Acacia nilotica: a traditional forage species among the Afar of Djibouti

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INTRODUCTION

The study of vegetation and grazing potential, financed by the European Development Fund and carried out in 1986, very quickly revealed that practically the whole of the area of Djibouti, with some exceptions, was composed of low quality steppe with the following average production:

- grassland: 20-200kg DM/ha/year
- trees and shrubs: 20-50kg DM/ha/year

For the maintenance of goats alone, normally reckoned as 0.1 TLU (Tropical Livestock Unit), the necessary annual stocking rate is 1.5-2ha per head on average and 5-9ha per head in the extreme. In such a situation, it is difficult to impose control or to institute a rotational management system. Every hectare is continuously used and all the resources are exploited.

The Government of Djibouti and the Department of Livestock wanted to develop the country's livestock production and it was necessary to provide extra available forage without encroaching on the existing production area. In order to do this, the intention was to improve the vast alluvial plains which are flooded once or twice a year and currently totally devoid of vegetation. Studies had shown that these areas were not sterile, so they required the reintroduction of a stable mixture of forage plants, resistant to uncontrolled grazing, of use to the stockbreeders and adapted to flooding.

The existence of natural populations of *Acacia nilotica* on similar sites and the interest of the grazers in this species made it desirable to find out more about this tree. Similar considerations showed that *Sporobulus helvolus* could be used to establish grass cover.

ORIGIN AND DISTRIBUTION

Acacia nilotica L. Willd. (family: *Mimosaceae*) is one of the most common and widespread of the *Acacia* species in dry tropical Africa, the Middle East and the Indian subcontinent. Ross (1979) has distinguished seven sub-species:

- subsp. *adstringens* (Schumach. and Thonn.)
- subsp. *nilotica*
- subsp. *tomentosa* (Benth.)
- subsp. *indica* (Benth.)
- subsp. *subulata* (Vatke)
- subsp. *biocarpa*
- subsp. *kraussiana* (Benth.)

There are numerous local names and the sub-species are seldom defined in West or Central Africa.

Distribution of sub-species

Subsp. *nilotica* is common in the Nile Valley in Egypt and in the Sudan. It is also found in Nigeria, Niger, Mali and Chad and, in the east, in Ethiopia (including Eritrea).

Subsp. *tomentosa*, very abundant in India and Pakistan, is also widespread in Senegal, Mali, Ghana, Nigeria and, in East Africa, in Sudan and Ethiopia. It is the sub-species found in Djibouti.

Subsp. *adstringens* is relatively common in west sahelian Africa, as far as Sudan in the east. It is also found in the northern Sahara, Libya and Algeria. The sub-species *tomentosa* and *adstringens* are quite often planted in the sudanese region and *nilotica* has been introduced into Qatar.

Subsp. *indica* is of Indian origin but has been grown in Africa. It has been introduced into Egypt, Ethiopia, Tanzania and Angola. Subsp. *subulata* is found in the south of Sudan, in Ethiopia, Uganda, Kenya and Tanzania. Subsp. *biocarpa* exists in Somalia, Kenya and Tanzania. Subsp. *kraussiana* occupies the area in the south of Tanzania, as far as Natal and is also found in Angola and Southwest Africa.

ECOLOGY

The three following sub-species are very important, from the point of view of biology, sylvo-pastoral use and economic value, and are very different in these respects. The subsp. *tomentosa* is most often found in pure stands on alluvial soils that are periodically flooded, sandy-clays and non-saline clay soils. It is resistant to temporary flooding and can grow in waterlogged soils for long periods. It is certainly one of the *Acacia* species most adapted to wet areas and is referred to as hydrophillic.

The subsp. *adstringens*, more adapted to dry conditions than the previous one, is only found widely dispersed and in dry areas. In the delta of Senegal, it is found on the edge of flood zones where populations of *tomentosa* have established.

The subsp. *nilotica* frequently forms dense tree belts around permanent or semi-permanent pools. It also grows along the banks of the Nile.

