispensable and multiple role in maintaining the balance of the Sudano-Sahelian ecosystem (21, 25). In any event, it is contended that without the addition of nitrogen to the area's soils...
there is not much hope of improving animal nutrition, the major constraint to higher animal output in Sudano-Sahelian Africa (48).

Those farmers in the Sudano-Sahelian area who do not raise cattle usually prefer the shea butter nut tree (*Butyrospermum parkii*) over *A. albida*. Different ethnic groups and ways of living are therefore distinguished by the trees they have in their fields (e.g., the Djerma in Niger are known for use of the *A. albida* while the horse-loving Mossi in neighboring Upper Volta are associated with the shea butter nut (47). Other useful trees which grow in the same ecosystem as *A. albida* are: *Acacia senegal* (produces gum arabic); *Acacia nilotica* (used to make commercial tannin); *Parkia biglobosa* (produces food for people; P. Felker (1978) recommends as a substitute for *A. albida*); *Tamarindus indica* (seeds are used to make drink); *Adansonia digitata* (Baobob—has many uses); and *Balanites aegyptica* (used to make cooking oil, etc., and mixed with *Acacia seyal* to form a syrup); and, in the northern, drier parts of the area, *Acacia raddiana* (its leaves are the favorite food of camels which, like goats, can subsist entirely on browse) (42, 39, 64).

It has been hypothesized that the ground cover provided by large stands of *A. albida* during the dry season has the potential of changing weather patterns by decreasing the earth's albedo (8). This may seem far-fetched, but not nearly as much as J. Ross' (1980) speculative report that *A. albida* might have provided timber for the construction of Noah's ark. (See Appendix C. for additional information on *A. albida*.)

**Summary of Commonly Cited Disadvantages of Acacia Albida**

*A. albida* grows slowly. It does not begin to produce pods until it is 7-8 years old and it does not reach full pod production (10-150 kgs/tree/yr) until 12-15 years after planting (19, 42). (See Appendix G for harvesting methods). Also, it does not begin to have significant beneficial effects on the soil until
10-15 years after planting. However, once its taproot enters the water table area, it grows faster than almost any other indigenous tree species and good soil conditions persist for up to 10 years after a mature tree dies. Some authors recommend replacing *Acacia albida* with *Prosopis cineraria*, which grows faster and is used in India (Rajasthan) in much the same way as *A. albida* is used in Africa (11, 19, 57).

*A. albida* must be protected for 3-4 years following planting, especially from free-ranging goats. It will not grow well during this period unless it is kept free from weeds, thus it does well in fields that are regularly cultivated. It will do best if pruned in a rational manner (over-pruning can kill and results in reduced pod production) throughout its lifetime, preferably during the first half of the dry season. The timely and appropriate intervention of man therefore is necessary for the regeneration and growth of *A. albida* (17, 24, 46, 57).

Ownership of *A. albida* trees is not usually clear and this discourages their proper care. In most instances, they are considered government or "common" property which subjects them to abuse for individual purposes or results in their underutilization. The situation is confused by civil and traditional laws which prohibit the cutting of branches or the tree itself (19, 27, 42, 46). This discourages farmers from using scarce labor time to tend trees they will never be able to fully utilize; yet, without some control over people and animals, it is unlikely that this tree can survive current population pressures.

The dry season foliage of *A. albida* attracts birds, which stay around to become crop pests during the rainy season. Bird manure does contribute, however, in a minor way to the high fertility of soil beneath tree canopy (58). There is also a possibility that *A. albida* harbors other crop pests. For
instance, C. Charreau (1980) states that nematodes which commonly infest young A. albida trees could do damage to crops. A. albida is known to be subject to attacks by many insect pests (19).

RECOMMENDATIONS AND CONCLUSIONS

The above summary of disadvantages brings to mind many actions which need to be undertaken to safeguard, manage and develop this valuable tree to its full potential. The research agenda for this tree is therefore a very long one, covering everything from plant genetics to agronomic and animal feeding trials. Unfortunately, the meager resources available for research on this tree will not permit much research to be carried out and it is possible that the results of any research effort will become available too late to prevent the demise of many of the individual agro-pastoral systems which revolve around this tree. It is therefore believed that, although much more research is needed, the available evidence justifies urgent and massive action to maintain and expand the use of this undeniably very desirable tree. Certainly, there is adequate knowledge and technology for arresting the decline of this tree and the systems it supports. Host governments, donors and concerned regional and international institutions need to work in concert to undertake priority measures which will ensure the rational management of the current tree population and the large-scale propagation of new trees (see Weber et al., 1978, and Africare, 1979, for examples of such efforts in Chad and Senegal).