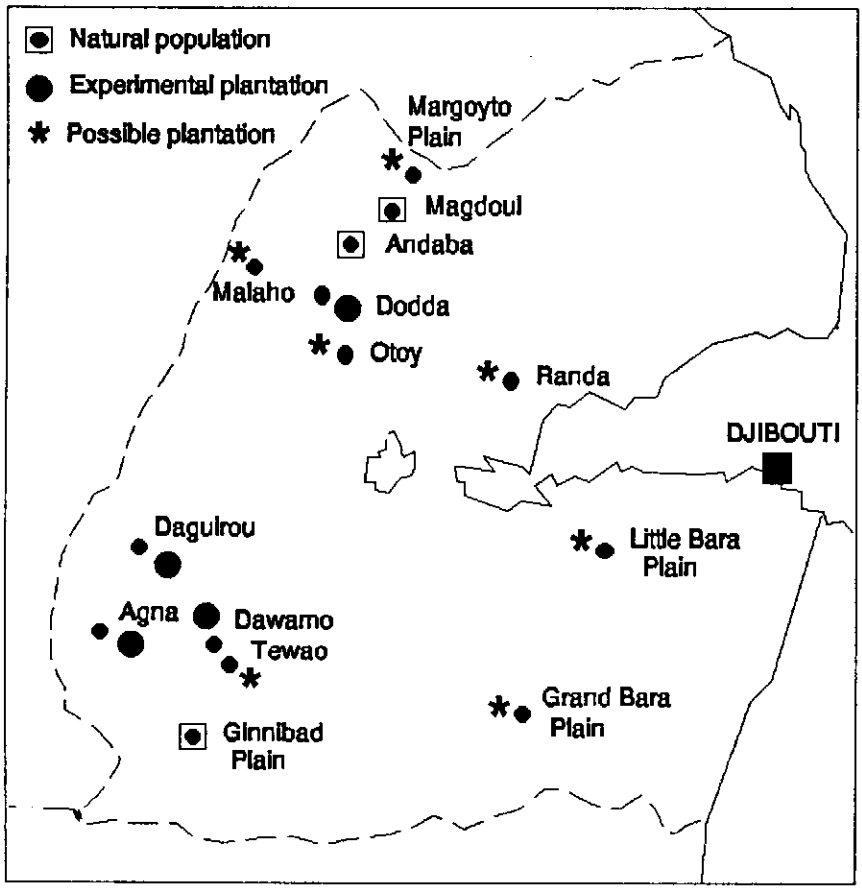
ACACIA NILOTICA SSP. *TOMENTOSA* IN DJIBOUTI

Acacia nilotica tomentosa is the only sub-species found in the Republic of Djibouti and is known locally in Afar as *Kassal-to* (pl. *Kassal*) and in Somali as *Xarmuku*. It naturally occupies the lowest, temporarily flooded parts of three valleys: Andabba, Madgoul in the north-west and Ginnibad on the Dakka plateau in the south-west (Figure 1). Elsewhere it is planted in the gardens of the local inhabitants throughout the country, everywhere where it can be watered. Experimental plantations exist at Dodda, Dagguirou, Agna and Dawano, established at the request of the farmers. There are other sites in the Republic of Djibouti (in particular, Petit Bara and Grand Bara) where its introduction does not pose any major technical problems.

General characteristics and botanical composition of natural sites

Acacia nilotica tomentosa is found in pure or nearly pure stands, associated with some *Ziziphus abyssinica*. In a broken circle round the edge of the valley and on the slopes of the hills, *Acacia ehrenbergiana* is associated with some *Salvadora persica* thickets. The soil is silty-clay on all the sites.

FIGURE 1. **Distribution of sites of *Acacia nilotica* ssp. *tomentosa*.**



Flooding, which is of longer duration in the Andabba and Madgoul valleys, allows the development of an aquatic field of *Aponogeton nudiflorus*. In the lowest areas which are therefore the most flooded, one notes some pockets of *Cyperus rotundus* and, in isolated patches, *Echinochloa colona*. In the less wet areas, such as the valley of Ginnibad, one finds some patches of *Citrullus colocynthis*, *Chrozophora plicata* and *Coldenia procumbens*.

Evolution of the flora

The tree population is in a relatively good state at Ginnibad and Madgoul but declining at Andabba, following too frequent and severe lopping. The herbaceous layer is poor and of low grazing value. However, it is reported that the small tubers of *Aponogeton nudiflorus* are consumed by man.

According to old people, grass existed forty years ago. Its disappearance occurred at the same time as a very great flood which happened after a very long period of drought. When the flood went down, all the herbaceous growth had disappeared. *Sporobolus helvolus*, *Echinochloa colona*, *Cyperus rotundus* and *Panicum turgidum* (on the edge) are still remembered as being there. All these species still exist in similar regions, often enough in a scattered state. They will be used to re-establish the grass cover.

Ecology

The soils of these valleys, alluvial in origin, are silty-clays with low organic matter, except in the Madgoul valley. These soils are quite regularly flooded and the limits of the flooding are very variable. It ranges from simple waterlogging to complete flooding which makes the valley inaccessible for 2-3 months. The sub-species resists waterlogging quite well, even for a long period. At the same time, it is very resistant to drought.

Experimentally, it can be transplanted into areas very different to those where it is normally found, with the only condition being to ensure the recovery of the transplant. A simple pit, a few metres deep, watered occasionally, will ensure the recovery and survival of the plant. The result is an improvement in the potential of the soil for water retention which allows growth to take place even in the absence of water for more than a year.

Finally, this species resists low levels of salinity.

IMPORTANCE OF THE TREE TO THE STOCKBREEDERS OF THE MADGOUL VALLEY

General land use

The Afar society is composed of tribes (*kedo*) and each of these is divided into family groups (*gulub*). The entire grazing areas are the property of the tribes but there are those that they can be freely used by everyone, whatever the season, including the families of other tribes who may use these areas with the same rights as the 'owners'; others are not free and access must be requested of the chief of the group or tribe. This request is generally granted. These grazing units are called *desso* and this is the usual practice of the Assayamara, the tribe of Madgoul.

This *desso* is a sort of traditional form of control that implies ownership of the land and maintains a certain quality of pasture. It involves, when the water rises after a flood or rains, forbidding all access by animals to an area of land where the plants have not yet flowered, which is a way of obtaining a maximum level of biomass of good quality.

The *desso* quite often implies the exclusivity of the pasture to one species of animal. Such land is destined for cattle with the exclusion of all other species, essentially for the cattle of breeders belonging to the family groups of the proprietary tribe. Finally, it sets a date for turning out to pasture.

As far as it goes, the principle is good but where the problem comes is that there isn't any regulation concerning the stocking rate and the end of grazing. The stockbreeder removes his animals only when he finds another favourable area of pasture.

This method of land use, although still not perfect, is at the same time relatively positive in the context of development projects aimed at improving or establishing pastures.

The existence of a land tenure system and the social organization of the Afar suggests that it is possible to collaborate more easily with them in a development programme. One may also state that all action to improve the pasture on the common land will subsequently be managed within the *desso* system.

Family ownership of the trees

On the common land or in the areas controlled by the *desso* system, the tree layer is not differentiated from the herbaceous layer. This is quite different to the situation in certain tree populations which are judged of value to the farmers, such as *Acacia nilotica* or species like *Ziziphus mauritania, Ficus vasta* and *Ficus sycomorus*. In these cases, the trees are the property of family groups or of the families which make them up.

In the Madgoul valley, given the existence of a herbaceous component, it is subject to the controlled management but excluding the trees. The tribe of Assayamara comprises six family groups forming, in this way, six grazing units involved in using the trees.

The use of trees by the stockbreeders

The breeders of Madgoul are essentially goatkeepers; some possess fat-tailed sheep and some dromedaries. *Acacia nilotica tomentosa* is a forage tree *par excellence*, as well as being a reserve for security of fodder supply. The leaves are cut and the pods and flowers are also collected. But the vegetative production obtained is extremely variable from one year to the next, depending on climatic conditions, which can be summarized as the presence or absence of water on which growth is directly dependant, and individual variability between trees in the same stand.

CLIMATE AND TREE DEVELOPMENT

The performance of the tree is variable and a function of the climatic conditions. In semi-arid areas, water determines the phenology. In the area inhabited by the Afar, the annual climate pattern is as follows:

Dec-Mar	*Guilal* (cool season) *Daddaa* (unique to the Godas and Mablas regions)	Rain possible
Mar-Jul	*Sougoum*	Rain possible
Jun-Jul	*Kamsin* (50 day wind)	
Jul-Nov	*Hagay*	*Karma* rains (summer rains of Ethiopia)

The pattern shows three possible periods of rain, of which the most certain is *Karma*. These rains fall, or don't fall, on the Madgoul valley, but fall on the surrounding region, flooding the valley, which serves as a catchment for the neighbouring hills.