As management and protection of the tree are prerequisites for the success of any regeneration effort, host governments should first and foremost develop a legal and policy framework which would encourage farmers to grow and care for this tree. This would include provisions for its individual ownership and rational exploitation. Although state-run nursery and tree-plantation efforts should be augmented, these efforts are more expensive than village-run efforts
and the number of trees produced is low in comparison with what a large number of villages could produce. Program emphasis should therefore be on educating people as to the importance of this tree and on developing the capacity of villages to propagate and maintain this tree. Given the high economic value of this tree, one novel action which might be experimented with is the payment of an annual, token "bonus" to villagers, and perhaps schools, for each tree they produce and keep alive in the field. In those areas without sufficient thorn brambles to build protective enclosures for the trees the government should provide (perhaps on a rotating, loan basis) barbed wire or other fencing materials. Given that even under the best conditions, *Acacia albida* seedlings suffer a high mortality from damage done to them by goats and wild animals, priority should be given to experimenting with low-cost, long-lasting animal repellents which can be easily applied to young trees.

While these activities are taking place at the local level to ensure the survival and multiplication of *A. albida*, institutions like ILCA should undertake multidisciplinary studies to determine the value and role of *A. albida* leaves and pods in the ruminant diet under actual conditions. Mixed farms using *A. albida* as animal feed should be selected for long-term, year-around study to determine total feed and water intake, noting for each animal type the amount and kind of *A. albida* feed consumed, when and how it is fed and how it affects animal performance. Included here should also be observations on how the shade provided by *A. albida* effects animal behavior and performance.

These field studies should be coordinated with laboratory and feeding-trial experiments designed to determine the nutritive value and digestibility of *A. albida* pods and leaves, with and without other combinations of feeds. The results of this research should provide practical guidelines on how much and often *A. albida* pods and leaves can be fed to different species of animals, according to their age, size, sex, health or maternal status, etc., and varying
environmental conditions, and the results that can be expected from such feeding in terms of weight gains and animal well-being. These results should be related to the cost, labor and numbers of trees required to produce the recommended amount of *A. albida* feed. This will necessarily involve recommendations regarding the improved management and development of tree stands and the feeding and care of animals during all seasons of the year.

An initial goal would be to attempt to use *A. albida* products as a "maintenance" supplement to prevent animal weight losses which always occur in the dry season when native grasslands are no longer capable of satisfy the nutritional needs of animals. In addition, experiments with grinding, heating, and various chemical treatments should be tested to see if they can enhance the digestibility of *A. albida* products. It must, however, be kept in mind that any improvements resulting from these experiments must be sufficiently low-cost and simple so that they can be easily adopted by subsistence farmers in the area. For example, an easily adoptable result may be the finding that the hand-chopping or grinding of *A. albida* pods and seeds enhances their digestibility.

Although all the efforts mentioned above are worthy of pursuit, they and others will not be successful unless policy-makers and technicians from various disciplines (e.g., agronomy, animal science, forestry, social sciences) begin working together in a concerted and systematic fashion and, more important, unless the people in the area are willing to change their traditional ways of living and begin exercising better control and management over their activities, especially their animal husbandry practices. Current and projected population levels require that extensive farming and pastoral practices be transformed into more intensive ones. The use of *A. albida* is one outstanding example of how such a potentially calamitous transition might be partially and peacefully accommodated. The *A. albida* tree can, with proper management, therefore also serve as a useful link between a happier past and a better future.
REFERENCES CITED


Other Useful References Consulted


Potentially Useful References Not Located


Probably first major work on browse as fodder, but suggested woody areas could be made more productive by substituting grass forage.


Cited on page 534, Herbage Abstracts, 1981, Vol. 51, No. 12. In view of following quote, this report merits attention: "Tree fodder was a very minor part of the diet selected, even when there was little grass available in the dry season. This was especially true for cattle." This study, therefore, contradicts many previous studies regarding the amount of tree fodder consumed.


Other Bibliographical Notes

- H. M. Burkhill's encyclopedic revision of Dalziel's Useful Plants of West Tropical Africa is currently in press. (Royal Botanical Gardens, U.K.)

- National Academy of Science is currently preparing a new book on Agro-forestry.

- Amadou Bello University of Nigeria has done quite a bit of work with Acacia albida.

- Several abstract references indicated that USSR scientists are doing relevant work in semi-arid zones with Camel Thorn tree, especially with regards to its use as a fodder tree.

- Some abstract references indicated work is going on in Zimbabwe and the Republic of South Africa with Acacia albida and related species.

- Work in Australia with Acacia aneura and in the U.S. with Prosopis juliflora is of much relevance.

- Three specimens from Southwest Africa of A. albida twigs, with leaves and pods, are in case no. 127, Bailey Hortorium, Cornell University, Ithaca, N.Y.

- IDRC is supporting important work on Acacia Senegal (Gum arabic tree) in the Republic of Senegal.
APPENDIX A: Maps Showing Sudano-Sahelian zone and *Acacia Albida* and Cattle in Africa.

MAP A

Source: Adapted from H. E. Jahnke, 1982.

MAP B

Native distribution of *Acacia albida*. (G. F. Wickens)


MAP C

Distribution of cattle in Africa (Deshler, 1963).

## Table 1: Basic Indicators on the Sudano-Sahelian Parts of Eleven Countries

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>POPULATION 1979 (000)</th>
<th>AREA (000 sq. km.)</th>
<th>GDP PER CAPITA ($1979)</th>
<th>PQLI (1975-76)</th>
<th>Ruminants (000 Head, 1981)</th>
<th>% OF COUNTRIES' RUMINANTS</th>
<th>GDP VALUE ($Million)</th>
<th>LIVESTOCK % OF TOTAL GDP</th>
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<tr>
<td>N. Cameroon</td>
<td>1,300</td>
<td>40.0</td>
<td>560</td>
<td>28</td>
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<td>800</td>
<td>850</td>
<td>2</td>
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<tr>
<td>S. Chad</td>
<td>3,000</td>
<td>320.0</td>
<td>110</td>
<td>20</td>
<td>2,000</td>
<td>2,000</td>
<td>1,850</td>
<td>150</td>
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<tr>
<td>W. Ethiopia</td>
<td>6,000</td>
<td>150.0</td>
<td>130</td>
<td>16</td>
<td>750</td>
<td>700</td>
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<td>Gambia</td>
<td>600</td>
<td>11.0</td>
<td>250</td>
<td>22</td>
<td>175</td>
<td>165</td>
<td>335</td>
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<tr>
<td>S. Mali</td>
<td>4,500</td>
<td>310.0</td>
<td>140</td>
<td>15</td>
<td>1,700</td>
<td>1,800</td>
<td>2,200</td>
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<tr>
<td>S. Mauretania</td>
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<td>18.5</td>
<td>320</td>
<td>15</td>
<td>170</td>
<td>270</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>S. Niger</td>
<td>4,000</td>
<td>127.0</td>
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<td>14</td>
<td>340</td>
<td>135</td>
<td>700</td>
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<td>N. Nigeria</td>
<td>15,000</td>
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<td>670</td>
<td>25</td>
<td>9,000</td>
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<td>8,550</td>
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<td>22</td>
<td>1,150</td>
<td>2,075</td>
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<td>Central Sudan</td>
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<td>1,400</td>
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<tr>
<td>TOTAL/AVERAGE</td>
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<td>2,248.5</td>
<td>312</td>
<td>21</td>
<td>23,535</td>
<td>18,145</td>
<td>26,595</td>
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</tbody>
</table>

1/ See Map A, Appendix A, for geographical area covered by these indicators. Includes 400-800mm rainfall zone.

2/ Based on country-wide statistics. Probably much lower for much of the area.

3/ Physical quality of life index, based on country-wide statistics. Probably much lower for the area. (World average is 65.)

4/ Estimates of only those animals permanently kept in the zone.

5/ Based on H. Jahnke (1982), Annex Table 11.

Table 2: Nutritional Composition of *Acacia albida* Browse Parts and Other Vital Statistics.

<table>
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<tr>
<th></th>
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<td>53</td>
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<td>9.7</td>
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<tr>
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<td>66</td>
<td>92.7</td>
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<td>21.3</td>
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<td>6.1</td>
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<td>7.6</td>
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<td>0.9</td>
<td>62.7</td>
<td>7.6</td>
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<td>85</td>
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<td>2.2</td>
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<td>6.1</td>
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<td>0.19</td>
<td>1.13</td>
<td>0.26</td>
<td>1.2</td>
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<td>F</td>
<td>Mali</td>
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<td>72</td>
<td>30.7</td>
<td>17.8</td>
<td>17.5</td>
<td>2.2</td>
<td>56.2</td>
<td>12.0</td>
<td>6.1</td>
<td>135</td>
<td>6.4</td>
<td>0.5</td>
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<tr>
<td>F</td>
<td>Niger</td>
<td>1970</td>
<td>—</td>
<td>19.7</td>
<td>19.6</td>
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<td>153</td>
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<tr>
<td>G</td>
<td>AO</td>
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<td>16.8</td>
<td>11.0</td>
<td>2.5</td>
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<td>21.5</td>
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<td>AO</td>
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</tbody>
</table>

**Symbols are as follows:** FrM = Mature Pods; FrS = Dry Pods; Fr = Pods; FM = Mature leaves; F = leaves; G = seeds.

**AO** = West Africa

**Dates:** Month-Year; SS = Dry season.


Other Vital Statistics and Miscellaneous Facts:

- *A. albida* annual growth: 50-160cm in height and 0.6-2.9cm in diameter (Felker, 1978).