The development of the tree is as follows:

Foliage growth. At Madgoul, the trees generally stay in leaf throughout the year, provided that the interval between two floods or two periods of rain does not exceed 10-12 months.

Flowering. At the beginning of each season, the smallest amount of rain provokes flowering. It is therefore possible to have three flowerings in the same year.

Fruit setting. Regardless of the number of flowerings in the year, there will only be one lot of fruit. This fruiting time is always after a flowering in October-November. The pods, which are slightly marcescent (mature without falling off), start to ripen from February to March.

Individual variation

Within the same natural stand, individual variability is another element of the variation in vegetative production. In natural regeneration and in the conditions of an unmanaged area, the sub-species always produces a very spiny juvenile form, with very few leaves and sterile until the differentiation of a shoot that produces branches and twigs, with few spines but with leaves, that is fertile.

When the young tree grows in favourable conditions of water supply, this juvenile form does not occur and all the functions of the tree are found to be modified. For example, it is reported, on the basis of a one year period of growth including the time in the nursery, that untimely flowerings were occasionally observed. Systematic recording of trees under different environmental conditions is going to be undertaken starting in 1992. This will provide better information on growth and development.

One thing that cannot be explained at present in certain older individuals is the maintenance of the very spiny stage over the whole of the top of the tree whether or not it has been pruned. The most curious

thing is that these trees are sterile, just like the young form. They do not flower or produce pods. The foliage is less abundant, the ends of the leaves cannot so easily be touched and the tree is of much less value for cutting. The farmers have observed this difference and the absence of flowers and pods but cannot explain the phenomenon. By monitoring some trees, perhaps an explanation will be found.

We also need to know the percentage of these sterile trees in natural populations and reafforested areas.

PRODUCTS AND USES

Foliage

The foliage is much sought after by small ruminants and camels. The camels, even when they are young, go for the ends of the shoots after browsing by the goats and sheep.

The trees are lopped in rotation every 18-24 months in the dry, cool season (*Guilal*) and, if the rains known as *Dadaa* don't fall, the lopping continues during the season called *Sougoum* (3 months). If it rains during *Sougoum*, the cutting is abandoned while other grazing is available. In every case, cutting is also stopped during *Sougoum* when the trees are defoliated, which is generally during May.

Cutting may be total or only partial. In any case, even when total, the farmers, concerned with the survival of the tree, leave one or two branches entire. When the crown has reformed, these branches are either left or cut, if they are still in leaf.

The best time for use is during *Guilal*, when the branches have plenty of leaves and are bearing pods at different stages of maturity.

The actual production has still not been established. It is known by the farmers that the complete foliage of an adult tree provides for the maintenance of 100 goats for one or two days, if feed supply is difficult.

Flowers

There may be three flowerings in the year but only the flowering at the end of *Hagay* (October) produces pods. The inflorescences which have fallen to the ground are the basis of feeding of young weaned goats from

1-1½ months.

The Afar, like others in desert regions, have adapted the management of their flock to the progressive poverty of the rangeland. The management of the livestock is essentially dominated by the need to obtain goat-milk production, sufficient for all the family and throughout the year. This is achieved by slaughtering young male goats between 8 and 15 days and the early weaning of young females.

Each production of flowers, which is difficult to quantify, is reserved exclusively for young goats and young lambs of both sexes which do not follow the flock during the 1-2 months after weaning.

The pods

The maturing of the pods is spread out like the flowering. The first ones are ripe at the end of January and the remainder carry on until the end of March/beginning of April. Quite often, part of the production is lost by the pods falling in the water or into the mud when the valley is still flooded.

The production of pods, which on average reaches 80-100kg per adult tree, is only partly collected by the women and children. Many of the pods are gleaned directly by the animals. They are somewhat marcescent and there are differences in humidity between day and night and gusts of wind which make them fall.

Stored in bags, they are fed, lightly crushed, at the end of *Guilal* (February-March) and the beginning of *Sougoum* (March-April), and the following months if the dry season persists. They are reserved for the remaining goats that are kept in the proximity of the camp during difficult periods to provide milk for the very young children. The milking camels also benefit during the same periods. While the camels consume the whole pod, goats only eat the casing and reject the grains.