- Pod yield range per mature tree: 6 to 135 kg/yr (Felker, 1978); 50 to 150kg/yr or 7-10kg of DM (LeHouerou, 1980, p. 356 and p. 434).

- Leave yield range per tree: 50 to 150kg/yr (same as pods) or 7-10kg of DM (LeHouerou, 1980, p. 356 and 434).

- Pod and leave production at 50 trees/ha gives a theoretical stocking rate of 2.5 sheep or 0.25 head of cattle (0.5 tropical livestock unit) ha/yr (LeHouerou, 1980, p. 356 and p. 434).

- At 43 trees/ha (approx. 15m x 15m spacing) potential leave production is 4.2 metric tons per year which provides the equivalent of 186kg of nitrogen (Wickens, 1969).

- 125kg of pods could provide for the production of 90 liters of milk or 12.5kg of meat (J. Kowel and A. Kassam, 1978).

- *A. albida* pod to seed ratio estimated at 1:4.4 and seed to pod weight in following range: 1:2.6 to 1:7.7 (Wickens, 1969).

(Cont.)
*Relationships of biomass of *A. *albida* to trunk circumference, etc. have been worked out (Cissé in LeHouerou, 1980).

*A. albida* seeds can be artificially germinated by treating with boiling water and nicking the seed coat. However, a low seed germination rate (60%) and a high tree mortality (30-40%) require planting many more trees in nursery and in the field than needed (Weber, 1971, 1978). Also, high heterozygosity in seedlings results in large variance in growth rate which requires selective transplanting to the field (Aioni, 1972).

*Pods are sold in the traditional markets in Mali, Niger and Senegal for $.20-$.25/kilo (or more during times of drought). (LeHouerou, 1980 and Wentling, 1981.)
<table>
<thead>
<tr>
<th>Language</th>
<th>Name(s)</th>
<th>Area of Use</th>
</tr>
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<tbody>
<tr>
<td>English</td>
<td>Apple-ring, winter thorn</td>
<td>U.K., East Africa</td>
</tr>
<tr>
<td></td>
<td>Ana</td>
<td>East and Southern Africa</td>
</tr>
<tr>
<td>French</td>
<td>Gao</td>
<td>U.S., Niger and Northern Nigeria</td>
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<tr>
<td>German</td>
<td>Gao</td>
<td>France</td>
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<td>Hausa</td>
<td>Gao</td>
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<td>Djerma/Songhay</td>
<td>Gao</td>
<td>Niger and Northern Nigeria</td>
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<td>Arabic</td>
<td>Haraz, Araza, Haraza</td>
<td>Arabic speaking countries</td>
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<td>Balanzan or belinka</td>
<td>Mali</td>
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<td>Mossi</td>
<td>Zanga</td>
<td>Upper Volta</td>
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<tr>
<td>Kanouri</td>
<td>Haragu</td>
<td>Lake Chad region</td>
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<tr>
<td>Fulfulbe</td>
<td>Traike, Tshiki</td>
<td>By fulani people spread across West Africa</td>
</tr>
<tr>
<td>Maure</td>
<td>Aferar, Ifrar, Haraza</td>
<td>Mauritania</td>
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<td>Wolof</td>
<td>Cad</td>
<td>Senegal</td>
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<tr>
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<td>Boudiancoune</td>
<td>Ivory Coast</td>
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<td>Mandingo</td>
<td>Baramsanhon</td>
<td>Guinea - other parts of W. Africa</td>
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<td>Tamachek</td>
<td>Attehes, Atiss</td>
<td>Northern Niger, Eastern Mali</td>
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<tr>
<td>Toubou</td>
<td>Teleli</td>
<td>Eastern Niger, Chad</td>
</tr>
<tr>
<td>Sebei</td>
<td>Dalyet</td>
<td>Kenya</td>
</tr>
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</table>
Ol-erai Masai
Mukababu Taveta
Kenya, Tanzania
Kenya, Uganda

Other Latin Synonyms

A. sacharata, Benth (1842)
A. senegalensis, Benth (1842)
A. mossambicensis, Bolle (1861)
A. microfolliolata, De Wild (1925)
A. variofolliolata, De Wild (1925)
  faidherbia Albida, Chevalier (1934)
APPENDIX E: Sketches of *Acacia Albida* Leaf and Branch Parts.

*Acacia albida* Del.

Showing (lower left) pods; (centre) leaves and flowers; (right) thorny branch.

APPENDIX F: Profile of a "Typical" Farm in Western Niger (Sudano-Sahelian Africa).

<table>
<thead>
<tr>
<th>(1) Principal Crops Raised</th>
<th>(2) $ Farms</th>
<th>(3) Avg. Ha. or Head Per Farm</th>
<th>(4) Avg. Yield per Ha. (Kg)</th>
<th>(5) Total Produced Per Farm (Kg)</th>
<th>(6) Consumed at Home (Kg or Head)</th>
<th>(7) Not Marketed (Kg or Head)</th>
<th>(8) Price Per Kg/Head (CFA)</th>
<th>(9) Gross Cash Earned (CFA)</th>
<th>(10) Cash Costs (CFA)</th>
<th>(11) Net Cash Income (CFA)</th>
<th>(12) Gross Value of Product (CFA)</th>
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<td>1. Millet</td>
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<td>2. Cowpeas</td>
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<td>500</td>
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<td>150</td>
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<tr>
<td>4. Miscellaneous crops</td>
<td>70</td>
<td>0.007</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>300</td>
<td>--</td>
<td>--</td>
<td>300</td>
</tr>
<tr>
<td>5. Sheep/Goats</td>
<td>70</td>
<td>6</td>
<td>--</td>
<td>1</td>
<td>3</td>
<td>4,000</td>
<td>12,000</td>
<td>500</td>
<td>11,500</td>
<td>24,000</td>
<td>24,000</td>
</tr>
<tr>
<td>6. Poultry</td>
<td>50</td>
<td>10</td>
<td>--</td>
<td>1</td>
<td>5</td>
<td>400</td>
<td>2,000</td>
<td>100</td>
<td>1,900</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>7. Donkeys/Horses/ Camels</td>
<td>40</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>25,000</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>25,000</td>
</tr>
<tr>
<td>8. Cattle</td>
<td>40</td>
<td>2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>25,000</td>
<td>25,000</td>
<td>1,000</td>
<td>24,000</td>
<td>50,000</td>
</tr>
<tr>
<td>9. Total</td>
<td>--</td>
<td>5.927 ha. (19 head)</td>
<td>--</td>
<td>1,479</td>
<td>1,283 kg (2 head)</td>
<td>191 kg (9 head)</td>
<td>--</td>
<td>47,220</td>
<td>4,300</td>
<td>42,920</td>
<td>162,990</td>
</tr>
</tbody>
</table>


1/ $1.00 U.S. = 210 CFA Francs.
APPENDIX G: Traditional Methods of Harvesting Acacia Albida Browse Parts.

As the tiny leaves decompose rapidly after they fall from the tree, the only way to make optimum use of the leaves for animal feed is to cut the branches and twigs (which are usually too high on a mature tree for animals to reach) and let the animals consume the leaves directly from them (the remaining wood is used for firewood, fences, etc.). In well-managed tree stands branches are lopped on a systematic, rotational basis.

In view of the above, it is evident that the pods provide more useable fodder than leaves. When the pods are ripe, they will drop to the ground and be readily consumed by livestock unless the farmer takes measures to prevent this. Often, children will be assigned the job of rising before dawn each day during the A. albida harvest season (April-June) to collect the fallen pods before they are eaten by animals. Just as often, farmers or herdsmen will use long poles to reach up into the tree and shake the ripe, or almost ripe pods for collection and storage, or for the immediate consumption by eagerly awaiting animals that devour them the moment they drop to the ground. Sometimes farmers, or more often their children, climb up into the trees and pluck or knock the pods to the ground.

The pods are collected on squares of cloth or grass mats and carried in these or baskets or fiber bags from the fields to the place of storage. The latter can be a traditional rammed-earth, thatch-topped grain silo (usually empty or nearly empty at this time of year), a corner in a room of the farmer's house (hut) or baskets that are suspended from trees. Prior to storage, care is often made to remove insects, insect-infested pods and pods with insect-made encrustations, and to thoroughly dry the pods in the sun. These pods, and damaged or broken pods, are the first that will be fed to livestock. The pods put into storage can, but seldom are, kept without deterioration for up to 2-4 years. (Wentling, M. Field Notes, Niamey Department, Niger, May 1976-July 1981.)