NUTRITIVE VALUE

The results from IEVMT relating to the laboratory analysis of various edible parts of *Acacia nilotica* are summarized in Table 1. They have been obtained from samples collected in Burkina Faso, Senegal and Djibouti. The leaves have been collected from August to April but the stage of development is not given. It has been assumed that the youngest leaves were gathered in September in Senegal, given the fact that the protein content diminishes with age. The inflorescences came from Djibouti and have been gathered in October. The pods and grains have been picked up or acquired from October to May in the three countries.

The organic matter content (100-ash) is of limited significance because the ash may include mineral matter of exogenous origin (sand, etc.). The enzymatic degradability of organic matter (DOM) was 65-80% for the majority of samples, except for the young leaves (25-30%). The low digestibility of the latter may be related to the high content of tannins because it is not explained by the chemical composition (protein content, cell wall constituents, etc. - see below). As a result, the energy value was between 0.6-0.9 UFL (6.8 and 10.3 MJ ME/kg DM) for the older leaves, inflorescences, pods, envelopes and grains, and between 0.2-0.3 UFL (2.3 and 3.4 M/D) for the young leaves. For each component, the variation is probably related to the tannin content and, as for all forages, to the cell wall contents.

The protein contents (N x 6.25) were between 9 and 24%. The measurement of solubility and fibre-associated protein (CP-ADF) allows the respective determination of the quantities rapidly degraded by the rumen microorganisms and the undegradable fraction. These fractions are quite variable in the leaf samples (older leaves) but, on the other hand, quite homogenous for the pods. The variation is quite small compared to between-species differences (Kone *et al.*, 1989a; 1989b).

TABLE 1. **Chemical composition, enzymatic degradability and estimates of the nutritive value of various component parts of *Acacia nilotica* analyzed at IEVMT.**

Part	Green leaves			Inflorescences	Pods	Pod	Seeds
Stage of development	Young	Intermediate	Adult	fallen to ground	entire	envelopes	
Number of samples	1	2	12	1	6	1	3
CHEMICAL COMPOSITION							
Organic matter (%DM)	78	88	83-94	84	95	93	94
Protein							
Total protein (%DM)	27	16	11-15	9	9-14	9	18-23
N-solubility (% protein) (Durand, in Verité and Demarquilly, 1978)	21	18	13-23	24	30	54	27-58
Residual protein in ADF (% protein)	33		7-13	10	5	9	4-8
CELL WALL CONSTITUENTS							
Neutral Detergent Fibre - NDF (%DM)			13-23	17	25*	28	32-44
Acid Detergent Fibre - ADF (%DM)	36		10-18	15	19*	22	25-32
Acid Detergent Lignin - ADL (%DM)	26		5-9	6	6*	8	3-4
ENZYMATIC DEGRADABILITY							
of Organic Matter (%) (pepsin-cellulase) (Aufrère and Demarquilly, 1989)	25	29	64-69	80	67	76	67-74
of protein by pronase - 1 hour (%) (Aufrère *et al.*, 1989)		24	24-33	31		61	35-64
of protein by HCl-Pepsin (%)	18	18	68-74		79*		4-8
NUTRITIVE VALUE (examples of estimates from the analysis)							
Energy value (UFL/kg DM)[1]	0.2	0.3	0.77-0.83	0.81	0.7	0.77	0.6-0.9
(MJ ME/kg DM)	(2.3)	(3.4)	(8.8-9.5)	(9.2)	(8.0)	(8.8)	(6.8-10.3)
Digestible Crude Protein (g DCP/kg DM)	50	50	60-100	40	40-90**	50	60-140

* 1 sample only

** depending on the number of seeds

[1] UFL = Unité Fourragère Lait : 1700 Kcal NE for milk

About a third of the protein is associated with the ADF in young leaves and, as a result, the enzymatic degradability is very low (18-25%). For the older leaves and other components, the degradability can reach 65-80% but, for the same sample, the results vary according to the method of enzyme digestion; the measurement of degradability by pronase appears to estimate the degradation of protein in the rumen, whilst HCl-pepsin digestion simulates post-ruminal digestion.

The order of magnitude of the levels of digestible protein are given; they have been estimated from the variations in chemical and enzymatic criteria and from some results obtained *in sacco* and *in vivo* for other species of tree forage. They are provisional.

The cell wall constituents are characterized by the Van Soest fractionation method. The total level of cell wall is a little high (NDF $\leq$ 45% of DM) but a third or more of the lignocellulose (ADF) is composed of lignin (ADL).

Conclusions

The estimates of energy and protein value may be improved by the results obtained in the course of measuring *in vitro* and *in vivo* digestibility (Project CEE-DG XII 5TD2 - 215: Nutritive value of ligneous forages), as well as by the study of the kinetics of enzymatic digestion (1-24 hrs) and the nylon bag method (6-48 hrs in the rumen) for protein.

The variability of results obtained so far shows that it is essential, in order to extrapolate to other samples, to define precisely the nature of the components collected, the stage of development of the tree, etc.

The first estimates of the nutritive value confirm, except for young leaves, the value of *Acacia nilotica* for young animals, lactating females, etc.

Palatability and intake are other parameters associated with forage value. The fallen flowers, with a high energy value, are highly palatable. The value of the pods is partly related to the content of seeds but the latter are less palatable to goats. The leaves, if they have a low tannin level, can have a high nutritive value but their consumption may require adaptation. As the basal feed for the small ruminants of the Afar, the

leaves are consumed only at the rate of 25g DM/kg $W^{0.75}$ (about 1kg DM/100kg LWt) by sahelian sheep adapted to herbaceous forages.

OTHER USES

Medicines

Pods, ground up in water, are used as a drink for diabetics and people with ulcers.

Wood

The wood is not used for heating or other purposes. The cut branches remain on the soil and rot where they are with successive floods. Some farmers use them to protect young trees against animals. The dead trees are also left on the ground.

If a system can be organized, the wood could be a source of revenue for the farmers as wood is scarce in the towns of Djibouti.

Tanning materials

The sub-species is tanniferous. The pods are rich in tannin and contain 20-30% in the DM. They are used by the stockbreeders of Madgoul to tan the hides of goats to make water-containers. The skin is filled with crushed, wet pods for 48 hours.

CONCLUSION

Re-establishment of the pastoral environment is a priority in the Republic of Djibouti and this objective must be approached within the limitations of the existing botanical composition of the degraded or lost land, so as not to cause problems for the stockbreeders.

The proposed system of forage management is simple. It consists of:

- 100 plants/ha of *Acacia nilotica tomentosa*. This is the optimum density observed in the undegraded natural populations at Madgoul. It is also the density which allows the maximum spread of the tree crowns; this is required when they are used for cutting.

- 625 plants/ha of *Sporobulus helvolus*. The grass is stoloniferous The growth of stolons is 70cm/month during the 2 months after *flooding* and grass cover is formed in 2½-3 years.

Save for the *Acacia* plants that are too young to be exploited, the first results for green biomass obtained at the flowering stage, after the first flooding following the planting, vary between 3000 and 3200kg DM/ha. At a rate of 1kg DM/goat/day, this level of DM production will support 12 goats/ha for 8½ months; the remaining 3½ months are the time when the plain is inaccessible during the floods.

The resulting herbaceous cover can be expected to nearly double this production as has occurred at Dodda in the north-west of the country where the plain is flooded twice a year on average.

Sporobolus helvolus, in fact, provides the grazing (that no longer exists at Madgoul), while *Acacia nilotica* remains the reserve of forage to provide security in case of drought. It remains to find a pasture legume to improve the grass component.

These results have led to the establishment of two projects:

- livestock development project in the north-west of the Republic of Djibouti, financed by the French Fund for Aid and Cooperation, for the creation of 3000-3500ha of pasture over 4 years

- project for the restoration and improvement of palm groves and development of animal production in the district of Yoboki, financed by FED, to put in place 2000-2500ha over 3 years.

There are other sites in Djibouti currently being studied and which are amenable to the same approach and techniques.

In conclusion, the creation of grazing will also permit:

- the safeguarding of the land currently in use and stopping the further reduction in value of large valley areas

- an improvement of the income of farmers by increasing the productivity of the herds that is made possible by the new available forage resources
- an increase in the contribution of livestock, and small ruminants in particular, to the national economy.

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